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Group on the Science System

UNIVERSITY RESEARCH IN TRANSITION: COUNTRY NOTES

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## PREFACE

These notes have been prepared as background information for the OECD study on university research, undertaken under the auspices of the OECD Group on the Science System and published under the title “University Research in Transition” (1997).

Most of these notes, but not all, are organised as follows (according to topics selected by the Group):

1. broad policy and budget funds;
2. mechanisms promoting knowledge transfer from university to industry;
3. relationships between university research and other parts of the public research system (national laboratories); and
4. international mobility issues.

Data and information provided in the notes refer generally to situations prevailing in early 1997.

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## AUSTRALIA

*Prepared by the Australian Department of Employment, Education, Training and Youth Affairs*

### 1. Policy and budget trends

Universities remain the principal performer of basic research in Australia, and the Commonwealth, through the programmes of the Australian Research Council (ARC)/Department of Employment, Education Training and Youth Affairs (DEETYA) its principal supporter. R&D performance by the higher education sector went through a period of sustained growth from 1990 through to 1993. Meanwhile, support for basic research remains at comparatively high levels in OECD terms.

The broad policy and budget trends affecting Australian universities were outlined in the Higher Education Budget Statement released by the Minister for Employment, Education, Training and Youth Affairs on 9 August 1996 preceding delivery of the newly elected Coalition Government's first Budget. The Statement outlined six major elements of policy including:

- responsible levels of funding for teaching and research;
- a fair balance of funding between public and private funding;
- additional opportunities and choice for Australian students;
- quality assurance and improvement commitment to equity; and
- a more strategic relationship between the Commonwealth and Universities.

The overall levels of funding for universities will remain just over A\$ 5 billion annually until the turn of the century. However, there will be a reduction of 1 per cent in 1997, a further reduction of 3 per cent in 1998 and further 1 per cent reduction to projected funding in 1999 (i.e. a cumulative reduction of 4.9 per cent over three years), mostly attributable to reductions in university operating grants. These reductions in operating grants will be most felt in 1998 and 1999.

Of the above A\$ 5 billion, the research related funding is approximately A\$ 1.6 billion. This research related funding includes a research and research training component of approximately A\$ 887 million (in 1996-97) of the university operating grants. There are three components of this A\$ 887 million: A\$ 276 million for the Research Quantum (identified as the component of the operating grant supporting research activities unrelated to teaching and training); A\$ 476 million for the Research Training Component; and, approximately A\$ 135 million of block grant support for the research schools and centres of the Institute of Advanced Studies.

However, the new Government's commitment to research and research training should also be noted, despite the overall reductions in support through the operating grant. This can be observed in increases in funding for the targeted research programmes of ARC/DEETYA. Additional funding for research of A\$ 129.3 million over the three years 1997-1999, including an additional A\$ 90 million over three years for research infrastructure, and additional A\$ 9.3 million over three years to support postgraduate training through additional postgraduate awards and an additional A\$ 30 million over three years for the enhancing research collaboration between industry and universities through the Collaborative Research Grants

Scheme were also announced in the Higher Education Statement. As a result, funding for the targeted ARC/DEETYA research programmes is expected to rise to A\$ 386 million in 1996, A\$ 408 million in 1997, A\$ 436 million in 1998 while dropping back to A\$ 420 million in 1999.

Outside of the DEETYA portfolio, research funding which universities and other research agencies are able to access is available from a range of Commonwealth Government science and innovation programmes. This includes the Cooperative Research Centres (CRCs) Program, Rural R&D Corporations and Councils, National Health and Medical Research Council grants and other health R&D, as well as smaller R&D grant schemes. While support for the CRCs program is rising (up 6 per cent in real terms in 1996-97) the residue of the other schemes shows a slight decline (down 2 per cent in real terms in 1996-97). In the foreseeable future, there is unlikely to be significant growth in direct funding sources through these residual schemes.

There are two other initiatives of the new Government which will influence the level of funding available for industry based research, through which universities are able to benefit as partners in university-industry collaborative research. The first is reduction of the R&D tax concession from 150 per cent to 125 per cent and to close off syndication provisions to new applicants. Secondly, the Government has introduced a new programme known as the 'R&D Start' Program for which it will provide A\$ 520 million over four years. This new Program will encompass and build on existing industry R&D support measures including competitive grants and concessional loans. The new Program will:

- provide a new contestable R&D scheme, to replace the R&D Syndication Program;
- provide a mix of support measures based on large grants, loans and interest rate subsidies;
- develop additional new market-based support measures in consultation with industry; and
- complement the R&D Tax Concession.

As noted above, a key element in the new Government's approach to higher education is responsible levels of funding for both teaching and research, and as such there has not been any direct emphasis on the funding balance between them. An indicator of the balance between training and research is the growth in the research training component (RTC) of the university operating grants. The RTC in 1990 was estimated to be 7.6 per cent of the operating grant. Due to strong growth in postgraduate research student load since 1990, the RTC has increased and is currently estimated to be 10.7 per cent of the operating grant, or A\$ 476 million in 1996.

A key policy initiative of the ARC to improve effectiveness of its own programmes has been its work on funding strategies for the support of basic research through ARC programmes. The ARC's objective is to ensure that Australia will have the most appropriate mix or balance of research training of basic research and research training across the disciplines as Australia moves into the 21st century. Given the high quality of academic research in Australia and the Council's ability to fund only a portion of all applications, decisions on the appropriate levels of activity, in relative terms, of research and research training across the disciplines can be made without jeopardising the fostering of excellence. Getting the balance right will ensure that Australia's research capacity meets the nation's current and future social, economic, cultural and environmental needs, as well as creating opportunities for development in the future.

Evolution of industry support for research and training has taken place in a background where, over the past two decades, Australian business performance of R&D has tripled in real terms. Since the early 1980s, Australia has had the leading growth rate among OECD countries both in business R&D funding and performance. Funding of research and training from non-government sources (notably industry) has up to now been stimulated by the 150 per cent tax concession for R&D, and supported through

Commonwealth Government schemes such as the Industry, Science and Technology portfolio's competitive grants for R&D, and the ARC/DEETYA programmes such as the Collaborative Research Grants and Australian Postgraduate Awards (Industry) (see Sections 2 and 3 below). In all this, it is important to note that the overwhelming source of funding for higher education has remained the Commonwealth Government. For example, in 1992-93, it was estimated that only A\$ 64 million of the A\$ 1 695 million of research performed in universities came from non-government sources. It is against this background that the new Government's emphasis on encouraging private sector investment in university research and the higher education sector can be understood.

## **2. Knowledge transfer mechanisms**

It is widely recognised by Australian policy makers that the best mechanism for knowledge transfer is through the movement of personnel with skills transfer including the problem solving methods of researchers, their instruments and informal networks of professional contacts. The Co-operative Research Centres (CRC) Program significantly benefits knowledge transfer (see Section 3) and its objectives include stimulating a broader education and training experience, particularly in graduate programmes, through initiatives such as the active involvement of researchers from outside the higher education system, and to enhance the employment prospects of students through initiatives such as involvement in major co-operative, user-oriented research programmes.

There are a number of Australian Research Council/Department of Employment, Education, Training and Youth Affairs (ARC/DEETYA) programmes which contribute to the promotion of knowledge skills transfer. These include:

- The Collaborative Research Grants Scheme, which supports research collaboration between universities and industry by funding high quality research which has the potential to economically and socially benefit Australia. It is a requirement for grants that dollar for dollar matching funds from industry are available to the grantee. In 1996-97, A\$ 20.5 million will be available to the scheme.
- Australian Postgraduate Awards (Industry) support higher degree research training for postgraduate students on research projects to meet the needs of industry. Each project is sponsored by an industry partner who is required to contribute A\$ 5 000 in cash plus an additional A\$ 5 000 in cash and kind for each year of the higher degree training course. The awards are made on the recommendation of the ARC and approximately 500 are available each year.
- Contribution of A\$ 0.6 million annually (following establishment funding of A\$ 1.4 million in 1992) to the operation of three Advanced Engineering Centres (AECs). These Centres were established as part of a wider agenda to enhance the contribution of engineering skill, research and development in the evolution of internationally competitive industries for Australia. They are designed to promote collaboration between higher education and industry to improve advanced engineering education, increase industry's capacity to apply and commercialise technology, and focus on teaching and short-term research and consultancy projects.

The relative success of these ARC/DEETYA Schemes has been demonstrated by increased demand. For example, the Collaborative Research Grants Program has experienced a strong growth in demand from 1995 to 1996 with more than double the number of applications. The Government has announced

additional funding for collaborative research of A\$ 30 million over three years beginning in 1997. The Government has also announced additional funding for postgraduate research scholarships of A\$ 9.3 million over the three years beginning in 1997. This additional funding should support additional APAs (Section I). A 1995 Review of the AECs recommended that funding of two of the Centres be continued for another two years while funding for the third continue for three years. The Review also recommended a maximum funding period of six periods of six years for existing and future AECs.

The status of industry-university collaboration generally may be affected by the reduction in the rate of the R&D tax concession from 150 per cent to 125 per cent. This may affect future levels of industry investment in university research, should industry find investment in research less attractive than before. There is some offset in the incentive of additional funding for Collaborative Research Grants and Australian Postgraduate Awards, as well as the revised R&D support measures in the 'R&D Start' Program. However, it is worth noting that the value of the decrease in business R&D support of revenue foregone through the industrial R&D tax incentive is estimated as a drop from A\$ 810 million to A\$ 547 million.

Intellectual property provisions are specified in all ARC/DEETYA grants and fellowships guidelines. With respect to Collaborative Research and other grants, neither the Government nor the ARC has any proprietary interest in the intellectual property which results from the research funds. In the case of Collaborative Research Grants, industry partners and universities must negotiate appropriate arrangements directly and it is expected that industry partners and universities will respect the right of researchers, including postgraduate students, to publish the results of their work, subject to the terms and conditions of any formal agreement.

### **3. University research and other public research**

There is a vast web of research and research training linkages between individual universities and the various public sector agencies. These linkages are further facilitated by major programmes to encourage research collaboration such as the Co-operative Research Centres (CRC) Program and the Major National Research Facilities (MNRF) Program, and by co-ordination mechanisms available through the Prime Minister's Science and Engineering Council, the Co-ordination Committee on Science and Technology and the Australian Science, Technology and Engineering Council.

The Government is currently restructuring the Australian Research Council (ARC). It has signalled that the new ARC will have an increased role in building research linkages between universities, the public sector and the private sector.

The key programme within Australia which builds linkages between the national research systems in universities and other public research systems is the CRC Program. With additional funding provided in the 1996-97 Commonwealth Budget, support for the programme will rise to A\$ 146 million annually and support 62 Centres. The CRCs Program provides support for long-term collaborative ventures linking research and research users from universities, Commonwealth- and State-funded research organisations and business enterprises. It promotes high quality co-operative research and education programmes through centres of research co-operation, strengthening the links between research and its commercial and other applications.

Commonwealth funding to the CRC Program is provided on the basis that those funds are matched by other core participants of each Centre. On average, the multiplier is 2.2, which brings the total annual operational resources available to the Centres to about A\$ 450 million. Universities contribute about

22 per cent or A\$ 99 million, the Commonwealth Scientific and Industrial Research Organisation about 16 per cent or A\$ 72 million and industry about 15 per cent or A\$ 67 million, to those Centres with a commercial focus.

The CRC Program was subject to a mid-term evaluation in 1995 by a Steering Committee chaired by Sir Rupert Myers. Key issues addressed in the evaluation included the overall effectiveness of the Program, the impact of the centres on universities, access to the Centres for small business, the development of Australia's research management skills, the most appropriate business structures for the Centres, and the ownership and protection of intellectual property. The Steering Committee found that the CRC Program had substantially improved Australia's research culture and that the prospects for commercial and other applications of CRC research were excellent. The continuation of support for the CRC Program under the new Federal Coalition Government in 1996 provides certainty for the Program in the foreseeable future.

In December 1995, seven new major national research facilities to be supported under the MNRF Program were announced. The MNRF Program is directed at keeping Australia at the leading edge of scientific and technological developments. Under the Program, funding is provided for facilities in a range of key scientific fields where the establishment costs are beyond the capacity of any individual Australian institution. In 1996-97, A\$ 17 million was allocated to the MNRF Program.

#### **4. International mobility**

Overseas Postgraduate Research Scholarships (OPRS) were introduced in 1990 to attract excellent overseas postgraduate students to Australia to enhance national research effort and standing. The scheme meets the tuition fees and health insurance costs of overseas postgraduate students who undertake research higher degrees at Australian higher education institutions in areas of research priority.

There are, each year, about 1 000 overseas graduate students and postdoctoral fellows studying under the OPRS Scheme administered by DEETYA. While the Scheme does not cover all overseas graduate students studying in Australia, it considerably enhances international research linkages. There are 300 new OPRS awarded annually; the recipients being selected on merit by higher education institutions in line with a quota allocation of OPRS. In 1995, 300 new OPRS were allocated and the cost for new and continuing scholarships totalled about A\$ 14.6 million.

A recent OPRS Scheme evaluation, published in April 1996, found that the Scheme is contributing in no small way to the international research and research training endeavours of the Australian higher education system. The international partnerships that exist because of the nature of the Scheme, between international students and their academic supervisors, are contributing to the development of informal international networks with the potential to lead to invitations to collaborate, or to formal arrangements to participate in planned programmes of research activity which transcend national boundaries. In addition, the Scheme facilitates fair access to Australian research opportunities and research credentials to highly qualified research students wherever in the world they may be.

The goal of the University Mobility in Asia and the Pacific program (UMAP) is to improve the quality of higher education in Australia through increased mobility of higher education students and staff. The UMAP Program is an exchange programme for university staff and students in the Asia Pacific region. Its general objective is to promote a better understanding of the cultural, economic and social systems of countries in the region.

The Program is overseen by a group of representatives from participating countries, which are: Australia, Brunei Darussalam, Cambodia, Canada, People's Republic of China, Hong Kong, Indonesia, Japan, Korea, Laos, Malaysia, Mongolian People's Republic, Myanmar, New Zealand, Papua New Guinea, Russia, Samoa, Singapore, the South Pacific Islands, Taiwan, Thailand, the Philippines, the United States and Vietnam.

Important elements of UMAP exchanges are fee waivers and full academic recognition for the study undertaken overseas. As such, UMAP can play a fundamental role in promoting the mutual recognition of qualifications in the region. UMAP exchanges are funded from a variety of sources, including from funding provided by the Australian Government. Since 1993, the Australian Government has funded over 950 UMAP student exchanges.

The Targeted Institutional Links Program (TIL), initiated in 1990, provides seed funding to Australian higher education institutions to support links with key research institutions in the Asian region fostering Australia's internationally competitive research and development in areas of national priority. This programme is complemented by scholarship awards to scholars from countries in the region.

All Australian higher education institutions in the Unified National System may submit proposals for research links with their counterparts in Asia in areas of national priority. Priority areas include: information technology and communications material technology; energy technology; scientific and medical instrumentation; raw materials processing; manufacturing technology; biotechnology; environmental sciences, including ecology and natural resources; business organisations; management and industrial relations; Asian studies and languages and marine sciences and technologies.

One indicator of mobility is the percentage of graduate students located overseas after graduation. According to the 1995 survey of the Graduate Careers Council of Australia (GCCA), 6.5 per cent of graduates surveyed in that year were located overseas (this includes both Australian residents and overseas students in work, study or holidaying overseas). For those students in the 1995 survey who qualified for the award of a bachelor degree (pass or honours), graduate entry bachelor degree, or three-year diploma, 3.4 per cent were in full-time employment overseas (2 226 out of 64 720) and 0.3 per cent were in full-time study overseas (219 out of 64 720).

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**AUSTRIA**  
**UNIVERSITIES FOR THE 21ST CENTURY**

*Prepared by the Bundesministerium für Wissenschaft und Verkehr*

**1. Policy and budget trends**

**1.1 University Organisation Law 1993**

(Though the following remarks are focused on higher education, they refer to a great extent to the research function of Austrian universities as well, due to inseparability of teaching and research.)

In 1991 an OECD review of the Austrian educational system confirmed the need for major changes; the centralised, compartmentalised and heterogeneous structure of Austrian (tertiary) education and research, the small and rather insignificant non-university sector, and the complete lack of a non-university sector for academic training were criticised in particular. It was recommended to deregulate and decentralise the system of post-secondary education, as well as to increase its flexibility and to strengthen institutional and personal responsibility.

Due to these recommendations the national debate on a reform of the system of higher education focused on the following keywords:

*Deregulation/flexibility:* Traditionally the Austrian system of education is regarded as just another branch of bureaucracy, being characterised by detailed regulations issued by the federal government, by public funding, and, last but not least, by the teachers' status as civil servants. The recent reforms aim at providing a less detailed framework of regulations

*Decentralisation/responsibility:* Within an increasingly complex system of education a central unit can no longer adequately fulfil the function of a steering mechanism. Autonomy of the individual institution/person is an essential precondition for a devolution of responsibility.

Reform measures concern two areas, firstly the organisation of universities (University Organisation Law 1993), and secondly the introduction of the entirely new sector of *Fachhochschulen* (see 1.2.).

*Main contents of the University Organisation Law 1993 (UOG)*

Although universities remain state institutions and are funded predominantly by the state (roughly 97 per cent), they are given a considerably higher degree of autonomy within the legal framework of the UOG 1993. By means of by-laws, the so-called statutes, each university is allowed to decide upon its own regulations. Universities now have the right to decide on the structure of their institutes, they are granted a higher degree of autonomy in the financial and budgetary sector, in the field of staff recruitment and in the areas of fund raising and research contracting. They are able to decide on the contracts with their personnel, on the distribution of their budget, and on their internal structure. This important transfer of power away from the Ministry opens the possibility for each university to develop an individual profile and to compete with other universities.

The new status of the head of the university, the rector, also stresses the transfer of power from the central unit to the individual university. He is given the right to start negotiations with a person applying for a vacant post as a university professor. Before the new law this was the duty of the minister.

*Decentralisation/responsibility:* Participation of all persons working at the university at all levels of decision finding processes is still guaranteed. But now rectors, vice-rectors, deans, deans of study and heads of institutes do have real deciding power and not only the duty to forward to the Ministry the proposals of the committees they are chairing. It is the committees' duty to give general guidelines for performing the tasks of those monocratic authorities. But the collegial bodies are also able to cancel decisions which do not follow these guidelines. Future development will show/prove if this is an effective instrument to check the power of monocratic authorities.

Increased autonomy and individual responsibility are just two sides of one coin. Thus evaluations in the fields of teaching and research will be compulsory. The findings, which have to be published, serve as a basis for decisions by the university organs and the Minister for Higher Education.

The implementation of the new University Organization Act 1993 had a promising start in the academic year of 1994/95 with five smaller universities. The new situation brings an extraordinary need and demand for training and development of managerial skills for the members of the academic staff. Programmes for staff development are currently to be implemented.

To further improve the Austrian higher education system, the organisational reform of the universities will be accomplished by a reform of the study law and university curricula to ensure a reduction of the length of studies and of the number of drop-out students. The law has passed legislation in early 1997 and will be effective by 1 August 1997.

## **1.2 Law on "Fachhochschul-Studiengänge"**

Since the OECD strongly supported the Austrian intention to diversify its rather homogeneous system of tertiary education, the Law on *Fachhochschul-Studiengänge* (FHStG) was passed by Parliament in May 1993; it went into force in October 1993.

### *General characteristics of Fachhochschulen*

*Fachhochschul-Studiengänge* are courses at university level without being part of the university sector. They are a new type of non-university higher education and are designed to provide a synthesis of theoretical and practical training. *FH-Studiengänge* are run either by the state or – which is more important – by corporate bodies of public or private law.

Access is possible via a final examination of a secondary II (*Matura*) or special university entrance exams designed for mature students without final exam, but also after vocational training. In the last case students may be obliged to do extra courses or exams.

Studies at a *FH-Studiengang* last for at least three years. Practical training periods prolong the studies for one or two semesters. Graduation at a *FH-Studiengang* requires a written paper (*Diplomarbeit*) and an oral examination.

Deregulation/flexibility: The FHSStG provides a very lean regulatory framework. It contains just 20 paragraphs, predominantly concerned with the guiding principles for *Fachhochschulen*, access to and procedural requirements for establishing *Fachhochschul-Studiengänge*. For the first time such programmes are not developed by the federal government, but by those corporate bodies which run *Fachhochschulen*. Additionally they are not passed by Parliament, but their quality is controlled by a separate body, the *Fachhochschulrat*. This is an independent agency of 16 experts, who are appointed for three-year terms by Ministers. This system eliminates the need for detailed regulation of curricular contents. Thus programmes are more easily adaptable to technological, economic and social change.

The law on *Fachhochschulen* does not contain any regulations on the funding of the new institutions. At present, the federal government pays for a certain number of students, whereas buildings and other resources must be provided by the corporate body running the *Fachhochschul-Studiengang*, respectively by provincial authorities, employers or other organisations.

Decentralisation/responsibility: The federal government is not directly involved in the administration of a *Fachhochschul-Studiengang*. Decentralised self-administration is to strengthen responsibility for handling of the budget as well as for the students' progress. *Ex post* evaluation serves as a means to check how the scope of action granted is used. A positive evaluation result is an essential precondition for a renewal of accreditation.

Graduates are admitted to doctoral studies at a university. For graduates of *FH-Studiengänge* these courses last two semester longer than for students who took their first degree at a university.

### *Implementation of the FHSStG 1994/95 and outlook for further development*

In 1994/95 the first ten *Fachhochschul-Studiengänge* started; they were attended by 695 students. In 1996/97, a total of 32 different studies with a focus on engineering and technology in various fields (e.g. automation, electronics, software engineering), on economic studies, and tourist and leisure industries is offered to 3 753 students at *Fachhochschulen* in all Austrian federal provinces (except Tyrol). Sixty one per cent have enrolled in courses in engineering and technology, 27 per cent in the field of economy. These studies are dominated by male students: 80 per cent on average of the total, but with a higher female percentage in tourism management (56 per cent) and economics (40 per cent).

### 1.3 *Structural Adjustment Law 1996*

This complicated law passed legislation extremely rapidly. Its main aim is to reduce the Austrian budgetary deficit considerably. In conjunction, for the first time in the Second Republic a two-year budget (1996 and 1997) passed legislation. The Structural Adjustment Law contains a large number of detailed new regulations in several fields, some of which have direct or indirect effects on the university system. Effects on research and teaching of these combined measures are difficult to calculate for the time being.

### 1.4 *Stagnation of the massification trend*

#### 1.4.1 *University personnel*

At present, universities offer more than 16 500 posts (an increase of about 8 per cent since 1993). 9 600 posts are taken by scientific personnel, of which roughly three quarters are university assistants; the number of the latter increased in particular (10 per cent). About 36 per cent of the university assistants have permanent posts, of which three quarters have highest scientific qualification (= "*Habilitation*"). The "10 to 7" ratio between scientific and non-scientific personnel has remained rather constant over the last years (Tables 1 and 2).

By field of science, the biggest share of all posts for scientific personnel is allotted to medicine (30 per cent), followed by natural sciences (20 per cent) and humanities (14 per cent). Medicine also shows the biggest increase in posts since 1993 (+ 18.4 per cent).

The share of women in scientific personnel was 22.2 per cent in 1995/96, an increase of 2 per cent compared to 1993/94. The share of women is still very different depending on the position within hierarchy: female professors account for only 4 per cent of the total (1992/93: about 3 per cent), and for 24 per cent of all assistants (1992/93 about 22 per cent).

**Table 1. Total posts for scientific and non-scientific personnel**

	1970	1980	1990	1991	1992	1993	1994	1995	1996
Professors (two categories)	906	1 589	1 732	1 809	1 819	1 834	1 854	1 854	1 854
University assistants and other scientific personnel	3 970	5 573	6 161	6 389	6 726	6 962	7 276	7 547	7 821
Total scientific personnel	4 876	7 162	7 893	8 198	8 545	8 836	9 130	9 407	9 675
Supporting staff	3 304	4 316	5 716	6 064	6 064	6 511	6 383	6 743	6 917

Source: *Higher Education Report 1996*.

**Table 2. "*Habilitationen*" by scientific personnel at Austrian universities, 1980-1995**

1980	1985	1990	1991	1992	1993	1994	1995
192	227	208	211	202	247	243	215

Source: *Higher Education Report 1996*.

#### 1.4.2 Student enrolments

The number of first enrolments in university studies increased up until the beginning of the 1990s and has receded slightly since then. During the winter semester of 1995/96, 19 813 individuals (10 611 female) began studying at universities. 8 907 additional students (5 594 female) enrolled in other studies at post-secondary institutions, such as schools of arts, *Fachhochschulen*, pedagogical academies, academies for social workers, special vocational courses, etc.

#### Student/teacher ratio

Since 1970, the total number of students has almost quadrupled. The number of teaching staff (professors, assistant professors and university assistants) has more or less doubled during the same period.

During the winter semester of 1995/96, 189 614 Austrian students in degree courses were enrolled at Austrian universities. Women accounted for 46.7 per cent of the regular enrolments. The entire student population consisted of 197 335 Austrian citizens and 27 093 international students in degree courses (12 382 female). 95.1 per cent of all students were enrolled as students in degree programmes, 4.3 per cent were non-degree students (*ausserordentlicher Hörer*), and 0.6 per cent auditors (*Gasthörer*).

Based on the figures of the winter semester of 1995/96, 13.8 per cent of the Austrian population between the ages of 18 and under 26 were university students. This percentage has increased steadily in the past 25 years from a weak 4.1 per cent in 1970, 8.1 per cent in 1980/81 and 11.6 per cent in 1990/91. The entire student population fell into the following age groups: 60 per cent were 18 to 25 years old, 21 per cent were 26 to 29; 16 per cent between 30 and 44; and 3 per cent 45 and older.

#### Graduates

There has been an increase in the number of graduates in recent years, which is a reflection of previous measures designed to improve general access to higher education. During the 1991/92 academic year, a new high point of 11 448 graduates was reached. Since the beginning of the 1980s, the percentage of women among graduates has increased steadily. In the early 1980s, the number of female graduates was just 34 per cent; by the early 1990s it had increased to 42 per cent.

The average duration of study for graduates was more than 13 semesters. Therefore, students exceeded the legally required minimum duration of study by four to five semesters as a rule. Only 4.4 per cent of the students completed their studies in the minimum required time. 82 per cent of the graduates received their first degrees under the age of 29; 12 per cent between the ages of 30 and 34; and 3 per cent between the ages of 35 and 39.

The ratio of university graduates (i.e. the number of people with university degrees in relationship to the size of the labour force) in Austria is 5.4 per cent. University graduates must take the fact into account that finding employment is becoming more difficult. The number of unemployed graduates has increased steadily in recent years. In March 1996, authorities had 5 572 university graduates seeking employment on record, and, above all, the percentage of university graduates over 50 seeking employment is climbing.

### 1.5 University budget

Austrian universities and schools of the arts are federal institutions. Therefore they are financed almost exclusively by the federal budget which covers almost all expenditures. In addition to public financing, Austrian universities and arts colleges have additional sources of income which cover roughly 3 per cent of their total expenditures. University budget refers to all portions of the Austrian Federal Budget pertaining to expenditures for personnel, operating costs, and infrastructure at Austrian universities and schools of the arts as well as the promotion of university research.

In 1996, the budget item "science and research" represented 3.97 per cent of the total federal budget and corresponded to 1.21 per cent of the Austrian gross domestic product. Personnel costs account for the largest category of expenditure and have remained stable in recent years at around 45 per cent (Table 3).

**Table 3. Budgetary development: total expenditure for universities and Colleges of Art and Music, 1996**  
(in Sch billions)

	1990	1991	1992	1993	1994	1995	1996
Personnel	6 637	7 375	8 064	8 722	9 527	9 898	9 899
Capital expenditure	6 690	8 040	8 534	9 747	10 969	11 289	11 493
Buildings	987	1 126	1 316	932	733	717	629
Total university budget	14 314	16 541	17 914	19 401	21 239	21 915	22 030

Source: Higher Education Report 1996.

#### Research funding at Austrian universities

Compared to other OECD countries, total research funding in Austria is below average. Only in civil R&D government expenditure is Austria positioned in the middle ranks. Average growth rates of total R&D expenditure 1981-1991 were also comparatively low. Long-time comparison shows that about half of the total R&D financing in Austria is borne by the public sector (state and provinces) and the rest by Austria's business community. This ratio has remained almost stable during the last 20 years. In 1997, about 46.5 per cent of the expenditures for research and development is estimated to be public money (40 per cent from the State, 6 per cent from the provinces, rest by other sources). The share contributed by entrepreneurs has risen slightly over the past few years (approximately 50.5 per cent in 1997). The Austrian Central Statistical Office estimates the present total R&D expenditure in Austria to amount to 1.5 per cent of the GDP (see Table 4). It should be noted here that there is practically no military research to be financed – at least not with public funds.

**Table 4. Financing of R&D in Austria, 1989-95**  
in Sch billions

	1989	1992	1993	1994	1995	1996	1997
Total research expenditures	22.9	30.3	31.2	34.7	35.9	36.4	37.1
of which financed by							
Government	8.5	12.3	13.2	14.8	15.0	14.9	14.7
Federal provinces	1.2	1.8	1.8	2.2	2.3	2.3	2.3
Business enterprise	12.2	14.9	15.5	16.4	17.3	18.0	18.8
Other (PNP, abroad, etc.)	1.0	1.2	1.2	1.3	1.4	1.3	1.3
% of GDP	1.37	1.48	1.49	1.53	1.53	1.51	1.5

Source: Austrian Central Statistical Office.

In 1997, the predominant part of public research funding in Austria (about 72 per cent), of which about 90 per cent is allocated to academic research, is administrated by the Ministry of Science and Transport.

Federal research promotion in Austria is essentially carried out by complete or partial direct financing of the staff and the equipment of federal scientific establishments, especially of universities or non-university institutions (85-88 per cent in total):

- by indirect financing via autonomous research promotion funds (FWF and FFF, about 10 per cent – 12 per cent in total);
- by the ministries, commissioning research contracts and expert opinions (about 2.5 per cent).

The **Austrian Science Foundation (FWF)** financed by the Federal Ministry of Science and Transport, is the most important promotion instrument for basic research projects. About 90 per cent of its resources are granted to university members (Table 5).

**Table 5. Development of public funds for basic research, distributed by the FWF (Austrian Science Foundation)**  
in Sch millions

	Federal budget	Budgetary advances	National Bank	Total available funds
1989	322	15	56	393
1990	402	140	71	613
1991	443	38	66	547
1992	497	163	53	713
1993	548	33	59	641
1994	589	60	81	730
1995	683	57	103	843
1996	700	47	92	840
1997	767 <sup>1</sup>	67	Not yet available	

1. Budgetary provision.

Source: FWF, Annual Report 1996.

The share of the various forms of research promotion by the FWF has remained rather stable over the past years, with a slight increase on focal areas, away from individual projects. But still the larger part of FWF promotion is granted for individual projects (about 61 per cent in 1996). Following the “bottom-up principle”, the funds are also used to accelerate formation of priorities within the autonomous university areas (14 per cent). Local “centres of excellence” at universities, which are qualified to counter international competition, are supported by funds for “areas of special research” (15 per cent). Funds are also provided for selected transfrontier research programmes, for scholarships at reputed foreign institutions for the new generation of academics, and for the publication of scientific research results. In 1996, more than 7 per cent of the total amount of the funds was spent on three research-scholarship programmes (Table 6) (see also: Part IV, Mobility).

**Table 6. FWF research promotion: distribution of funds by category, 1990-96**  
in per cent

	Individual projects	Focal areas	Special research areas (Centres of excellence) established 1992	Scholarships	Publication grants	Other
1990	81.9	9.2	..	5.0	3.8	0.1
1991	76.1	13.3	..	7.1	3.3	0.2
1992	70.5	13.3	6.2	7.9	2.0	0.1
1993	61.6	24.6	4.8	6.9	2.1	0.0
1994	67.7	14.2	8.6	7.6	1.8	0.1
1995	71.8	14.9	4.4	6.6	2.2	0.1
1996	61.1	13.8	15.1	7.3	2.0	0.7

Source: FWF, Annual Report 1996.

*Additional funds for university research from third parties (business enterprises etc.)*

Since the late 1980s universities, faculties, institutes, and university libraries have a legal status that allows them to accept gifts (for example, assets from an inheritance or foundations) or to execute contract research and use this income in a manner that contributes to the university's fulfilment of its tasks. But universities still receive the majority of the research funds from the Austrian Science Foundation.

Almost 1 000 institutional entities at Austrian universities enjoy the partial autonomy to accept and use additional income (in particular from research contracts). Seventy per cent of those institutes rendered accounts to the Ministry in 1994. Compared to 1991 (Sch 590 million) this additional income increased considerably until 1994 (Sch 1 billion). Compared to the total university budget, the contribution of additional funds from partial autonomy (under 5 per cent) is still rather low. Moreover, this sum cannot be distributed equally across all faculties, but is earned mainly by technical universities, medical faculties and a number of institutes in the natural sciences.

Tuition fees

Austrian students have not been required to pay tuition since 1972. Foreign students are required to pay tuition in principle, but this requirement has been waived for students from a fair number of countries, in particular from developing countries, or upon the basis of bilateral agreements. Universities and Colleges of Art and Music are free to use income generated by foreign student tuition for promotion of mobility of students and university staff.

## **2. Mechanisms for knowledge transfer**

### **2.1 Government technology policy concept 1996**

In 1994, the Federal Ministry for Science and Research, in co-operation with the Federal Ministry for Economic Affairs, entrusted an expert working group of three research institutes with the drafting of guidelines (concept) for a newly focused Austrian technology policy. On 9 September 1996, the draft passed the Council of Ministers.

Main contents of these new policy guidelines are:

- Based on theoretical considerations with respect to technological change and the effects of technology policy, an analysis of the goals, of general conditions, and of possibilities for an Austrian technology policy, including a comparative analysis of similar guidelines of other countries and consequences for Austria are elaborated.
- Focal areas of technology policy (economic competitiveness, environment, social change) are defined.
- Analysis of the Austrian technology policy system; Alignment of Austrian technology policy within international, national and regional dimensions; Innovation and labour-market policy.

Outline of key strategies:

- Diffusion orientation.
- Research orientation.
- Goal-oriented technology policy (cluster-oriented).
- Orientation towards improvement of material and immaterial infrastructure and quality of location.

Based on these key strategies, the Ministries have worked out detailed relevant policy measures for their respective areas of responsibility.

## **2.2 *Stimulation of co-operation between enterprises and universities via Industrial Research Promotion Funds***

In 1993, the Industrial Research Promotion Funds (FFF) introduced a new promotion scheme for young scientists (undergraduates, graduates, doctoral studies) who wish to join in practical research projects of SMEs for their grade. In Summer 1995, all project applications were evaluated and the three best projects were awarded a promotion prize. Since introduction of the scheme, 108 project applications have been filed, of which 98 were granted a total sum of Sch 61 million. Evaluation confirmed that all envisaged goals were met, particularly the improvement of relations between university institutes and SMEs, to promote practical experience of young scientists in the participating enterprises and to increase awareness of enterprises of the advantages of employing academics. Due to these positive results, the scheme will be extended.

## **2.3 *Technology and innovation centres***

Innovation and technology centres in Austria are grouped beneath an umbrella organisation “Association of Austrian Technology Centres” (VTOe). A survey in 1993/94 showed a total of 28 Innovation Centres in conjunction with 350 technology-oriented “young” enterprises and 45 research centres. Development in these enterprises is particularly dynamic: In 1993 about 2 800 employees worked in all firms and institutes of the association, with a yearly increase up to 40 per cent. At present, the number of employees is around 4 700. A positive side effect of the technology development and consultancy activities of these centres is that more than 500 enterprises in the surroundings receive intensive impulses. Thus, innovation centres have become an important economic factor since 1986, when the first one was founded in Graz (Styria). Products offered by the high-tech centres include most of the advanced technologies, from

biotech-, to laser-, information-, sensor-, environment-, and polymer- technologies. Some of these centres co-operate closely with local “*Fachhochschulen*”.

## 2.4 *Special government schemes*

Special government schemes to promote knowledge transfer between universities and the business enterprise sector were developed in the mid-1980s: “Scientists for the Economy” and “Scientists Found Their Own Firm”.

### 2.4.1 “*Scientists for the Economy*”

“Scientists for the Economy” allows a university assistant to take a one or two years leave from university to work in an enterprise research department with a guaranteed return to his post (or may remain in the firm), the enterprise in turn received a tax-free Sch 100 000 government subsidy for personnel costs.

This scheme was established to, on the one hand, enable university assistants to gain practical experience in enterprises, and by that bring practical experience to universities, and on the other hand, to enable enterprises to get additional know-how and scientific potential from universities. After a five-year pilot phase this scheme became permanent in 1987. Since this scheme was established at the end of 1982, a total of 233 contracts were signed (Table 7).

**Table 7. Development of the scheme “Scientists for the Economy”**

	Absolute values	Per cent
Current contracts	24	9
Returned to university	51	22
Remained in the firm	106	45
Changed to other firm	30	13
No information	25	11
Total	233	100

*Source:* Author.

Sixty contracts were prolonged, 30 were dissolved prior to expiring, of which eight assistants entered a new contract, 3 participated twice, 11 got an exceptional third year granted. 194 enterprises participated in the scheme, of which 24 employed more than one assistant. More than two-thirds were SMEs (Table 8).

**Table 8. Development of the scheme “Scientists for the Economy”**

87 small enterprises	(up to 50 employees)
53 medium enterprises	(51 to 500 employees)
54 big enterprises	(more than 500 employees)

*Source:* Author.

In total, 225 assistants participated, of which 11 worked consecutively for two enterprises. Average age was 32 years (range 24 to 52 years). Average duty time as assistants was six years. Most of the assistants came from technical universities or from institutes of business administration. In the enterprises, they mainly engaged in research projects, in product development, finance and accountancy, and software departments.

#### 2.4.2. *Scientists found their own firm*

This scheme offers a non-repayable grant (Sch 100 000) plus additional subsidies for investments into special equipment (up to Sch 250 000) for scientists who leave university to start their own firm. Until 16 September 1996, 158 applications were filed, of which 108 were accepted (Table 9). Reasons for rejection were mostly formal ones (time elapsed since foundation of the firm or too short service at university).

**Table 9. Number of cases 1986 to 1996**

1986	12
1987	7
1988	11
1989	11
1990	11
1991	7
1992	8
1993	9
1994	9
1995	13
1996	13
Total	108

Source: Author.

Eighty one per cent of the newly founded enterprises were located in the service sector (with a focus on software development and consultancy), 14 in the productive sector. About 30 per cent of the enterprises are thematically focused on technologies or consultancy for a clean environment.

These young entrepreneurs meanwhile employ a total of 400 employees. Distribution by regions is very uneven: three-quarters of all enterprises were established in Vienna (50 per cent) and Styria (25 per cent). Share of women of all these young entrepreneurs is nine of 108 (two enterprises were established jointly by a woman and a man).

#### 2.5 *Relative success of policies and mechanisms, including the status of university-industry research co-operation*

A study by the Austrian Economic Research Institute recently analysed the "Austrian Science Cluster". The study is based on data and on survey results, where data were missing or incomplete (average response rate 37 per cent, depending on type and size of university; maximum 48 per cent). According to that survey, 152 university institutes of a total of 220 responding mentioned co-operation with enterprises (Table 10).

**Table 10. University institutes: co-operation with enterprises, 1995**

Co-operation with	Number of partners	Number of projects	Number of institutes
National big enterprises	173	237	73
National SMEs	253	312	90
Foreign big enterprises	119	158	62
Foreign SMEs	45	62	22
National service sector firms	147	183	52
Foreign service sector firms	20	39	12

Source: Author.

Seventy four per cent of the respondents underlined the importance of personal contacts for co-operation with enterprises as a precondition for the preparatory phase. During this phase, mutual confidence and a common level of communication are being built up, thus providing the central requirements of co-operation between institutions of both sectors. Another important precondition for establishing co-operation are university graduates (63 per cent of the respondents) and initiative by enterprises (62 per cent).

Barriers against establishing co-operation were seen in information deficits concerning the research potential of a given institute (65 per cent of the respondents from enterprises); this number strongly correlates to "low interest of enterprises" on the side of university institutes.

According to respondents, professional intermediary agencies, such as PR institutes at universities, information exchange or liaison offices, only play a marginal role in promotion of contacts between enterprises and universities. As a consequence, this fact should lead to a thorough analysis of the tasks of these agencies (as far as funded by public money) and to appropriate new definitions of concepts and goals along with the necessary financial and personal resources.

#### *WFW contact programme*

In order to promote co-operation between universities and enterprises, the Austrian Science Foundation (FWF) has, in conjunction with the Industrial Research Promotion Funds, established a programme to foster contacts between both sectors ("WFW"). Payment of a certain fee (Sch 90 000) enables enterprises to get access to observer status (including regular progress reports) in research projects of all FWF categories (individual projects, focal areas, etc.) during the full term of the project. One third of the fee is allocated to the research project for consultancy. In the case of possible application of research results the observer fee increases, and further contacts are administered by the Industrial Research Promotion Funds.

### **3. University research and other public research**

In Austria, the public research system apart from the universities is comparatively small. The few institutions of a certain size are partially interlinked with university institutes on the personnel level through teaching at universities and/or by co-operation in research projects.

### **3.1 *Austrian Academy of Sciences***

In the field of basic research, the largest publicly financed research institution besides the universities is the Austrian Academy of Sciences which employs around 600 research and administrative staff. Research work is performed at 19 institutes, five research centres and some 50 scientific commissions based all over the country. There is a close interlinkage with the university system, as many of the academy's researchers are university teachers simultaneously.

### **3.2 *Austrian Research Centre Seibersdorf***

In the field of applied research and technical engineering, 50 per cent of the stock of the Austrian Research Centre *Seibersdorf*, which is run as a private limited company, is owned by the Federal Government. The Centre is located in the province of Lower Austria, near Vienna. The State's equity interest is administered by the Federal Ministry for Science and Transport. The Centre's functions include R&D and related services designed to support Austrian industry and commercially exploit findings and new products. In addition, students (also from abroad) and specialist personnel are trained. Research contracts financed by the Federal Ministry for Science and Transport form an integral and continuous part of the research co-operation policy of the Centre. It also plays an active role in 20 EU-sponsored programmes. Total staff including administration is about 550.

### **3.3 *The Research and Testing Centre Arsenal***

The Research and Testing Centre Arsenal, until 1997 a federal institution, is now run as a subsidiary company of the Austrian Research Centre *Seibersdorf*. It functions as an intermediary between research and application. Research projects concentrate on the fields of heat and energy engineering, industrial electronics, electrical safety, and in the various disciplines of environmental protection. In 1995, already the Centre entered a partnership agreement with the Joanneum Research Society in Styria and the Austrian Research Centre *Seibersdorf*. There are also research agreements with university institutes and other research and testing establishments. The Arsenal has about 220 employees (rated on a full-time basis).

### **3.4 *The Joanneum Research Society***

The Joanneum Research Society, which is owned by the Provincial Government of Styria and is run as a private limited company, employs about 280 people in research units in Graz and Leoben. It is also essentially engaged in applied research and in scientific services such as testing, information and counselling services, and the preparation of feasibility studies. About one third of the Joanneum is financed by public funds (in 1995 about Sch 106 million, ECU 8 million). The rest, a significantly higher percentage than with other comparable institutions in Austria or abroad, comes from earnings from research contracts, project promotions, etc. A close co-operation with the Technical University Graz is maintained on personnel and project levels. Research contracts financed by the Federal Ministry for Science and Transport form an integral part of the research co-operation policy of the Society.

#### 4. International mobility

Between 1990-1993, the process of internationalisation of the Austrian universities intensified considerably in preparation of full membership in the European Union. This fact is illustrated by the amount of funds allocated, and by mobility counts of scientists and the student population (Table 11).

**Table 11. Allocation of autonomous university funds for international relations**

	in Sch millions					
	1990	1991	1992	1993	1994	1995
International co-operation of universities	2.8	4.8	4.8	6	7.0	7.7
General funds for international relations	*	12	14.4	16	18.0	15.8
Scientific studies/research abroad	*	*	16.5	18	23.0	22.0
Joint study programmes	*	*	6.6	10	12.0	11.5
Total	2.8	16.8	42.3	50	60.0	57.0

\* Funds administered by the then Federal Ministry for Science and Research.

Source: Author.

##### *Guest professors*

Between winter semester 1993/94 and summer semester 1996, 737 foreign university teachers came to Austria as guest professors, usually for one or two semesters, but the share of longer stays is growing. Guest professors came from 50 countries, but Germany (34.5 per cent) and the United States (18.5 per cent) dominated. The number of guest professors from transition countries in Central and Eastern Europe has increased considerably.

Mobility between the university sector and other sectors (economy) is illustrated by the number of Austrian guest professors at Austrian universities: in the same time interval, 153 Austrians were invited.

##### *Special government schemes*

Special government schemes to promote knowledge transfer between universities and the business enterprise sector were developed in the early to mid 1980s: "Scientists for the Economy" (1982) and "Scientists Found their Own Firm" (1985). (see also Section 2, on knowledge transfer).

The number of appointments of university professors from the scientific staff of their own university has been reduced compared to former years, when this practice was more or less the rule. From 1993-95, however, still 27 of 214 newly appointed professors (12.6 per cent) had applied as assistants at the same university (institute). Numbers of Austrian post-docs who work in another country are not available.

#### **4.1 Studies abroad and research activities of Austrian students and postgraduates**

In order to promote international mobility of Austrian students, financial and organisational measures have been enhanced considerably since the beginning of the 1990s: "Foreign offices" were established at each university to deal with the administration of newly created scholarships and increased other funds allocated to research and education abroad. In 1989, a special office was established to promote Austrian participation in EUREKA by various information activities and technical assistance to institutes and firms.

In 1993, as a follow-up measure, the Austrian Office for International Research and Technology Co-operation (BIT) was established. Its main goal is the centralised promotion of and administrative, organisational and informational assistance for Austrian participation in the 4th European Union Research and Technology Framework Programme. Though difficult to quantify, these organisational measures reflect the marked intensification of the process of internationalisation of Austrian science and research (policy and practice) and mark a certain break with tradition at the beginning of the 1990s.

#### 4.1.1 Scholarships by the Federal Ministry for Science and Research

During the study year 1994/95, a total of 4 150 educational and/or research appointments abroad were directly or indirectly financed/administered by the then Federal Ministry for Science and Research, of which 3 326 were students, and 824 (19.85 per cent) were graduates. 50.2 per cent of all scholars were male, 49.8 per cent female. In relation to the number of student enrolments, smaller universities had a larger share of studies abroad.

The biggest share of all studies abroad was under the ERASMUS Programme, which was opened for participation of Austrian students in 1992/93 (Table 12). The number of grants from the European Commission rose from 882 to 3 193 at present. Participation in University Co-operation Programmes increased from 137 in 1992/93 to 358 in 1995/96.

**Table 12. Development of Austrian participation in ERASMUS**

	1992/93	1993/94	1994/95	1995/96
Austrian ERASMUS students	882	1 583	2 377	3 193

Source: Author.

Average duration of studies or research work abroad was 5.18 months. By field of study, students and graduates of business economics (410) were most numerous, followed by law (320), commerce (251) and English and American philology. As an example, the International Study programme Economy (University of Innsbruck) had 1 225 Austrian student enrolments and 138 financed studies abroad. But also students of agriculture have a considerable share, if compared to numbers of enrolments. Medicine, humanities and technical engineering are below average. The share of graduates is highest in medicine, law and natural sciences.

Of all countries visited, those of the European Union dominated (2 736 visits), followed by North America (725). Six hundred and ninety scholarships were spent in the United Kingdom, 561 in France and 381 in Spain. Two hundred and sixteen students went to countries in Central and Eastern Europe and Russia; 107 to Latin America and the Caribbean; 81 to Asian countries; 41 to Africa and 52 to Australia and Oceania. Eighty five scholarships were spent for studies at international organisations. The United States is very attractive for postgraduate-studies, more than 35 per cent of all scholarships to that country were awarded to graduates.

#### 4.1.2 Other scholarships for Austrian graduates

Since 1986, the Austrian Science Foundation offers specially designed research scholarships for Austrian postgraduates ("*Erwin Schroedinger Scholarships*"). This has been one of the most important measures for promotion of young Austrian scientists who wish to participate in research projects of leading

institutions abroad in their field, and want to improve their know-how and skills in methodology and performance. As a rule, a two-year stay can be envisaged, but for each year an application has to be filed separately (including an evaluated progress report for the second year).

During the past 11 years, a total of 841 Schroedinger scholarships were awarded to Austrian graduates. From 49 scholarships in 1986, this number rose to 122 in 1996 (72.6 per cent of applications) (Table 13).

**Table 13. Schroedinger scholarships, 1986-95**

1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
49	53	64	71	80	93	119	101	102	109	122

Source: Austrian Science Foundation (FWF); Annual Reports 1986 – 1996.

Sixty eight of the awarded graduates went to research institutions in the United States; 13 to the United Kingdom, 11 to Germany, 5 to Canada, the remainder to countries of the EU and to Switzerland and one to Costa Rica, Japan, New Zealand, and Turkey each. The share of female graduates awarded Schroedinger scholarships has risen considerably over the years to 24.6 per cent in 1996.

In 1993, the Austrian Academy of Sciences established a well-funded three-year postgraduate scholarship programme, “APART – Austrian Programme for Advanced Research and Technology”, which is applicable for research work abroad or in Austria. Of the 53 scholarships granted until mid-1996, 35 were spent for research work (at least partially) abroad.

#### 4.2 *Students from abroad in Austria*

In 1995/96, a total of 23 911 students (10 811 female) from abroad were enrolled in degree courses at Austrian universities (Table 14). 52.6 per cent thereof were citizens of EU Member States, 30.2 per cent came from developing countries. The share of foreign students increased more or less steadily after a relative drop in the early 70s, caused by the marked increase of Austrian enrolments, rising again to about 11 per cent at present.

**Table 14. Foreign students at Austrian universities**

Total, share of female students, per cent of all students in degree courses in Austria

	1970/71	1983/84	1986/87	1989/90	1991/92	1993/94	1995/96
Total	8 154	12 200	13 776	15 180	17 910	21 579	23 911
of which female	1 491	4 246	5 137	6 074	7 326	9 252	10 811
% of all students in Austria	15.9	8.9	8.5	8.4	9.1	10.5	11.2

Source: Author.

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## ANNEX: BACKGROUND INFORMATION ON CHARACTERISTICS OF THE AUSTRIAN UNIVERSITY SYSTEM

### A) Objectives and responsibilities of universities

The mandate of Austrian universities is clearly formulated in the University Organisation Act. They are to serve as institutions of research and instruction and, as such, bear responsibility for solving human problems as well as contributing to the beneficial development of society and the natural environment. They are specifically responsible for promoting the development of scientific and scholarly disciplines; educating and promoting a younger generation of scientists and scholars; transmitting methodologically sound professional qualifications; providing continuing education for their graduates; and informing the public about the manner in which they fulfil these tasks. The guiding principles of the universities are the freedom of research and teaching; the unity of research and teaching; the diversity of methodology and opinion; freedom of enquiry; the collaboration of university constituencies; the equal treatment of men and women; equal opportunity; and the judicious use of resources.

The concrete tasks of Austria's 12 universities vary considerably according to their size and structures. Universities established in the 1960s and 1970s have fewer faculties than traditional institutions. The University Organisation Law of 1975 also granted university status to a series of specialised institutions of higher education: the Leoben University of Mining and Metallurgy, the University of Agriculture, Forestry and Renewable Natural Resources in Vienna, the Vienna University of Economics and Business Administration, and the University of Veterinary Medicine in Vienna.

### B) *Fachhochschule* programmes

*Fachhochschule* programmes are tertiary educational programmes designed to provide students with well defined sets of vocational skills required by specific technical and service professions. The objectives of these programmes in the non-university sector are to give students an application oriented education that reflects the most recent developments in related disciplines; provide them with the skills necessary to master the practical demands of the respective occupations; and promote mobility within the educational system as well as the professional flexibility of graduates. The establishment and expansion of the *Fachhochschule* sector in Austria started at the beginning of the 1994/95 academic year.

The Austrian *Fachhochschule* sector (FHS) was established in 1993 by federal legislation that marked the end of the traditional "monopoly" which the Austrian federal government held in founding and funding tertiary institutions. The Minister of Science and Transport is responsible for granting *Fachhochschule* programmes the institutional title of *Fachhochschule* once they meet certain requirements, such as offering at least two accredited programmes that lead to *Fachhochschule* degrees, a specific organisational structure, and a developmental plan based on achieving an enrolment of at least 1 000 students.

*Fachhochschulen* may be established and operated by the federal government or by other entities of public and private law such as provinces, municipalities, professional chambers, and associations – or “joint venture” combinations thereof. A board of experts (*Fachhochschulrat*), nominated by the Minister of Science and Transport, but free to decide based on its own discretion, is responsible for the accreditation of *Fachhochschule* programmes.

### C) Students

An Austrian leaving certificate awarded to the graduates of the upper secondary school track (“*Matura*”) is the prerequisite for admission to all university degree programmes as well as to the majority of non-degree courses or programmes offered by universities. Access to universities is not controlled, and there is no institution or agency in Austria responsible for centrally assigning students places at specific institutions. Students are free to attend the university of their choice, provided they fulfil admission requirements, they have access to all courses at universities insofar as individual courses do not have prerequisites, such as specialised background knowledge, or must be limited in size due to space limitations. Individuals who are 17 years old and have the necessary background may enrol at universities as irregular or non-degree students (*ausserordentliche Hörer*) and complete course work.

### D) University teachers

The term “university teacher” encompasses various different kinds of scientists and scholars on the teaching staffs of universities: university professors (including retired professors or emeriti), guest professors, honorary professors, associate professors (*Dozenten*), and university assistants, and adjunct faculty. All people who instruct at universities are considered university teachers. However, there are important distinctions made between senior and junior faculty, respective levels of teaching qualifications, and the nature of employment contracts (tenured civil servants versus contract employees).

One of the distinguishing characteristics of universities in the German-speaking world is the requirement of a second, qualitatively distinguished and quantitatively more extensive thesis after the doctorate, the so-called *Habilitation*, the completion of which is a general prerequisite for being granted the rights and privileges of a fully-fledged faculty member with professorial status. Academics who complete a *Habilitation* are entitled to teach in a specific discipline – they are granted a so-called *Lehrbefugnis* (“teaching entitlement”) or *venia docendi* – and receive the title *Dozent*. The functions, rights, and status of teachers at universities and Colleges of Arts and Music are fundamentally determined by the dimensions of the so-called “*Lehrbefugnis*” or *venia docendi*. Although the *Habilitation* – or a corresponding record of equivalent academic achievement – is a prerequisite for professorship, it is not a prerequisite for instructing at Austrian universities.

University assistants, who hold master or doctoral degrees, but have not completed a *Habilitation*, as well as adjunct faculty, are appointed to teach individual courses in their respective fields of expertise. Although university assistants who have completed a *Habilitation* are technically junior faculty, in virtue of their academic titles (*Dozent*) and their teaching entitlement (*Lehrbefugnis*) they assume an intermediate position between university assistants and professors.

However, the University Organisation Act 1993 has introduced a uniform status for all professors without infringing on existing contracts. The university assistants’ right to teach is limited to specific courses or collaborative instruction with professors as is the right of other instructors – in particular, federal teachers (*Bundeslehrer*) – who frequently teach practical subjects that complement scholarly and scientific

disciplines. Guest professors at universities and universities of the arts enjoy the same rights and freedoms as professors at those institutions. Scholars, scientists, and artists also may be appointed as readers, instructors, and adjunct faculty (*Lektoren, Instruktoren, Lehrbeauftragte*) for specific classes. Under these circumstances, they are not regular university employees but receive contracts to teach specific classes.

#### *The initial training of university teachers*

There is no specialised system for the initial training of university faculty in Austria. University careers normally begin with an appointment as a university assistant. The completion of a degree programme in an appropriate field is the prerequisite for receiving a contract as an assistant at a university institute. No further educational prerequisites are demanded by university organisation laws or employment laws. After the expiration of an initial four-year terminal contract, university assistants may be offered a provisional contract, contingent upon the completion of a doctorate in the field as well as merit demonstrated in research, teaching, and the administration of institute affairs. In order to be granted a permanent contract, university assistants with this provisional contract must, within a six-year period, complete their *Habilitation* or have established themselves as researchers, teachers, and administrators.

The prerequisites for an appointment as a university professor are a university degree from an appropriate field, a *Habilitation* or equivalent academic qualification from Austria or abroad, and demonstrated ability as a teacher.

#### *Further education*

There is a very generally formulated obligation for all university faculty to continue their education in their fields in the law, but no further regulations or continuing education courses for university faculty. It is up to the universities and universities of the arts themselves to organise and offer continuing education courses for their own faculty.

#### *Work and employment conditions*

University professors, who automatically receive Austrian citizenship upon being appointed, are responsible for representing and cultivating their disciplines as researchers and teachers. They also are responsible for giving examinations and assume some administrative duties. Under their appointments, they are obligated to make a substantial contribution to teaching the number of required courses offered in their field. However, the number of courses and hours they must teach are not stipulated either by law or in their decrees of appointment. Full professors (*ordinarii*) are not subject to regular working hours during which they must be present, and the amount of time they are present at the university is contingent upon research. However, teaching and advising students do limit the extent to which professors are free to dispose of their time as they see fit.

The evaluation of the teaching and research performance of full professors have no legal consequences for them in terms of their contracts of employment. University professors are employed as tenured federal civil servants according to the provisions of public law. After the end of the academic year during which they have reached the age of 68, professors retire, which entails being relieved of their obligations to fulfil their duties, in particular teaching, but retain their rights to do research and teach as emeriti.

The salaries of full university professors are regulated by pay scales established by federal law, however the position they assume on the scale is not determined as it is with other civil services but negotiated upon appointment in light of their “market value”. Furthermore, professors receive various additional payments and disbursements: for example, fees for examinations.

The rights and duties of extraordinary university professors correspond to a great extent with those of full professors. However, distinct from professors, their teaching load is defined precisely. There also are differences in salary levels.

University assistants are employed by university facilities as co-workers in research, teaching, and administration and engaged in teaching, examinations, and providing guidance for students in their research, in particular. They are required to work 40 hours per week, and there are provisions for flexible hours in most cases. University assistants are either employed as federal civil servants or are private employees of the university.

If university assistants are employed as federal civil servants, their fixed-term contract is limited to four years. University assistants employed as such may apply to have this contract transformed into an indefinite contract and, if they satisfy the conditions of the indefinite contract, such as completing a *Habilitation* or establishing themselves as scholars, scientists, researchers, and administrators, they may submit an application for a tenured position. University assistants retire at the age of 65.

Contract assistants are employed either as federal civil servants with fixed-term contracts or as private employees of the universities. Their contracts are limited to two year periods but are renewable, and they may work part- or full-time. The duties of contract assistants correspond to those of university assistants.

## **E) Evaluation**

In contrast to university systems influenced by Anglo-American traditions, evaluation has played a subordinate role in Austrian higher education. The first decisive impulse to institutionalise evaluation came in 1990 with an amendment to the University Organisation Act which made evaluation a legally anchored responsibility of the public supervision of universities. Individual pilot projects in the evaluation of research have been executed, (relying on peer review procedures), since then (physics, electrotechnics and biochemical research). For evaluation of teaching, questionnaires answered by students in individual courses have been used as instruments.

The University Organisation Act of 1993 places great emphasis on evaluation. It legally requires the relevant university decision-making bodies and the Minister of Science and Transport to use the results of evaluation as a basis for their decisions. Furthermore, it prescribes a framework for evaluation and the assessment of performance. It establishes regular reporting as one of the cornerstones of evaluation. On the one hand, the Minister of Science and Transport must submit a “Higher Education Report” on the achievements and the problems of the universities, to the National Assembly every three years. On the other, the chairperson of each institute is required to submit a report to the rector with information on the courses taught and examinations given, the counselling provided for research work, and the research projects and publications of the academic personnel of the institute. The rector is required to have these reports published at least every two years.

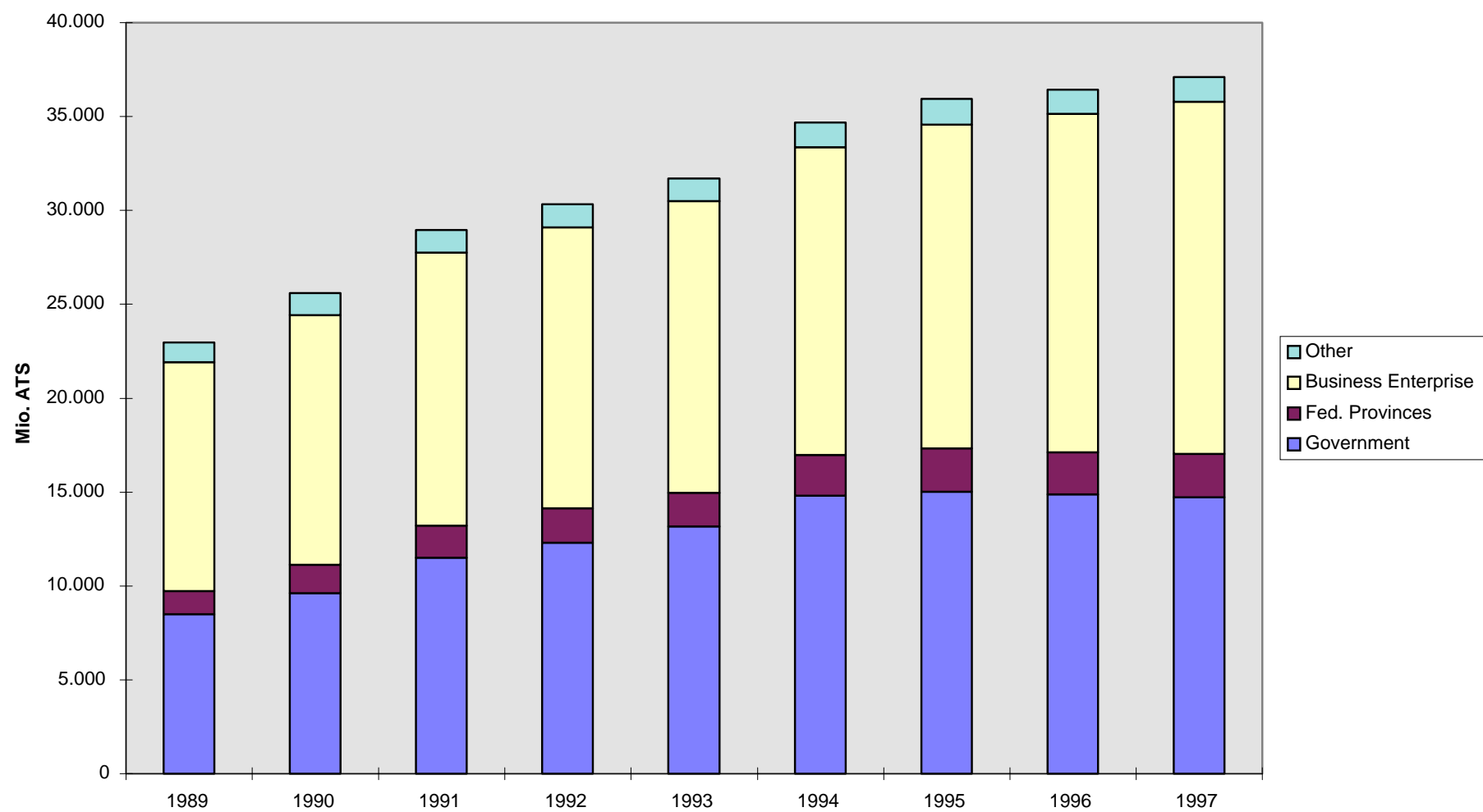
Individual courses are to be evaluated by students on a regular, semester-by-semester basis. This form of evaluation will be introduced at each institute. The results of course evaluations must be published by the

Dean of Studies (Studiendekan) every two years. In addition to course evaluations, study programmes or portions thereof are to be evaluated periodically with the assistance of experts.

In addition to these ongoing forms of evaluation, the University Organisation Act of 1993 provides for performance assessment. On the one hand, based upon proposals by or consultation with the Academic Senate, the rector may decide to have the development of specific university units or degree programmes evaluated. On the other, the Minister of Science and Transport may initiate evaluations in order to support planning for the university sector as a whole. In both cases, the university bodies or units involved must be informed and consulted on a regular basis.

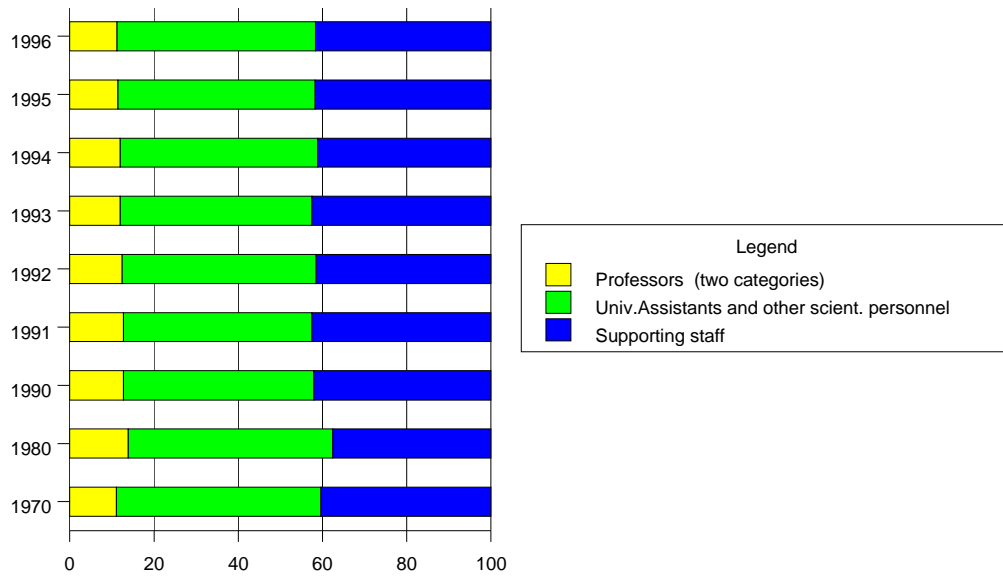
The involvement of all relevant university constituencies in the planning, execution, and analysis of evaluations should ensure that these procedures become a generally accepted and appropriate means of improving the universities.

Figure A1. GERD by funding sector, 1989-97



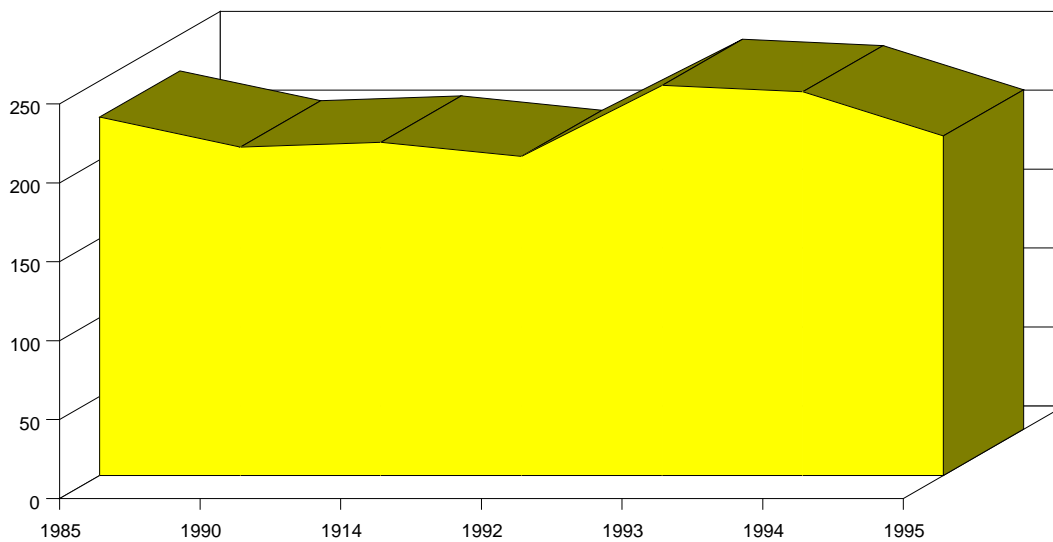
Source: Author.

**Figure A2. Categories of personnel, 1970-96**



Source: Author.

**Figure A3. "Habitations" of scientific staff at Austrian universities, 1980-95**



Source: Austrian Central Statistical Office.

## BELGIUM

**This note includes two contributions. The first one, prepared by Mr. Luwel, Delegate to the Group on the Science System, concerns Flemish Community Universities. The second note concerns the French Community Universities.**

### I. FLEMISH COMMUNITY

*by Dr. Marc Luwel, Ministry of the Flemish Community*

#### 1. Constitutional changes

During a series of constitutional reforms, Belgium changed from a centralised country and became a federal state. In 1989, the two linguistic communities became responsible for education and to a large extent for matters related to R&D. This document gives a brief overview of the Flemish higher education and R&D systems.

#### 2. Universities, schools of higher learning and public research institutions

In the Flemish Community, higher education is provided by universities and schools of higher learning. Nearly all publicly financed academic and academic-related R&D is concentrated in universities. Flanders has only a few public research institutions.

##### 2.1 *Universities*

Flanders has four fully-fledged universities, in addition to two university centres offering a limited curriculum. Table 1 presents an overview of the number of university students; Table 2 the number of staff members.

All universities are financed by the Flemish Community along the same rules, which are laid down in a Decree (regional law) voted in 1991. Each university receives a block grant which is linked, but not proportionally, to the (weighted) number of students at the different faculties. The grant is used to cover the wages and salaries of the tenured academic staff, the teaching assistants and part of the technical staff, the expenses for education, central services such as library and computer facilities and a small fraction of the basic expenses for research. The wages and salaries represent more than 75 per cent of the block grant.

The universities have a large degree of autonomy. The law stipulates in broad terms their mission statement (education, basic research and scientific service to the community) and lays down the minimal set of rules for financial and personal management. The Government does not intervene either in the overall management and the priority setting or in the nomination of staff and the designation of the Vice-Chancellor, who is the nominal head of the institution.

In addition to the block grant provided by the Flemish Government, universities receive grants and revenues from a large number of private and public organisations: research programmes of the Flemish Government, the Belgian Federal Government, the EU and other international organisations, contract research in collaboration with industry, revenues from training courses.

Tuition fees are rather low in Flanders and therefore it does not represent a large source of revenue for universities; the maximum annual fee is BF 18 000 (US\$ 485), although those who obtain a scholarship only pay BF 3 200 (US\$ 85).

## **2.2 *Schools of higher learning***

Flanders has 29 schools of higher learning. In 1995, the Flemish Parliament approved a law reorganising these institutions along the same lines as the universities. The central element in the mission statement of the schools of higher learning is vocational and professional training. However, these institutions are also allowed to perform R&D on a project basis in collaboration with universities, industry and other partners.

These institutions offer two-year and four-year education programmes.

For most schools of higher learning, the most essential part of their budget still comes from the block grant they receive from the Government.

## **2.3 *Public research institutions***

Flanders has only a few public research institutions. Two of them perform both basic and applied R&D in strategic sectors: microelectronics (IMEC) and biotechnology (VIB). Both institutions are inter-university research centres, bringing together researchers from Flemish universities. For IMEC, large central facilities were built, but part of the R&D remains located in the universities. Most of IMEC's senior researchers are part-time professors at one of the Flemish universities. VIB is an institute without walls, financing university research groups. Both IMEC and VIB are actively valorising the results of their research activities (contracts with industry, spin-offs, patents).

## **3. *Broad policy and budget trends of the Flemish Government for R&D***

Since it became responsible for (higher) education and for all but a small portion of R&D policy, the Flemish Government has made science and technology two of its priorities. Because the public R&D expenditures in Belgium were rather low (0.6 per cent of the GDP), the Flemish Government started to systematically and considerably increase its R&D budget (see Table 3). At the beginning of this legislative period, an annual increase of BF 2 billion for the period 1996-2000 was projected, of which BF 4 billion has already been realised (1996-97) and an additional BF 2 billion laid down in the annual budget (1998).

Roughly half of the increase is used to strengthen industrial R&D through a variety of mechanisms: specific programmes in areas considered to be critically important (e.g. information technology, multimedia), support for projects proposed by corporations (often in collaboration with industry).

In the academic sector, essentially four different mechanisms are used to strengthen the Flemish research capacity:

- The university research fund, managed by the research council at each university, is increased gradually. The universities can use these funds to develop their own research strategy.
- The budget of the Flemish Science Foundation is also increased. This research organisation, which does not have research facilities of its own, distributes grants and research positions (PhD fellowships and post-docs).
- The Institute for the Promotion of Industrial and Scientific Research (IWT), a public organisation which promotes industrial R&D, finances both PhD fellowships and post-docs. Candidates for these positions must present a project which has to be supervised by a senior university faculty member and a researcher from an enterprise.
- The Flemish Government provides grants for research projects selected within the framework of specific programmes, such as the humanities and social sciences programmes.

### **3.1 *Evolution of the number of students***

The number of students at Flemish universities has increased over the last six years by more than 15 per cent (Table 4). Within this overall increase, there is a wide variation among disciplines and institutions. For example, the number of students who began studying engineering decreased over the same period by 36 per cent.

The block grant, based on the number of students, increased only slightly less over the same period in real terms. This somewhat lower increase in the grant, as compared to the evolution of the number of students, can be explained on the one hand by internal variations in student population, and on the other hand by a governmental policy aimed at controlling the increase in the budget for education (Table 5).

### **3.2 *Evolution of the R&D budget at universities***

The R&D budget of the Flemish universities increased substantially over the last five or six years (see Table 6). This substantial growth comes from public grants as well as from collaboration with industry. The impact of the EU framework programme is considerable, attracting those research groups who achieve the most.

### **3.3 *Policies to promote knowledge transfer***

In Flanders, a whole set of mechanisms has been set up to stimulate collaboration between industry and academic institutions, e.g:

- Each university has its own science park and Innovation and Incubation Centre (ICC).
- Governmental programmes, such as the Action Programme in Information Technology, bring corporations and university research groups together around specific subjects.
- The government created a legal framework both for university participation in spin-offs as well as for third party collaboration.
- Flanders participates actively in EU programmes. The INNOVATION programme is an instrument to valorise R&D results and to bring universities and industry together around concrete results or projects.
- IMEC has a partnership with industry, paying special attention to Flemish SMEs.

### **3.4 *University trends***

Over the last 25 years, Flemish universities became more dynamic and open. In their overall budget, the importance of the block grant based on the number of students gradually decreased.

Today, universities rely almost exclusively on external resources, especially for their research activities. Only the wages and salaries of the tenured academic staff, as well as some of the administrative and technical staff, are covered by the block grant.

Most of the research grants are based on short-term contracts lasting, at best, only a few years. Under these financial constraints, it is difficult to create or to maintain the necessary critical mass. In a few sectors, through the establishment of inter-university research centres (microelectronics, biotechnology), the Flemish Government is providing the necessary funds to stabilise those research groups which are international leaders in their field. Moreover, the new legal framework for the university research fund allows universities to finance more long-term projects.

The “Inter-university network” programme financed by the Federal Government also provides long-term grants to outstanding research groups selected by international peer review.

### **3.5 *University challenges***

For the next decade, the major challenge facing Flemish universities is the ageing of their staff.

Table 7 gives the (evolution of the) age distribution of the tenured staff at Flemish universities. Massive retirement within the next 10 to 15 years poses severe problems regarding continuity for the academic community.

As a first measure to support the universities in this transition, the Flemish Government provided additional funds for the Flemish Science Foundation to finance more post-doc positions. A fraction of researchers finishing their first three-year post-doc can obtain a second one.

Research groups at Flemish universities are often small and of subcritical mass. This situation can be explained by several factors, e.g. the lack of a clearly defined research policy at the central university level, the lack of specialisation, certain 'fashion trends' in research redirecting a substantial fraction of the budget at relatively short notice, the number of Flemish universities versus the number of inhabitants or the GRP, the lack of inter-university collaboration.

Under the impulse of the Flemish Government, the Rectors Conference tries to define, in agreement with the universities, a set of guidelines for the creation of centres of excellence. This subject is presently being discussed.

The subtle equilibrium between curiosity-driven research proposed by researchers themselves, and more application-oriented work with relatively clearly defined goals, also becomes a topic of discussion which is presently debated among those responsible for R&D policy. Undoubtedly, strategic goals have been substituted to a certain extent for unfettered opportunity-driven research. The extent and implications remain a matter of debate both in policy circles and in the academic community.

**Table 1. The number of FTE students at the Flemish universities in 1995-96**

University	Number FTE students
KUB	777
KULeuven	26 811
LUC	2 299
UAntwerp	8 843
RUGent	19 951
VUB	8 005
Total	66 686

Source: U&B, August 1996.

**Table 2. Staff members at the Flemish universities**

Category	Number FTE
Tenured Academic Staff (block grant)	2 345
Teaching Assistants (block grant)	1 687
Technical Staff (block grant)	3 533
Researchers not on the block grant	2 647
Technical staff not on the block grant	2 163
Total	12 375

Source: U&B, August 1996.

**Table 3. Evolution of the staff paid by the block grant**

Year	1982	1986	1990	1992	1994	1996	Total
Tenured Acad. staff	2 506	2 447	2 466	2 452	2 393	2 345	14 609
Non-tenured Acad. staff	1 523	1 470	1 599	1 592	1 597	1 687	9 468
Technical staff	4 328	4 094	3 935	3 795	3 639	3 533	23 324
Total	8 357	8 011	8 000	7 839	7 629	7 565	

Source: U&B, August 1996.

**Table 4. Evolution of the number of FTE students at the Flemish universities**

Year	Number of students	% increase
1990-1991	56 627	0.00
1991-1992	59 175	4.50
1992-1993	61 231	8.13
1993-1994	62 840	10.97
1994-1995	64 530	13.96
1995-1996	66 686	17.76

Source: U&B, August 1996.

**Table 5. Evolution of the block grant  
(in billion BF)**

Year	Total amount	% evolution
1992	15.4	0.00
1993	16.2	5.19
1994	16.9	9.74
1995	17.5	13.64
1996	18.1	17.53

**Table 6. Public funds from the Flemish Government for non-oriented  
research at the universities  
(in million BF)**

Year	Total amount	% evolution
1992	2 900	0.00
1993	3 165	9.14
1994	3 369	16.17
1995	3 761	29.69
1996	4 447	53.34

**Table 7. Evolution of revenues from public versus private sources  
at the Catholic University of Leuven (KULeuven)**

Year	Contract research/ industrial support	Public support	Total
1992	2 804	467	3 271
1993	3 133	709	3 842
1994	3 244	886	4 130
1995	3 477	1 052	4 529

1. These data concerning the largest Flemish university are illustrative of a general trend.

Source: Annual Report of the KULeuven/private communication.

**Table 8. Age distribution of the tenured academic staff at the Flemish universities**

Age class	Absolute number	Cumulative %
< 30	15	0.40
30-34	174	5.77
35-39	381	17.40
40-44	451	31.17
45-49	652	51.07
50-54	677	71.73
55-59	592	89.80
60-64	327	99.79
65 and +	7	100.00

Source: U&B, August 1996.

## II. THE FRENCH COMMUNITY

In the French Community of Belgium (CFB) research is organised mainly in universities, where centres for basic and applied research and for services to industry have developed alongside teaching functions. Basic data on French speaking universities are provided in the following table.

### French-speaking universities in Belgium – 1994-95 (Figures as at 1 February 1995)

<b>Total students as at 1 February 1995:</b>	62 300	
of whom	27 740	1st cycle
	22 829	2nd cycle
	943	ESS
	7 364	Advanced or specialised studies
	3 433	Doctorate or AES
of whom	49 183	Belgian
	13 117	Foreign

#### Breakdown of foreign students by region of the world:

5 683	EU
7 431	Non-EU

<b>Total degrees/diplomas awarded 1993-94:</b>	18 037	
of which	6 940	1st cycle
	6 681	2nd cycle
	1 260	AESS
	2 682	Advanced or specialised studies
	474	Doctorate and AES
of which	14 955	to Belgian students
	1 489	to EU students
	1 593	to non-EU students

#### Total subsidies (in BF)

1992	14 149 300 000
1993	15 192 400 000
1994	15 280 000 000
1995	15 865 800 000
1996	15 747 400 000

### **The FNRS and basic research**

Basic research is funded by the National Fund for Scientific Research – French Community of Belgium (FNRS) and its four associated Funds: the Joint Basic Research Fund (FRFC), the Medical Scientific Research Fund (FRSM), the Inter-University Institute for Nuclear Science (IISN) and the Industry and Agriculture Research Training Fund (FRIA). The universities are closely involved at all levels in the process of decision-making by the FNRS bodies: academic experts and scientists from the universities sit on the Science Committees; their Vice-Chancellors take it in turns to chair the Board.

The scientific community in general can therefore apply to the FNRS for research mandates and for funds for running costs and equipment.

Having applications and output evaluated by experts from the institutions of the scientific community of the CFB and elsewhere helps to avoid, as far as possible, duplication of both the research programmes implemented and of equipment.

Within this framework, the FNRS still leaves the initiative to researchers, following what is referred to as a “bottom up” approach – one that is realistic in taking into account the resources and staff available. As a result, 82 per cent of the FNRS goes to basic research in the human, economic, biomedical and natural sciences. It provides support for over 85 per cent of the French Community’s publications in these fields.

In order to be able to provide this support, the FNRS tries to make optimum use of the limited funds at its disposal. The way in which it is organised, as outlined above, enables it to avoid the costs involved in infrastructure management and development for centres that are not in the same geographical location as the universities.

This policy is proving particularly satisfactory. Despite the modest funding involved, we are able to count our scientific community among the most successful.

### **Researcher and student mobility**

There are several programmes to encourage researcher mobility through bilateral agreements and initiatives, or through ad hoc arrangements between institutions. Student mobility is also encouraged: the attached table shows the numbers of European and non-European students and postgraduates that the French Community attracts.

It will be recalled that in the French Community of Belgium, some university institutions are directly sponsored by the Community and some are grant-aided private institutions. There are nine such institutions; some have full university status and are accredited to award academic degrees in all disciplines, others are authorised by law to award a limited range of degrees.

Three Universities – Liège, Leuven and Brussels – have full university status, i.e. they have the core faculties (philosophy and arts, law, science, medicine, applied science) plus a varying number of other faculties and schools (social science, politics and economics, psychology, education, etc.).

The University of Mons Hainaut has full university status but offers courses only in selected fields of study, some up to “candidature” level only (1st cycle).

The other institutions, i.e. the Notre Dame de la Paix University Faculties in Namur, the Gembloux University Faculty of Agricultural Sciences, the Mons Polytechnic Faculty and Catholic University Faculties and the Saint Louis University Faculties in Brussels do not have full university status.

### **Assessment of research activities**

The assessment of basic research activities conducted in the laboratories of CFB university institutions and financed by the FNRS and associated funds is ensured by the Fund's scientific bodies.

The first stage involves a performance assessment of research projects and the activities of mandated researchers by Belgian and foreign experts of the Scientific Committees. Assessment takes place at the end of the research agreement and covers methodology, performance and output of the research carried out as well as any publications related to the project concerned.

All research programmes are subject to an agreement specifying the research theme, objectives, number of researchers, technicians, operating procedures and equipment available to complete the approved research project. Agreements are assessed at the end of the implementation period, which is generally four years; the experts' decision determines whether any requested extensions are granted and whether other projects put forward by the same team will be considered.

All research mandates granted to individual researchers are subject to a contract that specifies the programme to be completed and requires the researcher to present the results of his or her research within a specified time. These mandates enable degree candidates to conduct research for their theses and research team leaders to set up programmes allowing them to specialise in a specific area of research. Researchers with indefinite-term mandates send in an annual report on their work and a five-yearly report detailing: group composition; publications; external collaboration; research and development activities; comments.

The assessment covers the research work performed by teams and individual researchers; a second assessment is also conducted in the form of a sectoral overview. Sectoral overviews, seven in all, each cover one research sector: biomedical science, chemistry, physics, earth sciences, applied sciences, mathematics, human and social sciences. For each sector they examine researcher participation over a four to five year period – fixed-term or indefinite-term mandates – and the contribution of teams granted agreements for the advancement of knowledge in the sector concerned. The aim of this assessment is to provide a sector-by-sector overview of ongoing activities in university research laboratories in the French Community of Belgium, to identify their strengths and weaknesses, gaps and potential. It is followed by a review of each researcher's individual contract.

### **Research in universities**

In French-speaking universities the breakdown of available resources is generally taken to be 75 per cent for teaching and 25 per cent for research.

As far as the French Community's universities are concerned, expenditure on R&D can be estimated at BF 7 billion, of which BF 3 billion from the Community, BF 1.2 billion from the Wallonia and Brussels Regions, BF 1.2 billion from federal government and BF 1 billion from European public funds.

### **Relations with industry**

The universities have had close ties with industry for some years now. As university/industry co-operation programmes are conducted under one-off contracts rather than in accordance with an overall co-operation plan, the universities are now trying to work out a joint policy to define a business approach methodology and develop tools to this end: a “partnership guide” setting out the purpose, modalities and ethics of research partnerships; a “showcase” showing the practical achievements that have resulted from partnerships between businesses and universities; a continuously updated list of the available resources, expertise and areas of excellence of each institution, contact points, etc.; and the compilation of a “directory of further university education” of all the further education opportunities offered, in co-operation with a variety of business sectors through a network of inter-university centres.

## CANADA

*Prepared by Mireille Brochu for the Social Sciences and Humanities Research Council of Canada*

### 1. Introduction – overview of the Canadian university system

There are over 80 universities and affiliated colleges in Canada's ten provinces. Their 36 000 academic staff provide education and research training to approximately 850 000 students, 175 000 of whom are awarded undergraduate and graduate degrees each year. Institutions range from small liberal arts colleges dedicated mainly to undergraduate education, to large universities offering comprehensive doctoral programmes and housing major research centres.

Collectively, in 1994, they spent C\$ 11 billion on operating and capital expenditures, including C\$ 1.8 billion for sponsored research.<sup>1</sup>

Except for a small number of degree-granting institutions affiliated with religious organisations, Canada's universities are public institutions, receiving most of their operating funds from provincial governments, and increasingly from tuition fees. Education is a provincial responsibility, but research is supported by both levels of government (Canada's constitution is silent on research).

The federal government is the largest sponsor of university research, but private funding (from both business and not-for-profit foundations) is increasing at a fast pace. With a few notable exceptions, provincial governments are not large sponsors of the direct costs of university research. However, as the major source of general university funds, the provinces have traditionally provided much of the university research infrastructure (e.g. faculty salaries, space, facilities, utilities).

In recent years, both levels of government have been reducing spending in a massive effort to cut deficits.<sup>2</sup> Therefore, both operating funding and publicly sponsored research are on a downwards trend.<sup>3</sup>

Because Canadians opted in larger numbers for post-secondary education, undergraduate enrolments are relatively stable, despite demographic trends which suggested that significant decreases would occur in the 1990s.

These are difficult times, for higher education in general and research in particular. However, many are optimistic that Canadian universities will emerge from the period of change stronger than ever and well equipped to help the country face the challenges of the twenty-first century.

Before turning to the research environment in Canadian universities, this document will briefly highlight the federal science and technology strategy and the evolving role of government laboratories in the Canadian R&D system.

## 2. Federal science and technology strategy

The dilemma facing Canadian research has been highlighted in a recent publication of the Association of Universities and Colleges of Canada (AUCC, 1996): “Canada’s research environment is being transformed primarily by two opposing factors, the rise of the new economy in which knowledge, R&D and innovation are seen as the key to competitiveness and the continuing fiscal crisis facing governments.” It is in this context that the federal government developed its science and technology strategy (Industry Canada, 1996), released in 1996.

The organisation of science at the federal level has been the subject of debate for decades, with some advocating central responsibility for science, others seeing science as an integral part of the activities of government departments, such as health, environment or agriculture. The 1996 strategy called for increased co-ordination, but leaves responsibility for science activities with individual ministers. Co-ordination and broad policy are the responsibility of the Minister of Industry, seconded by a Secretary of State for Science, Research and Development (junior minister). Key federal agencies responsible for science and technology report to the Minister of Industry, whose portfolio also includes agencies responsible for regional development, marketplace services and microeconomic policy.

The strategy recognised the role and importance of science and technology in the new economy and puts a high priority on solving the innovation gap. Knowledge transfer beyond academic circles was thus a major thrust of the strategy, which stressed the need for Canada to become more effective at translating research achievements into economic and social development. The strategy called for partnership between the public sector, the private sector and the universities to build a strong national system of innovation.

Another major aspect of the strategy is increased collaboration between the various departments and agencies of the federal government itself, bringing more focus and co-ordination to internal and external scientific activities. A case in point is the above-mentioned Industry Portfolio, which includes the National Research Council (NRC), the Canadian Space Agency, the Communications Research Centre and two of the three research granting councils, the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC)<sup>4</sup>. Portfolio agencies have developed co-ordination mechanisms and launched several joint projects. The three granting councils also work closely together.

Finally, the strategy called for better governance of federal scientific activities and stronger planning and evaluation tools. Each department and agency responsible for science and technology programmes was asked to prepare a science and technology plan and to develop output-based performance indicators as well as measures of results and impacts. Agencies must also develop evaluation frameworks and obtain external advice from their clients and stakeholders. At the same time, and to provide decision-makers with better tools, Statistics Canada has undertaken a major project aimed at improving existing science and technology indicators and developing new ones, focused on innovation and the new economy.

Through the strategy, the federal government is increasing its role as a co-ordinator and a catalyst, while decreasing its involvement in the performance and funding of science and technology. In 1979, the government funded 49 per cent of Canada’s R&D, and by 1995, this share had fallen to 26 per cent.

### **3. Federal government laboratories**

In the last decade, the federal government's relative role as a performer of R&D has declined significantly. For example, national laboratories performing research in natural resources areas such as agriculture, fisheries, oceans, forestry and earth sciences have been restructured and streamlined. NRC laboratories have also experienced budget decreases and some programmes of the laboratories of Atomic Energy of Canada Limited have been terminated. It is important to note that science has not been singled out for cuts. On the contrary, it has fared relatively well compared to other programmes as federal government operations and subsidies in all areas have been drastically reduced in an effort to restructure government and control deficits.

Restructured public laboratories have become more applied and "client-oriented", with external advisory boards involved in the selection of research thrusts and priorities. Regulatory activities are the focus of a number of government laboratories, but many also have a mandate to contribute to economic and social development, both regionally and nationally. Strong local collaboration already existed in several regions of the country, but there have been an increasing number of co-ordinated initiatives involving all performers and funders of R&D, including universities as well as provincial and territorial partners.

### **4. Recent trends in university research funding and policies**

Since the early 1980s, universities have been performing about a quarter of Canadian R&D<sup>5</sup>. This apparent stability masks dramatic changes in the funding sources for sponsored research, with increased contributions from the private sector (from 18 per cent to 31 per cent) and decreased contributions from federal government sources. Private sector contributions are now much higher than in most other OECD countries.

There is no question that universities have been successful in attracting new sources of support for their research activities. These sources have helped strengthen research in areas of practical importance and have opened new opportunities for the training of students in fields of interest for industry.

However, this change in funding pattern comes at the same time as the knowledge-intensive economy is transforming the way knowledge is created and transmitted and the way research problems are defined and approached. Research is becoming more complex and finding the answers to many of today's research questions requires intellectual and physical resources that go well beyond the capacity of the average research team. As a result, more and more successful researchers are working jointly with colleagues from other disciplines, other institutions, other sectors and other countries. This draws on a precious commodity: time. Active faculty members are busy with teaching, research and committee work; the time required to build successful networks and to seek diversified sources of support is at the expense of other academic activities.

This new mode of knowledge production also has a major impact on the universities themselves, with teaching responsibilities associated with traditional discipline departments, and research often carried out in interdisciplinary centres or units. This entails additional costs in time and resources, adding pressures to overcommitted research budgets.

In many disciplines, the most successful, highly competitive researchers have become research managers, and are no longer "hands-on" in the laboratory. They must add management and active fund raising functions to those of teaching, research and community service. This is difficult, because researchers are not necessarily experts at these activities, and to do this properly, competent assistants are required. This

is seldom possible in emerging areas that do not have a long tradition of research and few sources of public and private research funds.

The transition period may present a challenge and lead to increased tensions between teaching and research and between “have” and “have not” disciplines and institutions. However, in the long term, this restructuring of the research function will likely bring new opportunities and enhance research productivity and effectiveness.

#### **4.1 *University research and the federal government***

As consensus was building that knowledge and innovation are key to competitiveness, hopes were high in the research community that the 1996 federal science and technology strategy would translate into increased support to university research after a long period of chronic underfunding.

Although the strategy was not accompanied by funding increases, the 1997 federal budget brought good news to the university research community, by announcing the creation of the Canada Foundation for Innovation (see section 4.1.5). Deficit reduction is ahead of schedule and R&D has been clearly identified as a government priority.

The three granting councils, MRC, SSHRC and NSERC, are the major instruments of the federal government in support of university research. They provide grants which contribute to the direct costs of research. Universities (or hospitals) are expected to cover the salaries of the principal investigators and all the indirect costs of the research. The councils offer standard research grants for investigator-driven research and more targeted grants in support of various forms of partnerships. They also promote research training, through their grants programmes, and through an array of scholarships and fellowship programmes.

##### **4.1.1 *Cuts in base budgets***

Starting in 1995, the federal government cut the base budgets of the granting councils: NSERC and SSHRC base budgets will have decreased by about 17 per cent by year 2000, whereas that of MRC is decreasing by about 13 per cent.

MRC’s annual budget submission to the government (Medical Research Council of Canada, 1997) clearly spells out the problems: “Over the four year period ... the MRC budget has been reduced by 13 per cent, and its purchasing power further weakened by inflation, with the result that the Council must now turn down applications for support of projects that would be considered excellent by any scientific standard. Budget reduction has also required lowering the dollar amount of grants to levels that place Canadian researchers at a disadvantage relative to those in other countries where the budgets of federal health science agencies have been increasing.”

As a result of budget cuts, some of the researchers who depend entirely on standard research grants for support find it difficult to cope with the increasing costs of research and must scale down their research and training efforts. Other researchers, mainly in more applied areas, are doing very well since new sources of funding were added in the last decade, as will be seen in the next sections.

The federal granting councils have made efforts to maintain a reasonable balance between their more “traditional” research and training funding programmes and new funding mechanisms, but this has become increasingly difficult.

SSHRC’s 1996 strategic plan, entitled *Striking the Balance* (SSHRC, 1996), eloquently stresses the need to recognise and value all types of research. The plan’s conclusion states: “...SSHRC will strive to strike and maintain a balance between the immediate and longer-term needs of researchers and Canadians as a whole – now, and into the future.”

#### 4.1.2 *Priority for partnerships*

Federal programmes created in the last decade have promoted research partnerships funded jointly by the federal government (generally through special funding to the granting councils) and the private sector. For example, between 1986 and 1991, under the “matching funding policy”, increases to the budgets of the granting councils were contingent upon the universities obtaining research support from the private sector.

The three councils have partnership programmes aimed at fostering collaboration and at leveraging funds from other sources. In the case of the social sciences and humanities, partners are often community groups, trade unions or not-for-profit organisations; few are in a position to bring hard cash to the table, increasing the funding gap between the social sciences and humanities and other disciplines. Researchers in disciplines where small companies constitute the bulk of the sector also have difficulties leveraging funding from partners.

Partnership means joint funding, but also means collaboration, bringing more diversified intellectual resources to bear on research problems and facilitating the creation and transfer of knowledge. It often means breaking from the traditional disciplinary mode of doing research. While this provides opportunity for more effective and productive research, it also requires an adaptation on the part of many university researchers who have traditionally been the only ones involved in selecting and defining their research programmes.

Partnership also often means pressure to do more applied research. There is a consensus that a proper balance needs to be maintained to avoid an erosion of the knowledge base, but many in the research community believe that the pendulum has swung too far and that the time has come for the federal government to increase support for the research base in Canada.

#### 4.1.3 *Networks of centres of excellence*

One noteworthy federal programme is the Networks of Centres of Excellence Program, launched in the late 1980s and managed jointly by the three granting councils and Industry Canada. This unique programme recognised that few universities in Canada had the critical mass necessary to tackle some of today’s key research areas in a concerted fashion. It called for the research community from all sectors and from all areas of the country to mobilise itself around significant research problems in areas of its own choosing. In the first round, 15 networks were selected after an intense competition. Awards were of a magnitude (multi-million dollars per year per network) that enabled researchers to work together on a scale not possible under other funding sources. A second round in 1994-95 saw ten of the original networks renewed, and four more added, this time in targeted areas (environment, health research, technology-based learning and advanced technologies).

The 14 current NCEs involve about 1 000 researchers, 1 400 graduate students, and close to 500 postdoctoral fellows in 48 universities, with partners from more than 400 participating companies, 37 hospitals, 76 government departments, ministries and agencies across the country and 63 other organisations. Successive evaluations of the programme have been very positive, with strong indications that the socio-economic benefits of the research are likely to be well in excess of the programme costs. A third competition is underway, which will see some of the original networks renewed and new ones added.

#### *4.1.4 Other federal support*

Departments and agencies of the federal government also rely on university research, either by contracting research work to universities or through programmes aimed at enhancing research and research training in their area of responsibility. Given the massive cuts to departmental budgets mentioned earlier, this type of federal support of universities is also down. This is particularly alarming for researchers in disciplines with more limited opportunities for private sector funding.

#### *4.1.5 New initiatives*

There are strong indications that the tide may be turning for university research support. In addition to the renewal of the Networks of Centres of Excellence Program, a number of initiatives have been announced by the federal government in the last year.

#### Health Services Research Fund

In the 1996 budget, the federal government announced the creation of the Health Services Research Fund, which will fund research to examine the effectiveness of health services and the outcomes of accepted procedures. The government has committed C\$ 65 million over five years to endow the Fund. Additional commitments will come from partners, including other levels of government, the private sector, health-care institutions, and academic health centres. (The Fund is an endowment, so that only the revenues will be available for research.) Partners and stakeholders will participate in setting research priorities and will benefit from the research results.

#### Canada Foundation for Innovation

The 1997 federal budget had good news for the university community, the creation of the Canada Foundation for Innovation. The Foundation is being set up as an entity independent from the government with an endowment of C\$ 800 million (the largest foundation in Canada). Its mandate is to invest in research infrastructure in universities and research hospitals. Targeted areas include science (undefined), engineering, health and environment. The plan is that it will invest approximately C\$ 180 million per year that will be at least matched from other sources, producing a total investment in research infrastructure of about C\$ 2 billion over five or six years. Granting councils will be involved in the review process. According to NSERC's recent newsletter (NSERC, 1997), "a lot of the credit for convincing the government to respond to this long term need of universities must go to the university community, which was able to mobilise all its constituents (administrators, professors, students, business leaders) who spoke with a consistent and unified voice of the urgent need to rebuild Canada's research infrastructure."

The research community is pleased with the budget announcement, and even surprised at the sheer size of the Foundation's endowment. As the Foundation is being set up at the time of writing this report, it is much too early to speculate on the type of facilities and equipment which will be financed. Nevertheless, universities are already hard at work developing proposals and exploring new sources of matching funds. Although the overall response is positive, this is yet another matching programme, and there is concern that some critical basic research areas may not be able to raise the matching funding required to tap Foundation funding. Smaller institutions and universities in less prosperous regions of the country are also worried that they may not have the same chance of securing matching funding from the private sector and the provincial government.

#### **4.2 *Provincial support of university research***

Provinces provide the bulk of general university funding, which pays most of the faculty salaries and provides for the indirect costs of research. Operating grants have been under severe constraints in most provinces. In Alberta, the pain is over, and the government has started strategic reinvestment in universities. The budgets of Ontario universities, after several difficult years, will not be cut further in the current year. In Quebec, deficit reduction policies are more recent and cuts to operating grants make life difficult for universities, especially because they cannot increase tuition fees to partly offset the loss.

Direct provincial support for research varies from province to province, ranging from almost nothing to full-fledged granting councils. On average, provinces provide 17 per cent of sponsored research funding, down from a peak of 20 per cent in the late 1980s.

Most provinces realise that strategic investment in university research infrastructure by provincial governments can be very effective in attracting federal government or private sector research support to their universities. At the time of writing this report, most provinces are looking at various ways to help their universities tap the newly announced Canada Foundation for Innovation by providing the required matching funding. Only Alberta and Ontario have officially announced such programmes in their 1997 budgets.

Proportionally, Québec is the largest funder of university research. Québec is the only province with granting councils covering all disciplines and supporting mainly investigator-driven research and research training. The councils were created to build a critical mass in the various disciplines and to ensure complementarity with federal granting councils. Québec's councils have promoted team research, thus encouraging universities to focus their research (and recruitment) efforts in areas where they already had core strengths. Québec also provides universities with an overhead of 15 per cent (10 per cent in the biomedical area) on peer-reviewed research support, including federal research grants.

Unlike Québec, Ontario does not have a cadre of formal programmes, but it has a small "research infrastructure" envelope allocated on the basis of federal research funding. Over the years, successive programmes have promoted university-industry interaction. Many have been phased out, but the Ontario Centres of Excellence Program, created in the mid 1980s, has recently been renewed. The bulk of Ontario's investment in university research is in the area of agriculture. After a long drought, the 1997 budget included good news for Ontario universities, through the creation of a R&D Challenge Fund, enlisting the private sector to help universities attract and retain excellent university researchers. The province is providing seed money and expects that the universities, the private sector and federal grants will contribute C\$ 5 for each provincial dollar.

Over the years, British Columbia has encouraged universities to develop research and to recruit and retain excellent academic staff. BC's science and technology policy, first developed in 1988, formally recognises research, science and technology as instruments of economic development and recognises the role of post-secondary institutions in applied research and technology transfer.

The Alberta Heritage Foundation for Medical Research has fostered the development of world class research centres in the province's research and teaching hospitals. It is only recently that policies and programmes of the Ministry of Advanced Education have explicitly recognised university research. A policy framework, *Fostering Excellence*, was adopted in 1996. This framework includes a research excellence envelope, a fund to help newly recruited university researchers and a recently announced infrastructure renewal envelope.

Given the size of their economy, less populous provinces provide rather modest funding for specific initiatives, such as indirect cost funding for participation in Networks of Centres of Excellence, or funding for health research. Most are looking at ways of helping their universities compete successfully for funding from the Canada Foundation for Innovation.

#### **4.3 *Private funding of university research***

Since 1993, private sources (industry and non-profit organisations) account for over 30 per cent of sponsored research in Canadian universities, compared to 18 per cent in 1980.

Industry has become a significant funder of university research, thanks in large part to matching programmes of the granting councils, fiscal incentives and, in the biomedical/pharmaceutical fields, patent legislation.

Most universities have opened industrial liaison offices, which help researchers find industrial partners, contribute to the development of institutional policies for the protection of intellectual property, set up mechanisms to identify promising results and market university-based inventions.

Much of the initiatives funded in part by industry are peer reviewed by the granting councils, ensuring that research funded jointly by government and industry meets high quality standards. The Pharmaceutical Manufacturers Association of Canada, for example, pledged C\$ 200 million for the five years to 1999, in partnership with the Medical Research Council.

Canada's biggest challenge is to translate research achievement into commercial products and processes. This is not necessarily due to the lack of entrepreneurial spirit of Canadian researchers. The lack of a strong indigenous industrial base to capture the results and the unavailability of capital are also major impediments. More often than not, promising Canadian inventions sit on the shelf or are licensed abroad, because the necessary funding could not be raised in Canada. There is progress on this front however, and thanks in part to fiscal incentives (federal and provincial), investors, such as labour-sponsored pension funds, are starting to invest in the early-stage commercialisation of R&D.

Two funds stand out, as they work in partnership with federal granting councils and other agencies to ensure that the selected projects meet high standards of excellence and to maximise the success of the ventures: the labour-sponsored Canadian Medical Discoveries Fund (CMDf) which, in two years, has raised C\$ 200 million in venture capital for companies willing to advance health-related research findings along the path to commercialisation, and the newly created Canadian Science and Technology Growth Fund, in support of the commercialisation of research results in the natural sciences and engineering. The

funds are tax-assisted venture capital investment programmes, with a policy to invest in businesses in early stage commercialisation of research and/or product development.

Other private sources, such as non-profit and philanthropic foundations are also increasing their R&D investment, mainly in biomedical areas. For example, in 1995-96, the non-profit sector, including agencies such as the National Cancer Institute of Canada, invested over C\$ 230 million in biomedical research.

## **5. International collaboration**

International collaboration is growing, but is mostly informal, i.e. through individual research teams rather than through formal agreements. Data published by the Government of Québec (1994) show that about a quarter of 1990 Canadian publications were signed jointly with international collaborators (compared with less than 20 per cent five years earlier). Collaboration is highest in mathematics (close to 50 per cent) and physics (37 per cent). Overall figures are much higher than for the United States and Japan, but somewhat lower than for most European countries. There are few formal international programmes or agreements, and limited participation in “big science” projects in Canada. Canadians are involved in international big science projects, for example in the area of ocean drilling, global change, subatomic physics, astronomy, the human genome. However, federal funding for such projects is decreasing, and many agreements have not been renewed.

Major facilities in Canada include:

- TRIUMF, the largest subatomic physics facility in the country, located on the campus of the University of British Columbia (operations funded mainly through the National Research Council, and research projects through the Natural Sciences and Engineering Research Council); and
- The Sudbury Neutrino Observatory, under construction in an active nickel mine in Sudbury Ontario; it involves participation from several countries.

Canada does not have a synchrotron radiation research facility, but a proposal to build one at the University of Saskatchewan has received the full support of the research community. Funding has yet to be found.

The weakening of international links is of major concern. To quote NSERC’s newsletter (NSERC, 1997): “we are weakening our links with the international research community. We can no longer receive as many foreign students and postdoctoral researchers as the reputation of Canadian research attracts. Our ability to send Canadians for research training and collaboration with laboratories abroad is diminished, and our participation in major international research projects is declining, not for lack of ability or recognition, but for lack of money”.

## **6. The professoriate**

Canada’s 37 000 faculty members have been recruited from across the world. For example, in 1997, 46 per cent of the 7 300 faculty members who hold NSERC grants have received their bachelor’s degree in a country other than Canada (down from 51 per cent in 1988).

Canadian universities expanded quickly in the 1960s and early 1970s. The young faculty members of that time have aged, to the point that the average age of faculty reached 48 in 1993, with 58 per cent of faculty members being over 45 years of age (AUCC, 1996). These global figures mask discipline differences, with growing areas, such as health sciences and engineering, having a more normal age distribution than the social sciences and humanities which have an older population on average.

In 1993, women accounted for 22 per cent of faculty members, up from 14 per cent in 1976. Hiring freezes and cutbacks make it difficult for universities to continue to increase this proportion.

The current period of financial restraints has led to early retirement programmes and to generalised salary and hiring freezes in many provinces. Vacant positions are often not filled and sessional lecturers are hired to perform the teaching duties of recently retired faculty members.

When positions are filled (generally in areas of high growth), they are often filled for a short term (one to three years). The workload of new faculty members is high and “start up” research funding is low. Facilities are inadequate. Some universities are complaining of a “brain drain” of faculty members who opt for careers elsewhere, mainly in the United States. In the absence of solid data, it is not possible to say whether these losses are compensated by equivalent intake from other countries.

Canadian universities were successful in attracting outstanding individuals 30 years ago. These teachers and researchers have contributed to the economic and social development of the country, helping Canada become one of the most attractive places in the world to live. However, given the deteriorating research support described earlier in this paper, Canadian universities are vulnerable. If they want to continue to attract and retain the best talent by international standards, they (and the governments and taxpayers that support them) will have to find ways to provide an environment which promotes research and rewards excellence. This may not be easy in the short term, but optimism prevails for the medium to longer term. The Canada Foundation for Innovation should play a large role in helping restore the environment.

## **7. Research training**

Training of students for research and through research has been a priority of funding agencies in the last decade. All three federal granting councils offer comprehensive fellowship programmes for researchers in training and encourage holders of research grants to include trainees in their teams. Training is now a criterion in NSERC and SSHRC grants competition. The integration of undergraduate and graduate students in research teams is not a tradition in the social sciences and humanities, but in the last decade, SSHRC has taken action to reverse the situation and intends to continue its efforts in this regard. In its 1996 strategic plan, SSHRC “intends to work more closely with the university community to help identify best practices for providing world class research training to the next generations”.

Many provinces offer competitive scholarship programmes for graduate students, and universities generally provide financial support, supplementing scholarships with part-time teaching or research assistantships. In general, rigorous external mechanisms are in place to assess the quality of existing and proposed graduate programmes.

The presence of experienced post-docs is an obvious asset to research teams and a succession of postdoctoral positions in top-notch labs is one of the best training mechanisms for the younger generation of researchers. However, there is incomplete and often contradictory information about postdoctoral positions in Canada (and postdoctoral positions abroad for Canadians).

On one side, faculty members complain that their grants are so low that they cannot afford post-docs. They argue that the ability of Canadian laboratories to attract top-notch international post-docs is decreasing.

On the other side, the uncertainty in research funding and the cutbacks in university and government positions mean that long (three to five years or more) post-docs are not unusual in many disciplines of the health and natural sciences. There is no doubt a significant pool of researchers in temporary positions, waiting for posts in academia, hospitals, government or industry. This reliance on “soft money” has a downside for these rather senior trainees who must devote a significant portion of their most productive years to seeking what is often a succession of temporary positions. But the extent of the problem is not well documented. Indeed, it may take longer to obtain a position, but partial data show that highly qualified individuals do find employment.

According to a recent NSERC survey (1996) of former winners of its postgraduate scholarships, unemployment rate for individuals was very low (between 2.1 per cent and 2.7 per cent) in 1996. The survey included individuals who had started their graduate studies in the natural sciences or engineering in the mid-1980s; about half of the respondents had obtained doctorate degrees, the others opting for a master's. Six per cent were still in graduate school and 12 per cent in postdoctoral positions. Universities (39.5 per cent) and industry (36.5 per cent) were the major employers. About 19 per cent of the respondents were living outside Canada (mainly in the United States) at the time of the survey, giving an indication of the mobility of Canadian trainees. More than half intended to return to Canada should they find attractive employment there. Respondents in computer sciences were much more likely to be working outside Canada (47.6 per cent) than respondents in other disciplines.

Given the importance of measuring outcomes of research and training programmes, more studies of this nature are needed to fully understand the dynamics of highly qualified human resources, including the international mobility of Canadians and the presence of international post-docs in Canadian laboratories.

International student enrolments at Canadian universities fluctuated over the course of the 1980s, peaking in 1983 at almost 31 000. In 1994, the number stood at 27 700. At the doctoral level, the proportion of international enrolment remained steady at 27 per cent between 1988 and 1994. There is no solid data on postdoctoral positions.

## **8. Conclusion**

Canadian university research is going through a major period of change. In the new knowledge-based economy, research is more applied, more interdisciplinary and more of it is done in partnership with industry, other universities and public laboratories. This transformation from disciplinary based academic departments to “problem based” research centres and networks is taking place with the strong support of the private sector, which has significantly increased its support of university research, recognising the value of investing in knowledge and training. But this transformation is also occurring at a time of severe government cutbacks, forcing universities to make difficult choices.

Fiscal deficits are now under control at the federal level and in most provinces, and governments are sending positive signals that university research is recognised as a key component of innovation systems. The prominence given to research in the 1997 federal budget, action taken by several provinces and the continuing interest of the private sector in university research are clear indications that science and technology are moving to the forefront of the national agenda.

Among the signals are the renewal of the Networks of Centres of Excellence; the creation of the Canada Foundation for Innovation and the likely responses of many provinces to it.

There is even more reason for optimism: the newly re-elected federal Minister of Industry has stated that the granting councils will be a major priority of his second term and the Minister of Finance has indicated that research will be one of the few priority areas for government investment once the deficit is reduced to zero.

Although there is optimism, there are also concerns, mainly because most of the new initiatives favour applied research in areas of predictable economic impact. There is serious concern that the pendulum has swung too far and that the country will no longer have sufficient depth in basic research.

At the time of writing this report, the research community is mobilising itself and its partners to demonstrate the importance of basic research as a reservoir of knowledge which needs to be replenished to ensure a constant stream of applications. To quote the NSERC newsletter (NSERC, 1997): “It is a fact that Canadian university researchers have become extraordinarily productive in terms of the excellence and the amount of research output for the money invested in their work. Their record is a story of great accomplishment which should be a national source of pride, but there is another story in what is not in the record. There are important areas of current research which Canadian researchers simply cannot afford to enter. And the research community as a whole has become conditioned to “think small.” ... A shortage of research grants means that young scientists setting out on their careers must start slowly, and our very best performers are held back, because they can’t have the research support they need...As a nation, we invest tens of billions annually in education, but we may be jeopardising the high end of the returns on that investment because we are a couple of hundred million dollars short in research support.”

## NOTES

1. Sponsored research excludes general university funds (GUF); Statistics Canada estimates that universities devote an additional C\$1 billion per year to research.
2. Although an exclusive provincial responsibility, post-secondary education is funded in part by transfer payments from the federal government to the provinces. Along with all other government programmes, transfer payments for education (and health) were reduced, making it difficult for provinces to sustain their level of support for health and social programmes, including education. This added enormous pressures on universities.
3. In some provinces, the shortfall in operating funds can be partially offset by increases in tuition fees. In others, tuition fees have been frozen in an effort to increase the number of individuals acquiring post-secondary education.
4. The third council, the Medical Research Council is in the portfolio of the Minister of Health.
5. This percentage is high in comparison with other members of the G7. However, it should be kept in mind that, at 1.5 per cent of GDP (gross domestic product), Canada's gross expenditures on R&D are low when compared to the same countries (except Italy, which is at the same level).

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## FINLAND

*Prepared by Marja Pulkkinen, Ministry of Education and Science, Finland (1996)*

### *Note to the reader:*

There is widespread consensus among Finland's political parties, and within the private sector, that the economic future and social well-being of the country can only rest on a strong foundation of education, high-quality research and know-how.

On 6 September 1996, the Government's Ministerial Committee for Economic Policy considered the question of government research and development appropriations. The Committee decided that the governmental R&D expenditure will be increased by 1999 making it possible to raise the total national R&D expenditure from its present level of about 2.4 per cent to about 2.9 per cent. Public R&D spending will gradually be increased during the years 1997-1999 so that in 1999 it will be about Mk 7.5 billion which is about Mk 1.5 billion more than planned.

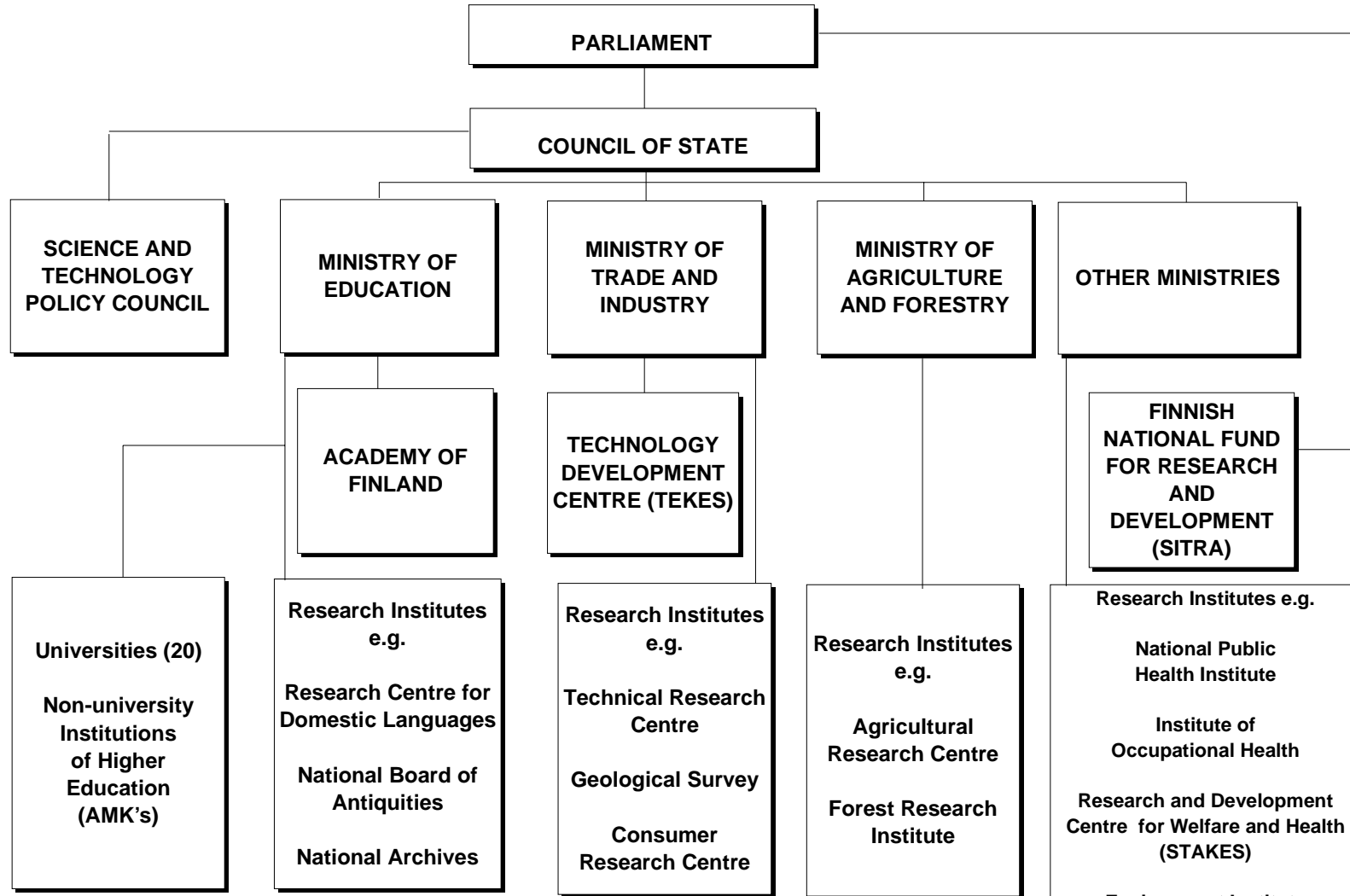
The policy decided is the most important decision within industrial and R&D policy made by the present government. The increase in governmental spending will be financed by revenues from the sale of certain state-owned companies. In accordance with the Government's programme, revenues from these sales are to be directed to the strengthening of industrial production and structural changes.

During the autumn, the Science and Technology Policy Council of Finland will prepare a new governmental growth and financing programme for R&D. Based upon this programme the Government decides in February 1997 upon the changes to be made to the state budget. A substantial share of this expenditure will be directed at Universities and the Academy of Finland during the years 1997-1999.

### **Organisation of research**

Research in Finland is carried out by the universities, the research institutes and certain state and private companies. Universities are state-financed and state regulated but autonomous. There are 21 state-run research institutes which collaborate closely with the universities. The universities' own budgets form the basic funding for research and in addition there are two significant public sector financing organisations: the Academy of Finland and the Technology Development Centre. The Academy of Finland promotes basic research. The Technology Development Centre allocates state funds for research and development in research institutes, universities and industry.

Figure 1. Decision-makers, funders and performers of research in the public sector in Finland



## 1. The Finnish university system and policy

Finland has 20 universities – ten multi-disciplinary and six specialist institutions and four art academies – all of them State-run and engaged in both education and research. Nearly one quarter of Finnish R&D is carried out in universities. Over half of the research done by universities (59 per cent) is financed from State budget allocations. External funding has increased by approximately 5 per cent since 1989, 10 per cent since 1983. The significance of external funding varies from one discipline to the next. Some 74 per cent of engineering research was sponsored by outside sources in 1993. In research undertaken in medicine, the social sciences and the humanities, budget allocations exceeded external funding, although even here the latter has increased. The Academy of Finland is the most important external source for basic research. In 1995, 87 per cent (Mk 375 million) of the Academy's research financing was delivered to universities. The Academy has mainly directed its support to extensive research projects and new research areas. Nearly 20 per cent of the research financing of the Technology Development Centre (TEKES) was also delivered to universities.

### *Goals and trends affecting universities from the 1960s to the 1980s*

Up to the 1950s, the university system grew without any nation-wide policy plan or unified guidelines. The first step in the direction of a more systematic higher education policy was the National Committee for Higher Education, which existed from 1952 to 1956. The first national higher education policy, however, was not introduced until the mid-1960s, when Parliament passed the Higher Education Development Act for the years 1966 to 1986.

The rapid expansion of the university education system in the 1960s had some undesirable side effects. Although admissions rose, the increase was mainly in sectors requiring little additional funding. Studies suffered from bottlenecks and inadequate resources. Rapidly growing industries and services were short of labour, while graduates in the humanities and social sciences had difficulty finding jobs.

Improving the standards and international competitiveness of education, ensuring sufficient and steady growth in resources and co-ordinating education with demand arising from job trends were the policy considerations on which the Higher Education Development Act of 1966 was based. The purpose of the Act was to give a larger proportion of each age group a chance to study at university, to balance the regional distribution of higher education, to shift the sectoral distribution of student places towards technology and the natural sciences, and to promote research at universities.

The goals written into the Act were largely achieved, though many problems in higher education had emerged by the end of 1986. Graduation was tending to last even longer, and the drop-out rate was high. Many domestic and international assessments noted that postgraduate education was poorly organised in this country. University management was beset by structural and functional inadequacies. The planning and budgeting systems were rigid and overly centralised. Co-ordination and contacts between universities were haphazard and insufficient. Universities' international relations needed to be intensified.

To remedy these defects, work started on reformulating the development programme and planning methods. The time was ripe to rethink the relationship between governmental authority and university education. The new approach of the mid-1980s, which can be characterised as a shift from regulations to objectives, culminated in 1986 with the new Higher Education Development Act and the Government decision on higher education development. The new Act marked the end of an era in higher education.

The objective of the new Act was to guarantee stable resource development for the universities until the mid-1990s and to prepare the ground for internal reform. The Government decision established a significant increase in resources between 1986 and 1991 and set development objectives stipulating:

**promotion** of management by objectives within the universities, increased independence in decisions on the use of allocated resources and a more flexible definition of teachers' duties;

**introduction** of an assessment system at all universities producing adequate and compatible information about the results and costs of research and instruction;

**preparation** by universities of regular performance reports, including a summary to be drawn up for the higher education and research development plan approved by the Government at four-year intervals;

**consideration** of performance in allocating new funds to research and instruction, and reallocation of existing resources on the basis of changing needs;

**more efficient** undergraduate instruction enabling most students to graduate (obtain the higher academic degree) within four-five years;

**more efficient** postgraduate (doctoral) education as a joint effort by the universities, enabling students to complete a doctorate after four years of full-time study.

The development programme was implemented with good results at a time of extremely favourable progress in higher education funding. In January 1995 a new graduate school (doctoral) system was introduced to supplement researcher training. The system comprises 93 graduate schools working at the universities and offering nearly 4 000 full-time positions in researcher training. About 30 per cent of all postgraduate students are within this new system. The new programmes are linked to the centres of excellence, to high-standard research projects or to comprehensive national networks. Research institutes and business enterprises also contribute to the programmes.

### *Trends towards the end of the 1990s*

At the end of 1995, the Government fixed the guidelines for higher education up to the year 2000. Education and research are crucial to Finland's strategy for the future, which aims at the well-being of its citizens, cultural diversity, sustainable development and prosperity.

The watchwords in education over the next few years will be high quality, educational equality and the principle of lifelong learning. In research, the focus will be on high quality, ethics, freedom of research and striking a balance between basic and applied research. Safeguarding the harmonious development of the innovation system is also a prerequisite for improvement in the economy and the employment situation.

Development of education and research in the late 1990s will focus on:

- the principle of lifelong learning;
- responding to changes in the workplace and creating jobs;
- internationalisation;

- introducing a more varied language syllabus at all levels of education;
- implementing the information strategy for research and education;
- recognising sustainable development as a key aim, and applying it in practice;
- improving mathematics and science skills;
- emphasizing the cultural mission of universities and schools;
- providing basic educational security;
- continuing the policy of rewarding centres of excellence and upgrading the training of researchers;
- strengthening the status of evaluation as an integral part of a steering and development policy emphasizing the importance of quality.

The emphasis in the development of universities will be on scientific research as a basis for instruction. Every effort will be made to provide the operating conditions necessary for high-quality basic research and researcher training. Flexible, adaptable arrangements in research and education, and the profiling of individual universities in their areas of strength, will prepare the ground for research and education to attain the highest possible standard. More funding will be provided to new units and promising new disciplines, and also for the study of vital research topics. Better opportunities will be provided for junior researchers doing postdoctoral research. Joint university-business research projects promoting new industrialisation will be supported.

Between 1994 and 1996, a new, two-cycle degree structure has been adopted in most university disciplines. The aim is for students to complete the Bachelor's degree in three years and the Master's degree in five years of study (or two years after completing the Bachelor's degree). Another goal is that at least 75 per cent of new students should complete the Master's degree, generally taking the Bachelor's degree as an intermediate step. Thus, admission to university confers the right to complete both degrees.

The purpose of the degree reform was to establish an internationally compatible degree structure providing students with the opportunity to combine studies across disciplinary and institutional boundaries. In future degree development, increasing attention will be paid to establishing close links with the workplace. Links between instruction and research will be promoted, and special importance will be attached to teaching skills. Reducing the drop-out rate and the time taken to complete degrees remain on the agenda. The functioning of the new degree system, both from the students' point of view and from a workplace perspective, will be monitored closely.

Rapid social change and the emergence of the principle of lifelong learning have made the adult education function of universities increasingly important. The range of open university instruction will be diversified, especially in mathematics and natural sciences, technology and economics. A path will be opened up from open university studies to university degree programmes. Provision of continuing education will also be diversified and directed towards long-term study programmes set up as a response to changes in the workplace. The Licentiate may also evolve in the direction of a postgraduate degree with a vocational emphasis, particularly suitable as a second degree for job-holders studying with adult education objectives.

Structural reform of the university system will continue, aiming at specialisation in areas of strength, increased co-operation in appropriate fields, and pruning of redundancy with due regard to economic realities. Savings achieved through rationalisation will be channelled into the areas of development focus.

The universities will be assured stable funding in order to enable institutions to produce results and engage in long-term operations. To this end, the Government will submit to Parliament a proposal for extending the Higher Education Development Act, which expires in 1996, for another ten years. Research funding channelled through the Academy of Finland will be reviewed in the light of objectives set by the Science and Technology Policy Council. The impact of performance-based funds will be enhanced by criteria emphasizing quality and potential, job placement of graduates and effectiveness of operations. The volume of funding from international and other outside sources will increase.

## 2. Doctoral studies

Operation of the Finnish university sector is based on the unity of research and instruction. Scientific postgraduate education, in particular, is closely linked with the research work done at universities.

In the new degree structure, students can start working for a doctorate as soon as they have obtained the Master's degree. The Licentiate is a voluntary degree, and is not offered in all fields of study; in certain cases, Licentiate programme may include specialist training.

In some fields of study, particularly the natural sciences, students can start working for a doctorate directly upon completion of the lower academic degree. In all cases, students must demonstrate independent and critical thinking in their specialisation, and personal commitment to the demands of research and researcher training.

The number of doctoral candidates has risen sharply in the 1990s, with a record 698 doctorates being completed in 1994. The number increased in virtually all disciplines, particularly in the natural sciences.

**Table 1. Licentiate's and Doctor's degrees conferred in 1982–1994**

Year	Licentiate	Doctorate
1982	319	305
1985	358	292
1988	512	401
1991	604	524
1994	786	698

Source: Author.

Finns complete their doctorates rather late by international standards, at the age of 37 on average. Several international evaluations have commented on this, including the 1986 OECD country report on science and technology policy, all the international evaluations of research arranged by the Academy of Finland, and most recently the OECD's evaluation of Finnish education policy in 1994.

Functional arrangements for doctoral studies and research done by students have been sought by many working groups and committees in recent years. An important step towards systematic, professional researcher training was taken in January 1995 with the introduction of a national research schools, known as graduate schools.

The graduate schools were established to supplement earlier arrangements for researcher training. The new system currently comprises 93 graduate schools working at the universities and offering a total of 4 000 full-time positions in researcher training. This number covers approximately 30 per cent of all students working for a doctorate.

The purpose of the reform is to raise the quality and efficiency of postgraduate education, making it possible for students to obtain doctorates much more quickly than before. Ideally they should be able to complete their dissertation in four years of full-time study.

The graduate schools have greatly increased the opportunities for full-time postgraduate education. Students receive top-level research guidance in Finland's leading research teams as well as joint instruction consisting largely of nation-wide or international intensive courses.

The graduate schools cover all the main areas of research. Together they form a network ranging from units concentrated in a single faculty or locality to nation-wide establishments combining the resources of several faculties. The graduate schools help extend successful co-operation between universities, industry and research institutes.

### **3. Research**

Most basic research in Finland is undertaken by universities. Nearly one quarter of Finnish R&D is carried out in universities, companies undertake more than half (58 per cent). The Academy of Finland is the most important external source of financing for basic research. With the gradual obscuring of the once strict division of research into basic and applied, co-operation between universities, research institutes and industry is on the increase. The universities are active in international research co-operation, including EC research programmes and the operations of CERN and ESA.

#### ***Policy objectives***

Finnish research policy has been based on striking a balance between scientific basic research, postgraduate education and innovation on the one hand, and technical and applied research on the other. The goal is for research funding to reach 2.9 per cent of GDP by 1999. Research funding exceeded 2 per cent of GDP for the first time in 1991. In 1993, Finland spent 2.23 per cent of her GDP on R&D, well above the European Union average of 1.96 per cent.

The quest for quality is a dominant feature of Finland's science and technology policy. It is generally realised that Finnish research can only be competitive if the standards of her scientists and the quality of research proposals are high enough. Quality is sought in different ways. Increasingly, research funds are being allocated on the basis of peer review of competing research proposals. Research fields, research institutes and whole universities are evaluated *ex post* by impartial, highly respected experts, normally from abroad.

Another concern of national science and technology policies is to ensure the application of research results. Co-operation between industry, universities and research institutes is continuously improving in Finland.

The 1980s were years of increasing investment in research. Finland had the fastest R&D growth rate in the entire OECD. State financing for research continued to grow in the early 1990s, though at a slower rate – real growth was 2.4 per cent in 1992 and 2.9 per cent in 1993. The recession has brought growth in R&D investment by industry to a standstill. The ratio of private to public research financing was 58:42 in 1993.

The number of Finns working in R&D rose 8 per cent from 1989 to 1993. In 1993, 42 100 researchers worked for a total of 30 500 research years. Companies accounted for 50 per cent of this figure, the public sector for 23 per cent and universities for 27 per cent. Thirty-two per cent of all research staff were women; the proportion of women was highest in the public sector (44 per cent); 39 per cent of researchers at universities and 22 per cent of researchers in the private sector were women.

An important effect of policies to enlarge higher education and research has been a rise in both the number of university graduates and of qualified researchers. Since 1985 the stock of university graduates has increased by 40 per cent. Over half of all university graduates are women. Finland ranks third among the EU countries in a comparison of the number of university graduates in the youngest segments of the work force (25-34 years). The number of doctorates has more than doubled. The proportion of women holding doctorates has also risen, and is now 37 per cent. In 1993, some 40 per cent of all those under 65 holding a doctorate or licentiate and some 12 per cent of those with a Master's degree were involved in R&D.

### *Research at universities*

The usefulness and results of investment in research in the 1980s have been noted in international disciplinary evaluations of research, which find Finnish research to be generally of high quality. Finnish universities have several research teams and units of international stature, producing top-level research and training outstanding researchers. Establishing and supporting centres of excellence has high priority. The Ministry of Education has requested the Academy of Finland to select centres to be designated as national centres of excellence in research. The main selection criteria are the research units' scientific merits and future prospects, their significance for researcher training and the larger research community, and their involvement in high-level international scientific co-operation. In 1995, 17 centres were selected.

Costly equipment and large-scale national science initiatives, such as the biotechnology and molecular biology development programmes, are further areas of focus in the Ministry of Education's budgeting. Biotechnology and molecular biology have been key research fields from the mid-1980s, and will continue to receive special funding. Research on high-energy physics connected with CERN also receives special funding.

Natural sciences and technology are the main research disciplines. The proportion of medical research has diminished somewhat in the past few years, whereas research in the humanities and social sciences has increased slightly. This conclusion is based on a survey asking university teachers to state the time they spent on research, administration and other duties. According to the survey, the proportion of research has increased at all levels of the hierarchy.

Scientific and ethical values have come to the fore lately, especially in genetic engineering, which is used increasingly as a research method. The Ministry of Education set up a committee on research ethics in early 1992 to deal with such problems. After sounding out the need for legislation on biotechnology, the committee drew up draft legislation on genetic engineering making genetic research subject to licence.

Total research spending by all Finnish universities in 1993 amounted to MK 2 185 million, 21 per cent of all research expenditure; this corresponded to 8 422 person years of research. Finland invested 0.46 per cent of its GDP in university research, which is close to the OECD average.

Over half of the research done by universities (59 per cent in 1993) is financed from State budget allocations. External funding has increased by approximately 5 per cent since 1989. It is noteworthy,

however, that about two-thirds of all external funding originated from various public sources, especially from The Academy of Finland and the Technology Development Center, and only little more than one-tenth from Finnish firms in 1993. Yet, the volume of the commissioned R&D by firms in universities has grown in the past years, but is still modest.

The significance of external funding varies from one discipline to the next. Some 74 per cent of engineering research was sponsored by outside sources in 1993. In research done in medicine, the social sciences and the humanities, budget allocations exceeded external funding, although even here the latter has increased.

Engineering sciences as a whole received over 63 per cent of the total funding by domestic firms to universities in 1993. The second largest recipient of R&D funding from Finnish firms was the discipline of natural sciences. Together engineering and natural sciences thus received a lion's share, over 81 per cent, of firms' funding to R&D in the university sector.

Within the field of engineering, electrical engineering and engineering physics were the most research-intensive disciplines in 1993 as their share of the total research expenditures in the field of engineering was over one-third. Over 70 per cent of the research conducted under the disciplines of electrical engineering and engineering physics was covered by external funds. Moreover, research conducted in universities in the fields of electrical engineering and engineering physics received both proportionately and absolutely the largest amount of funding from private sector compared to any other field of science. Of the total research funding to universities by domestic firms over one quarter was expended in the field of electrical engineering and engineering physics alone.

**Table 2. R&D expenditures, share of external funding and funding by Finnish firms in major fields of science in 1993**

Field of science	Total R&D expenditures	Outside funding total	Funding by Finnish firms
	Million Mk	Million Mk (% of total R&D exp.)	Million Mk
Total R&D expenditures	2 100.3	893.9 (43%)	99.6
Natural sciences	465.8	201.7 (43%)	18.2
Engineering	547.8	343.7 (63%)	63.0
<i>Electrical engineering and     Engineering physics</i>	<i>209.8</i>	<i>147.1 (70%)</i>	<i>26.0</i>
Medical & nursing sciences	374.1	118.3 (32%)	9.4
Agriculture & forestry sciences	90.5	48.1 (65%)	2.1
Social sciences	403.8	125.2 (31%)	6.2
Liberal arts	218.2	56.9 (26%)	0.8

Source: Statistics Finland, Science & technology 1995:1, Table 27.

### ***The Academy of Finland***

The Academy of Finland is the leading external source of financing for research at universities. The Academy's main duties include the financing, planning and co-ordination of basic scientific research and expert consulting in matters of science policy. Fostering international scientific research co-operation has become increasingly important in recent years.

The Academy of Finland promotes science primarily through the provision of research posts and research grants. The Academy currently sponsors nearly 500 research posts (academy professors, senior and junior researchers, research assistants) and distributes MK 350 million in grants annually. Most holders of

Academy research posts work at universities; the universities also receive an estimated 85 per cent of all research grants. The grants are awarded on the basis of competitive applications.

Academy financing takes various forms, including long-term research programmes, research posts, multi-year research contracts, project grants, grants for senior scientists and grants for postgraduate education. The Academy funds some 1 500 researchers every year. The Academy promotes research co-operation among university departments, as well as among universities and research institutes, for example through research programmes, through co-operative research projects, by promoting new fields of research, and by supporting researcher training in co-operation with universities and research institutes.

The Academy handles a wide range of duties related to international scientific co-operation, maintaining relations with its counterparts in more than 30 countries. Academy funding enables thousands of Finnish researchers to take part in international co-operation projects every year.

As of 1995, The Academy of Finland comprises a Board and four research councils, the Research Council for Culture and Society, the Research Council for Natural Sciences and Engineering, the Research Council for Health, and the Research Council for Environment and Natural Resources. The restructured Academy is now capable of functioning with greater flexibility and efficiency than previously and of attaching greater weight to both national and international science policy objectives and challenges.

A president, appointed for a fixed term by the President of the Republic, serves as the head of the Academy of Finland and as chairman of its Board. The other members of the Board are the chairmen of the four research councils and members appointed by the Council of State. The Academy also has an Administrative Office with some 80 employees charged with attending to the preparation and presentation of matters to be dealt with by the Board and the research councils, as well as with putting their decisions into effect.

### ***International research co-operation***

Active participation in international science and technology co-operation is vital to Finland's chosen strategy.

Finland has been a full member of the European Union since January 1995. The EEA Agreement came into force one year earlier. So far, Finnish researchers have been doing quite well in the competition for EU research funds. Finland is also involved in other joint international organisations, notably EUREKA, CERN, ESA and EMBC; Finland became a full member of ESA in 1994.

For a small country like Finland, the benefits gained from contacts with high-level research are particularly important. Research co-operation offers the opportunity to raise the standard of national research environments and provides impulses leading to interesting research and valuable findings. It is therefore important for Finland to create synergy between the national science and technology policy and that of the EU. Finland's ambition is to be an attractive and competitive partner in the international knowledge and information exchange market. For this ambition to be fulfilled, high-quality research teams and internationally recognised centres of expertise are needed. Good research environments attract foreign researchers.

Commitment to costly international co-operation in science and technology is a relatively recent development in Finland, and has resulted in the accumulation of rising participation costs over a relatively

short term. Nonetheless, increased co-operation is desirable as long as the momentum of domestic R&D can be maintained.

Along with new modes of participation, Finland continues to use existing channels of co-operation with the United States and Japan, Scandinavia, the CIS and the countries of Eastern and Central Europe. The nearby regions of Russia and the Baltic countries have risen to the fore lately: joint projects are under way to build up the science and technology infrastructure and to increase co-operation in technology and industry. Certain problem areas, such as research related to environmental protection, have special priority.

### *Future prospects*

Stable growth in research is crucial for economic, social and cultural progress in the 1990s. Finland's future prosperity depends increasingly on the potential opened up by research and new technology.

Finland's R&D spending has trebled during the last ten years. Finland now ranks fourth among the EU countries in terms of the ratio of research spending to GDP. By increasing public R&D expenditure to 2.9 per cent Finland ensures that by the end of the century it will be among the leading countries in terms of GDP share of R&D expenditure. During the same period, high-technology products have trebled their share of total exports. High-tech exports have increased more rapidly than in most comparable countries; in fact Finland is one of the few EU countries, and the only Nordic one, where high-tech exports exceed imports.

Finland has embarked on a policy based on rapid utilisation of research results, long-term commitments to a high standard of education, science and technology, co-operation between the public and private sectors, and internationalisation. The future of the economy, employment, and intellectual and material well-being depends heavily on a strong yet flexible system of innovation.

Cohesion between universities will continue to be enhanced by having each university specialise in its areas of strength. At the same time, the universities' co-operation with other research institutions will be encouraged. Co-operation between universities, research institutes and business will be enhanced by the new graduate schools. The international approach will assume greater weight in matters of co-operation.

A considerable proportion of university research will be geared to providing efficient support for internationally competitive industrial production in this country. Funds are being channelled into joint training and research projects by universities and industry.

## **4. Universities in the innovation system**

### *Recent trends*

In addition to teaching and research, other service functions have emerged within the university sector in the past years. These include activities such as continuing education, commissioned R&D and contract research. A number of science and technology parks and business incubators have been established next to universities.

### *New technology-based firms in Finland*

Following a period of economic growth during the 1980s, an infrastructure promoting the creation of new technology-based firms emerged in Finland. Universities and research institutes adopted active policies to encourage researchers to commercialise their expertise via science parks, technology and incubator centres. A network of science parks and the business incubator systems was established. The public funding support mechanisms, many of which had been in place since the 1970s, developed alongside.

The nine science parks were established in the 1980s and they are located near universities. The main services provided by science parks are office space and basic services for new technology-based firms. Additional services are provided, e.g. seed-money, incubator centres, and innovation centres. Typically, these services are located in science parks and performed by firms and financed by TEKES, SITRA and/or the Ministry of Trade and Industry.

Universities and research institutes, VTT in particular, have their own activities in commercialising the research results and encouraging the establishment of new firms. Most Finnish universities have a liaison office for promoting linkages between research and industry while some of them use the services of the local innovation centre.

### *Science parks*

The science parks (i.e. technology centres in Finland) aim at creating new linkages between industry, research institutes and universities. They seek to promote technology transfer from universities and research institutes to the private enterprise sector and to encourage the establishment of science and research-based firms. Science parks in Finland are private firms owned by a consortium of local and regional authorities, firms, regional universities and research institutes.

The first science park was established in Oulu in 1982. During the 1980s, six more started operations in Espoo, Turku, Tampere, Lappeenranta, Kuopio and Jyväskylä. The science park of Joensuu started in 1993. The science park of Helsinki was scheduled to open in 1997.

The nine science parks are located near universities and research institutes and are primarily regional technology centres in nature. The basic idea of the science park has been applied also locally as some local technology centres have been established in the vicinity of technology colleges and regional branch units of universities. Their business ideas resemble those of science parks. In respect to new firms the local technology centres encourage merely new start-up firms using the best "state-of-the-art" technology, while science parks are focusing on science and new technology-based firms.

The number of firms located in science parks has increased steadily since the 1980s and is presently about 800. The average annual growth rate in the number of employees has been 20-30 per cent during the last five years and they employ some 8 000 employees at the moment.

**Table 3. The number of firms and their employees in science parks in 1995 and the size of the city by number of inhabitants**

Science park	No. of firms in the park	No. of employees in the park	Adjoining city population
Oulu (Teknopolis, Medipolis)	250	1 500	100 000
Espoo	200	1 500	200 000
Turku (DataCity, ElectroCity, BioCity)	100	2 000	160 000
Tampere (Hermia)	150	1 500	180 000
Lappeenranta (Kareltekk)	50	500	55 000
Kuopio (Teknia)	50	500	85 000
Jyväskylä	50	1 000	72 000
Joensuu	20	100	50 000
(Helsinki)	..	..	500 000

Source: Ahola, 1995.

The technological fields presented by firms in science parks are presented in the table below. In general, the firms specialise in knowledge-intensive fields of technology or high technology. They draw on the scientific and technological resource base of their locality. The Espoo technology park, for instance, is adjacent to the Helsinki University of Technology and the Technical Research Centre of Finland, VTT. The science park in Oulu is located near the university of Oulu and the VTT research institute of Electronics. The science park in Lappeenranta, next to the Russian border, serves as a gateway to Russia and provides expertise in trade and technology transfer activities. It has a technical research base at the Lappeenranta University of Technology and at a local VTT unit. The science park in Tampere is located close to the Tampere University of Technology and to the local research units of VTT.

**Table 4. Fields of technology represented by firms located in the Finnish science parks**

Main fields of technology	Espoo	Helsinki	Joensuu	Jyväskylä	Kuopio	Lappeenranta	Oulu	Tampere	Turku
Automation	x							x	
Space technology	x			x			x		x
Biotechnology		x			x		x		x
Electronics	x				x		x	x	x
Energy			x	x		x			x
Information technology	x		x	x	x	x	x	x	x
Instrumentation technology					x		x		
Logistics				x		x		x	
Medical engineering		x					x	x	x
Material research	x		x	x					x
Metal structures						x			
Woods and forestry			x						
Optoelectronics	x		x				x		
Pulp and paper	x			x		x			
High-energy physics	x			x					
Telecommunications	x					x	x		
Technologies of sports				x	x				
Environmental technologies	x	x	x	x	x	x	x	x	x

Source: Ahola, 1995.

*Technology transfer from universities and research institutes to industry*

In the early 1990s most of the 21 Finnish universities developed links to local business life by establishing a liaison office. Their main activities encompassed the promotion of contract research for the industry as well as commercialisation of publicly financed research results. In practice, however, the commercialisation aspect was difficult to realise due to the fact that the intellectual property rights of new inventions belonged to the inventor, not to the university. In the future, however, it is expected that the general law on employee inventions will increasingly be applied for inventions made in universities. The liaison offices also conduct PR activities in order to enhance university – industry linkages and act as the contact points in incubator and technology transfer activities.

VTT established a technology transfer firm in 1984. Finntech Oy has been the pioneer of technology transfer in Finland. In 1994 its turnover was some MK 30 million. The turnover comes mainly from licensing and product selling, patent advisory services and project management services. The owners are the state of Finland (60 per cent, VTT and the University of Technology) and SITRA (40 per cent). TEKES and the Ministry of Trade and Industry are also represented in the board.

With the example of Tinntech (Otatech), new technology transfer firms were established in co-operation with the universities and SITRA in four universities of technology (Tampere, Turku and Oulu), and in Helsinki University. These firms are typically located in science parks and technology centres.

**Table 5. Technology transfer companies in 1995**

Firm (city and the year of establishment)	Owners
Aboatech Oy (Turku, 1993)	SITRA, and the foundations of the University of Turku and Åbo Akademi
HU Licencing Oy (Helsinki, 1993)	Helsinki University Holding Oy and SITRA
Finntech Oy (Espoo, Otaniemi, (1984 Otatech), 1993)	VTT, Helsinki University of Technology, SITRA
Oulutech Oy (Oulu, 1994)	SITRA, the foundation of the University of Oulu and the Science Park of Oulu
Tamlink Oy (Tampere, 1986)	SITRA, Tampere University of Technology, Foundation of the University of Technology, City of Tampere and KERA

Source: Ahola, 1995.

Technology transfer firms offer four types of services: licensing of research results, services for the commercialisation of research results and products developed in universities, management assistance for new business start-ups and research projects as well as co-ordination of monitoring activities for new product ideas.

Both TEKES and SITRA participate in technology transfer operations in universities. TEKES is the main provider of outside funding for R&D conducted in technical universities and research institutes. TEKES also funds and manages projects for searching potential product ideas from research organisations, to be commercialised through spin-offs or by licensing or selling the property rights to existing firms. SITRA is focused on technology transfer through licensing and through consortia between research organisations and existing firms.

Local technology centres also provide technology transfer services. Most technology colleges have an office promoting linkages between the institutes and local industry. The Foundation of Finnish Inventions has assigned regional representatives to local technology centres.

**Business incubators**

Incubator activities and services are typically part of science parks' operations. The main purpose of incubators is to promote the establishment of new technology and knowledge-based firms. The first business incubator in Finland was established in 1988 and presently there are about 15 incubators all over Finland, mainly located in science parks and local technology centres.

**Table 6. Business incubators in Finland in 1995**

City	Parent organisation	No. of firms in incubator	No. of employees in incubator firms
Espoo	Technology Center of Otaniemi, Spinno	25	85
Turku	Incubator DIO	15	30
Kuopio	Technology Center Teknia Oy	8	8
Lappeenranta	Technology Center Kareltek	3	6
Tampere	Technology Center Hermia	15	30
Jyväskylä	Technology Center of Jyväskylä	30	100
Kajaani	Kainuu Incubator center	3	5
Vaasa	Merinova	4	4
Lahti	Neopoli	4	7
Kemi	Incubator of KemiTOL – college	8	20
Oulu	Incubator of YTOL – college	5	8
Kokkola	Development company of Kokkola	2	2
Kotka	Kotkan Portti Oy	5	10
Kontiolahti	Tietopesäke Oy	5	12

Source: Ahola, 1995.

There are some variations with regard to the business concept of the incubators. Some incubators provide mainly office space and basic services for start-up firms. Courses and consulting services on how to manage a business are also often offered. Incubators located in science parks and technology centres usually provide access to funding and venture capital. Basically, there exist three main types of incubators:

- Each science park and regional technology centre offer, in principle, incubator services, although these may not necessarily be organised as independent firms (e.g. in Oulu the technology transfer firm Oulutech Oy provides incubator services).
- Local technology centres, located near technology colleges, also have incubator services for promoting the commercialisation of the specific fields of expertise offered by the colleges. The services are often limited to offering office space.
- In addition, there exist a number of local incubators with the mission to promote all kinds of spin-offs, particularly in regions with high unemployment and declining manufacturing base.

Incubator Spinno in Espoo has been a model for many incubators in Finland. Spinno was developed in 1990 by VTT. Presently, its activities cover most of the universities and research units in the capital region. Most of its client spin-offs have actually been located outside the Technology Center of Otaniemi during their incubator phase. Funding support for the first 6 to 12 months of operations is available from the Ministry of Trade and Industry.

*Centres of expertise*

With the initiative of the Ministry of the Interior of Finland, the Centres of Expertise Programme was launched in 1994. The objective of the programme is to facilitate the prerequisites for the location and development of internationally competitive enterprises which require a high degree of expertise. The programme supports regional specialisation and assignment of tasks to appropriate centres of expertise. The aim is to enhance the development of the knowledge base by promoting collaboration between new technology based firms and the higher education institutes, research centres and the government sector authorities. In the fiscal budget for 1995, a sum of MK 15 million was reserved to fund the programme. Eleven centres of excellence were nominated in different parts of Finland. Eight of these were regional and three sector-based, the latter covering the wood and forestry industry, the food industry and tourism. The foci of the regional centres of excellence is in areas such as biotechnology, automation, information technology, paper manufacturing, energy technology, environmental technologies, electronics and medical technologies. The regional programmes are planned and organised by the regions. Projects are typically performed by technology centres and local consultants.

**Table 7. The centres of expertise and their areas of specialisation**

Region	Area of specialisation	Funding in 1995 Mk million
Uusimaa	Internationalisation	1.5
Varsinais-Suomi	Biotechnology, material research	1.6
Tampere region	Engineering, automation, information technology, healthcare technologies	1
Kaakkois-Suomi	High technology steel structures	1
Länsi-Suomi	Energy technology and applications	0.9
Jyväskylä region	Paper manufacturing, energy and environmental technologies	1.5
Kuopio region	Medical technology, animal biotechnology	1.5
Oulu region	Electronics, medical technologies	1.6
Woods and forestry	Forestry economics, wood processing	1.6
Foods industry	Network of education, R&D and firms	1.5
Tourism	Network	1.3

Source: Ahola, 1995.

*Programme for re-industrialisation*

In 1993 the Ministry of Education and the Ministry of Trade and Industry launched a joint Programme for Re-industrialisation. The programme was conducted as a stand-alone project with a fixed duration. In 1993-1994, under the programme a total of MK 115 million was granted to 94 knowledge-intensive R&D projects with prospects of generating new industrial activities. The focus of the programme was on the development of high-tech products, creation of new firms, and the promotion of university-industry collaboration in R&D. According to the evaluation, the basic idea and the set-up of the programme were perceived, in principle, as good, but the funding mechanisms were criticised for their short time focus; in programmes such as this, the funding support needs to be allocated over the period of several years. It was recommended, for example, that for such programmes, in the future, the possibilities for co-operation with the centres of excellence be assessed.

## 5. University resources

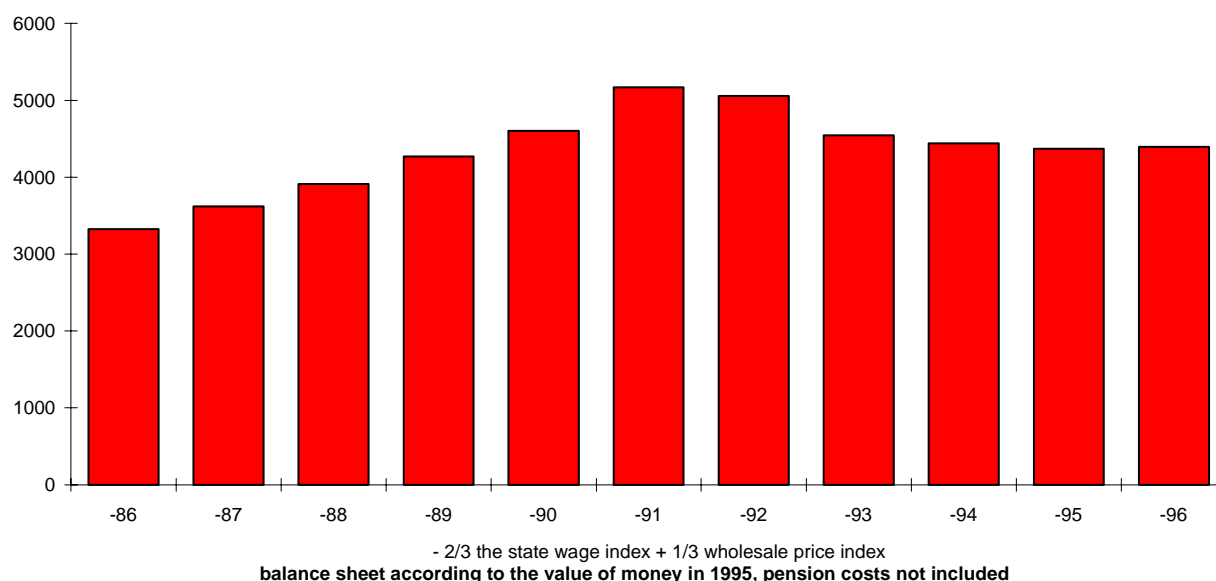
Appropriations for universities have been increased annually since 1967 in accordance with the Higher Education Development Act. In 1990, university education accounted for 2.9 per cent of the national budget. As a consequence of cuts in funding, this proportion fell to below 2.5 per cent in 1994. From 1991 to 1994, however, funding declined by 16 per cent in real terms. No more cuts have been made since 1995 and the budget will be slightly increased although the austerity measures still continue. Three-quarters of all spending on university education is financed from State budget funds channelled through the Ministry of Education. The aim is to widen the financial base by increasing private funding and other financing not channelled through the Ministry.

### *Funding of university education and research*

The first Higher Education Development Act, in force from 1967 to 1986, sought to safeguard steady growth in university funding. Growth was tied to other targets, including a larger number and more balanced regional distribution of student places.

The Higher Education Development Act of 1987 also specified steady budget growth as an objective. Under the Act, total budget funds allocated to universities were to be raised annually between 1987 and 1996 by no less than the rise in costs. The recession, however, resulted in the passing of an amendment cancelling this requirement for 1993 and 1994.

**Figure 2. University appropriations 1986-1996**



Source: Author.

In conjunction with the Act of 1987, the Government issued a decision under which total expenditure on salaries, other consumption, scholarships and appropriations for research would be increased by no less than 15 per cent a year. On the whole, this target was met.

With the recession of the early 1990s, public sector financing got into difficulties, forcing cuts in university funding in the years 1991-1994. As a result of the tight schedule called for in the austerity

programme, savings hit general operating expenditure the hardest; thus, purchasing by libraries had to be cut drastically, and purchases of equipment had to be postponed.

Action promoting the structural development of universities was initiated during the recession. The aim was to find solutions to improving the quality of research and education which would also promote the emergence of a more economical and streamlined university organisation. As resources become available, they were tied to the universities' areas of focus and development projects. The Government and the universities agreed on a reallocation of some MK 200 million between 1994 and 1998.

The resource guarantee offered by the Higher Education Development Act expired in 1996. In order to safeguard long-term university funding, it has been proposed that the guarantee be extended to 2006. There has also been discussion of the adoption of multi-year budgeting.

Three-quarters of the university budget is financed from the State budget and channelled through the Ministry of Education. The Academy of Finland finances part of basic research and researcher training at the universities. The volume of chargeable services provided by universities to business, industry and public authorities increased rapidly in the 1980s; they now account for 15 per cent of all higher education funding. The budget breakdown for 1994 was as follows:

- direct budget financing: 69 per cent;
- chargeable services: 15 per cent;
- other outside financing: 16 per cent.

Since universities do not charge tuition fees, purely private funding accounts for no more than 3 per cent of the total budget. In a time of dwindling public finances, the narrowness of the financial base is a liability. The aim is to widen this base by increasing private funding and other financing not channelled through the Ministry of Education.

In the current system of management by result by the Ministry of Education and the universities, the universities' operating costs are covered by allocations consisting of basic funding (c. 90 per cent), performance-based funds (5 per cent) and project funding (5 per cent). Project funds are earmarked for new research and education projects of national importance.

As of 1996, a form of budgeting was adopted in which the basic funding of universities is based on agreed graduation and degree targets. Result bonuses will be distributed on the basis of the results and quality of operations. A working group appointed by the Ministry of Education is currently examining the principles and operating procedures of result management.

### *Cost-effectiveness as a criterion for allocating funds*

Since 1988, a certain proportion of the appropriations for universities has been allocated on the basis of cost-effectiveness, defined mainly as the ratio of degrees to teachers in relation to the objectives set. The indicators used have varied somewhat from year to year, as Doctor's degrees have been given greater weight than Master's degrees. The annual cost-effectiveness bonus has amounted to 3-4 per cent of total appropriations for university education.

Rewarding of cost-effectiveness began cautiously. The appropriation was small and the criterion simple: to start with all universities received a bonus. By 1993, though, only half of the universities were receiving this special appropriation. The appropriation was increased and new criteria were adopted in 1994, emphasizing performance in basic, doctoral and adult education and in international co-operation.

“Centres of excellence” were also rewarded. Since 1995, the focus has been on quality, innovation and job placement of graduates. Centres of excellence in teaching as well as in research and in the arts are rewarded.

Rewarding of performance has a powerful incentive effect even if the appropriation allocated in this way is small. The criteria used influence university actions in two ways: they draw attention to results considered significant and they induce universities to develop performance criteria of their own and to reward their top units.

### *Staff*

Total university teaching staff in 1995 was approximately 7 550. The universities also employed some 8 300 people paid from budget funds and 7 500 paid from external funding sources.

In the 1980s, increases in university education staff were still determined in detail in the State budget. In the 1990s, the universities began to adopt operational budgeting and management by result. This called for a redefinition of personnel resources. Only professorships, associate professorships and certain administrative posts are now specified in the budget. Otherwise the university receives a lump sum which it may spend as it wishes, treating personnel as a resource on a par with others.

The proportion of women among teaching staff has not risen as fast as that among students. Eleven per cent of all professors, 20 per cent of associate professors, 30 per cent of senior assistants, 38 per cent of assistants and 44 per cent of lecturers at Finnish universities are women. Fifty-two per cent of students at the universities are women.

The rapid expansion of chargeable services has contributed to the capacity of universities to employ new staff. The number of staff funded from external sources has grown significantly in the past few years.

In efforts to boost operations, the universities work together with local authorities and businesses. In recent years, universities have received donations to set up new professorships in fields which the donors consider important. Such donors undertake to provide the funds required for a minimum of five years.

Efforts have been made to provide opportunities for university staff to establish international contacts. In 1994, over 13 per cent of all Finnish university researchers and teachers spent an average of five months working at a university or research institution abroad.

In an effort to develop teaching methods and forms of instruction, forge closer links between research and teaching, and to improve the results of the education process, an experiment in the distribution of teachers’ workload was started a few years ago at three universities. By dismantling the regulations on teacher’s working time, universities were able to arrange the teaching and research duties of their teachers more flexibly. The workload experiment is an integral part of the policy of delegating authority which is essential to management by objectives. It should help management by allowing for better and more rational planning and monitoring of operating costs.

## **6. Internationalisation of higher education**

The research undertaken at Finnish universities has always been of an international nature. Special attention began to be paid to internationalisation in the 1980s; the first clearly defined quantitative targets

for international operations were set at the end of that decade. Naturally, fostering international student and staff exchanges was not an end in itself.

Internationalisation had two main objectives: first, to influence students' attitudes, capabilities and skills so as to prepare them for working successfully in an increasingly international society and workplace; and second, to improve the quality and effectiveness of education and to diversify its supply.

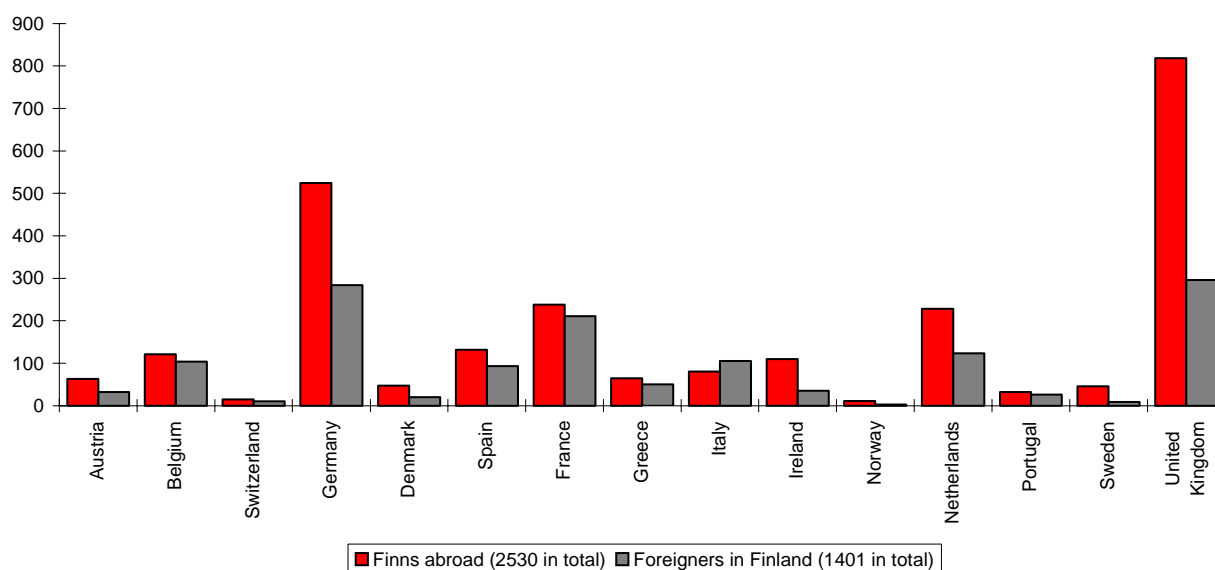
The universities have met the quantitative targets for student exchange set in the 1980s. The measurable goal was that every postgraduate student and at least 5 000 students studying for a basic degree should spend at least one academic term studying abroad.

The volume of exchanges by Finnish universities and internationalisation has been one of the indicators referred to by the Ministry of Education in rewarding results. This has helped focus attention on the importance of international links in instruction and study. The universities have considered the policy of rewarding internationalisation appropriate.

The barriers to international interaction have been considerably lowered by the rapid advance of, and easier access to, information technology; this trend continues. New technologies have also transformed the educational environment, making international interaction and co-operation an everyday part of instruction and research. Information networks permit real-time co-operation by much larger groups of people than those participating in student exchanges. Quota targets for student exchange have therefore become obsolete.

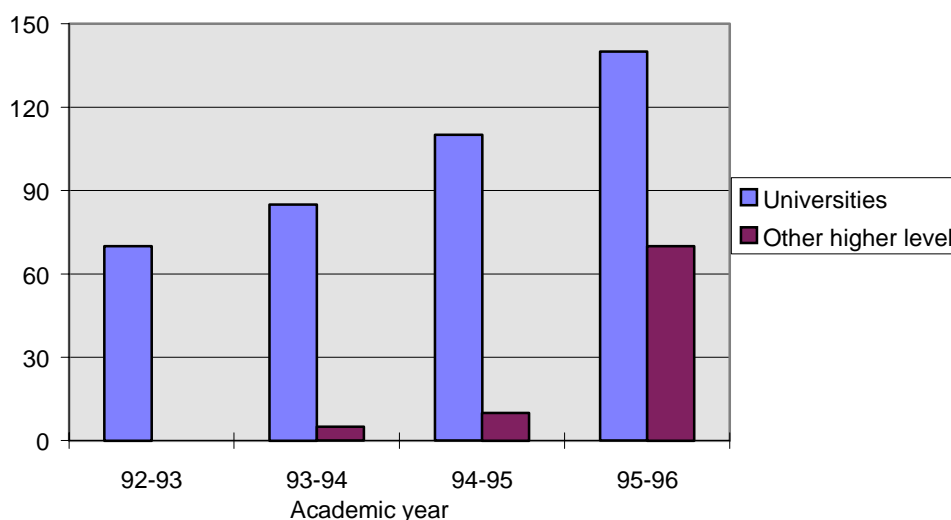
Finnish universities have successfully seized the opportunities for close European co-operation offered by EU membership. In the last few years, special attention has been given to improving the balance of international student exchange by increasing the capacity of Finnish institutions to admit foreign students. This means allocating sufficient resources to the administration of universities as well as special efforts to increase and upgrade foreign language instruction. Currently all universities offer study modules in foreign languages, usually English.

**Figure 3. Erasmus: student exchanges in the academic year 1995-1996**



Source: Author.

**Figure 4. Study modules taught in foreign languages in academic years 1992-93 to 1995-96**



Source: Author.

Finland's accession to the European Union led to a rapid transformation in Finland's operating environment in international politics. The main education policy objective is to provide Finnish citizens, through education and research, with the knowledge and skills to enable them to participate in and influence decision-making which concerns them at the European as well as the national level.

Planning of education and science must take into account the new obligations and opportunities resulting from EU membership. The basic premise of Finland's participation in EU co-operation is safeguarding national interests. EU objectives in research and education must not be allowed to supersede or replace Finnish objectives; Finland seeks to influence EU policy from within in such a way that it reinforces national objectives. One of the key challenges of the immediate future is to take the initiative in educational and research co-operation initiatives proposed by the Member States which underscore their role in formulating Union policies.

EU science and technology co-operation is aimed explicitly at improving the international competitiveness of European industry. EU research policy has a significant impact on Finnish R&D owing to the funding available from research programmes. Finland must take domestic action to avert the danger that European research co-operation might steer our national policy in an excessively technocratic and utilitarian direction.

Finland's geopolitical status leads to a certain focus in international co-operation outside the EU Member States: Nordic co-operation, and co-operation in the Baltic and Arctic regions. As an EU member, Finland is expected to furnish special expertise in these areas, and action is being taken to boost this asset. In 1995, a project was launched to increase and deepen Finland's expertise on Russia. The project will finance research on Russia and teaching of Russian, and promote Russian language studies at all levels of the education system.

The United States and Asia are also important areas to Finnish business and industry. Finnish universities have long had close contacts with the United States; in particular, a large number of postgraduate students have done research work there. Finnish contacts with universities and other educational institutions in

Asia are being promoted, with a special programme for enlarging university study programmes aimed at extending the knowledge of Asiatic languages and culture.

**Table 8. International degree students at universities in 1981 -94**

	Total	% students	Europe	Africa	North America	Latin America	Asia	Oceania	Unknown
1981	658	0.78	360	77	70	26	117	3	5
1982	690	0.80	360	92	75	26	131	4	2
1983	766	0.89	374	126	101	19	36	7	3
1984	929	1.05	439	170	118	24	168	7	3
1985	979	0.08	468	184	116	19	173	6	13
1986	1 024	1.09	501	180	120	20	177	4	22
1987	1 168	1.19	552	218	141	21	211	5	20
1988	1 230	1.20	550	244	139	29	259	4	5
1989	1 356	1.24	583	265	129	29	340	6	4
1990	1 617	1.46	688	297	130	41	444	7	10
1991	1 899	1.64	807	301	143	47	575	9	17
1992	2 182	1.79	962	300	139	51	670	12	48
1993	2 348	1.86	1 063	302	135	57	731	11	49
1994	2 566	2.00	1 195	317	145	55	789	11	54

Source: Author.

## 7. Development of sectoral research

The operational environment and conditions in sectoral research have changed just as in basic research. Another factor which has concrete influence on sectoral research is the ongoing central administration reform. In this connection, the present arrangements in sectoral research are being submitted to a critical scrutiny. There is also a clear demand for the structural development of government research institutes.

The basic idea underlying the central administration reform is a one-level administration model with a clear division of work between ministries and the units subordinate to them. Apart from legislative tasks, ministries also have a pronounced role in social development. Sectoral research occupies an important place in the new administrative culture. The adoption of management by objectives has already intensified objective-setting in research.

Sectoral research is a strategic resource and an important tool of social development for the ministries. Sectoral research is thus linked to the overall development objectives of the central administration. On the other hand, sectoral research constitutes scientific activity, which is subject to the same quality requirements as other research and must, moreover, be directed appropriately in terms of social development. In this way, the development of sectoral research also has strong links with the development objectives set for the national research system. Despite such conflicting pressures, which are further complicated by the cutbacks in the public sector, it must be possible to find adequate mechanisms for both the development of research and the utilisation of research results.

As a result of the general model of sectoral research outlined in connection with the central administration reform, the development programme described above is twofold. The ministries have a clearer role as clients in contracting, in financing and in utilisation, but this is separated from actual research, which is the task of research institutes, universities and enterprises in Finland and abroad. In order to be able to acquire and utilise relevant research results of high quality, ministries must have access to high standard scientific expertise and sufficient non-committed resources to meet the need.

The contracting party must subject the contracts to open competition. Government research institutes must be reorganised on a functional basis, so that they can compete for research contracts offered by more than one ministry. Research institutes must also be encouraged to raise external funding and to pool resources. If the reorganisation creates research institutes which are comprehensive expert organisations serving all those who use research in their fields, their position will be strengthened both in financial terms and in relation to the administration. It is also conceivable that a research institute negotiates and agrees on target results with more than one ministry.

The reorganisation of sectoral research institutes must also solve the problem of how the other tasks currently assigned to them can be appropriately executed. Government research institutes have various educational, consultancy, service, supervision and control, sampling and registration tasks, which must all be taken care of, either in these institutes or elsewhere. The institutes have also been assigned a role in mission-oriented basic research and postgraduate education, which create long-term conditions for responding to new challenges in sectoral research. A contractor who deals with current research needs cannot alone take care of these needs. The reorganisation has to find feasible solutions to financing in this respect.

The functional development of sectoral research should reduce the number of government research institutes. The same objective is also included in the overall development of the central administration. A new element has, however, emerged in the field of sectoral research, in that central agencies – again owing to the general reform of the central administration – are being developed into research and development centres, or their former research and development tasks have been transferred to ministries. The number of the institutes is thus growing rather than decreasing: the only decision taken by the Government to cut their number so far is to incorporate the Tampere Peace Research Institute into the University of Tampere as of 1 August 1994.

## GERMANY

*Prepared by the Federal Ministry of Education, Science, Research and Technology*

### 1. Policy and budget trends

In general higher education in Germany is publicly funded. Based on the principle of cultural sovereignty in the federal system, the universities, *Fachhochschulen* (colleges of higher professional training) and other institutions of higher education are maintained by the *Länder* (states) of Germany. As the *Länder* enact individual legislation on higher education, the German system of higher education is characterised by a certain diversity. However, the Federal Framework Act of higher Education (*Hochschulrahmengesetz*) sets general principles. As a consequence all 16 *Länder* are coping with several common issues.

The number of students attending institutions of higher education rose from 0.9 million (1977) to 1.6 million (winter semester 1996/97) in the 11 old (western) *Länder*, with an additional 0.21 million in the new (eastern) *Länder*. At the same time the staff of the institutions of higher education remained basically unchanged. That effected the student-teacher ratio unfavourably, making overcrowding of the universities and *Fachhochschulen* a matter of concern.

For the universities this has led to an increasing teaching load. Nevertheless the research activities of the universities do not seem to be seriously affected. However, the high average time students take until graduation at the universities (6.4 years average) and *Fachhochschulen* (5.6 years), which increased by about one year over the past 15 years, required serious consideration. There are big efforts to reduce the number of years spent at university until graduation by various measures.

Despite the increase in the number of students the percentage of the gross national product allocated to the institutions of higher education (excluding medical schools) did not increase accordingly. The severe financial difficulties of the universities have created a controversial debate about introducing tuition fees in Germany. So far students do not have to pay for higher education and it looks as if this will remain in the near future.

Apart from the universities there are *Fachhochschulen* which were set up around 1970 to provide a practice-oriented curriculum mainly in the fields of economics, social work and engineering. In addition to their main responsibilities, teaching and training, the *Fachhochschulen* are engaged in application-oriented research and development, including technology transfer. This is limited by the staff and funds they have at their disposal; therefore they depend largely on external funds for these additional activities. Federal and state governments are supporting the *Fachhochschulen* with specific programmes to assist this new and developing function; private business provides contract money as well.

Further issues are the implementation of global budgets for the universities in combination with increased autonomy on the one hand and increased accountability and regular evaluation on the other hand. There is

a broad tendency to set the preconditions for a more professional management of higher education institutions.

## **2. Knowledge transfer mechanisms**

### *Policies to promote knowledge transfer*

Managing the innovation process in industry is first and foremost a task for business enterprises. Government is supporting the science base as well as the transfer of knowledge and know-how from the scientific community to industry in an effort to help overcome the modernisation and innovation crisis. Support is given above all to pre-competitive approaches cutting across industries. Small and medium-sized enterprises play a major role in technological innovation.

Research and technology policy will perform a key function if, besides focusing on the provision of an efficient research infrastructure, it also aims to ensure the necessary linkage of research, development, innovation and diffusion as well as the integration of different innovation-promoting approaches. Research and technology policy must contribute substantially to a dynamic innovation and economic system by means of an intelligent mix of traditional research support, stimulation of exchange and transfer between science and industry and the development of an innovation-promoting environment.

The Federal Government therefore considers research and technology policy an integral part of broad-based innovation promotion aimed at the improvement of co-operation between science and industry and the promotion of favourable conditions and co-operation networks for the innovation system. The Federal Chancellor's Council for Research, Technology and Innovation is a forum focusing the dialogue between science, industry associations and the political community on vital issues. The recommendations issued by the Council are addressed to all those concerned, inviting them to make their own contribution to the promotion of innovation and knowledge transfer.

### *Transfer mechanisms in research support*

In its endeavours to support research, the BMBF uses the following transfer mechanisms:

#### Indirect-specific programme for small and medium-sized enterprises (SMEs)

The main goal of this support programme, which was launched in 1991 and concluded in 1996, is the rapid and large-scale transfer of research results to industry. Above all the R&D activities of small and medium-sized enterprises are to be increased to achieve that goal. Funds amounting to DM 100 million had been earmarked for a period of five years. A simplified application procedure facilitated access to grants. A total of 350 projects have been funded covering major areas of medicine/pharmacy, the food industry, plant breeding and environmental biotechnology. Such funding helped reduce the risks involved for SMEs and newly established companies when starting biotechnological work. In this way it was possible to encourage numerous firms to engage in biotechnological activities. They were given an opportunity to open up new fields of activity and new markets. Already in 1994 an analysis of this support programme revealed that it had contributed substantially to speeding up the commercialisation of biotechnology in Germany. In addition it provided a sound basis for further steps towards sustained industrial application of biotechnology.

### Transfer agencies for environmental biotechnology and molecular biotechnology

The BMBF is providing start-up funding over a period of five years for three environmental biotechnology transfer agencies in Leipzig/Halle, Bochum and Hamburg. The aim of such national networking is to promote the development and application of biotechnological processes for environmental purposes and so provide easier and quicker access to the market.

### “BioRegio competition”

The “BioRegio competition” funding concept announced in October 1995 pursues a systemic approach integrating biotechnological capacities and scientific and economic activities. This is to speed up the transfer to application of knowledge gathered in academe, turning it into marketable products and processes. The aim is to promote commercialisation of biotechnology in Germany. Support is given to the elaboration of biotechnology development concepts by competing regions. A main element is co-operation between all those concerned in science, industry and public administration. Three regions will receive awards and special support. The selection procedure will be based on the concepts submitted up to September 1996.

The *Deutsche Forschungsgemeinschaft* (DFG) intends to set up transfer programmes in the framework of its special research programmes. These transfer programmes will involve time-limited pre-competitive co-operation by research institutions and business enterprises or others applying research results in a certain field to develop a prototype. In the pilot phase, about eight to ten transfer programme proposals are to be considered. At present, the following transfer programme proposals are under consideration: “Assembly in a flexible production plant” and “Locating and operating survey vessels” (both Stuttgart) as well as “Assembly automation by means of integration of planning and construction” (Munich).

Linking basic and application-oriented research can help promote innovation. The German innovation system depends on co-operation by science and industry, by basic research and those applying research results so that the knowledge generated is also transferred to the application stage.

### Results of research co-operation between university and industry (collaborative research) and related sectors

The collaborative research approach has proved a big success in BMBF project support. Collaboration by different business enterprises and research institutions under one research project contributes to:

- improved exploitation of limited research capacities by pooling resources;
- the acceleration of technology transfer between science and industry;
- the generation of synergy; and
- large-scale, instead of selective, promotion.

At the same time, collaborative research prevents competitive distortion in government technology funding as only pre-competitive projects can be accepted by the industrial partners of a branch of business. Consequently almost all projects involve basic industrial research. When the R&D results are available, the industrial partners involved in the collaboration and also third parties can develop company-specific solutions without government support. Furthermore, collaborative university/industry research gives major impulses to research co-operation in Germany, as it has been found that innovation in industry increasingly needs inter-company R&D co-operation.

Collaborative research has, since its introduction in 1984, developed into the predominant technology and innovation promotion tool. In some fields including manufacturing technology, microsystems technology and information technology, support means almost exclusively support for research collaboration by industry and research institutions; in other fields such as materials research and biotechnology, the major part of support is provided for collaborative research. Relevant studies revealed that transfer between science and industry has been markedly improved. Another important result is that small and medium-sized enterprises with their excellent knowledge in specific fields can be involved to a particular extent. In this way, SMEs have direct access to cutting edge technologies.

The BMBF's "research co-operation" programme, which aims to increase the innovative power of small and medium-sized enterprises, contributes in numerous ways to even closer, application-oriented co-operation between science and industry. Hundreds of co-operative research projects involving SMEs and research institutions are funded each year including universities. Fachhochschulen and other institutions of higher education engaged in all fields of research and technology. Co-operative activities include:

- work as subcontractors in joint research projects of enterprises;
- R&D work as contractors of enterprises;
- the temporary exchange of research personnel between business enterprises and higher education institutions.

The above-mentioned co-operation possibilities contribute not only to technology transfer but also to the development of closer links between science and industry in Germany and with the scientific and industrial communities abroad.

#### Lead projects

An important improvement in supporting the co-operation between research and industry and related sectors was the introduction of lead projects. From the very outset, lead projects will involve in the research process both industry and users, that is, those who are responsible for the application of research results. Lead projects are to act as pacemakers. They are to pool knowledge and resources so that Germany – in an international comparison – will clearly develop an edge on other countries in terms of competence. This is the particular importance of lead projects for Germany's attractiveness as a site for business and science.

The following important fields were initially identified:

- innovative products based on new technologies such as materials and surface technologies and miniaturisation as well as related production techniques;
- utilisation of the knowledge available world-wide for training, continuing training and innovation;
- diagnosis and treatment with the tools of molecular medicine;
- mobility in conurbations.

### 3. University research and other public research

German universities are characterised by the unity of research and teaching. All universities are doing research in a broad variety of disciplines. They get their institutional funding for research and teaching from the *Länder* (states). In addition professors and other academics at the universities can apply for research grants from the *Deutsche Forschungsgemeinschaft* (DFG), various federal and state ministries, the EU, industry, and private foundations. Research at universities is supplemented by research activities in non-university institutions, which are funded jointly by the federal government and the *Länder*: e.g. Max Planck Society, Fraunhofer Society, national research centres and Blue List institutions.

The **Max Planck Society** (MPG) runs more than 70 research institutes. They are mainly devoted to selected fields of basic research, to a large extent in the sciences and to a lesser degree in the humanities. The MPG tries to take up promising, new areas of research not yet sufficiently developed or, because of their scope or institutional structure, less suitable for university research.

The **Fraunhofer Society** (FhG) is engaged in applied research and, because it performs contract research, is an important partner of industry. A limited basic budget for the nearly 50 FhG research institutes is provided by federal and state governments. The predominant part of the budget, is, however, derived from contracts with industry, the service sector or the governments.

The 16 national research centres (recently named **Helmholtz-Centers**) conduct research and development in scientific and technical, as well as biological and medical fields, which require interdisciplinary co-operation and a concentration of manpower, funds and equipment. They contribute to government-sponsored R&D programmes and often use large research equipment (accelerators, nuclear reactors, ships).

The 83 so-called **Blue List institutions** are independent research institutions and facilities having a service function for research as well as organisations supporting research institutions, which are funded in addition to national research centres, MPG and FhG, provided they are of supraregional importance and national scientific interest. They are registered in the Blue List, an annex to the implementing agreement on research institutions of 5-6 May 1977 whose first edition was printed on blue paper.

It is an important goal of federal and *Länder* research policy to improve the co-operation between universities and non-university research organisations. Several recommendations of the **Science Council** (*Wissenschaftsrat*) suggested measures to foster close co-operation between the various organisations and universities. Most of the recommendations have already been implemented. The most effective links are joint appointments of professors by universities and non-university institutes.

The professors direct an extra-university institute or department and teach at a university, guiding doctoral research. This allows a steady input of young scientists into the institutes and opens opportunities for the universities to use specialised equipment in the institutes. In addition joint research projects – mostly supported by research grants – are very useful. In some cases, close co-operation in the field of doctoral training is well established and is typically funded by the **Deutsche Forschungsgemeinschaft** as Graduate Colleges (*Graduiertenkollegs*). As a general rule, close proximity of extra-university institutes to a university campus promotes the development of productive links. Newly founded institutes are therefore often located on or near a campus.

The number of joint appointments is steadily increasing and is especially high in the recently founded institutes in eastern Germany. For many Blue List institutions and national research centres joint appointments are already standard procedure in all parts of Germany. They are also established in some

institutes of the FhG and MPG. In general co-operation has been steadily improved and has reached a high degree, to the mutual benefit of the participating research institutions.

#### 4. International mobility

##### *Statistical basis*

The number of foreign students in the old German *Länder* increased from 47 000 in 1975 (5.8 per cent of all students) to 136 300 in 1995 (8.2 per cent of all students). In the new German *Länder*, 10 200 foreigners (5.2 per cent of all students) were enrolled in 1995. The overall number of foreign students in Germany was therefore about 146 400 in 1995 (7.88 per cent of all students).

About 28 per cent of the foreign students enrolled in the 1994 winter semester had obtained their higher education entrance qualification in Germany. If these are deducted from the total number of foreign students, the share of foreign students goes down to 2.21 per cent of all students in the 1994 winter semester. At the same time this greatly modifies the importance of the increase in the absolute number of foreign students as it must be assumed that the percentage of foreigners who acquired their school education in Germany was far below 40 per cent in early 1975, the year of comparison.

The highest percentage of foreign students who acquired their school education outside Germany can be found in the subject group "languages and cultural studies" (6.1 per cent) while this percentage is lowest in sports (1.8 per cent). There is an average interest in engineering. Foreign students who acquired their school education outside Germany are under-represented in law, economics and social science studies, that is subject groups which, as experience has shown, play an important role in the training of future foreign executives.

Percentage of foreign students who acquired their school education outside Germany broken down according to type of higher education institution attended:

Fachhochschulen	2.1%
Comprehensive universities	3.4%
Universities	5.0%
Colleges of theology	6.7%

In contrast to the overall trend, the number of foreign students who acquired their school education in developing countries seems to be stagnating or even decreasing. At least this is indicated by the number of participants in prep courses for foreign students. Although the number of such courses offered increased from 17 to 25 after German unification, the number of participants has been steadily decreasing from 6 193 in the 1992/93 winter semester to 4 397 in the 1994 summer semester (minus 31 per cent).

A large proportion of foreign students come from a few countries (1994):

Turkey	19 317
Iran	9 957
Greece	7 663
China	5 726
Austria	6 154
France	5 617
Italy	5 160

Africa, Latin America and Asia (with the exception of Iran, Korea and China) are under-represented (for example 667 Indian and 1 592 Japanese students in Germany).

Over the past 20 years, the number of students from that part of the world which is most dynamic in economic terms, i.e. the Asian-Pacific region, has hardly increased or even decreased, exceptions being China and Korea. The number of Koreans studying in Germany has slightly increased in recent years.

<b>Students from Asian countries at German higher education institutions (old German <i>Länder</i>)</b>		
Country	1975	1991
China	66	5 168
India	686	629
Indonesia	3 324	2 178
Japan	1 137	1 236
Korea	614	4 486
Taiwan	300	1 069
Thailand	267	230
Vietnam	1 118	1 155
Other Asian Countries	3 073	4 983
Iran (for comparison)	3 825	10 723

### ***Existing programmes to promote mobility***

Mobility is promoted through the Training and Mobility of Researchers (TMR) programme. The aim of this programme is to improve the scientific potential within the European Union by increasing scientific co-operation in Europe as well as the training and mobility of young scientists. TMR has a duration of four years (17 November 1995 to 31 December 1998) and a budget of 800 MECU. It is implemented through the following four activities:

#### *Activity 1: Research Networks (360 Mio. ECU)*

To be eligible for support, a research project should include 5-13 excellent groups of scientists from the Member States or associated countries with complementary expertise. The financial support is focused on the training of young scientists (a minimum of 55 per cent of the budget must be devoted to the employment of researchers from other Member States). Under this action TMR will provide approximately 2 000 jobs abroad for young researchers within the next few years.

#### *Activity 2: Access to large-scale facilities (120 Mio. ECU)*

Research institutions in Europe which have a special and unique research infrastructure are supported by the TMR programme. TMR buys 10-20 per cent of the operation time of these large-scale facilities with the aim of opening them to researchers who would otherwise not have access. Special emphasis is given to the training of new users.

#### *Activity 3: Marie Curie Research Training Grants (280 MECU in TMR)*

Twelve of the specific programmes of the 4th Framework Programme, including TMR, offer research training grants. They follow the common scheme of the Marie Curie Research Training Grants. These grants are offered mainly to young postdoctoral researchers and some postgraduate researchers for training or specialisation outside their home country, with a duration of 6-36 months. In special cases grants with a duration of 3-12 months are offered to established researchers. Thus, 6 000-7 000 training grants will be provided under the Marie Curie Scheme.

*Activity 4: Accompanying measures (40 Mio. ECU)*

This activity comprises support for the following types of events:

Euroconferences, which are scientific meetings with a focused theme and a maximum of 100 participants. Summer schools and practical training courses which provide advanced training for young postgraduate and postdoctoral researchers. The support through TMR consists mainly in covering the participation costs for young scientists.

***Barriers to mobility***

- unclear situation of fellow in host country (work contracts, taxes, social security);
- language barriers;
- housing problems – many fellows have a family, difficult to find adequate housing for the short period of the fellowship.

## HUNGARY

*Prepared by the Ministry of Culture and Education*

### Research policy at universities

In Hungary the R&D policy is determined by the Government. In R&D policy formation the Government relies on the support of the Science Policy College, which is a counselling body chaired by the Prime Minister. The College consists of the highest ranking (governmental and non-governmental) officials of the RTD bodies. Permanent members of the College are as follows: the President of the Hungarian Academy of Science (MTA), the Minister of Culture and Education (MKM), the president of the National Committee for Technological Development (OMFB), the President of Hungarian Scientific Research Basic Programmes (OTKA).

The Parliament passed a new Law on Higher Education on 13 July 1993. (This is the first independent legal regulation of Hungarian higher education.) “The law regulates the system, operation, and autonomy of higher education institutions, as well as the role played by the state in higher education. By means of its provisions, it ensures freedom of teaching, freedom of study, and the freedom to cultivate the arts and sciences alike.” (Preamble of The Higher Education Law, 1993).

National higher education bodies were established: the Hungarian Higher Education Conference, the Higher Education and Research Council (FTT), the Hungarian Accreditation Committee (MAB).

Higher education is the most numerous and in many respects the most active segment of the Hungarian scientific community.

The university departments have always been considered as a research unit. More than 70 per cent of researchers with PhD degree are in HE. Staff members spend on average one third of their working capacity on research. The part of the total HE budget in 1997 directly supporting research is below 10 per cent. For statistical purposes, 25 per cent of the teaching budget is accounted for by research at universities, 10 per cent at colleges.

**Table 1. R&D resources**

	1989	1994	1995 <sup>1</sup>
Total number of researchers	33 836	22 401 (66.2%)	20 859
in HE	13 957	13 897 (99.5%)	12 665
<b>HE/Total %</b>	<b>41.2</b>	<b>62</b>	<b>60.7</b>
Total number with PhD	5 869	6 257 (107%)	5 979
in HE	3 846	4 567 (119%)	4 298
<b>HE/Total %</b>	<b>65.5</b>	<b>73</b>	<b>71.9</b>
R&D expenditures/GDP	1.96	0.88	0.80
in HE	0.26	0.24	0.19

1. As a consequence of the global cut-back in the sphere of HE and R&D.

Source: Hungarian Central Statistical Office and Statistics of MKM.

The total number of staff with a PhD in HE (1 October 1996):

Full-time:	9 759
Part-time:	1 587
Employed by the Hungarian Academy of Science (MTA) <sup>6</sup> :	302

In order for the position of the university research as one (maybe the largest) segment of the national research system to be consolidated, the criteria for budgetary support to HE should give considerable weight to the scientific impact of university activities.

The first step in this direction was the start of doctoral schools in 1993. The Higher Education Law gave back the right of universities to award the doctoral (PhD) degree. It was the right of MTA since the 1950s. The government has acknowledged this combined Teaching & Research activity by a triple educational norm relative to the ordinary undergraduate studies. This regulation proves to be a major motivation for universities in submitting new doctoral projects for accreditation. At the Hungarian universities, 234 doctoral students were enrolled in 1994 and 2 200 in 1996 (about 7 000 together with PhD students having a position outside the academic sphere). The prospective expansion of the doctoral schools should be one of the most important strategic goals of the development of HE.

The second step has been supported by the “Catching up with European Higher Education” (FEFA) programme started in 1992-1993. The emphasis here has been put on modernising the introductory courses, but a separate grant period has been devoted to the development of the doctoral schools and to new curricula, also adequately demonstrating the latest scientific achievements.

Approximately 60 per cent of the newly purchased scientific equipment came from this programme and the Hungarian Scientific Research Fund (OTKA) in 1994. There are also other financial sources to support the R&D activities of HE (e.g. the Central Basic Programme for Research and Technological Development (KMÛFA) administered by OMFB). Increased state support to research HE institutions in better performing in R&D, has been introduced into the text of the Amended Act on HE (June, 1996), as from 1997. The increased support to R&D or R&D related activities in HE is allocated in different forms.

**Table 2. Increased support to R&D or R&D related activities in HE, as allocated in different forms**

Personal	Project	Institutional
<ul style="list-style-type: none"> <li>• PhD student's stipend</li> <li>• System of postdoctoral positions</li> <li>• Széchenyi Professorial Fellowship</li> </ul>	<ul style="list-style-type: none"> <li>• Competitive Grant System enlarged</li> </ul>	<ul style="list-style-type: none"> <li>• Normative support based on performance indicators of R&amp;D</li> <li>• Textbook publishing; journal subscription</li> <li>• Special informatics, infrastructure development and maintenance</li> </ul>

Source: Author.

The enlarged support is 20 times bigger than the direct science support given earlier by the MKM to HE.

Some detailed comments on certain new forms of R&D support at HE institutions in Hungary are provided below:

- The programme financing budget is a competitive support system which cannot be less than 15 per cent of the summary educational norm, and should enable the continuation of high quality study programmes for the most talented student, research assistantship of university students, postdoctoral fellowship, international relations, etc.
- A set of simple and flexible indicators of the normative budgetary science support system have been proposed and discussed by representative boards of HE institutions. The indicators must be *general, objectively measurable, and accepted by consensus*.

Indicators:

- of PhD and equivalent holders (FTE);
- of R&D grants (increased weight expresses preferential treatment of contracts from business and internationally financed research projects);
- income from R&D grants (in the previous year);
- of PhD students (Doctoral schools; higher number of fields of science having obtained accreditation receives extra bonus, a system of career-tracing is suggested, whose result will be included among the indicators starting in 1998).

This is the first normative science-supporting budget allocation system in Hungary. The non-state owned HE institutions receive R&D support also, distributed after comparing the same set of indicators.

The Competitive Grant System is restricted to HE in two categories:

- projects of less than 5 million HUF yearly support (for individuals, research groups, departments, etc.);
- projects of greater than or equal to 5 million HUF annual support (for institutes; public hearings and one foreign referee are introduced).

Priorities: emphasis is given to support for centres of excellence;

- co-operation matching principle, complex investigations, centres run by consortia, international projects (EU);
- participation in developing knowledge-intensive products;

- resolution of regional (transborder) problems with scientific methods (local governmental collaboration).

Széchenyi Professorial Fellowship brings a radical increase in the income for outstanding academic staff members for four years. Five hundred fellowships are awarded each year. The number of fellows grew in four years to 2 000. The main goals are: avoiding forced multiple jobs of academic staff, within and outside HE, fighting against the internal and international brain-drain (temporary escape). The amount of Széchenyi fellowship exceeds the average monthly salary. The criteria to obtain the fellowship are high-quality teaching and renowned research.

### **System of postdoctoral fellowships**

The work toward conceptual foundation of the new employment category for postdoctoral fellowships has been started. This issue is of extreme importance from the point of view of the country's science policy.

The integration of the institutes of the fragmented HE networks is a programme starting in 1998 supported by FEFA (renamed "*Higher Education Development Basic Programmes*") and the World Bank. The goals of the development programme are fixed in a "White Paper on Hungarian Higher Education", to be made public in the near future.

The Hungarian Accreditation Committee (MAB) will focus its activity over the next years on accreditation of every higher educational institution. In this process MAB and MKM are preparing the establishment of a valuable database of the scientific products of each faculty or department. (However it is the educational activity which lies unavoidably in the centre of MAB evaluation.) The construction of the updating and searching protocols of the database will also enable the extraction of the relevant data for scientific assessment at different levels. A pilot project – managed by the Division of Scientific Affairs of MKM – started in October 1997, at a few representative universities and colleges, and will lay the foundation of a new evaluation culture in Hungarian HE and advance the process of self-regulation.

### **R&D forecast (until 2000)**

All the HE institutions (also outside the sphere of state-owned institutions) were requested to submit a scientific forecast, a short term R&D plan for the period 1997-2000. These documents were prepared and submitted to the Department of Scientific Affairs of the Ministry at a 50 per cent response level. An agreed list of strategy components has been approved by the forum of the R&D representatives of HE institutions, which ensures the comparability of the documents. The forecasts are of immediate use in the orientation of universities to participate in the EU 5th Framework programme.

**NOTES**

6. There are associated research groups employed by MTA working with HE institutes.

## ITALY

*Prepared by Sueva Avveduto, Delegate to the Group on the Science System*

### **Broad policy and budget trends**

In spite of the more active S&T policy role expressed by the new government since 1996, Italy's overall R&D effort remains limited. The size of funding for R&D in Italy has grown substantially in the last two decades (70s and 80s) but it remains far from the levels of other advanced countries. As a share of GDP, Italy spends for total R&D (allocations for 1995) about 1.1 per cent of GDP, while the 1995 OECD average was 2.2 per cent.

In Italy, as in other countries, the growth of R&D expenditures slowed down in the early 1990s, due also to the effects of the economic recession. Italy's total R&D expenditure fell in real terms by 0.3 per cent in 1992, by 1.3 per cent in 1993 and by 4.9 per cent in the allocations for 1994. A more marked fall is found in the business sector, where expenditures decreased by 3.5 per cent in 1993 and 5.4 per cent in 1994.

Even the rapid economic growth of the post-war decades has not led Italy to reach the same research intensity as other advanced countries; productivity levels, however, have substantially increased using a variety of other sources of technological know-how which have made up for the inadequate research effort. In particular, Italian economic growth has largely relied on the role of investment (which embodies innovations first introduced elsewhere) and on the non-formalised innovative activities that are typical of the sectors of Italian industrial specialisation (traditional industries such as textile and leather, food, etc. and industrial machinery).

The lack of a large high-technology sector of the economy, the limited presence of industrial R&D laboratories and the small number of large firms active in research-intensive fields in Italy have all led to a limited interaction between science and technology research and the industrial world.

In recent years, greater attention has been paid to the interactions between the world of research and industry, the public and private sectors, but the extent of co-operation lags behind the activity by now common in other European countries, due also to the rather rigid institutional structure of Italian research.

### ***Higher education***

Higher education is provided in Italy essentially by universities, which are almost totally publicly funded and run structures. The private component in higher education, although very fast growing (specially for some segments such as business schools), has traditionally been minor.

The Italian university system consists of 66 universities, of which 53 are state institutions, ten free or private universities and three higher education institutes that can be assimilated to universities. Some universities have ancient origins and an illustrious history (the Universities of Bologna and Naples for

instance date back to the beginning of this millennium); others, on the other hand, were established only recently.

The resources devoted to rationalise and develop the Italian universities are defined in a three-year plan.

Italian university professors are State employees. The total number of professors was 57 725 in 1995-1996. Professors are divided into two groups: the first, full professors (*ordinari*, 14 194 in 1995-1996), have a higher salary and can take up managerial posts; the second, associate professors (*associati*, 16 265 in 1995-1996), receive a lower salary and can perform only a limited range of managerial functions.

The university researcher/lecturer (*ricercatori* 19 876 in 1995-1996), has some teaching assistance functions but his/her primary function is to carry out research activities. There are also other types of professors, such as "lectures" and "assistants", who are only relevant to specific fields.

The remaining university staff can be divided into two main functional groups: technicians, who participate in research, and administrative staff.

University research activities are financed from various sources. First and foremost comes state funding; part of these funds is allocated directly to inter-university projects of national importance by the Minister for Universities and Research upon the proposal of the National University Council (CUN).

Universities also receive funds from other public research establishments, such as CNR, INFN, ENEA and ASI. Further funds come from industry, from private institutions and from international research projects, the EU programmes, and so on. ISTAT estimates the financial resources devoted to R&D in the Italian universities as more than L 4 000 billion (Tables 1 and 2).

**Table 1. University budget**  
in L billion

	1992	1993	1994
R&D expenditures	3 990	4 156	4 175
<i>As a percentage of total public R&amp;D expenditures</i>	17.9	19.4	19.4
R&D expenditures at 1985 prices	2 546	2 541	2 466

Source: ISTAT, 1995.

**Table 2. Italian universities: resources indicators**

	1992/93	1993/94
<i>Expenditures</i>		
Average expenditure per student (in L million)	6.15	7.25
Average expenditure per graduate (in L million)	109.0	140.8
Percentage of current expenditure on total expenditure	89.9	72.5
Percentage of R&D expenditure on total expenditure	6.6	4.9
<i>Personnel</i>		
Average number of students per professor	28.6	30.9
Average number of graduates per professor	1.7	1.9

Source: CRUI, 1996.

The Italian organisation has led to a very centralised and uniform way of structuring higher education in the country both at geographical, management and disciplinary level. The students follow the courses and have to pass a number of tests (according to the discipline from 20 to 33 in four, five or six years) to obtain a university degree (Laurea, ISCED level 6). In a given discipline the path to follow is the same in

any university all over the country, and in terms of number of tests to pass and of compulsory disciplines, it is largely determined by the central education authority. The main reason is to guarantee anyone to be offered the same “amount” of knowledge anywhere in order to award a degree whose consistency and completeness is the same independent of the university awarding it. The quality of courses, professors and facilities of course affects the final quality of the graduate greatly, but the State offers everyone the same possibilities, at least in principle.

From a quantitative point of view, the higher education sector is composed of almost 1.5 million divided almost exactly between males and females as a total number, while in some disciplines the ratio is very unbalanced (e.g. there is a strong prevalence of males in engineering and of females in humanities). The high number of students does not correspond to a high number of graduates; many students in fact leave university after the first year and only 30 out of 100 achieve the final degree.

The experience of training for research in Italian universities, structured as a formalised set of courses for post-graduate students, is a rather recent one. A proper system of post-graduate education as an independent process leading to a post-graduate qualification in research was set up only in 1980. Up to 1996, almost 15 000 PhD degrees had been awarded.

### **Changes currently under way in the governmental S&T system**

#### *Universities*

The reorganisation of the higher education system, which was started in 1980, brought about a number of changes at the beginning of the 1990s; in order to meet international requirements and standards, and to reduce the student drop-out rate, the first diploma cycle (*Diploma universitario*, ISCED level 5) was introduced.

Administrative autonomy of universities was initiated in 1989 together with the promotion and application of monitoring and assessment for research programmes.

The implementation of the three-year (1991-93) development plan led to the establishment of new universities. The aim was the diversification of the teaching offered to students and the reduction of overcrowding in older universities.

According to the financial law (1996), all universities with a population of more than 40 000 enrolled students have to be split up in separate sections. This means that most of the universities in the big metropolitan areas will be divided in parts, all autonomous and self-organising. This will bring a major organisational change in the future.

### **Relationship between national university research system and other public research systems**

#### *Profile of the national S&T system*

The Italian R&D system consists of three networks: universities, public research establishments and enterprises. The major public research establishments are: the National Research Council (CNR), which is engaged in general research, the National Agency for New Technologies, Energy and Environment (ENEA), which is concerned with energy and related environmental issues; the National Institute of Nuclear Physics (INFN), which deals with high-energy physics. Moreover, the Italian Space Agency

(ASI) finances space research. Finally, the network of enterprises is made up of private and public enterprises and state-controlled corporations, a significant part of whose capital is state owned.

Government responsibility for research and higher education lies with the Ministry for Universities and Scientific and Technological Research (MURST). The Minister oversees the university system as a whole, supervises the public research establishments and manages the instruments provided under the legislation directing and supporting industrial research.

Many other ministries have an interest in research in specific sectors and have appropriate research bodies: for example, the Ministry of Health uses the Higher Institute of Health (ISS) for medical, pharmacological and environmental research, while the Ministry of Posts calls on the Higher Institute for Posts and Telecommunications (ISPT) for research in this field.

### ***Public research establishments***

The Scientific Institutions are asked to play an essential role in contributing to the global research strategy of the country and therefore to enlarge the science and technology base. The effects of their action are to be found both at scientific and economic level, i.e. on the advancement of knowledge and also on scientific employment and competitiveness.

The scientific institutions such as public research bodies have certainly contributed to developing a different attitude in considering co-operation between universities and business sector; the number of plans and programmes which have been launched over the last 15 years (relying on the intermediary function of scientific institutions) and that have brought together research resources coming from public and private sectors owe part of their success to the capability of scientific institutions to create the right links and provide scientific and organisational skills to manage the programmes and obtain results.

Public research agencies are highly specialised scientific institutions. Most of them are single-discipline agencies that undertake R&D and provide various government organisations with services in their particular fields. The public research establishments fund, plan and manage research programmes aimed at those objectives identified by the Government (ranging from the targeted programmes of the CNR to the national research programmes, space programmes and joint international projects). They also implement the national sectoral plans (the five-year plans of the ENEA and the INFN) and finance and manage the research programmes associated with support activities for agriculture, industry, health services, infrastructures, etc.

In 1994, about 7 000 researchers and 11 000 technicians were employed by the public research establishments.

In 1994, the government appropriations for research agencies amounted to L 3 154 billion. The financial resources available for the national and international research programmes of the Italian Space Agency (ASI) are L 852 billion.

A brief description of the six major research establishments is given below.

*The National Research Council (CNR)*

The Council's scientific work is carried out directly by 289 research bodies, including 157 institutes, 115 study centres and 17 research groups; in addition there are 13 areas. The activities and operations of the research bodies are under the control of 15 National Advisory Committees. The Institutes are entirely dependent on the CNR, whereas the study centres and research groups arise from collaboration with universities and other agencies.

Beyond undertaking research activities directly, it carries out studies for and gives advice to the Government, assigns research grants and scholarships for training in research.

The budget appropriations for 1995 are L 1 457 billion.

About 7 400 are employed by the CNR (approximately 2 800 researchers) all of them full time and most of them as tenured staff. Some 2 000 people are operating on research contracts (three to five years) and on fellowships (one year).

In the mid-1970s, CNR launched its "finalised projects" involving all sections of the Italian scientific and technological system; these are five-year research projects aimed at achieving important national economic and social objectives. The results of these experiments – which embraced a variety of sectors ranging from advanced technology to town-planning and environment, from human health to agricultural and food resources, the economy and services – are to be seen in more than 1 400 "products" that are transferable and can be used by third parties, and in more than 6 300 scientific articles published in international and national journals. The budget appropriations for the period 1992-96 are L 1 043 billion. From the original five launched in 1975, the number developed to the present 17 in many science and technology fields.

The setting out of a new project is a mix of a top-down approach, by the choice of priority areas made by the Government and the scientific institutions, and a bottom-up one by the process of call for proposals directly answered by the scientific and industrial communities.

The international activity of the CNR is carried out both on a multilateral and a bilateral basis. Substantive priorities are correlated with national programmes, and international commitment, such as the EC Framework Programme.

In 1994, the total amount of CNR expenditure for international co-operation was L 50 billion. The activities financed by the CNR are subdivided into:

- a) bilateral agreements between CNR and equivalent organisations;
- b) major international projects;
- c) subscriptions to international scientific organisations;
- d) attendance at CNR seminars, congresses, etc. by foreign contributions to Italian cultural institutes and bilateral seminars involving Italy and other countries;
- e) visiting professor scheme;
- f) other specific co-operation, such as the participation in the European Synchrotron Radiation Facility or within EC programmes.

The intense research activity carried out by CNR research institutes with foreign partners, which cannot be easily quantifiable, is certainly an important commitment for this agency, and must be added to the specific programmes and schemes as an important tool of mobility of scientists and engineers.

*The Italian National Agency for New Technology, Energy and the Environment (ENEA)*

ENEA carries out its activity in the field of national energy policy in order to promote the development and expertise of Italian industry while protecting human health and the environment; it operates in conjunction with the other energy agencies and is one of the instruments for the implementation of national energy policy. It is responsible for supervising and monitoring nuclear safety and protecting the health of workers and the population at large.

ENEA employs around 5 000 staff in a number of interdisciplinary research centres distributed around the country. Its budget for 1994 was around L 770 billion.

The Agency's programmes are developed in accordance with the guidelines laid down by the Government and Parliament in the national energy plan; ENEA has three main areas of activity: energy, the interaction between energy and the environment, and technological innovation. It also manages national programmes involving several agencies, as is the case of the National Antarctic Programme.

*The Italian Space Agency (ASI)*

Italy has been involved in space activities for the last 30 years. Early efforts were fragmented, but a strategic planning was gradually introduced which led to the five-year space plan of 1979. The establishment of the ASI in 1988, to co-ordinate all space activities, was meant to give further impetus to rationalisation of the sector.

ASI is responsible for planning scientific, technological and applications programmes in the space sector, to improve the expertise and competitiveness of the Italian aerospace industry.

ASI drafts and implements the national space plan, by directly co-ordinating national and international programmes contracted out to industrial firms and harmonising them within the international context. It is also an instrument for Italy to join in the ESA programmes.

Space activities entail not only co-ordination by the ASI but also the involvement of scientists and industrialists: universities, CNR laboratories and industries.

In 1994, Government appropriations for ASI were L 852 billion.

*The National Institute of Nuclear Physics (INFN)*

INFN, which was founded in 1951, was recognised as a public-law body with its own budget in 1971. Its objective is to carry out both experimental and theoretical basic research into fundamental interactions, in particular in the field of particle and nuclear physics. This entails ever greater use of highly advanced technology, which for the most part the Institute develops itself by means of parallel R&D programmes in technological fields.

The Institute's activities are organised on the basis of five-year plans, which it draws up and submits to the Government for approval by MURST. The 1994-99 plan is currently under way.

The INFN has four national laboratories (Frascati, Legnaro, South and Gran Sasso), 19 sections, seven associated groups and one national centre, and a central administration for general managerial tasks.

Close co-operation has been set up between the Institute and the universities. This has been an integral part of INFN policy since its foundation. The Institute therefore operates via both its own personnel and university staff.

In 1994 a total of 2 760 university lecturers and researchers and 315 university technicians were associated with INFN programmes. At the end of 1994 the INFN employed 1 825 staff, of whom 470 were researchers, 905 technicians and 235 administrators. The Institute's total budget for 1994 amounted to L 406 billion.

#### *The National Institute for Statistics (ISTAT)*

ISTAT drafts the National Statistical Programme, carries out the censuses and other statistical surveys laid down in this Programme, directs, co-ordinates, provides technical assistance for and evaluates the statistical work carried out by the agencies and offices belonging to the national statistical system. It also lays down the nomenclature and methodology for classifying and recording demographic, economic and social phenomena, carries out research on the results of censuses and surveys and on statistics relating to phenomena of national interest included in the three-year programme, and so forth.

In performing its functions ISTAT can call on the assistance of public and private agencies and companies under a number of contracts and agreements, and through interests in the capital of the bodies and companies concerned.

In 1994, ISTAT employed a total of 2 554 staff, of whom 170 are researchers.

#### *The National Institute of Health (ISS)*

The ISS, which is the technical and scientific arm of the Ministry of Health and the National Health Service, was established in 1934. It is currently governed by Acts of 1973 and 1978 that allow it greater organisational flexibility than is possible in other state agencies. The Institute comprises 20 laboratories, and eight technical departments.

In 1994 the Institute employed more than 2 000 people. The technical and scientific personnel consisted of 389 researchers and 835 technicians. The Institute's financial resources amounted to around L 217 billion in 1994.

### **Student mobility**

The development of an international, and specifically European dimension in Italian universities is one of the objectives to be attained in the next years.

Each university should enhance its international activities and promote their development. The implementation of the Socrates Project by the European Union is perceived as a useful tool for promoting

and orienting the mobility of students around Europe. This project offers students a multiple series of opportunities for attending part of their university courses in another European university. Italy has actively adapted to this project and the previous one, ERASMUS.

The attractiveness of Italian Universities for foreign students is for some groups of countries quite remarkable. Most enrolments take place in the Medical faculty: some 5 500 of the total 20 800 foreign students enrolled in Italian universities are in the medical area.

More than half of foreign students enrolled come from European countries (12 100) with a large share of Greek ones (5 400 out of the 8 400 EU countries). The others mostly come from near East countries (notably Iran, 1 400) and the remainder is divided over the other continents as follows: Africa: 2 400; America: 1 800; Oceania: 480.

The number of foreign students qualified in Italian Universities was 1 750 in 1992; out of which 630 in medicine. Most graduates come from Europe (930 in all, mostly from Greece: 490), followed by near and far East countries (461), Africa (168) and America (130).

### **Relevant documents**

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## JAPAN

*Prepared by the Ministry of Education, Science, Sports and Culture (Monbusho)*

### Overview

Japanese Universities have recently undertaken a complete reform.

#### 1) Education

“Reform of University Education” has been advanced toward a more flexible system which may meet the various and growing needs of students and society.

#### 2) Research

The budget for science and technology has been increasing, in the spirit of the 1996 Science and Technology Basic Plan, which states “Especially important are two entities: research at universities and national/public research institutes that should focus on basic research.” The allocation of research funds has also been changing to be more competitive.

#### 3) Research co-operation between universities and industry

There are several types of research co-operation between universities and industry. In order to promote future co-operation, the Japanese Government is now considering the amendment of laws that restrict the research activities of professors of national universities in private corporations.

#### 4) Internationalisation

The meaning of “internationalisation” has been rapidly changing to be a positive exchange of personnel and information rather than to be only acceptance of overseas information. International scientific exchange has been promoted by the enhancement of co-operative research and exchanges of scientists. Student exchanges have also been promoted by the Ministry of Education, Science, Sports and Culture (Monbusho) according to its plan to increase the number of foreign students studying in Japan to 100 000 by the beginning of the 21st century.

The Government of Japan decided on the Science and Technology Basic Plan on 2 July 1996, which has had considerable impact on universities, especially in their efforts to expand the research function.

This report describes the current situation of the research system at Japanese Universities.

## **Universities: continuing reform of higher education**

### ***Higher education system in Japan***

#### *An outline of the higher educational system*

Institutions of higher education in Japan are classified into universities, junior colleges, technology colleges and special training colleges offering advanced courses.

#### Universities and graduate schools

The purpose of universities, as centres of advanced learning, is to conduct in-depth teaching and research in specialised academic disciplines, and to provide students with advanced knowledge. Universities require the completion of upper secondary schooling or its equivalent for admission. They offer courses usually lasting four years (six years for medical, dental and veterinary courses).

A university may set up a graduate school. A graduate school offers Master's degrees (standard number of years required for course completion: two years) and Doctor's degrees (standard number of years required for course completion: five years, except for medical, dental or veterinary courses, which require four years).

#### Junior colleges

Junior colleges conduct in-depth teaching and research in specialised subjects and develop students' abilities for vocational or practical life. Junior colleges require the completion of upper secondary schooling or its equivalent for admission. They offer courses lasting two or three years. Those who have successfully completed a junior college course are awarded the title of associate.

#### Technology colleges

Technology colleges provide in-depth instruction in the technological arts, with the aim of equipping their graduates with the skills necessary for gainful employment. Different from universities or junior colleges, technology colleges enrol junior high school graduates. The course lasts five years (five and a half years for the merchant marine course), and graduates are awarded the title of associate.

### ***The rationale of university reform***

#### *Moves toward university reform*

The National Council on Educational Reform, which was established in 1984, submitted 16 reports on a wide range of issues, including the improvement and individualisation of university education, the sweeping enhancement and reform of graduate schools, fiscal policies relating to higher education, the organisation and management of universities, and the establishment of the University Council.

In September 1987, in response to the National Council on Educational Reform's recommendation, Monbusho established the University Council as an organisation to deliberate basic aspects of higher education in Japan.

Since then the Council has been considering concrete approaches to university reform. As of November 1997, it had submitted 18 reports, and it continues to examine pending issues. Major systemic reforms have been implemented on the basis of these reports, and universities and other institutions of higher education are now carrying out various reforms in response to such changes referred to below.

#### *Reasons for university reform*

These reform efforts reflect a number of significant changes affecting higher education. They also reflect rising expectations of higher education as a result of those changes listed below:

- progress in scientific research and changes in human resource development needs;
- rise in the percentage of students continuing to higher education and diversification of students;
- growing need for lifelong learning and rising social expectations of universities.

#### *Recommendations of the University Council and systemic reforms*

This situation is reflected in the intensive deliberations carried out by the University Council since 1987 and in the recommendations that the Council has responded to by implementing a variety of measures, including major systemic reforms. The main changes are as follows:

##### 1) Improvement of university education

- abolition of the distinction of subject areas, e.g. between general and special subjects (June 1991 amendment of the Standards for the Establishment of Universities) and enhancement of students' learning;
- relaxation of criteria for credit calculation methods, course duration, etc. (June 1991 amendment of the Standards for the Establishment of Universities);
- recognition of equivalence of some credits for study at educational institutions other than universities (June 1991 amendment of the Standards for the Establishment of Universities).

##### 2) Provision of greater flexibility in the graduate school system and improvement of the degree system

The University Council recommended that the graduate school system be made more flexible and pointed out the need for substantial qualitative and quantitative improvements. A number of measures are being implemented in response to these recommendations.

##### 3) Introduction of a self-monitoring and self-evaluation system

Continuous self-monitoring and self-evaluation are vital both as a means of revitalising universities and improving educational and research activities and as a way of ensuring that universities fulfil their social responsibilities. This need was reflected in the explicit inclusion in the June 1991 amendment of the Standards for the Establishment of Universities of a provision requiring universities to strive to maintain self-evaluation systems for their educational and research activities. Similar self-monitoring and self-evaluation requirements

were established for graduate schools, junior colleges, technology colleges, and special training colleges.

Universities and other institutions are now striving to meet society's expectations of higher education, by implementing wide-ranging reforms in response to the reports of the University Council, and systemic changes and other measures based on those reports.

### ***The role of universities in the promotion of basic research***

#### *Scientific research institutions*

The nucleus of scientific research in Japan is the universities and their affiliated research institutions. To elaborate, these include university faculties and graduate schools, research institutes and centres attached to faculties, inter-faculty and inter-university joint-use facilities, research institutes attached to universities (including those for joint use), and inter-university research institutes.

#### University faculties and graduate schools

Education and research are integrated in undergraduate faculties and graduate schools, but the latter plays an important role in training researchers. Graduate schools have traditionally been structured along the lines corresponding to undergraduate courses to enable the unified management. However, in response to recent scientific development and social needs, postgraduate courses which are not based on specific faculty departments, and even new type of universities which consist of graduate schools only, are beginning to emerge.

#### University-affiliated research institutes

Japan has a long tradition of establishing special research institutes and units in universities to conduct research in scientific fields to meet contemporary needs. In 1953, a new type of institute was established, which was open for joint usage to university researchers throughout Japan, while it was attached to a certain national university. The same type of institutes have been established since then. Efforts have also been made to promote the joint use of the research laboratories attached to national universities. In 1971, a new type of joint-use research institute, called the inter-university research institute, was established.

#### Inter-university research institutes

The inter-university research institutes are not attached to the national universities. As platforms for domestic and international research in their respective fields, these institutes make a significant contribution to the advancement of scientific research, because they provide researchers from national, public and private universities with a place for conducting joint research, an opportunity to use the most advanced research facilities and equipment, and shared access to highly specialised research data and materials.

### Research institutes attached to national universities

Sixty-two research institutes are attached to national universities, to conduct research in specific fields. Emphasis is placed on co-operative research and use of joint facilities by all university researchers. Of the 62 institutes in 20 universities, 20 allow joint usage.

### Research centres and university department-affiliated research facilities

In addition to the institutes mentioned above, there are 422 research centres/facilities attached to the national universities, some of which are open to all researchers. Dedicated to specific scientific fields, and varying widely in number of researchers and types of research facilities and equipment, each carries out research activities in line with its university's specialisation. About 300 institutes and laboratories have been established in public and private universities.

## *Finance*

### Recent trend and current situation of research budget

#### 1) Government budget for science and technology

The government budget in the general account for FY 1997 totalled Y 77 390 billion, of which Y 5 819.8 billion or 7.52 per cent was allocated to Monbusho. The Monbusho also receive funds from a special account for national educational institutions in the amount of Y 2 684.8 billion (of which Y 1 555 billion was transferred from the general account). This special budget, which is administered separately from the Monbusho's general budget, has an important function in enhancing educational and research conditions in the national universities and the inter-university research institutes.

The FY 1997 government budget for science and technology, excluding humanities and social sciences, totalled Y 3 002.8 billion, among which the Monbusho's allocation of Y 1 289.0 billion accounted for 42.9 per cent.

#### 2) Monbusho's budget for science and technology

The Monbusho's budget for science and technology is appropriated through both the government's general and special accounts. The general account appropriation totalled Y 324.1 billion, including grants-in-aid for scientific research (Y 112.2 billion), subsidies for JSPS (Y 39 billion), allocations to research institutions under the Monbusho's jurisdiction, and assistance to public and private universities. The special account appropriation amounted to Y 964.8 billion, primarily comprising allocations to the national universities and the inter-university research institute, covering their general and basic research expenditures, travelling expenses, special research expenses, staff salaries, expenditures for facilities and equipment, and so on.

The budgets for general and basic expenditures are calculated using a standard formula based on the number of researchers in a national university (the inter-university research institute) and applied to its ordinary research expenses for facilities and equipment, books and materials, printing and publication, expendables, wages, utilities, and so on. The budget for general and basic expenditures for FY 1997 amounted to Y 154.1 billion.

Besides support received from national and local governments, universities obtain research funds from various sources including tuition fees and other self-generated income, commission for contracted research, outside donations, and so on.

#### Increasing research funds by selective allocation

##### 1) Grants-in-aid for scientific research

The Monbusho offers research support in the form of research grants. Grants-in-aid for scientific research are awarded directly to researchers working at universities and research institutes, based on the merit of their proposals as determined by the Science Council's Research Grant Committee. Grant recipients are expected to make significant contributions to the advancement of science. The FY 1997 budget for the grants was Y 112.2 billion, an increase of Y 10.4 billion (10.2 per cent) over the previous fiscal year.

##### 2) Research for the future

The Japan Society for the Promotion of Science has adopted a policy of vigorously promoting scientific research that is rich in creativity and able to contribute to the solution of global-scale issues and to the advancement of both economic and social development. In support of this effort, in FY 1996 Monbusho began to make a capital investment in this new programme, entitled "Research for the Future". The programme is designed to promote, through a system of funding and co-ordination, specific projects of frontier and pioneering research implemented mainly by Japanese universities.

##### 3) Another increase of research support comes from industry, e.g. joint research, commissioned research, grants and endowments, which will be described below.

#### Formation of a "centre of excellence" (COE)

To spur new advances in scientific research in Japan in the lead up to the 21st century, in addition to maintaining and upgrading the country's scientific-research base, it will be necessary to create centres of excellence (COEs). These COEs, to be established at selected research institutions, will be given priority allocation of resources and the latitude to employ highly innovative approaches in pursuing the world's most advanced fields of science.

In 1997, the Monbusho implemented the following two measures to establish COEs:

- 1) It established a support programme for core research institutes, such as inter-university research institutes and joint-use institutes attached to national universities, that possess COE characteristics in specific fields. Support provided through this programme is destined to research at these institutes.
- 2) It launched a programme to create core research institutes, which provides supports to key research institutes/groups that possess the potential to conduct state-of-the-art research at a high international level, with a view to raising them to COEs, and to strengthen the university research infrastructure and postgraduate levels.

The Monbusho has augmented its budget for research activities, facility/equipment maintenance and upgrading, fellowships for both Japanese and foreign researchers, and international symposia. It also provides support to research groups in universities that are endeavouring to become COEs.

## **Expansion of graduate education and support for research training**

### *Expansion of graduate education*

#### *The growing importance of graduate schools*

In addition to their role in the pursuit of scientific research, especially basic research, graduate schools contribute to the training of researchers and the development of human resources with advanced specialised skills. In fiscal 1997 there were graduate schools in all 98 of Japan's national universities, in 37 of its 57 local public universities, and in 285 of its 431 private universities. The 420 universities that have graduate schools represent approximately 70 per cent of the 587 national, local public, and private universities in Japan.

As of May 1997, there were 171 547 students enrolled in graduate schools. National universities thus account for two-thirds of total graduate schools enrolment in Japan. Between 1975 and 1985, the number of graduate students increased by a factor of approximately 1.4, from 48 464 to 69 688. The number has more than doubled over the past decade and its likely to rise still further in the future.

Expectations of graduate schools have risen in line with various changes in recent years, including the advance of scientific research, rapid technological innovation, the increasing sophistication and complexity of social and economic systems, internationalisation, and the shift to an information-oriented society. The achievement of significant qualitative and quantitative improvements in Japan's graduate schools has become the highest priority from the viewpoint of responding to these expectations and discovering new directions in scientific research.

For this reason, efforts are now being made to provide greater flexibility in the graduate school system, including course objectives, organisational structures, and educational methods and formats. The purpose of these changes is to enable individual graduate schools, in accordance with their own aims, to achieve further advancement and revitalisation across a diverse range of educational and research activities. In addition, new departments and other organisations are being established to ensure that graduate schools are capable of meeting today's needs, especially in leading-edge and interdisciplinary fields.

Technological innovation and changes in the industrial structure have also generated a growing demand for human resources in occupations that require rich creativity and specialised knowledge and skills. The abilities required for such occupations are likely to become increasingly sophisticated and specialised, and graduate schools are expected to play a major role as centres for the development of necessary human resources. Graduate schools need to actively work to train professionals with sophisticated specialised skills. They also need to enhance their refresher education to enable people to enhance their knowledge or acquire knowledge in new fields during their working lives.

#### *Training and supporting young researchers*

It is high national priority to cultivate innovative and creative young researchers who will be able to further develop and strengthen the foundations of scientific research in Japan. To attain this objective, in

addition to enhancing education and research programmes at the graduate level, in 1985 the Monbusho established a fellowship programme for young researchers, called “Fellowships for Japanese Junior Scientists”.

With an aim to cultivate young researchers who will conduct innovative and trail-blazing research, this fellowship programme provides promising young researchers with scholarship and research grants so as to allow them to concentrate on their research, which they conduct in laboratories or under supervising researchers of their choice for a specified tenure. Some features of this programme, which is administered by the Japan Society for the Promotion of Science, are as follows:

- a) Research venues: Grantees freely choose their research theme and the institute where they will conduct their research work. They are encouraged to do their research in institutes other than those of their primary affiliation. Among their options are universities, joint-use research institutes, government institutes, and private research institutes. A grantee may also conduct research in a corporate research institute or in an overseas research institute for a given duration.
- b) Applicants: Applicants must be either postdoctoral researchers (PD) or doctoral candidates (DC), and under 34 years of age.
- c) Fellowship: For PD grantees, fellowship provided are approximately equivalent to the salary of a research assistant at a national university.
- d) Research Grants: Successful applicants are provided with research grants of up to 1.5 million for conducting their research.
- e) Duration: The duration of the grant is normally for two or three years.

### **Encouragement of research co-operation between universities and industry**

The growing importance ascribed to science and technology has created new demands and expectations on university research to contribute to the solution of social problems. For universities to make a maximum effort to meet society’s demands, this will have the effect of stimulating scientific research in them while they make contributions to society. Therefore, the Monbusho conducts a number of programmes to encourage increased co-operation between universities and industry.

#### ***1) Joint research***

A system of joint research was created in 1983 by the Monbusho to encourage researchers at national universities to conduct joint research in their laboratories on an equal footing with researchers from private companies, on topics of common interest. Research funds are also received from the participating companies. This system has been expanded in scale year by year.

Joint research is being actively carried out particularly in such fields as materials development, equipment development, software, civil and architectural engineering, biotechnology, and electronics.

Patents generated from the joint research are owned jointly with the participating companies, and the companies (or persons designated thereby) receive patent-licensing priority for up to seven years. (FY 1997 budget: 5.5 billion).

**2) *Commissioned research***

This system enables instructors and researchers employed by national universities to conduct, on a contract basis, research commissioned by private companies, government institutes and other external bodies. The cost of such research is borne by the external body. The consignor (or his designee) receives patent licensing priority for up to seven years. (FY 1997 budget 41.9 billion).

**3) *Commissioned researchers***

This system provides researchers and engineers employed by private companies with the opportunity to conduct graduate level research in national universities. This system was limited to scientific and engineering fields, but was opened up to all academic fields including humanities and social science in 1989. About 1 500 contracted researchers are now conducting research projects at national universities under this system.

**4) *Centres for co-operative research***

To promote full-scale co-operation with the private sector through joint and commissioned research, the Monbusho has been establishing centres for co-operative research within the national universities since 1987. At present, there are 49 such centres established in the national universities.

**5) *Grants and endowments***

National universities are authorised to receive donations from private companies and other outside organisations for promoting scientific research and educational activities. In 1987, a system of endowed chairs and funded research departments was introduced through private donations. At present, there are 47 endowed chairs and 11 funded research departments in a total of 25 universities, and one funded research departments in one national inter-university research institute. The donations are utilised flexibly in line with the donor's objectives, and play an important role in promoting scientific research in various fields. (FY 1997 budget: 52.8 billion).

**The promotion of internationalisation**

**1. *International scientific exchange***

Scientific co-operation on the international level not only serves to enhance Japan's academic standards but contributes greatly to the advancement of science the world over. In order to promote international exchanges in universities and their affiliated research institutes, the Monbusho carries out various programmes either directly through its own offices or through JSPS.

These international exchanges may be divided into four categories.

The Monbusho's budget for these international exchange programmes totalled about 36.4 billion in 1997. Under these programmes, 12 400 researchers were sent abroad and 6 742 invited in 1996.

1) *International co-operative research*

- Co-operative research based on intergovernmental agreements [e.g. LHC project at CERN, Ocean Drilling Program (ODP)].
- Co-operative projects proposed by the International Council of (ICSU) and UNESCO [e.g. International Geosphere and Biosphere Program (IGBP), Global Ocean Observation System (GOOS)].
- Scientific Co-operation Programs of UNESCO [e.g. International Hydrological Program (IHP), Man and Biosphere Program (MAB)].
- Activities under the Overseas Scientific Research of Research Grants Program [Field Research, Joint Research with researchers abroad, University-to-University Co-operative Research, Cancer Special Program].

2) *Exchange of scientists*

- Monbusho Fellowships and travel grants go towards university researchers, acceptance of foreign researchers as members of the research community, and teaching staff of Japanese universities and affiliated research institutes.
- JSPS exchange programmes: postdoctoral fellowship programme for foreign researchers, exchanges of scientists based on memoranda of understanding with counterpart institutions.
- Provision of accommodation facilities for foreign researchers.

3) *Research meetings*

- Travel grants to researchers attending international symposia held overseas.
- Support funds to universities organising symposia in Japan.

4) *Exchange of scientific information*

- Grants to assist researchers in presenting their research results in academic journals and other publications.
- Promotion of exchanges of data and research results through international computer networks.

The Japan Society for the Science (JSPS) which is a quasi-governmental organisation, has an important role to promote international scientific exchange (FY 1997 budget: 7.2 billion).

## 2. *Student exchanges*

The acceptance of students from other countries plays an important role in improving the level of educational and research standards both in Japan and in the other countries concerned. It also serves to increase mutual understanding and friendship between the Japanese and other peoples. The acceptance of students from developing countries is extremely significant in that Japan's co-operation with these countries contributes to the development of skilled manpower.

As of 1 May 1996, approximately 53 000 foreign students from 148 countries were studying in Japanese universities and colleges. Monbusho has a plan to increase the number of foreign students studying in Japan to 100 000 by the beginning of the 21st century. To this end, it has been carrying out a wide range of measures on a comprehensive basis. The measures include the Japanese Government (Monbusho) Scholarship Program for foreign students, promotion of short term study programmes, financial aid to students studying at their own expense, assistance with living accommodation, the improvement of teaching and guidance for foreign students, the dissemination of information related to study in Japan, and follow up services after the students return to their home countries.

## THE NETHERLANDS

*Prepared by the Ministry of Education, Culture and Science*

### **Higher education policy in the Netherlands**

Knowledge has to be considered as one of the driving forces of innovation and vitality of society. This implies that there is a need to build bridges between public and private partners, between learning, teaching and research functions, between the natural and engineering sciences and the humanities and social sciences. In the past, the emphasis was laid on the generation of knowledge for its own sake. Nowadays more attention is paid to the connection between societal demand and public supply of knowledge, including such issues as access to knowledge production, knowledge transfer, diffusion and use.

In the context of general developments of the last few years, this paper first describes the dynamics of the higher education policy of the Netherlands' government. Secondly, this paper will concentrate on specific policy initiatives to promote knowledge transfer, initiatives to strengthen the relationships between the university research system and other public research systems and initiatives in policies to promote mobility. Thirdly, in the appendix the characteristics of the Dutch research and education system are described.

#### **1. Introduction**

Higher education in the Netherlands is divided into two sectors: academic education and higher vocational education (HBO). During the last decades considerable changes have taken place in the higher education system. These changes can be attributed to the increase in the number of students, changes in the job structure and employment market, internationalisation of economy and society, and changes in attitude towards the role of the public sector. Compared to other countries, government funding of universities in the Netherlands is high: about Gld 4.5 billion, student fees amount to approximately Gld 0.4 billion. Approximately Gld 2.7 billion is spent on research (general university funds).

The Higher Education and Research Plan (HOOP) 1996 shows the policy trends for the higher education system in the Netherlands. In the coming decade the objective is to balance the accessibility, the quality and affordability of the higher education system in the Netherlands. The ultimate goal is to focus the university on its core business of providing an academic education and of undertaking fundamental strategic research, besides its function of transmitting knowledge obtained in the pursuit of scholarship for the benefit of the community, as a service to society. The universities cover a broad range of academic disciplines and the education function of universities is fulfilled within a research environment. The objective for university research is to reach beyond frontiers and, where possible, to contribute to solutions to societal questions or problems. Therefore, in order to train human capital of good quality, universities not only have to strive towards high quality in disciplinary research but also have to cope with multidisciplinary problems.

The HOOP 1996 document defines another objective: to restore the balance between the education function and the research function of universities. Research has become more specialised, whereas the education function has a more general character. For a long time, academic research seemed to be more important than academic education. Recently, more attention is being paid to the education function. Education has to be offered at the highest level and talented students have to be correctly selected.

Since 1995 the number of students, which showed a dramatic increase over the past decades, has stabilised and even shows a declining tendency recently, but a solution still had to be found for the resulting tension between massification and quality. Therefore, the Dutch government has chosen to implement mechanisms of selection in order to make a clearer distinction between academic education and higher vocational education. A stronger selectivity of academic students after the first year by remitting them either to university or to higher vocational education will upgrade the quality of graduates and post-graduates. It is foreseen that because of this so-called propaedeutic selection mechanism, the total number of academic students eventually will diminish, whereas the number of students who will be trained at the higher vocational education institutes will rise.

The research function of the university should achieve its strength by co-operating with the training function, instead of functioning in total isolation. This was one of the reasons why the organisational structure of scientific (academic) research was changed. From the beginning of the nineties, the universities have been setting up so-called research schools (graduate schools). These research schools have two tasks: providing a structured education and training programme for PhD students and bringing together the best university research on a specific theme.

By bringing together the best researchers and the best research programmes in separate research schools, scientific centres of excellence can be formed which enable Dutch researchers to compete better at the highest international levels. Moreover, grouping talented young researchers together provides them with an advanced scientific environment in which to carry out their PhD studies. Defining or creating such top-quality research schools and technological institutes is an objective of the 1997 Science Budget.

Cutbacks in government funding have caused the universities to turn their attention also to the "market". In the last ten years the funds for contract research have become increasingly important for universities. Contract research accounts for about a quarter of all university research in terms of personnel input and about 20 per cent in terms of budget. So, the relationships between the university research system and other public research systems are getting stronger, as well as the relationships between universities and societal organisations, and/or companies.

### ***The research foresight process***

Policy decisions concerning science and technology need to be based on an understanding of which scientific and technological developments can be foreseen, which social issues are likely to arise and which contributions science and technology can make to solve them. For this reason the Minister of Education and Science introduced research foresight as a basis for strategic science policy development. In 1992 he established the independent Foresight Steering Committee (OCV), which issued its final report in May 1996.

An essential feature of the foresight process in the Netherlands is the development of consensus on the most interesting options for future research. Priority setting and the application of priorities are seen as mutual processes whereby actors deal with bottom-up and top-down signals. During the foresight process which resulted in the final report of the Foresight Steering Committee, R&D organisations and "users" of

scientific knowledge (such as ministries or companies) were involved in formulating options. Research foresight is seen as a way of developing a strategic policy, in close co-operation between government, the research world and experts from (potential) sectors which use scientific knowledge. Research foresight is and in the future will be used by the government to set priorities in science policy but can (or even should) also be used by research organisations and institutes when formulating their strategies. The way the process is organised has also resulted in broad support for the recommendations of the Foresight Steering Committee, which will enhance the opportunities for implementing the priorities set.

The Foresight Steering Committee managed the process of formulating options for R&D, and thereby taking into account the interests of the research community and of relevant societal sectors. The Minister of Education, Culture and Science has used this report as a basis on which to establish priorities for science and technology which have been laid down in the 1997 Science Budget, which was issued in September 1996.

Universities (and other research organisations) are requested to take note of the priorities identified by the Foresight Steering Committee and to integrate them in their research strategies. In a number of fields the 1997 Science Budget puts extra emphasis on new research orientations, announcing specific initiatives for changes in research in universities and elsewhere. The Minister, together with the universities discusses procedures in order to make these changes visible in the spending of funds by universities.

The Foresight Steering Committee has concluded its activities. The foresight process will now be carried out by the Advisory Council for Science and Technology Policy (AWT).

In the summer of 1996 the Minister of Education, Culture and Science made an agreement with the Dutch Research Council (NWO), the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Association of Dutch Universities, that these parties will develop strategies which take into account the priorities established by the Foresight Steering Committee. They will work out procedures to stimulate research schools of top quality. Reallocations of funds may be necessary in order to reach that goal.

## **2. Specific policy initiatives**

Higher education policy and science policy are narrowly related. During the past few years the Minister's policy concerning universities concentrated primarily on the student grant system; the costs of unemployment benefits for former university personnel; the internationalisation of education and research; the strengthening of research co-operation between universities and the quality of university education and research.

Science policy as described in the 1997 Science Budget, will concentrate on four issues in the coming years:

- making choices and creating strategic partnerships for investments in R&D;
- preserving and strengthening the top-quality position of the Netherlands in certain areas of science and technology, by creating conditions to stimulate research of excellent quality;
- intensifying co-operation in the framework of the European Union and with neighbouring countries;
- strengthening the support in society for science and technology.

Policies concerning the promotion of knowledge transfer, the relationship between the national university system and other public research systems, and policies for the promotion of student mobility are all related to the above-mentioned topics.

#### *A. Policies to promote knowledge transfer*

Between 1980 and 1992 universities trebled their income from contract research, which now takes up about a quarter of their research capacity. Companies account for a fairly small proportion of this, about 20 per cent of total external income, amounting to some Gld 140 million. This means that companies fund between 4 and 5 per cent of university research. Co-operation with external parties can be beneficial for the universities. The benefits can be found in bringing forward new themes for scientific research, a better match between education and the labour market, a more prominent role for universities in society and a broader access to research funding.

In the policy document 'Knowledge in Action' (June 1995), the Minister of Economic Affairs, the Minister of Education, Culture and Science and the Minister of Agriculture, Nature Management and Fisheries initiated activities to increase the knowledge intensity of the Dutch economy. The Minister of Education, Culture and Science, who has primary responsibility for most of the research and education system, will therefore encourage the system to respond actively to the needs of industry and other actors. The Minister of Economic Affairs is mainly concerned with stimulating business R&D, which is increasingly being carried out in partnership with the public research system. He therefore helps to set priorities for government-funded research.

The transfer of knowledge starts with the formulation of research issues, programmes and projects on the basis of strategic long-term as well as short-term problems of specific organisations, societal sectors or society at large. Co-operation in R&D is vital for effective transfer of knowledge.

As for the universities, strategic long-term relationships with external parties, aiming at basic mission-oriented ('strategic') research, fit in best with their education and research mission. Education can be seen as by far the most important mechanism for knowledge transfer from the knowledge infrastructure to society.

As far as applied research institutes are concerned, their mission – apart from strategic long term relationships with external parties – asks for a large number of smaller projects for research (increase of co-funding; accessibility, "transparency" of the system; transfer).

The measures proposed in the policy document "Knowledge in Action" are based primarily on public/private co-operation. The objective is to realise long-term strategic partnerships between universities and private partners. This can occur through setting up so-called Leading Technological Institutes, for which an extra Gld 55 million a year is made available, and through other strategic partnerships between universities and companies. In the case of the Leading Technological Institutes, substantial co-funding by the private sector is a criterion for public support (apart from high scientific quality and high industrial relevance). Through an elaborate selection process Leading Technological Institutes are now being set up in the areas of Metal Technology, Polymers and Polymer Processing, Telematics and Food & Nutrition Research.

Numerous co-operative relations between companies and universities and research institutes exist. Some examples are:

- joint research projects between the University of Twente's Biomedical Technology Institute and companies such as Akzo Nobel, Medtronic, Philips Medical Systems;
- a contract between the Delft University of Technology and Philips setting boundary conditions for specific research projects;
- co-operation between Utrecht University and Glaxo-Wellcome Pharmaceuticals;
- a contract between the Physics Research Council, FOM (part of the NWO) and Philips.

A few years ago the Government introduced a new investment scheme to improve the economic structure of the Netherlands. Investments in the physical infrastructure were accompanied by investments in the knowledge infrastructure, based on public-private partnerships. Within this framework a number of R&D programmes were set up – universities take part in some of them. As part of this investment scheme the Ministry of Education, Culture and Science allocates 6.5 million yearly for investments in equipment in the area of biotechnology.

Other initiatives presented in the document "Knowledge in Action" give impulse to the infrastructure for R&D, such as:

- Investments of Gld 70 million yearly in the electronic highway to offer a first class information technology infrastructure.
- Gld 45 million will be allocated yearly to the programme "Economy, Ecology and Technology". This programme aims to develop and apply technologies with a good chance of success, a high environmental yield and excellent market potential.

Knowledge transfer happens mostly through people. Therefore, it is important to create networks of researchers. They have their roots in the research schools and university research groups and in company research groups. The competitiveness of the national economy depends on the quality of networks and alliances.

The Ministry of Education, Culture and Science introduced the PROMOTIE Programme to stimulate research in the SMEs. This programme allows companies to take on research assistants in the context of doctoral research (four years) or technological design (two years) to work on a problem selected by the company and under the academic responsibility of the university. Half of the overall costs of hiring the research assistant (gross pay and overhead/infrastructure) are reimbursed. The execution of the PROMOTIE programme is entrusted to the Netherlands Technology Foundation STW (of NWO).

Furthermore, fiscal incentives will be introduced to stimulate employment of apprentices and research assistants. Through this scheme tax deductions are offered for the salaries of university research assistants working within the framework of research contracts with private companies.

The government has focused considerable attention on the issue of improving co-operation between companies and research institutes. This used to happen partly in the form of intermediary organisations such as liaison offices at universities and other research institutes, the Innovation Centres (ICs) and the Branch Centres for Technology (BCTs). The "Wachtplan" is a joint pilot project of the Ministry of

Economic Affairs and the Ministry of Education, Culture and Science. In this project public research institutions work together with Randstad R&D services B.V. (Limited) and the Netherlands Innovation Centres Network. The Wachtplan aims to provide former PhD students, who during their PhD research training were employed by these public research institutions, with a research job in a private company for a period of one year, with a realistic prospect for a further employment contract with this company. The first year's salary costs for the postdoc are shared by the company and the former employer.

***B. Relationship between the national university research system and other public research systems***

Through a number of research programmes, such as NWO stimulation programmes, and Innovation Oriented Research Programmes (IOPs), the government encourages programme-based collaboration between universities and research institutes, and companies.

NWO has announced that as well as focusing on the scientific quality of research, it would also devote more attention to promote (university) research for building and strengthening the Netherlands' innovative capacity. Where possible and desirable, experts from industry will be included in programme committees when the programmes are being established and carried out. NWO will invest an extra Gld 50 million for this initiative over five years, apart from the programmes it is already funding out of its regular budget.

As to the OCV's recommendations (the results of the foresight process) the Cabinet expects that the universities and research institutions will integrate these in their own priority setting and science policy. The choices made by the Cabinet in the Science Budget must be identifiably present in the plans made by the individual institutions. In addition, the relevant government departments, together with the Minister of Education, Culture and Science, will provide extra funding for a number of research programmes. Therefore, the Minister of Education, Culture & Science has commissioned NWO to administer a Stimulation Fund of Gld 15 million for these multidisciplinary, multi-sponsor programmes.

The IOPs are a scheme under the responsibility of the Ministry of Economic Affairs. These programmes for strategic research are to be carried out mainly at universities, in areas of importance to industry. Programme themes are defined on the basis of industrial interest and demand for knowledge. Programmes are carried out under the responsibility of programme committees in which experts from industry take part. The budget for IOPs is about Gld 20 million a year.

TNO can challenge the universities to a more intensive type of co-operation by directing part of its basic funding to the universities in the context of strategic collaborative partnerships through "centres of expertise" (some examples are the Centre for Protein Technology in co-operation with the Agricultural University, and the collaboration of the Centre for Advanced Ceramics of TNO and the Eindhoven University of Technology) or also part-time professorships. The Netherlands Organisation of Scientific Research (NWO) could also make a financial contribution to this kind of initiative.

The Minister of Education, Culture and Science discusses with the Technical Universities and TNO how they can co-ordinate their financial and policy priorities to bring about the establishment of technological knowledge centres in collaboration with industry. This will also be discussed with the Large Technological Institutes (GTIs). The possibility of making broader use of GTI facilities for scientific and technological purposes will be considered.

### C. *Mobility*

Education and industry have been trying to improve the match between education and the labour market. In universities, the curricula for engineering courses are being planned in co-operation with the industry. An ongoing point of concern is the decline of the number of students in science and engineering fields. In several disciplines (e.g. chemistry, chemical engineering, physics, maths) influx of students shows a 50 per cent decline since 1990. In such fields as science and engineering a growing shortage of manpower with technical skills looms in the future. These problems are very complex, as the image of these studies despite of the career opportunities is among the causes of this decline. An action plan will be prepared to counter these problems. More specific information on student mobility is described in the article "Mobility Reviewed: trends and themes in the Netherlands", in the *European Journal of Education*, vol. 31, no. 2, 1996.

Student mobility in the Netherlands can be defined along two axes, which are both reflected in the current debate and policy development. One concerns the mobility of students in terms of exchange or short study abroad periods. The other relates to the participation of foreign students in regular or full degree courses in Dutch higher education institutions. With regard to exchange, it should first be noted that the Netherlands (probably the only EU country at this point) has achieved the aim of 10 per cent mobility (over 11 per cent in 1993) of the country's total student population (van Dijk, 1994). Regarding the participation of foreign students as regular students, there is a remarkably low percentage (2.2 per cent) of foreign student participation in the Netherlands, especially when compared to other European countries with a colonial past (e.g. Belgium 8.9 per cent, France 9 per cent and the United Kingdom 5.7 per cent) (UNESCO, 1994).

#### *International mobility of students*

In the Netherlands, NUFFIC is set up to promote international co-operation between the Netherlands and foreign institutions of higher education and is responsible for the administration of the exchange programmes, the selection of candidates and applications for international scholarships.

In the last few years, Dutch universities have paid increasing attention to international student mobility. There have been a considerable number of exchanges in the area of research. Nowadays, programmes of the Netherlands government and the European Union, both in education and in technological research, promote international co-operation. The most famous multilateral EU programmes to stimulate mobility of students and faculty within the European Union are ERASMUS and LINGUA, followed by Socrates and COMETT, followed by LEONARDO. The largest internationalisation programme in which the Netherlands universities take part is the ERASMUS programme of the European Union, set up in 1988 to facilitate the international exchange of students within Europe. In 1994/1995 some 8 000 Dutch students studied abroad for a period of time (including some 1 000 students who studied in the EFTA countries). A comparable number of foreign students spent several months in the Netherlands.

STIR, a programme of the Ministry of Education, Culture and Science, facilitates mobility of students and professors to countries beyond the European Union. In 1997, this programme will stop for university students, but is to be continued for students in higher professional education. A new scholarship system will be introduced for graduates to study abroad. In addition, many universities have their own co-operative connections with foreign universities (in the United States, Europe and a number of Asian countries).

In the area of research, Dutch universities work together with research institutions in other European countries to a considerable extent. In 1992, for example, an agreement for co-operation in the education and training of young researchers was made with neighbouring countries.

**Table 1. Short-term mobility of Dutch students in 1990 and 1993-94**

	1990			1993-94		
	Study abroad	Internships	Total	Study abroad	Internships	Total
<i>University sector</i>						
STIR	731	231	962	827	498	1 325
Cultural Agreements	140	–	140	180	–	180
ERASMUS	1 173	–	1 173	2 637	–	2 637
LINGUA	30	–	30	138	–	138
Total University Sector	2 074	231	2 305	3 782	498	4 280
<i>Hogeschool</i>						
Sector						
STIR	132	2 178	2 310	648	4 586	5 234
Cultural Agreements	43	–	43	21	–	21
ERASMUS	374	–	374	1 567	–	1 567
LINGUA	8	–	8	89	–	89
Total <i>Hogeschool</i> sector	557	2 178	2 735	2 325	4 586	6 911
Comeu <sup>2</sup>	–	153	153	–	399 <sup>3</sup>	399
Total Higher Education	2 631	2 562	5 193	6 107	5 483	11 590

1. Calculated per academic year from 1993-94, owing to changes in data collection methods.

2. Comett figures include university and *Hogescholen* sector.

3. Total achievement for 1993.

Source: Author.

## APPENDIX

### **Characteristics of the research and higher education system in the Netherlands**

In the Netherlands there are a variety of research institutes: universities including the research schools, the para-university institutes, the Netherlands Organisation for Applied Scientific Research (TNO), the Agricultural Research Organisation (DLO), the so-called Large Technological Institutes and other research institutes.

Universities, including research schools, provide scientific education and perform basic and strategic research. Most of the para-university institutes, carrying out fundamental research, are affiliated with the Netherlands Organisation for Scientific Research (NWO) or the Royal Netherlands Academy of Arts and Sciences (KNAW). Both organisations are almost wholly funded by the Ministry of Education, Culture and Science.

The Netherlands Organisation for Applied Scientific Research (TNO), the Agricultural Research Organisation (DLO), the Large Technological Institutes (GTIs) and other institutes perform applied research for industry and other sectors of society.

#### ***Universities***

The Netherlands have set up 13 universities: nine General Universities, three Technical Universities and one Agricultural University. Moreover, a number of theological universities of different denominations, the Open University, and a few private universities, most of them branches of American universities, exist. The 13 publicly-funded universities differ markedly in size and specialisation. Three of these are characterised by their special denomination: the Catholic Universities in Nijmegen and Tilburg and the Protestant Free University in Amsterdam. These universities are private institutions which are funded by government in the same way as the public universities.

The Dutch universities differ in size and educational provision, but in other respects they are largely comparable. They are all of the same general level and have the same scientific status, capable of attaining the same levels in education, research and scholarship. This is expressed in the same tuition fee for all students and the same manner of government funding for all the institutions.

The 13 universities receive more than 20 per cent of the total R&D budget in the Netherlands, Gld 11.5 billion, of which Gld 5.3 billion from Government.

According to the Higher Education and Research Act, the university system has three core activities: research, education and societal services, e.g. knowledge transfer.

University studies consist of a four-year education programme to obtain a degree equivalent to a Master's and a second, postgraduate programme for a limited group. Some different forms of postgraduate courses may be distinguished:

- research trainees (four years maximum, up to PhD);
- two-year design engineer and researcher courses (two years maximum);
- vocational training courses.

The public funding system of universities distinguishes two sources of funds:

- the “first flow of funds”, direct funding from the Ministry of Education and Science to universities (for the Agricultural University, the Minister of Agriculture, Nature Management and Fisheries is the funding authority);
- the “second flow of funds”, funding from the Ministry through intermediary organisations, especially the Netherlands Organisation for Scientific Research (NWO).

A so-called “third flow of funds” is the income universities obtain through contract research and education; mostly strategic and applied research, for companies, governmental departments, medical charity funds, and international organisations.

An important development of the last few years is the increasing attention the universities give to quality assessment of their education programmes and research function. The quality of the research programmes and their results are tested in the first place by the faculty to which the research group belongs. In addition, the Association of Dutch Universities recently has set up a system of quality control for university research. In this system research in specific disciplines is reviewed country-wide by international review panels. In the workshop on Evaluation of Basic Research, organised by the OECD in April 1997 a Dutch report on evaluation methods was presented.

#### *Consequences of massification*

To be able to enter universities students need to have finished a pre-university education. In order to improve accessibility the government introduced a student grant system available to all students. The university student population has grown very rapidly during the last 20 years. In 1975 there were about 115 000 students at the universities. That figure had risen to about 153 000 students (plus 22 000 *extranei* – students who only pay for their exams – and auditors) in 1995. The growth in the number of students has had two other consequences: education has changed in character. Previously, students were taught in small groups. Nowadays, lectures are given in some subjects to several hundred students at a time. Mass higher education could have a negative influence on student achievement: too high a proportion may fail, or take much longer than the formally scheduled course duration.

Another consequence of the large number of students is that employment prospects for graduates have declined. In the past a university education guaranteed a job. Now, about 5 per cent of graduates are unemployed (1994) [which is well below the general level of unemployment (7 per cent in 1994)].

#### *Research schools (graduate schools)*

The four year programme for research training is an important factor in university research. In order to offer better training programmes to the PhD students and to create stimulating research environments for

research training, research schools were introduced within the university system from 1990. Proposals for setting up research schools are to be submitted by the universities, which increasingly develop their own research “profile”. Through the research schools, co-operation within universities, between universities and with other institutes has increased significantly.

Research schools are to be accredited by a special Committee under the auspices of the Royal Netherlands Academy of Arts and Sciences (KNAW). To receive a five-year accreditation, research schools have to fulfil various criteria in terms of budget guarantees, quality, organisation and scope. In 1997, 107 research schools were accredited by the KNAW. Twenty of these research schools, already accredited for the first time in 1992, have now received a prolongation of accreditation for another five years.

#### *Personnel categories*

In total about 44 000 full-time equivalents (FTE) (about 50 per cent of the scientists) work in the universities (1994). The majority of the academic staff have the rank of assistant professor or associate professor (about 8 000 FTE). A small proportion of the academic staff are professors (2 450 FTE). A relatively new personnel category is that of the AIO's or OIO's, research trainees employed by the university to carry out research for a PhD over a period of four years (5 800 FTE).

In addition to the academic staff the universities also have non-academic personnel, carrying out support and administrative tasks (22 000 FTE).

Between 1990 and 1993, the personnel had risen because of the employment of PhD researchers with a modest salary, the above mentioned AIOs. Recently, however, reorganisations were necessary. Large sums of money were necessary for unemployment benefits of former university personnel and early retirement pensions, which the universities themselves have to pay for. In relation to the 1993 data, the total personnel in 1994 had declined by 2 per cent.

#### ***The Netherlands Organization for Scientific Research (NWO)***

The Netherlands Organization for Scientific Research (NWO) was created in 1988, replacing the Netherlands Organization for Pure Scientific Research (ZWO), which dated back to 1950. The small change in name was accompanied by major changes in the objectives, the ambitions and the procedures of the organisation, as well as in its organisational structure.

While continuing to focus on universities and para-university institutes, NWO's sphere of activity was expanded to include the promotion of both applied and pure research in all fields. The NWO was also expected to pursue a proactive stance rather than a passive response to unsolicited research proposals, and to encourage research on the basis of societal considerations. In addition, knowledge transfer was added to its list of statutory duties.

The NWO is responsible for promoting quality and innovation in academic research in the Netherlands. Its activities include the funding of university research programmes and projects and research trainees, and the provision of scholarships. NWO is also responsible for the exploitation of a number of institutes, especially in physics, astronomy, mathematics, marine sciences, space science and history. Apart from these institutes, NWO is involved in a number of joint ventures with top-level academic research groups, particularly in the field of chemistry.

The NWO had a budget of approximately 600 million guilders in 1996. Approximately Gld 430 million of the operating budget is allocated to the universities as indirect funding.

### ***KNAW***

The Royal Netherlands Academy of Arts and Sciences (KNAW), apart from its task as an advisory body on basic research for the government, runs its own institutes and provides scientists with facilities to establish national and international contacts. Originally the KNAW was merely meant as a “meeting” place for scientists. And up to today this is one of its main functions. In addition, the KNAW funds post-graduate research at universities. The KNAW budget amounts to Gld 122 million, of which circa 60 per cent is allocated to its own institutes. As the KNAW institutes focus on the humanities, social sciences and life sciences, there is little overlap between research fields covered by these institutes and those covered by the institutes of NWO.

### ***TNO***

The primary task of TNO is to carry out technical and scientific research serving the central and lower authorities, the business sector and other social groupings, including government departments. TNO functions independently from the government.

TNO has 13 institutes in the fields of industry, nutrition, health, environment and energy, transport and infrastructure, construction and defence research, besides which the organisation undertakes policy studies. Its workforce amounts to more than 4 000, its budget is about Gld 750 million (1995).

The TNO budget can be divided into three main parts:

- A basic subsidy (about 15 per cent of the TNO budget) from the Ministry of Education, Culture and Science. This is meant as an instrument for research policy of the TNO Board of Management with which TNO can enter into high risk research of an exploratory nature in an early stage of development and for entering new fields. The objective is the building, strengthening and maintaining of an adequate scientific basis for specific research at medium to long term and for contract research for departments, private enterprises and other social organisations. TNO policies referring to this objective are presented in a multi-year programme to the Minister of Education, Culture and Science.
- Programme subsidies (29 per cent of the TNO budget) from the other ministries.

The programme subsidies are used for specific multi-year research programmes for the different ministries. In these programmes TNO’s expertise is geared towards fields the ministries consider important in the medium term. Programmes are proposed by TNO, and after negotiating TNO and the ministries make up yearly bilateral agreements about these programmes.

- Funds from contract research (56 per cent of the TNO budget) which must be cost-effective and funded entirely by the client (private sector, government, international bodies).

***DLO (Service for Agricultural Research)***

In the Netherlands there is an extensive and internationally renowned public system for agricultural research. It consists mainly of three parts:

- The Agricultural University.
- The Agricultural Research Department, in which 12 institutes are united. Its budget is about 300 million guilders (mainly covered by government subsidies). These institutes carry out strategic and applied research in fields like plant and animal production, agro-technologies, land management, nature management and fisheries.
- The Agricultural Research Stations and the Regional Research Centers carry out applied research and give advice to farmers and agricultural organisations. These institutions are funded by the government and the private sector organisations in about equal amounts.

The agricultural research system is considered very successful. It has contributed significantly to the high level of Dutch agriculture, the Netherlands being the largest-but-one exporter of agricultural products in the world. However, a difficult process of change is now needed, due mainly to the agricultural policy of the European Commission and the importance of the environmental issues.

The DLO and the Agricultural University are being merged into one organisation called “Knowledge Center Wageningen” (KCW).

***GTIs***

Like TNO, the Large Technological Institutes (GTIs) form an essential link between fundamental scientific research and technological application, but now in specific fields of technology. There exist five such institutes in the Netherlands. Two of those are affiliated to the Ministry of Economic Affairs: the Energy Research Foundation (ECN) and the Maritime Research Institute Netherlands (MARIN). The other three institutes: the Geotechnics Delft (GD), the National Aerospace Laboratory (NLR) and the Hydraulics Laboratory (WL), are affiliated to the Ministry of Transport, Public Works and Water Management.

***Other institutes***

Apart from the institutes mentioned, there are a number of institutes belonging to ministries and a number of autonomous institutes that are substantially government funded.

Among the ministerial institutes are the State Institute of Health and Environment (RIVM), which is part of the Department of Health, Welfare and Sports, and the specialist Directorates of the State Water Management Service (Department of Transport, Public Works and Water Management), which work in the fields of waste water treatment, civil technology and traffic and transport. Other important institutes are the Netherlands Cancer Institute (NKI) for fundamental and strategic research on cancer, and the institutes for international education at a university level, such as the International Institute of Social Studies (ISS).

## NORWAY

*Prepared by Hans Skoie, Delegate to the Group on the Science System (1996)*

*This version, updated in December 1997, includes information from official documents and statistics. It also includes interpretative passages which are the responsibility of the author and do not necessarily reflect the policies of the Ministry of Education, Research and Church Affairs.*

### **Introduction**

#### ***The Norwegian system of universities and higher education***

The Norwegian university system is comparatively young. Three of the four universities were established after World War II; the sector has expanded tremendously in the post war period in Norway, as in most OECD countries.

In a major reform of higher education in Norway in the early seventies, traditional institutions for teacher training, nursing etc. were upgraded and seen as part and parcel of a system of higher, or tertiary, education. At the same time approximately 15 new junior/community colleges were founded to give short-cycle, vocational education as an alternative to traditional university degree courses. Many staff members with an academic background were recruited to these new institutions, many of which came to emulate the universities rather than the traditional institutions in this sector. This academic drift was not intentional.

The upgrading of existing schools and the new junior colleges led to a rather heterogeneous college sector comprised of more than 100 institutions. In 1994 a major effort was launched to streamline the sector through mergers; the result being 26 state colleges. However, the mergers did not change the geographical location of the institutions; it was essentially an administrative reform, and considerable heterogeneity still exists in the sector both with regard to content and location.

Thus, today the Norwegian system of higher education is essentially a binary one, with two sectors with roughly the same enrolment: a sector of research-based universities and university colleges, and a college sector. However, the two sectors are in many ways not so far apart. An American type credit system in much of higher education in Norway gives considerable flexibility for studies and credit transfer among institutions. Also, in terms of selectivity and prestige, differences between institutions are smaller than in many other countries.

In 1995 the two sectors were linked even closer together by the new Higher Education Act which applies to all higher education. The special character of the universities is stressed, including their special responsibility for research. However, it is somewhat vaguely mentioned that the college sector shall be research based. This has been interpreted by several college presidents as a responsibility to carry out research at the institutional level in these schools, rather than as an actual right for each individual staff

member to do research; individual qualifications and responsibilities have to be taken into account. The research component in these schools is in any case likely to be strengthened in the future, according to many spokesmen. Academic drift has obviously taken place in greater parts of the college sector for years – particularly so in the junior/community colleges which were founded in the 1970s.

### *Universities and higher education – key figures*

Table 1 gives some key figures for the two sectors of higher education in Norway. It is to be noted that the number of students in 1997 is expected to be somewhat higher in the college than the university sector. For the budget figures the situation is the opposite, primarily due to more costly studies (e.g. medicine) and the higher expenditure on research in the university sector, longer and more advanced education (e.g. research training) etc. The two right-hand columns give the estimates for research expenditures according to the national R&D statistics.

**Table 1. Key figures for the university and college sector respectively in Norway**

Sector	Number of institutions	Number of students	Budget (1997) (Ministry) Mill. Nkr	R&D <sup>2</sup> (1995) Total Mill. Nkr	External (1995) funding Mill. Nkr
University	9 <sup>1</sup>	85 000	7 200	3 800	1 150
College	26	97 000	4 900	300	50
Total	35	182 000 <sup>3</sup>	12 100	4 100	1 200

1. Four universities and five university colleges (*Wissenschaftliche Hochschulen*).
2. National R&D statistics, NIFU.
3. Including 12 000 students in private institutions.

Source: National R&D statistics (NIFU), Statistics Norway.

**Table 2. Staff in the university and state college sector respectively, according to position in 1995**  
Total and percentage of women

Position	The universities <sup>1</sup>		State colleges	
	Total	Women (%)	Total	Women (%)
Professor	1 817	10	87	3
Other tenured positions	2 248	28	4 879	45
Externally paid	873	33	82	30
Staff paid by hospitals	903	17	..	..
Recruitment personnel	2 914	39	89	31
Total	8 755	27	5 137	44

1. Includes university-level colleges.

Source: NIFU.

Table 2 gives figures for full-time faculty in universities and colleges respectively, according to academic rank. Most college faculty are not involved in research, and the numbers of professors and fellowship-holders differ greatly between universities and colleges. In the universities, the share of women is largest among fellowship-holders.

Figure 1 gives a breakdown of the university R&D activities according to source of funds. We observe that the floor funding from the Ministry covering most salaries etc., is the dominant source for university research in Norway followed by research council funds. Industry contributes Nkr 220 million, approximately 5 per cent, i.e. essentially contract work. Accordingly, public funding is the dominating source.

### ***International orientation and co-operation***

Stimulating the international dimension of R&D in general and international co-operation in academia in particular has been an important task in Norway for a long time. The country's small size and geographical location also make such a policy more or less imperative.

In the 1980s this policy was purposely intensified. Research staff were strongly encouraged to travel internationally, and the country became a member of such collaborative efforts as EMBL, ESA and the ECs Framework Programme through the European Economic Area Agreement. The changes in Eastern Europe also brought opportunities for more intensive co-operation with these countries.

Comparatively speaking, the international mobility of Norwegian research staff is probably higher than in most OECD countries. This may be a consequence of traditionally rather weak research training in Norway and of relatively generous financial support by the research councils for travel and longer visits to foreign countries, in particular after World War II. It may also be fair to say that the research community by and large has recognised and accepted the value of professional training and experience from good departments and laboratories abroad. In 1959 the Nordic ministers of education recommended that professorships be advertised in all Nordic countries. To some extent, this is done.

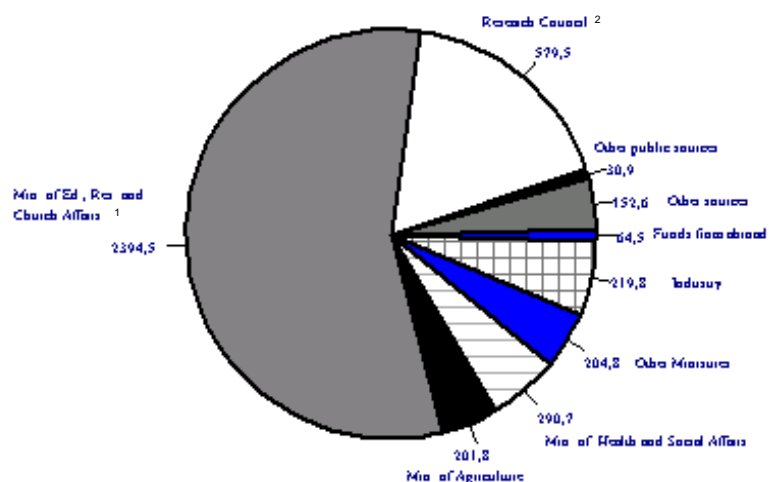
The geographical orientation of personnel mobility has increasingly been Anglo-American, in strong contrast to the situation before World War II when co-operation with the other Nordic countries and Germany in particular was dominant. The Anglo-American orientation has obviously been strengthened by attractive research training programmes leading to a Ph.D. Furthermore, the effect of the rise of institutional co-operation in Europe in R&D – particularly in basic research – as well as co-operation within the European Union, has probably had a significant impact in recent years.

### **Recent trends in policy and budgets**

#### ***Student enrolment***

Student enrolment in higher education has increased greatly in the post-war period and in the last few years in particular (c.f. Figure 1 which shows total student enrolment in universities and colleges). We notice that the college sector, which includes teacher training, nursing and engineering colleges, now has a larger enrolment than the university sector. Both sectors have experienced enormous growth during the last decade.

**Figure 1. Research funding in the Higher Education Sector according to source of funds 1995**  
Million Nkr

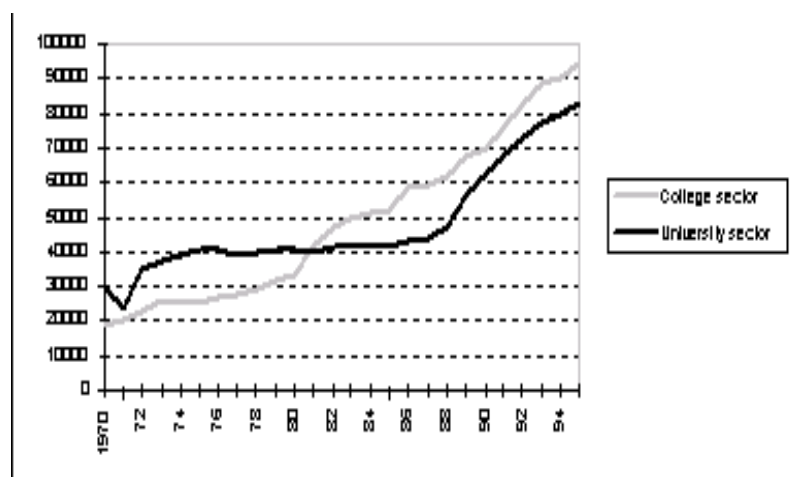


1. Ministry of Education, Research and Church Affairs (2 394.5).
2. Research Council (579.5).

Source: Statistics Norway.

In the university sector we find growth in enrolment numbers in all fields during the 1983-95 period. The pattern of growth is uneven, however. The strong growth in the humanities and the social sciences recently is particularly noteworthy. Enrolment in engineering and science faculties has also increased (cf. Figure 2 which shows enrolment by field of study in the period 1983-95). Their share of the total student population has, however, declined.

**Figure 2. The number of students in the university and college sectors, 1970-95**



Source: Statistics Norway.

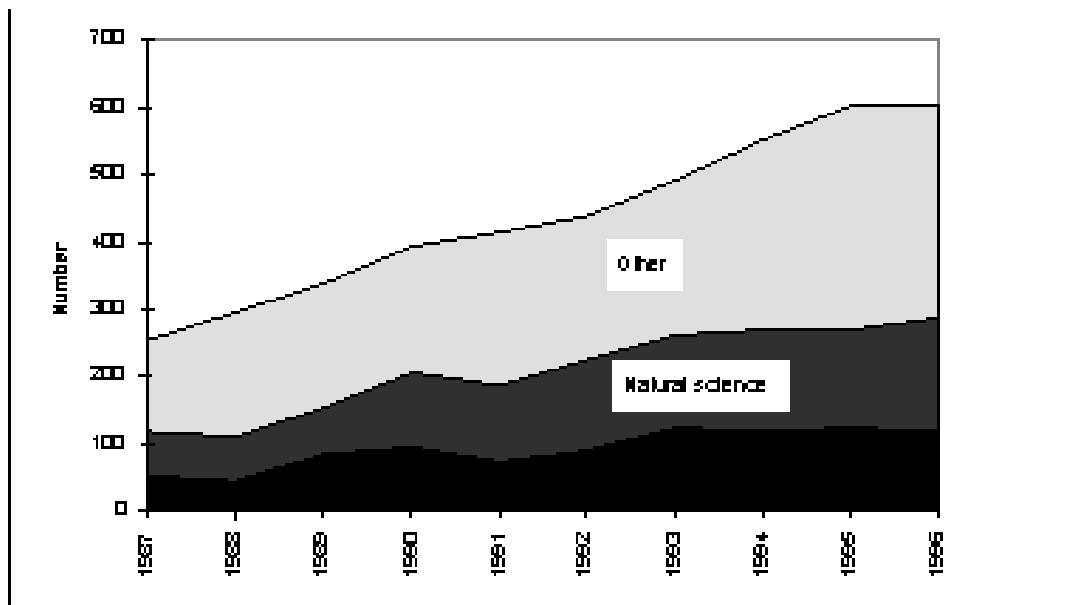
When these data are analysed in greater detail, we observe that biological sciences have fared better than the physical sciences at university level.

In the college sector, the three-year **engineering** courses have been less popular the last few years and certain courses have not been able to attract qualified entrants to all available places.

At the postgraduate (MA/MSc) level the **number of graduates** has increased considerably in the 1983-95 period in all fields. However, the relative shares of graduates among fields have not changed much. This is a consequence of the fact that science and engineering students are more efficient in terms of time to obtain a degree and have lower drop-out rates.

The **number of doctorates awarded** has increased considerably in recent years – not least due to more available fellowships and the introduction of a new degree programme somewhat similar to an American Ph.D. Looking at the growth in doctoral degrees conferred in the 1983-96 period, we notice that the number of doctorates awarded has doubled over the last decade. The share of women recipients has also increased considerably.

**Figure 3. Doctoral degrees conferred by Norwegian institutions, by field, 1987-1996**

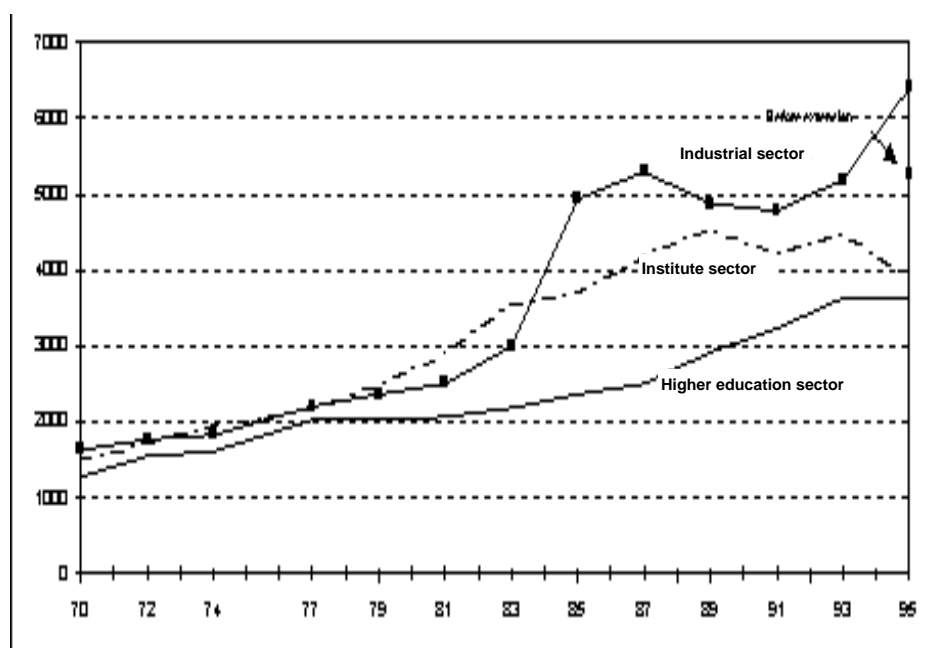


*Source:* Norwegian Institute for Studies in Research and Higher Education/Statistics Norway. The survey of R&D activity in the industry sector was expanded in 1995. The point before extension shows the R&D expenditure in 1995 using the old sample of units.

### ***R&D expenditures – the overall picture***

Figure 4 gives an overall picture of the R&D expenditures in Norway by sector. We note that research expenditure in the universities has grown substantially in Norway in the last few years, according to the national R&D statistics. The rise in student numbers followed by considerable staff expansion, including fellowships for research training, accounts for much of this development. The statistics may, however, possibly be inflated, as the basic parameters for the estimates are somewhat dated. We also note that R&D performed in Norwegian industry has levelled off – a fact which currently worries many policy makers (and doctoral students who want to find work!) in Norway.

**Figure 4. R&D expenditure in Norway 1970-95 by sector of performance**  
Fixed 1990 prices, Million Nkr



Source: NIFU/Statistics Norway.

### ***Funding of university research and research training***

In addition to the floor funding coming from the Ministry of Education, Research and Church Affairs, the Norwegian Research Council is the second most important contributor to university research, as we have seen in Figure 1. The Council is the result of recent major changes in the R&D organisation. In the period 1988-1993 Norway has totally changed both its advisory system and its public funding system for R&D. The former research councils – essentially one basic and four applied – have been merged into a single council. The Advisory Council for Science Policy has been abolished and the advisory function included with the tasks of the new Council. Furthermore, the new Council has been given a role as an umbrella organisation for the sizeable sector of government institutes and laboratories.

The merger was in no way obvious given the diverse nature of the former councils. The majority of the councils were applied and mission-oriented: to technology and industry (NTNF), agriculture (NLVF), fishery (NFFR), and applied social science (NORAS). Only the NAVF with its four sub-councils for science, medicine, social science and the humanities was a traditional university-oriented council as part of a dual funding system for the universities. Furthermore, the councils were attached to different ministries.

The dominant research council in terms of funds, the NTNF, has been seen as an important element in government industrial policy through funding of R&D – not least the development part. It could be argued that the NTNF should not be viewed as a research council in the traditional sense. In the other Nordic countries, for example, substantial parts of activities like those of the NTNF were not organised on a research council basis. The new arrangement represents a centralisation under the Ministry of Education, Research and Church Affairs, and obviously seeks to integrate very different and

well-established sub-cultures and missions. The stated objective of the merger was to make Norwegian R&D organisation simpler, more rational and more efficient, and to achieve better integration between basic and applied research.

The new Council is divided into six sub-units, each with its own board, comprised of researchers as well as users:

- Industry and Energy (including oil, shipping and service industries);
- Bio-production and Processing (i.e. fishery, aquaculture, agriculture, veterinary, medicine, forestry and food industry);
- Environment and Development;
- Medicine and Health;
- Culture and Society (the humanities, social sciences, public administration and services);
- Natural Sciences and Technology.

The Council has a nine member board appointed by the Government, while the six research boards are appointed by the Council board. It should be noted that in addition to funding from the Ministry of Education, Research and Church Affairs, the Council also receives regular funding and guidance from several other ministries, notably those for industry, agriculture, fisheries and the environment.

Research training in Norway has been rather generously supported through fellowship schemes directly applying government staff regulations, guidelines and pay scale. During the last few years, the training for the doctorate has been brought closer to an American PhD system. The number of fellowships was expanded considerably, on the assumption that the new PhDs are also suitable for work outside academia. In its 1997 budget the Government calls for a more thorough analysis of the requirements, in view of the situation with regard to research training and employment.

### **Knowledge transfer**

The merger of the former research councils in 1993 was also meant to facilitate knowledge transfer and closer contact between basic research at the universities, and other parts of research and society. In this respect it is important to keep in mind that only one of the former councils was a traditional university-oriented research council; the other four were essentially applied and mission-oriented, as noted above. (There was no funding mechanism comparable to the single science vote which exists in the United Kingdom.) The new Council has user representatives on all boards and committees and is working hard to improve its links to the practical world. This includes efforts to commercialise ideas and to strengthen the knowledge base in SMEs. It remains to be seen to what extent the new Councils' efforts are successful on these accounts.

The universities also try to establish better institutional links with society at large through science parks etc. Their record in this area is not an unequivocal success. Here we should bear in mind the important fact that Norway has a larger institute sector than most OECD countries. This is apparent from Table 3 which compares this sector for eight OECD countries. It is particularly engineering and technology institutes serving industry which count in these figures. Norway has, however, a considerable research activity in independent institutes engaged in social science / policy research.

**Table 3. Key indicators for the institute sector in Norway and seven other OECD countries, 1993<sup>2</sup>**

Country	Billion Nkr	Share of total (%)	Share of GNP	Per capita (Nkr)
Canada	14.3	18	0.3	500
Denmark	2.6	17	0.3	510
Finland	3.5	22	0.5	690
The Netherlands	9.7	21	0.4	630
Norway	4.5	32	0.6	1 050
Sweden	3.8	9	0.3	440
Germany	51.8	16	0.4	640
Austria <sup>1</sup>	2.0	14	0.2	260

1. 1989 figures.

2. Source NIFU.

### **National funding agencies**

The Norwegian research councils, in particular the former NAVF, the university oriented Council already mentioned, have traditionally played an important role in funding university research in Norway. The new Council described above is also meant to have an important role in this respect. However, it has so far experienced a levelling-off in budget appropriations. Essentially the budget for 1998 is still at the 1993 level, and actually below in real terms. In the new Council, rather extensive use of research programmes in contrast to researcher-initiated projects has become an issue. Also, the limited use of peer review is much debated. The regional dimension, i.e. to what extent the council should give the regional colleges special treatment in the coming years, is also noticeable.

### **Mobility**

#### ***International mobility***

In Norway there is a tradition of going abroad to study resulting from the inability of the educational system to provide sufficient training in some professional fields as well as weak research training. In most of the years since the Second World War, between 10 and 20 per cent of the total number of Norwegian students have been enrolled abroad, mainly in Western Europe outside Scandinavia. This enrolment has been heavily concentrated in certain professional fields like engineering, medicine and dentistry. At the doctoral level, 20 per cent of all holders of doctorates had obtained foreign degrees at the end of the sixties – today this proportion is probably smaller.

In a study of tenured university faculty at the University of Oslo in 1968 we found that 75 per cent of the staff sampled had made at least one visit abroad for not less than one term; each of them had an average of two visits. Nearly 80 per cent of the visits were for one year or more. The number and direction of long visits of this kind are good indications of active scientific co-operation among countries. Accordingly, some data on such visits is presented in Table 4.

**Table 4. Visits abroad by University of Oslo staff members in different time periods, according to country of visit (by percentage of all visits)<sup>1</sup>**

Time period	The Nordic countries	Elsewhere in Europe	Canada and United States	Elsewhere in the world	Total number	%
1939 and before	11	71	18	0	28	100
1940-54	15	32	52	0	65	100
1955-68	9	24	61	6	147	100
Total	11	32	53	4	240	100

1. Hans Skoie: "The Problems of a Small Scientific Community; the Norwegian Case", *Minerva*, VII/1969: 3, pp. 399-425.

Source: Author.

Table 4 shows that Canada and the United States have the highest rate of visitors – 53 per cent in total and particularly so in the post-war period. Eastern Europe has not been specified, but the number was negligible in the early post-war period.

The pattern of such visits in more recent years has been studied in two major surveys of tenured staff in Norwegian universities based on data from 1981 and 1991 respectively and covering all four universities in Norway.

**Table 5. Longer research visits abroad by region and field**  
Percentage of number of visits 1991<sup>1</sup>

Region	Humanities	Social sciences	Natural sciences	Medicine	Technology
West Europe excluding the Nordic countries	47	30	21	20	21
North America	32	48	64	57	66
Eastern Europe	2	2	..	1	1
Other	6	15	8	12	10
Nordic countries	13	5	8	11	3
Total	100	100	101	101	101
(N)	(198)	(192)	(445)	(160)	(122)

1. Inger Marheim Larsen, NIFU Report 11/92.

Source: Author.

Table 5 shows that the North American dominance is still strong in all fields except the humanities. Furthermore, few visit Eastern Europe.

### *Internal mobility in Norway*

The extent to which Norwegian researchers are mobile is a question which often surfaces in debates on science policy. The role of the sizeable institute sector is usually seen as important in this connection. Studies show that a substantial number of researchers in this sector leave every year to take up jobs in industry, public service etc. It seems to be more worrying that researchers in industry form a modest base for recruitment to both the institute and the university sectors. Within academia, mobility seems to be

modest in Norway both in terms of internal mobility and of staff inclination to leave the sector for other jobs, in research or elsewhere.

### **Critical issues and perspectives**

The future of university research depends on several factors. First of all, *the size of the higher education sector* is important. Should we expect this sector to continue to expand in the years to come, or is it likely that the expansion we have seen for years will level off? The percentage of school leavers who go on to higher education is more than 40 per cent in many countries. This high proportion is probably somewhat influenced by the difficult employment situation for school leavers in these countries.

A second question is related to *the structure of the sector* of higher education – the degree of differentiation among institutions, courses and professions. What share of eligible students chooses classical academic institutions, and what proportion goes to alternative institutions which usually offer shorter courses of vocational/semi-professional character? How do public authorities choose to structure the sector in response to such demand and their judgement of the future job market?

An increase in the flow of students into higher education might lead to greater institutional *diversity*, including a great many institutions which are not intended for or able to do research, for example. At the same time, we often find a tendency of “academic drift” in parts of higher education – alternative institutions tend to move toward the university model. The courses they offer are increasingly similar to university courses, their staff get involved in research, and traditional academic values and procedures become dominant on campus. Due to the resources and scientific equipment involved, “academic drift” of this kind may be expected to happen more often in the humanities and social sciences. At the same time, the pattern seems to vary considerably with respect to diversity and academic drift in higher education in the Western World today.

A third crucial point is related to *the role of research in the institutions* of higher education and the universities in particular. Due to budget constraints, the expansion of the sector and the increasing cost of research (“the sophistication factor”), we observe a growing diversity within traditional universities. The number of universities able to sustain a viable research component may actually decrease, and a stratification similar to the American pattern may develop. This may happen by deliberate government policy or as a consequence of competition in the area of research funding.

Fourthly, we may also ask what kind of research will be dominant on the campuses of the future. Can we still expect researcher-initiated *basic research* to be particularly prominent, or is it more likely that a top-down approach by research councils, industry and government increasingly becomes the order of the day?

The distinction between basic and applied research is not universally accepted by all. The OECD distinction is based upon the primary *intention* behind the investments made by those who finance the activity: “Basic research” is the term if no special non-scientific criteria are specified or are alluded to. “Applied research” means that non-scientific considerations are the basis for the investment by the funder. This does not necessarily mean that the research itself is methodologically or in any other way different. Accordingly, it is not unusual to find both kinds of research at one and the same institution.

In order to still have a fair amount of basic research initiated and controlled by the scientific community, an alternative might be for research universities to consider restricting traditional demands for expansion in order to better secure the greater freedom which traditionally goes with basic research. *The continuous*

*demand for growth* in research has increasingly been met with demand for greater influence on research priorities and direction by the funders.

This defence of basic research does not imply that all university research should be basic research, or that the universities should isolate themselves from other areas of society. Nevertheless, the universities should still be the proper home for basic research activities which society wants to fund.

In my view, the role of research in higher education should now be dealt with at length in different quarters. The past expansion and the new economic climate may imply that most governments are no longer willing or able to sustain a vital/sizeable research base in many universities. Basic research may be particularly threatened. This kind of research traditionally strengthens the scientific community. Accordingly, the vitality and independence of the entire university may be at stake.

## PORTUGAL

*Prepared by Mrs. Miranda, Delegate to the Group on the Science System*

The overall and world-wide growth in university student population in the last decades was, at least in part, determined by the progressive recognition of the intrinsic value of education (highly trained workforce also to assure international competitiveness) on the societal level and the rise in individual's educational expectations. The student population doubled in most developed countries from 1970 to 1980, and (UNESCO, 1992 data) between 1980 and 1990 the number of students increased from 16.3 million to 28.1 million. With budgetary constraints, access to Higher Education became a major issue, together with the need for diversification of the system. Equality and quality are the two sides of the coin and a challenge to higher education systems and policies (Marques, J.F., Miranda, M.J., "Access to Higher Education in Portugal: selection procedures revisited, from studies at the University of Lisbon", *Oxford Review of Education*, 1996, 22[3], 337-347).

Information-based economies make a strong demand on human resources as the "economic mainstays of the knowledge-intensive society" in which "information and knowledge will become the basic raw material". Expressions such as "re-engineering of education" / "information superhighways" / "virtual university" entered the Higher Education administration vocabulary; the new technologies became a must, in spite of the economic context of "holding down or trimming public expenditure in all areas, education included". Therefore, "among all the issues confronting international higher education in the 21st century, financing is certainly the most challenging". ("The state of Higher Education", The International Association of University Presidents, San Francisco CA, July 1996, mimeo).

The paper is organised according to the information available on guidelines in the Chairman's letter dated June 5: The Higher Education System in Portugal (Brief Description, Recent Evolution, Public Universities Students and Academic Staff), The S&T System in Portugal (Main features, Personnel in R&D, Financial Indicators), Universities Budget (General Budget, R&D Budget), Knowledge Transfer Policies, International Co-operation in S&T Training.

### **1. The Higher Education system in Portugal**

#### **1.1 Brief description**

The strong evolution since the 1970s was marked by a) the creation of several universities (on the continent and one in each of two autonomous regions, Madeira and Azores), b) the implementation of Polytechnics in most parts of the country, and c) the *numerus clausus* in higher education. As well as the institutionalisation of the private sector (eight universities and over 70 colleges recognised by the Ministry of Education).

The public sector comprises now 14 universities:

- Universidade de Coimbra
- Universidade de Lisboa
- Universidade do Porto
- Universidade Técnica de Lisboa
- Universidade Nova de Lisboa
- Universidade de Aveiro
- Universidade do Minho
- Universidade de Évora
- Universidade dos Açores
- Universidade do Algarve
- Universidade de Trás-os-Montes e Alto Douro
- Universidade da Beira Interior
- Universidade da Madeira
- Universidade Aberta (Open University)

and 16 Polytechnic Institutes:

- Instituto Politécnico de Aveiro
- Instituto Politécnico de Beja
- Instituto Politécnico de Bragança
- Instituto Politécnico de Castelo Branco
- Instituto Politécnico de Coimbra
- Instituto Politécnico do Cávado e do Ave
- Instituto Politécnico da Guarda
- Instituto Politécnico de Leiria
- Instituto Politécnico de Lisboa
- Instituto Politécnico de Portalegre
- Instituto Politécnico do Porto
- Instituto Politécnico de Santarém
- Instituto Politécnico de Setúbal
- Instituto Politécnico de Tomar
- Instituto Politécnico de Viana do Castelo
- Instituto Politécnico de Viseu

The Council of Rectors of Portuguese Universities (CRUP) is composed by the rectors of the 14 state universities and the rectors of the Universidade de Macau (in Macao) and of the Universidade Católica Portuguesa (the Portuguese Catholic University). Since the 1988 Autonomy Law, the universities are autonomous.

The *numerus clausus* is stipulated at the governmental level, upon proposals submitted by each university. Admittance is based on a final score, the weighted mean of the secondary education record (grades

10 to 12) and grade 12 national examinations results (according to the student's application, one basic discipline and discipline(s) determined by universities for each course).

The Portuguese University offers three degrees: *licenciatura* (four to six years), *mestrado* (MA/MSc., two years, including a dissertation), and *doutoramento* (PhD). Tuition fees are due both in under-graduation and post-graduation.

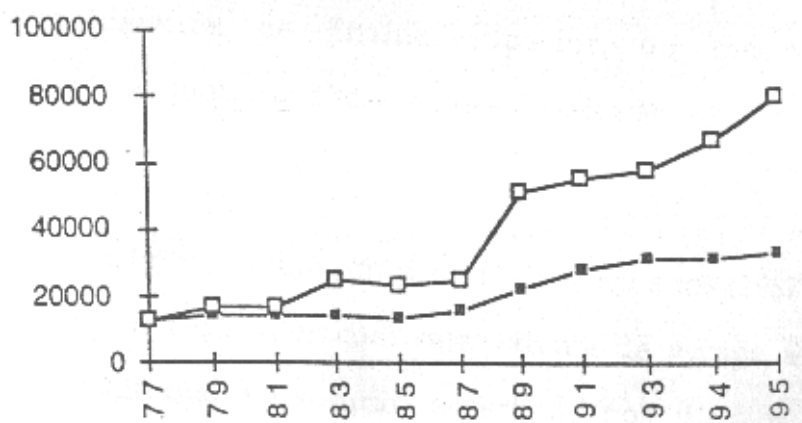
In a recent document by the Council of Rectors the following short-term measures are recommended: creation of a network of vocational post-secondary schools, extension and quality improvement of polytechnic training (three years, and turned towards the labour market), quality evaluation and monitoring of universities, cut-off scores in access to higher education, the enhancement of academic success (through facilitation of transitions between subsystems, tutorial teaching, etc.), improvement of social support to students, investment in continuing education ("Repensar o Ensino Superior", "Rethinking Higher Education", CRUP, May 1996, mimeo).

As is the case for many other universities in Europe, several Portuguese Universities are currently engaged in an evaluation process.

## 1.2 Recent evolution

Figure 1 shows the evolution of *numerus clausus* and of the number of candidates to Higher Education, from 1977 to 1995.

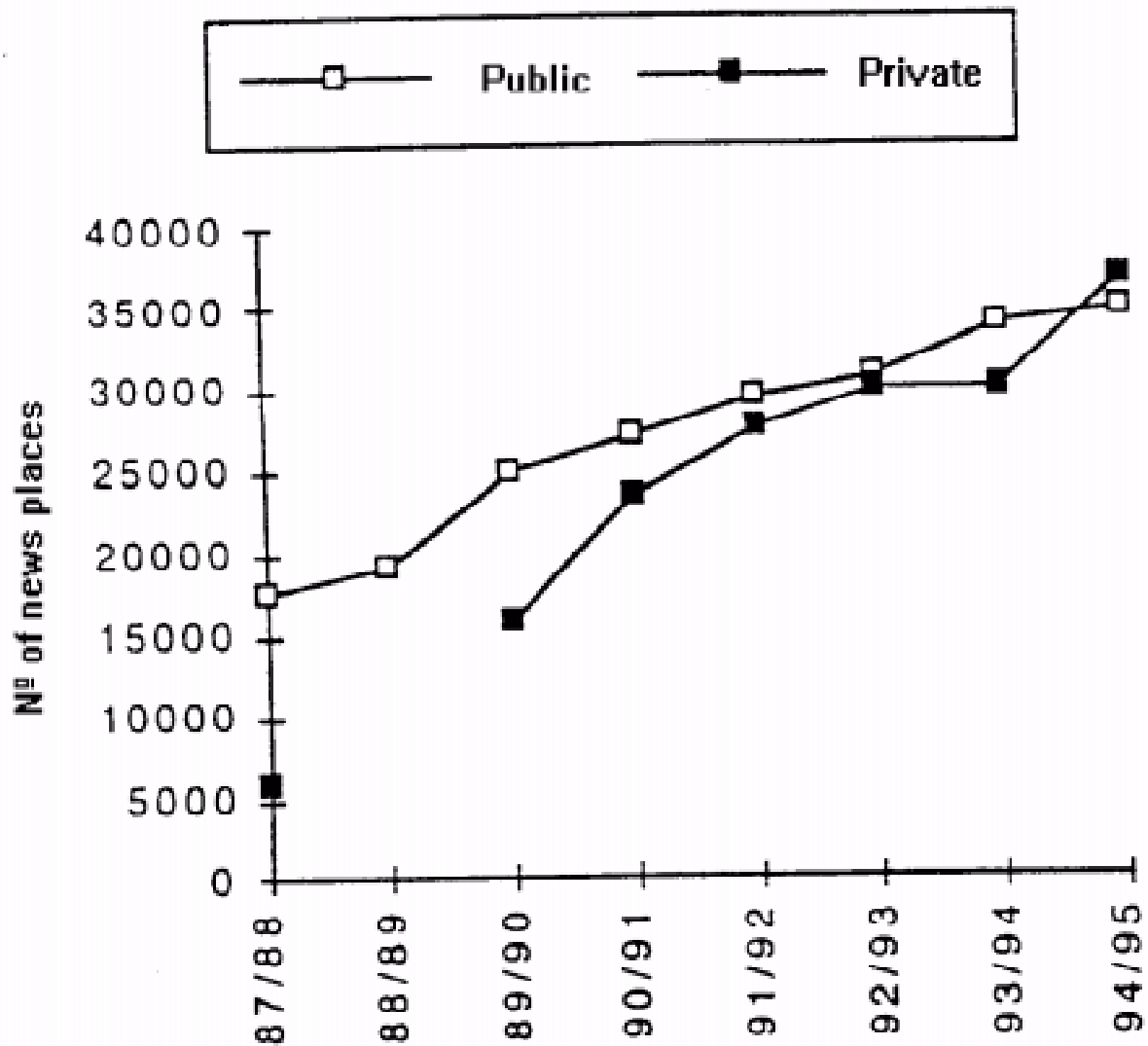
**Figure 1. Numerus Clausus (■) and candidates (□) to Higher Education, 1977-95**



Source: "Repensar o Ensino Superior", (Rethinking Higher Education), CRUP, May 1996, mimeo.

The data in Figure 2 concern the evolution of *numerus clausus* in the public sector (Universities and Polytechnics) and private sector, from 1987 to 1994.

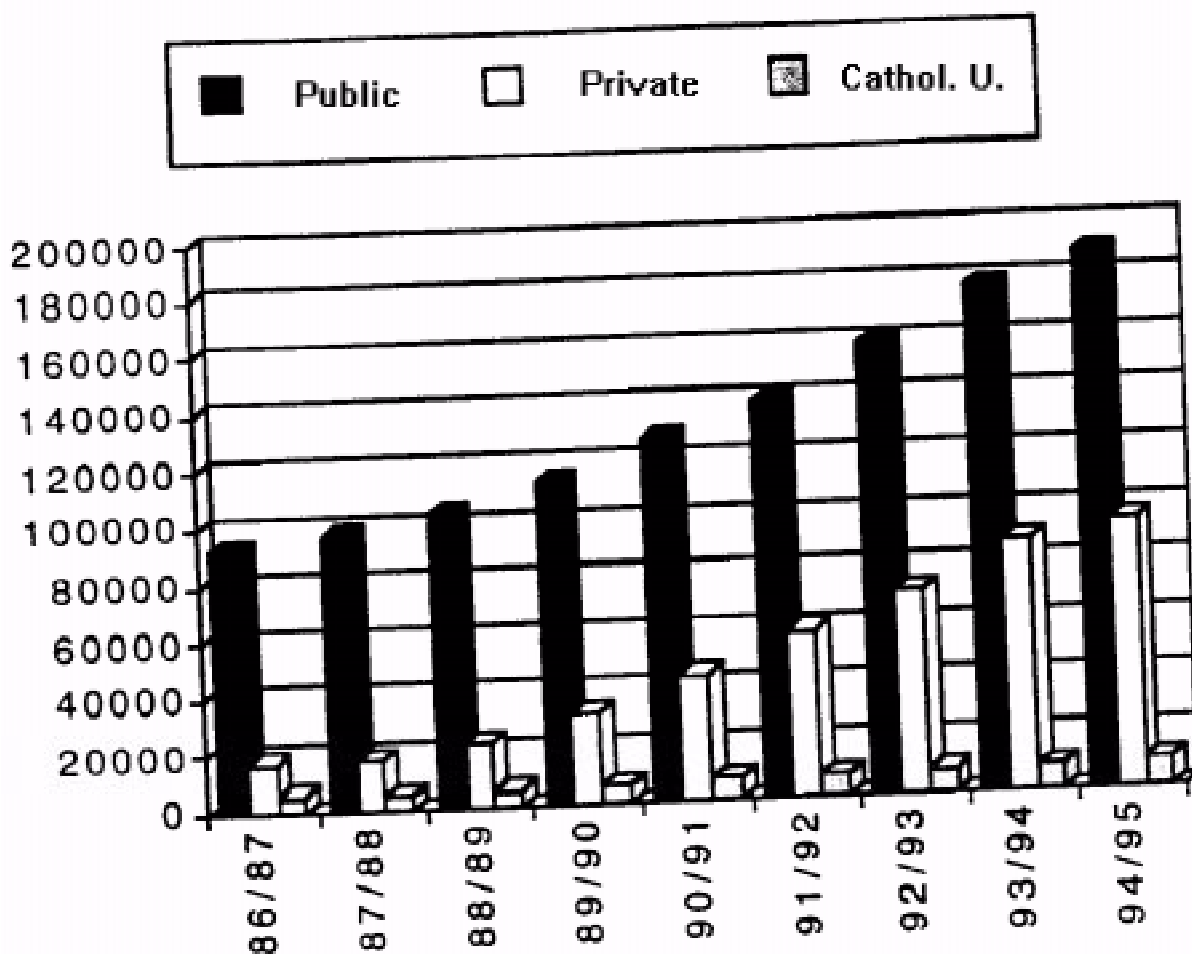
Figure 2. Numerus Clausus, 1987/88 to 1994/95



Source: Author.

Figure 3 shows the number of enrolments in Higher Education (public, private, and the Portuguese Catholic University) from 1986/87 to 1994/95.

Figure 3. Total number of students in Higher Education



Source: Author.

### 1.3 Public universities studies and academic staff

Source: Ministry of Education, Department of Higher Education, December 1995.

The total number of students in 1994/95 in public universities was 124 821 undergraduates, and 5 466 graduates (in 1993/94, 119 940 and 4 920).

The academic staff reached 10 091 (FTE, full-time equivalent) in the different academic categories, 80 per cent having a Ph.D. or a M.A./M.Sc. degree (42 per cent and 38 per cent respectively).

## 2. The scientific and technological system in Portugal

*Source: Ciência e Tecnologia 1993/94, Secretaria de Estado da Ciência e Tecnologia, Lisboa, 1995.*

### 2.1 Main features

The scientific and technological system in Portugal comprises four types of R&D institutions: non academic research institutions and universities (public), and non-profit institutions and companies (private).

Twelve Laboratories and Institutes offer high technological services to the public and the private sectors in the following fields: ocean sciences, tropical research, nuclear sciences, geographical information, agriculture sciences, earth sciences, energy and industrial technology, education, civil engineering, health sciences, meteorology and seismology. The JNICT (National Scientific and Technological Research Agency) does not execute R&D directly, as it is committed by the government to the national planning of R&D and to international co-operation in scientific and technological research, and to the financial management of scientific research and technological development programmes. Since 1994, JNICT also co-ordinates university research.

The role of universities in R&D in the various scientific fields is fully recognised: basic and applied research, advanced training of human resources. The former National Institute for Scientific Research (discontinued in 1993) was responsible for a large network of research centres located at universities; after 1993, all those centres were integrated in the universities, and the financial support to research activities is provided by JNICT (projects, contracts).

Several non-profit private institutions were created in partnership (public universities and laboratories / corporations, business and industrial associations), and are considered as a bridge between universities and the productive sector. Main areas are electronics and computer science, biotechnology, biology and biomedical sciences, mechanical engineering and production technologies, and new technologies.

The investment in R&D of ten major national and foreign companies in 1990 (7 065 - 10 million Esc, current prices 1990) reached 50 per cent of the total investment in R&D in the productive sector.

### 2.2 Personnel in R&D

Table 1 shows the distribution (full-time equivalent, FTE) of personnel in R&D, by scientific/technological area, in universities, other public research institutions (PRI) and non-profit private institutions (NPPI) in the early 1990s.

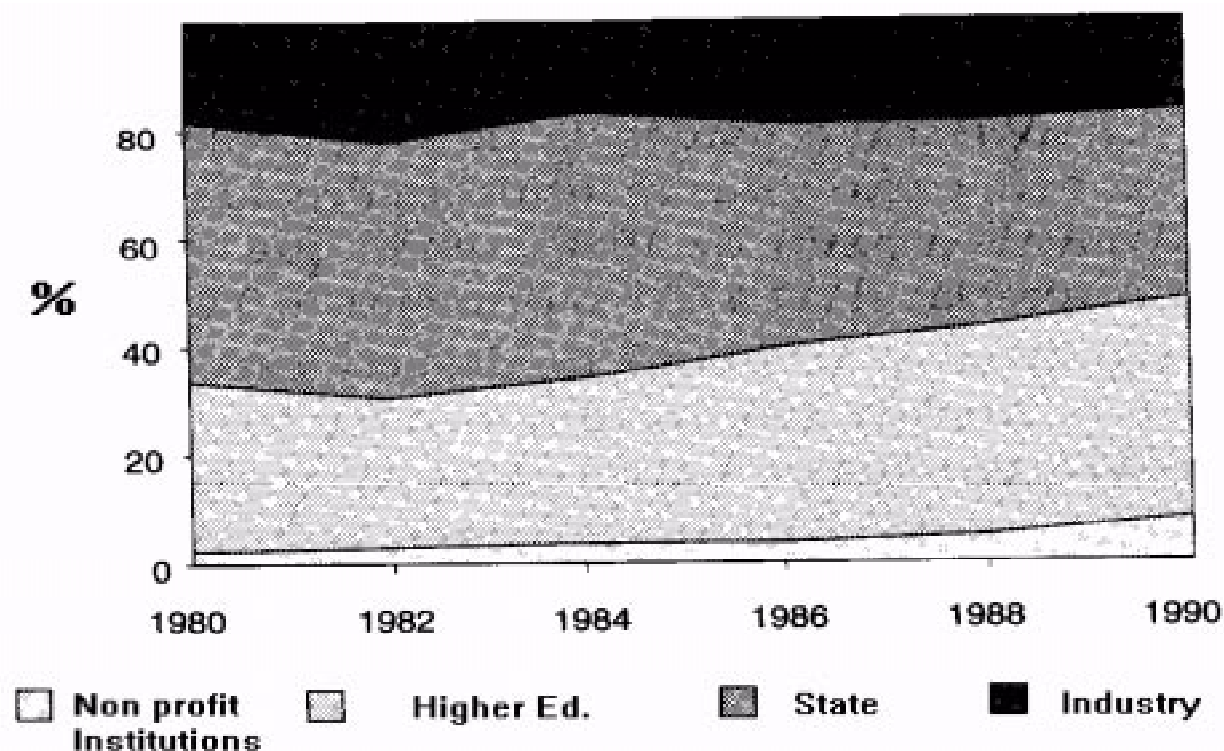
**Table 1. R&D personnel distribution (1990)**  
N = FTE

S&T AREA	University		PRI		NPPI		Total	
	N	%	N	%	N	%	N	%
Exact Sc.	1 061	21.9	262	6.2	94	6.2	1 417	14.1
Natural Sc.	688	14.2	533	12.6	124	12.6	1 344	13.4
Engineering	840	7.4	924	21.8	636	21.8	2 400	23.9
Health Sc.	726	15.0	275	6.5	34	6.5	1 035	10.3
Agriculture	417	8.6	1 755	41.3	12	41.3	2 174	21.6
Soc. & Human	1 109	22.9	491	11.6	75	11.6	1 675	16.7
<b>Total</b>	<b>4 481</b>	<b>100.0</b>	<b>4 230</b>	<b>100.0</b>	<b>975</b>	<b>100.0</b>	<b>10 046</b>	<b>100.0</b>

Source: Author.

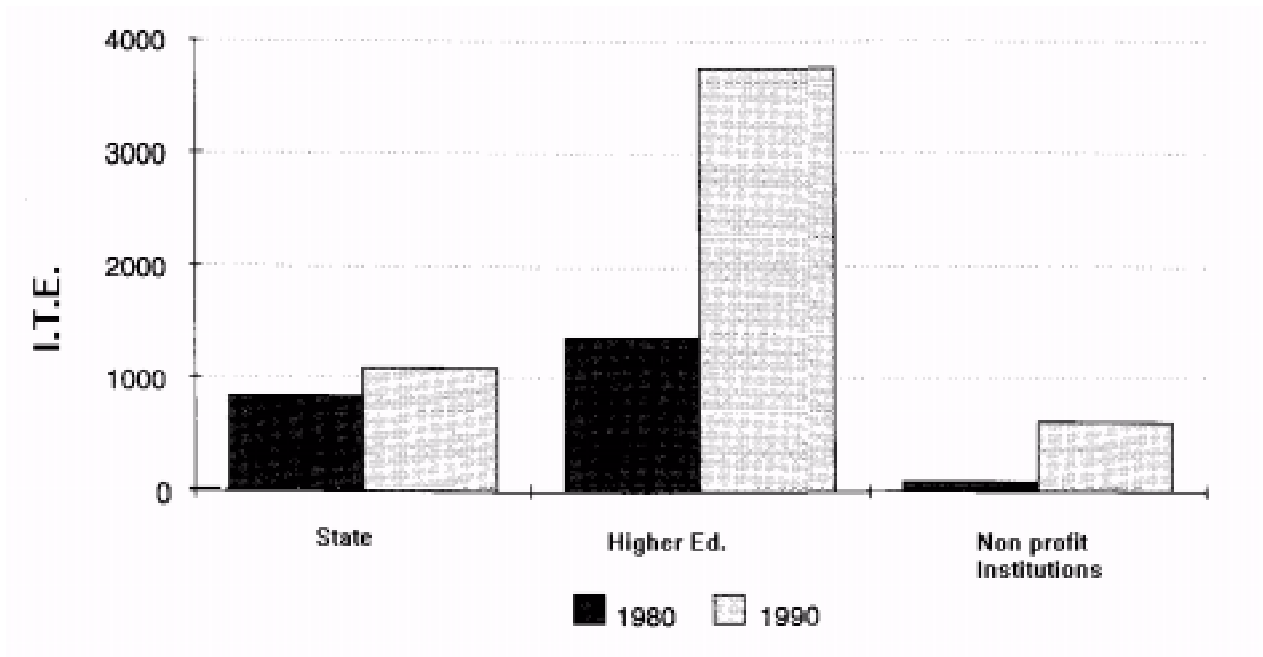
Figure 4 shows the distribution of R&D personnel (FTE) in universities, other public research institutions, university-based non-profit private institutions and the industrial sector, in the 1980s. Figure 5 summarises the evolution, in universities, other public research institutions and non-profit institutions (FTE).

**Figure 4. Distribution of R&D personnel (FTE), in the 1980s**



Source: Author.

Figure 5. Evolution of R&D personnel (FTE), 1980-90

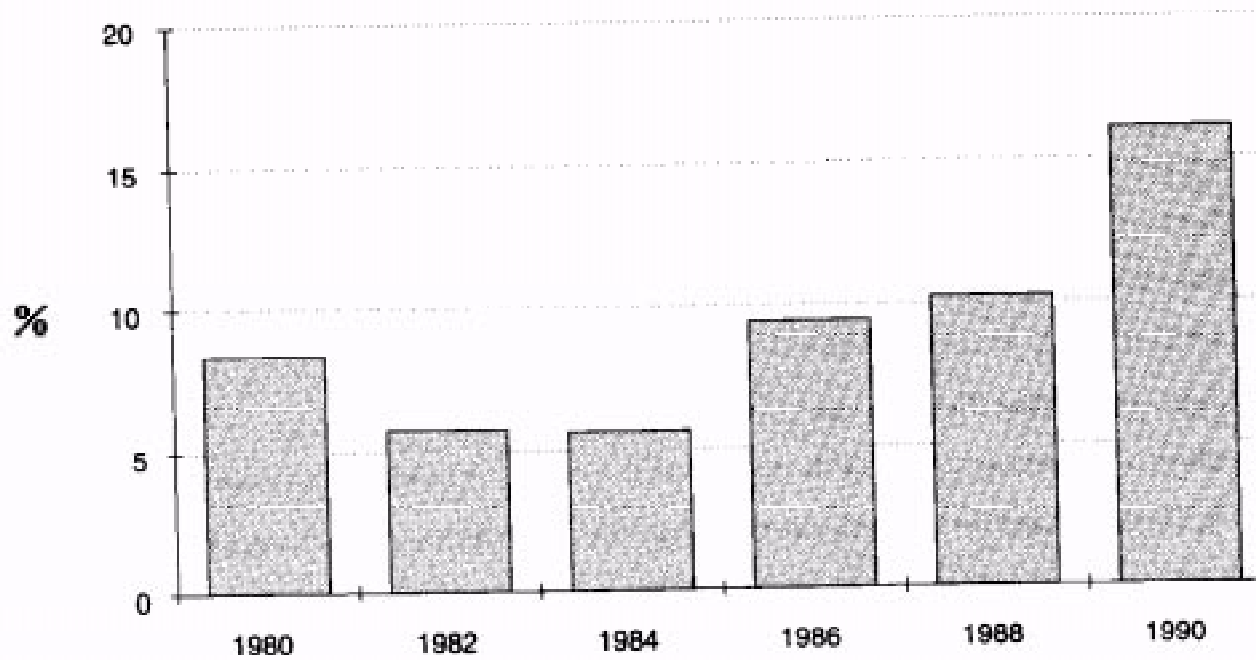


Source: Author.

### 2.3 Financial indicators

Figure 6 shows the growth rate in R&D execution in the 1980s.

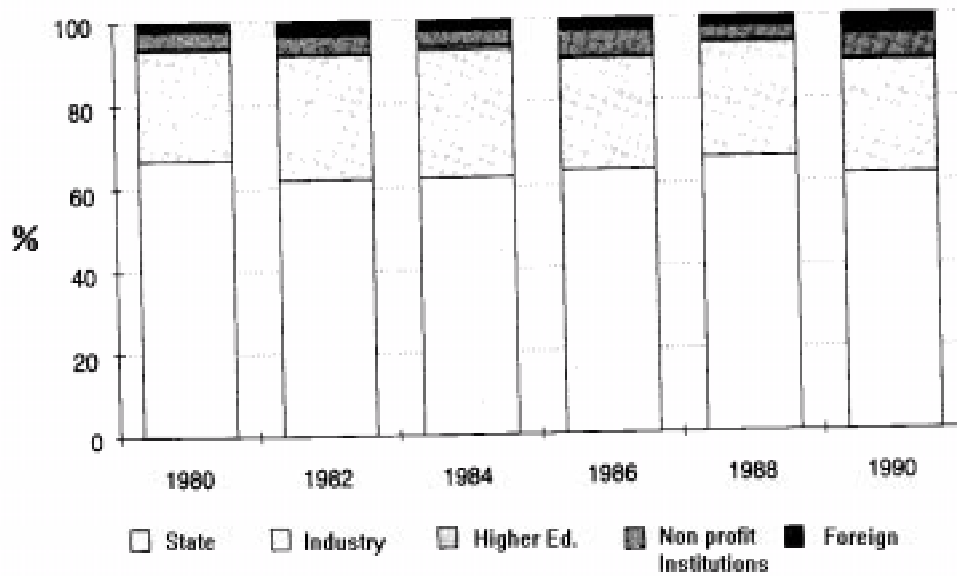
Figure 6. Growth rate (%) in R&D execution, 1980-90



Source: Author.

Figure 7 shows the proportion of R&D financing by the state, industry, the universities, the non-profit institutions and foreign funds, in the 1980s.

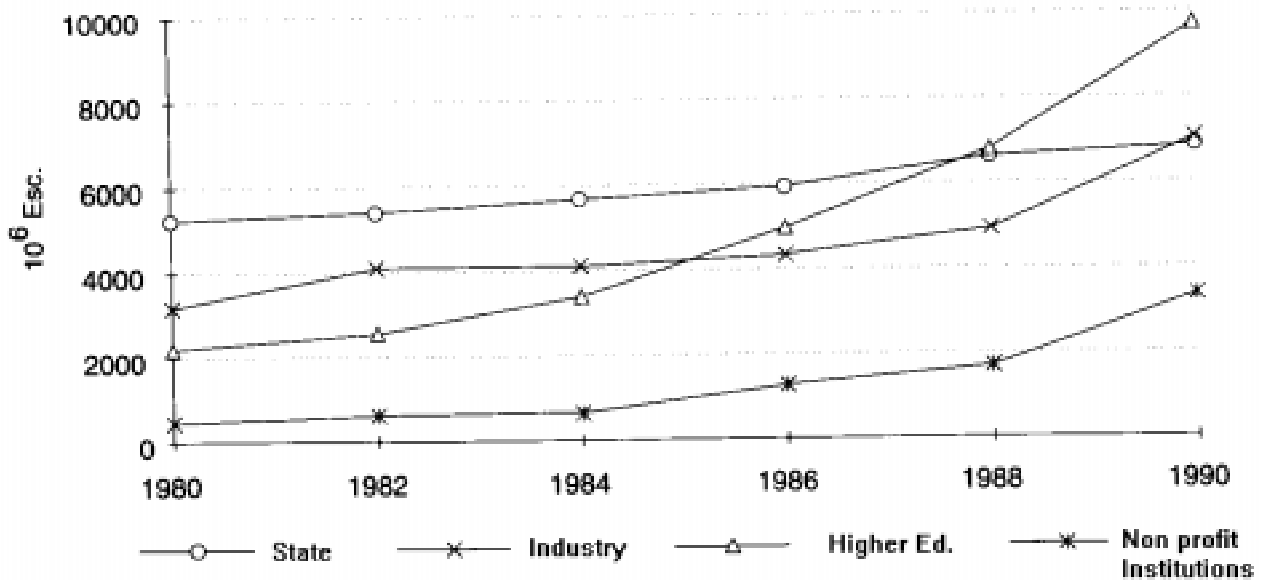
Figure 7. R&D funding (%), 1980-90



Source: Author.

Figure 8 shows the evolution of the total expenditure in R&D, from 1980 to 1990.

Figure 8. Evolution of R&D expenditure, 1980-90



Source: Author.

### 3. Universities' budgets

#### 3.1 General budget

Table 2 shows the evolution of universities' budgets from 1993 to 1996.

**Table 2. Evolution of the general budget**  
(1993/1996)

10 million Esc			
1993	1994	1995	1996
67 008.5	71 321.2	82 819.8	89 228.2

Source: *Evolução entre 1990 e 1996*, Departamento do Ensino Superior, 1996, mimeo.

#### 3.2 R&D budget

Table 3 shows the evolution of R&D university budget from 1992 to 1994.

**Table 3. R&D university budget in 1992, 1993 and 1994**

10 million Esc		
1992	1993	1994
12 000	15 300	22 594

Source: *Ciência e Tecnologia 1993/94*, Secretaria de Estado da Ciência e Tecnologia, Lisboa, 1995.

### 4. Knowledge transfer policies

Source: *Livro Verde da Cooperação Ensino Superior-Empresa*, (Green book on the co-operation Higher Education-Industry), Conselho para a Cooperação Ensino Superior (CESE)-Empresa, Lisboa, 1994.

In 1989 the Council for the Co-operation between Higher Education/Industry (CESE) was created by the Portuguese government (Cabinet Resolution 2-A/89, 31.1.89). Its main functions were the planning of national co-operation policies (universities/other research and technological development institutions/banks), to promote co-operation activities, and to centralise the information on the COMMETT Programme.

Recognised major advantages of co-operation were: the collection and updating of information, the research/innovation policies, knowledge transfer and training. Main technological areas identified were energy, telecommunications, food industries, ocean resources, forest resources, and civil engineering.

Electronics and materials, automation and industrial production, quality testing of products and chemistry and biotechnology, are indicated as the most promising sectors as far as university/industry co-operation is concerned. In terms of concentration of human and technological resources, the universities seem to be best equipped in information technologies, chemical technology, and materials technology.

Organisations and human resources, initial and advance training, research and development of technological infrastructures, and international mobility (the training in new technologies and their applications of professionals from both university and industry sectors in EU and EFTA countries in the framework of COMMETT) were singled out by CESE as the main bases to promote co-operation activities.

## **5. International co-operation in S&T training**

*Source: Ciência e Tecnologia 1993/94, Secretaria de Estado da Ciência e Tecnologia, Lisboa, 1995.*

A large number of scientific co-operation agreements involving mobility exist between Portuguese universities and universities all over the world, and play a major role in international co-operation in S&T academic training. The bilateral agreements are signed by the rectors and administered internally, as universities are autonomous; national figures therefore are not available.

Measures concerning advanced training (Ph.D., M.A./M.Sc.) in S&T were included in the European programmes CIENCIA (1989-93) and PRAXIS XXI (1994-99). Under CIENCIA, 1 840 grants have been awarded in priority fields (information and telecommunications / production and energy / new materials / health / agriculture / biotechnology and chemistry / oceanography) and 1 376 grants in exact sciences and engineering, earth and environment sciences, economics and management. Under PRAXIS XXI, 1 707 grants were awarded in 1994.

JNICT, under the PFMRH programme to promote international mobility of young scientists, graduates and post-docs, awarded 590 grants for studies in Portugal and abroad, in 1993 and 1994. In 1994, JNICT also funded 181 missions of foreign scientists in Portugal.

Cultural agreements, bilateral JNICT/foreign R&D institutions agreements, and multilateral co-operation agreements are also intended to foster international mobility in S&T. Portugal has cultural agreements with an S&T impact with most European countries, Latin America, African countries, Mexico, India and China. Under JNICT/R&D institutions agreements (Europe, United States, Latin America) 513 missions were funded in 1993, 551 in 1994 and 125 in the first semester 1995. Insofar as multilateral co-operation is concerned, 236 grants were awarded by OTAN between March 1993 and June 1995, and in 1995 Portugal participated in 53 COST actions and 14 EUREKA Projects.

In 1995/96, 185 foreign graduates were studying in public universities in Portugal.

European mobility programmes such as ERASMUS and TEMPUS played an important role in international exchanges through the years: student mobility (undergraduates, graduates), teaching staff mobility and fellowships, and teaching and research partnerships.

## SPAIN

*Prepared by the Ministry of Education and Culture*

### 1. Broad policy and budget trends

During the past two decades, Spain has undertaken a major legislative and budget effort, in order to stimulate the science and technology system (S&T), and hence, increase its production standards. Although this policy has yielded qualitatively and quantitatively valuable results, the size of the S&T fund remains far lower than the OECD average.

Due to historic circumstances, Spain was long kept out of the socio-economic development undertaken by the other countries of Western Europe after the Second World War. Such an isolation had effects not only on the delay of its socio-economic development, but also on its universities, which were also isolated and devoid of any support to carry out qualified scientific activity. The little research performed in the University in those times was due to vocation and personal effort of a group of excellent professors. Thus, when the country started to develop in the early 60s, neither the political power nor the directors of the big firms, worried about the importance of the S&T system for an economically and culturally balanced development of the country. So, apart from tourism and traditional industries, investments were mainly devoted to buying patents proved elsewhere, while little attention was paid to creative or innovative technological activities.

This situation, however, changed over the following years, first slowly and then quickly in the 80s, when a vigorous policy oriented to increase the S&T system was put into place. Important reforms were approved and allocations to higher education were increased, shaping a scientific policy that could be characterised by the following actions and results:

- Organic Act on university reform (LRU);
- reform of the third cycle (Doctorate) studies;
- design and development of the First National Plan of Research and Development (*Planes Nacionales de I+D*), comprising priority programmes and budget forecasts for a period of three years (currently up to the third R&T plan);
- establishment of the National Agency for the evaluation of S&T programmes and resources;
- increase of funds devoted to research and technological development programmes;
- programmes for training of future researchers, through pre- and post-doctoral fellowships;
- increased exchanges between Spanish and foreign researchers, through mobility programmes;
- increased co-operation between public research institutions with private enterprises.

**Table 1. Evolution of the indicators of the Spanish S&T system**

Indicators	1987	1993
R&D expenditure (millions Ptas)	230 509	552 010
GDP share (%)	0.64	0.92
R&D expenditure per inhabitant (US\$)	58.5	116.8
R&D staff (total)	48 100	74 100
Ratio/thousand active population	3.3	4.8

Source: Author.

**Table 2. Results of Spanish S&T production for the period 1987-1993**

Overall results	1987	1993
Scientific production	8 816	15 250
% of world-wide production	1.22	2.02
% of EU production	4.2	6.3
Patents	23 539	50 265

Source: Author.

**Table 3. Some 1993 Spanish R&D indicators in the international context**

Indicators	Spain	EU	OECD
GDP share expenditure	0.92	1.97	2.2
R&D staff/active population	4.8	9.3	..
Researchers/active population	2.8	4.4	5.4
R&D expenditure per inhabitant (US\$)	116.8	335.8	396.7

Source: Author.

All this led to a general and rapid increase of the budget allocations to science and technology, the extension of a research-favourable atmosphere in universities, and an overall increase of the S&T system production. In 1993 (once the First National R&D three-year plan was concluded), Spain spent Ptas 552 000 million in S&T, which represented a GDP share of 0.92 per cent. Six years ago, expenditure in S&T represented a GDP share of 0.64 per cent. As well, S&T staff had increased from 48 100 to 74 100, which represented a variation of 3.3 to 4.8 per thousand active population. Finally, the expenditure in S&T per inhabitant increased from US\$ 58.5 in 1987 to US\$ 116.8 in 1993. This effort yielded excellent results (Table 2): Spanish scientific production represented 6.3 per cent of the EU overall production, and 2.2 per cent of the world-wide production. Technological results also notably improved, although in a more modest way: applications for patents abroad were 2.8 per cent of the EU and 0.6 per cent of the OECD totals.

In spite of this effort and the good results, indicators of Spanish S&T expenditure and production are still modest when compared to the EU average. (Tables 2-3). In 1993, EU countries averaged a GDP share of 1.97 per cent, a S&T staff *ratio* of 9.3 people per thousand active population, and US\$ 335.8 of S&T expenditure per inhabitant. EU and OECD scientific production and, especially, technological results were higher. These data recommend maintaining a steady policy of increasing investment in S&T. The economic recession of the early 90s and the budget constraints due to Maastricht convergency have obliged to slow down this trend, but this is conjectural, and a reactivation of this policy is beginning to take place.

An important aspect of the S&T development in Spain is the unbalanced effort made by the public and the private sectors. In 1993, Spanish enterprises allocated 42 per cent of funds and spent 48.7 per cent of the expenditure in S&T. In the EU, enterprises allocated an overall 53 per cent of the S&T funds and spent

63 per cent. This confirms the little inclination of the Spanish private sector to invest in technological innovation. Nowadays, there are high technology industries in Spain, especially in the fields of computing, pharmaceutical laboratories, machinery and motor vehicles, and telecommunications. However, most of these industries are subsidiaries of multinational enterprises, whose innovative activities have been traditionally located in more developed countries. In recent years, both the central and regional governments have developed policies intended to involve the private sector in S&T activities. The establishment of technological parks (e.g. in Madrid), and the programmes to transfer research results, and co-operation, between public research centres and private enterprises, are changing the situation.

## 2. Higher education

Higher education is mainly provided by universities, which are mostly public run and funded. In recent years, a number of private universities have been established, but their role in the educational system is still modest. The Spanish university system comprises 56 universities, of which 46 are state-funded and ten are private institutions. With the establishment of 14 new public and 6 private universities in the last 15 years, the system has experienced a great increase of potential offer.

Until 1983, the Spanish higher education system was strongly centralised and closely dependent on the Ministry of Education (MEC). After the adoption of the Organic Act on University Reform (LRU), the universities became autonomous institutions, organically dependent on the regional governments. Autonomy means that they are vested with powers to draw up their respective by-law or basic standards, including the rules of procedure regarding administrative and financial procedures as well as education personnel management, relations and co-operation with other universities and institutions.

The rector is the highest authority of the university, whose administration and governance runs at three levels: the university itself, university establishments (e.g. faculties or schools) and departments. Foremost among the university bodies is the *social council (consejo social)*, the body through which society participates in university affairs, and which is in charge of approving budgets and supervising both financial operations and service performance; the *university assembly (claustrum universitario)*, a body where the different parts of the university community are represented, and whose task is to draw up the by-laws, to elect the rector and to approve the university's overall line of action; the *governing board (junta de gobierno)*, the university's ordinary governing body, whose functions include development of assembly's guidelines, academic and personnel standards, proposals for budgets and programmes, co-operation with national and international institutions, etc. The rector is assisted by a manager, a general secretary and several vice-rectors.

In each university establishment, specific administrative tasks are undertaken by the establishment's collegiate body (*Junta de Facultad o Escuela*) and the individual officers: the dean or director (assisted by vice-dean or vice-directors), the secretary and the establishment manager. The departments are the basic units in charge of organising and implementing research and teaching activities relative to their respective disciplines. Their governing bodies also comprise collegiate organisations, the *department councils*, and the individual officers, the directors, who are each assisted by a vice-director and a secretary. Planning, co-ordination and supervision of the whole university system is carried out by the *universities council (Consejo de Universidades)*, an advisory and executive body, which is formed by the rectors of public universities and the regional education authorities and is headed by the Minister of Education.

**Table 4. Total number of teaching staff and profile of public university professors for the academic year 1991-92**

Fields	All. universities	Private	Public total	% women	% permanent
Humanities	9 067	532	8 535	38	63
Social & law sciences	20 143	1 085	19 058	35	34
Experimental sciences	7 701	115	7 586	32	94
Health sciences	15 488	920	14 568	34	26
Engineering & technical sciences	15 169	720	14 449	17	29
Total	67 841	3 645	64 196	31	42

Source: Author.

There are two categories of university employees: the teaching staff composed of professors, and the administrative and service staff. Administrative personnel are responsible for the bureaucratic and managerial affairs, while the technicians are responsible of technical matters and assist with research and teaching. All professors of public universities are state employees and are grouped into two categories: *principal university professors (catedrático)*, the highest category, with a higher salary and access to all managerial posts; *tenured university professors (profesores titulares de universidad)*, with a lower salary and access to all managerial posts, though access to the rectorship is reserved for exceptional circumstances. As well as teaching, all of them should have research activities.

School professors have similar names and categories, although with different salaries and duties. Among these categories of permanent professors, there is an important number of non-permanents – lecturers, visiting professors and assistants who have temporary contracts. They take part in teaching and research activities, but cannot hold managerial posts. As an example of the university professor profile, data from the academic year 1991-92 (Table 4) show that Spanish universities had a total of 67 841 professors (*sensu amplo*), of which 64 196 belonged to the public universities, and 3 645 to the private ones. Health, social and law sciences had the highest figures of professors and a low *ratio* of permanent professors (34 and 26 per cent). Conversely, experimental sciences and humanities had the lowest figures and a high *ratio* of permanent professors (94 per cent in experimental sciences).

These data illustrate a situation characteristic of the current Spanish universities, where a strong increase of student enrolments in some careers has led to increased contracting of non-permanent professors. Table 5 summarises the evolution of the number of students and professors during the last 15 years, and it may be observed that the number of students increased 2.3 times; in order to keep similar ratios of students/professors, the teaching staff has also increased, mostly through temporary contracts. These non-permanent professors earn lower salaries and their precarious situation is one of the present problems of the Spanish university system.

As for the presence of women in the university teaching staff, figures indicate an average of 31 per cent, which increases in health (34 per cent), social and law sciences (35 per cent) and reaches a peak (38 per cent) in humanities. On the other hand, the presence of women in engineering and technical studies is very low (17 per cent). Higher education is organised around cycles with specific educational objectives and autonomous academic accreditations. According to this organisational model, higher education may be broken down as follows:

- First cycle education: studies taking three years, after which a junior graduate, technical engineer or technical architect diploma is awarded.

- Dual cycle studies (without intermediate degree): studies taking four or five years, organised into a first cycle of two or three years and a second one of two years. Upon completion, a bachelor's (*licenciado*), architect's or engineer's degree, is awarded. Some courses include the possibility of earning an intermediate degree after the first cycle.
- Second cycle education: two-year courses allowing students who have completed the first cycle of another degree to earn a bachelor's, engineer's or architect's degree (see Table 5); certain specific first cycle studies or degrees are requisite to admission.
- Third cycle education: studies reserved for university graduates (bachelors, engineers or architects); these are two-year courses organised around seminars, intended for specialisation in a scientific, technical or artistic field, as well as for research training. In order to earn the doctor's degree, students have to pass the cycle courses and submit and defend a doctoral thesis on an original subject and research. The process of obtaining the PhD covers a maximum period of five years.

In addition to these official degrees, universities, through their autonomy, may deliver other kinds of education and award the corresponding *diplomas* or *certificates* (*titulos propios*).

In order to guarantee minimum standards of quality and to facilitate the approval of official degrees delivered by the different universities, the government has regulated not only the kind of training, but also the *curriculum* to be followed to earn an official diploma or degree. This comprises *trunk subject areas* (requisite to each degree at nation-wide level), *subject areas defined by each university* (some requisite, others optional), *subject areas that students may choose freely* among the whole range of branches given at the university. Since 1990, university education is the subject of a large reform, including the establishment of new degrees and the adoption of curricula from previous ones. A part of this reform is the incorporation of the *credit* (*equivalent to ten hours of classroom attendance*) as a tool for evaluating the students' performance.

**Table 5. Evolution of numbers of students and professors in state universities for the last 15 years**

	81-82	86-87	91-92	96-97
Professors	41 577	46 705	67 841	71 174
Students	669 848	871 822	1 168 738	1 478 279
Ratio student/professor	16.11	18.66	17.22	20.76

Source: Author.

**Table 6. Distribution profile of students in different fields and cycles, in academic year 1996-97**

Field	All cycles	%	Long total	Cycle %	Short total	Cycle %
Humanities	155 735	10.0	152 336	15.0	3 399	0.7
Social and law	800 381	51.6	528 647	51.8	271 734	51.8
Experimental science	129 122	8.3	123 465	12.1	5 657	1.0
Health science	110 447	7.1	69 671	6.8	40 776	7.8
Engineering & technical science	348 477	22.4	145 625	14.3	202 852	38.7
TOTAL	1 551 969	100	1 019 744	100	524 418	100

Source: Author.

In the 1996-97 academic year, Spanish universities had a total of 1 551 969 students in first and second cycles, of which 1 478 279 studied in public universities, and 73 690 studied in private ones. Women represented somewhat more than 53 per cent, and foreign students less than 1 per cent. The age segment most represented was that comprised between 18 and 24 years (1 159 926), while those 25 years and over represented a minority (392 043).

In long-cycle education (Table 6), social and law social sciences and technical studies were the most in demand (51.6 per cent and 22.4 per cent), whereas health and experimental sciences showed a lesser demand (7.1 per cent and 8.3 per cent). In short-cycle education, a similar situation occurs and the most relevant facts are the major increase of technical studies demanded (38 per cent) and the drastic fall in experimental sciences (1 per cent) and humanities (0.7 per cent).

As for the third cycle, 56 700 students were enrolled in doctorate studies in the academic year 1996-97, of which 54 976 studied in public universities, and 1 784 studied in private ones. The *ratio* men/women in doctorate studies was around 50 per cent.

### 3. University funding

Most of the financial resources (75 per cent) of public universities come from state funding, either directly from the central government or through regional government budgets. The remaining 25 per cent corresponds to student fees and private or semi-private enterprise funding. In the period 1987-93, university expenditure increased 2.5 times (Table 7), ranging from a GDP share of 0.65 per cent to 0.98 per cent. While the public funding increased in parallel 2.8 times, and grew from a GDP share of 0.47 per cent to 0.78 per cent, private expenditure increased 1.8 times, growing from a GDP share of 0.17 per cent to 0.19 per cent. Thus, state funding remains the main support of university finances.

State funding is executed in two ways: base-funding and grant-funding. The former is proportional to student numbers, staff and activity size, and is devoted to staff salaries as well as running expenses. The second is a percentage (10-15 per cent) of research grants or contracts of their researchers. Although most universities have a single budget, grant-based incomes are preferably devoted to cover costs of scientific infrastructure and maintenance, e.g. buying books and scientific newspapers, large scientific apparatus for common use, computer networks, etc.), as well as to pay travel grants for participation in congresses abroad, and fellowships for third cycle studies.

**Table 7. Evolution of private and public expenditure (research included) in public universities (billions Ptas)**

Year	All		Public		Private	
	Total	GDP %	Total	GDP %	Total	GDP%
1987	234.7	0.65	171.6	0.47	63.1	0.17
1989	346.0	0.77	269.4	0.60	76.6	0.17
1991	490.1	0.89	398.8	0.73	91.3	0.17
1993	593.8	0.98	476.5	0.78	117.3	0.19

Source: Author.

Most of the research carried out in the country is undertaken in universities. So, research funding is one of the capital questions when dealing with university financing. In 1993, Ptas 4 180 094 000 were allocated to 465 university research projects, which represents an average of Ptas 8 989 445 per project; Ptas 4 174 484 000 went to public universities, whereas Ptas 5 610 000 million corresponded to private establishments (only one project). Distribution of these grants is made in accordance with the priority

programmes established by the government through the National R&D Plan, and on the basis of the scientific quality of the proposals and research teams. So, universities with more active and talented teams have more grant-based income. Nevertheless, this part of university incomes is still low and should be increased in the future, since it precisely benefits those more competitive and qualitatively outstanding universities.

#### 4. Science and technology profile

The Spanish research and development system consists of three networks: universities, public research establishments and enterprises.

##### *Universities*

Higher education institutions are the main research centres. In the period 1992-1995, 64 per cent of the research projects were developed in universities, representing 64 per cent of the total national expenditure for R&D.

**Research and teaching balance.** As stated in the introduction of the Act on university reform, the university has three basic functions: 1) contribution to scientific development; 2) professional training and 3) culture promotion and extension. Achievement of these functions is based on a balanced research and teaching activity. Based on the assumption that these activities are mutually reinforcing, Spanish professors are both teachers and researchers. In the last decade, possibly due to the need to stimulate research, there has been a trend to underestimate teaching in favour of scientific merits, especially in promotion contests. However, everybody agrees that the more the teaching and research excellence of a professor is balanced, the better the professor.

In fact, a professor's salary includes a separate bonus for teaching and research productivity. Every five years, after the acquisition of the status of permanent professor, the teaching is evaluated, and in the case of a favourable evaluation, the salary is increased by adding a complement for teaching productivity. In addition, scientific production is evaluated every six years by a national committee, and a favourable result implies the assignment of a research productivity complement. The scientific evaluation is voluntary, although a large number of members of the university community think that it should be obligatory and relate to shorter periods.

**Basic and applied research.** One of the topics subject to discussion when defining a research policy is the distinction between basic and applied research. Conceptually, the border between them is not always clear, since what seems to be basic today may be applied tomorrow or give rise to applied research lines (e.g. molecular biology, superconductivity physics, etc.). Assuming that the difference lies in the immediate availability or not of the practical use of results, it could be said that most of the research carried out in Spanish universities is basic. This is concordant with the academic nature of these institutions and with the traditionally little interest of enterprises for research. Until now, the Spanish Government has well supported this situation, since most of the university research funding has been devoted to basic research.

Among other programmes, basic research has been funded through a specific programme, the *programme for knowledge promotion*, which is playing a leading role in the improvement of national research standards. Besides funding scientific projects, this programme includes expenses for scientific infrastructure, personnel training and mobility, integrated actions with other countries, etc. In 1995, the

total appropriations for this programme were Ptas 9 238.2 million. While the private sector does not generously implicate itself in research, the university expects the government to go on with basic research funding.

Basic research funding does not imply applied research oblivion. In recent years, within the objectives of the second and third S&T National Plans, both the central and regional governments have devoted important allocations to applied research, with a view to increase technology standards, and encouraging co-operation between enterprises and public research institutions. In 1995, the expenditure for technological research projects was Ptas 57 896.5 million, of which Ptas 21 955.4 million were provided by the state.

### *Other public research institutions*

Outside universities, the **Superior Council for Scientific Research (CSIC)** is the major public research institution. It comprises numerous institutes embracing almost all knowledge fields, focused either on basic or applied research. Some of them, e.g. the Centre of Molecular Biology in Madrid, are very famous for their scientific excellence. In the period 1992-1995, CSIC institutes contributed to the national R&D programmes with 22 per cent of the projects, and obtained grants equivalent to 25 per cent of the total expenditure in research grants.

Besides the CSIC, which depends on the Ministry of Education (MEC), there are other public research institutions supported and run by the different ministries. These institutions combine an advisory and service function with research. In some cases, this combination of two very different functions leads to ambiguous functioning and to doubtful scientific or technological profitability.

Universities hold good relations with all of them, especially with the CSIC institutes. These relations involve co-operation in teaching and research activities. Although CSIC staff is entirely devoted to research, some qualified researchers are invited to co-operate voluntarily in doctorate courses or seminars. Also, joint research teams are frequently formed between university and CSIC researchers. Some universities have CSIC institutes on their campus, e.g. the Autonomous University of Madrid with four institutes (Centre of Molecular Biology, National Centre of Biotechnology, Catalysis Institute, Institute of Materials Physics), and this physical proximity provides for mutually beneficial co-operation.

### *Enterprises*

Traditionally, enterprises have not been very concerned with research. In 1987, in Spain there were 1 140 enterprises involved in innovative research, and their expenditures in these activities represented a GDP share of 0.35 per cent. Six years later, the number of enterprises had increased to 1 874, and the GDP share expenditure to 0.43 per cent. Most of the R&D funds were own funds (Table 8), while more than 10 per cent came from state funding. In the period 1987-1993, both own and state funds declined, while those corresponding to EU programmes increased.

**Table 8. Evolution of fund origin for R&D expenditure in Spanish enterprises  
(expressed in percentage of the total expenditure )**

Fund origin	1987	1993
Own funds	80.8	76.1
From Public funding	13.7	10.7
From other enterprises and institutions	3.1	4.1
From abroad (EU programme)	2.4	9.1

Source: Author.

**Table 9. Evolution of enterprises' R&D effort according to firm size  
(% effort is the % of total R&D enterprise expenditure)**

Size	1987 number	% effort	1993 number	% effort
Less than 100 workers	532	16.1	1 089	18.6
100-499	393	23.4	558	23.6
500-999	91	10.4	115	14.8
More than 1 000	124	50.1	112	43
TOTAL	1 140	100	1 874	100

Source: Author.

As for the possible influence of the firm size on the R&D effort (Table 9), data for the period 1992-1995 are relevant: the number of small firms (less than 100 workers) increased notably, but their overall effort did so in a modest way (from 16 per cent to 18 per cent of the total expenditure); the two categories of median enterprises increased in absolute terms but their effort remained more or less similar, while the number of large enterprises declined, as well as their overall effort. However, the large enterprises support more than 40 per cent of the total private expenditure in science and technology.

### ***Relations between public and private sectors***

A balanced R&D effort of both the public and private sectors is essential for a correct development of the S&T system of a country. For this, enterprises have to spend generously in innovative research and involve the public research centres; in turn, these have to be open to enterprises and the policy rectors have to encourage the interaction between both sectors.

Significant progress has been made in recent years in Spain, where interaction between public research institutions and enterprises has been traditionally poor. Co-ordination bodies like the *University-Enterprise Foundation (Fundación Universidad-Empresa)*, comprising representatives of the regional research authorities, the universities and enterprises, have been extensively established. Besides holding data bases of potential customers, they organise meetings of both sectors and facilitate the contact between them.

Most universities have non-profitmaking foundations, whose role is the management of all the affairs concerning relations with enterprises. As part of these foundations, the *offices for transference of research results (OTRI/O-TT)* play a major role, since they serve as information bridges between research centres and enterprises and give legal support to the researchers in contract signing and management. In 1995, these offices managed Ptas 35 147.9 million, corresponding to 20 090 contracts. Compared to the whole national expenditure in R&D, this amount is still modest, but headed in the right direction. In fact, the current National R&D Plan includes a specific programme aimed at enhancing all the existing

procedures in order to increase and make more profitable the interaction between the worlds of research and enterprise.

## 5. Changes and challenges

Compared to 20 years ago, the present Spanish university sector is far better. However, the historical delay with respect to other advanced countries, future European integration and the technological changes oblige it to evaluate the situation and adapt to new times. Such changes affect all the aspects of the university sector, especially the following ones:

- **Management:** the University Reform Act defined a suitable and satisfactory frame for the management of universities. Nonetheless, the size of some public universities (21 universities have more than 30 000 students, among them six with more than 50 000 and two with more than 100 000 students) make a major decentralisation into smaller units, easier to manage, advisable. At present, the government is revising the University Reform Act.
- **Funding:** public universities are state funded. This status must continue since there is a general agreement that it is the only way to guarantee the same chance to all citizens. However, teaching and research resources are still insufficient and more investments have to be made in order to maintain and improve the quality of research and teaching.
- **Teaching career:** besides defining the types of professor, the University Reform Act made recommendations on the necessary increase of university staff for the coming years. In addition to the partial non-compliance with these recommendations, the dramatic increase of student enrolments in recent years obliged to engage a significant number of non-permanent teaching staff (with temporary contracts), currently with low salaries and subject to precarious professional conditions. Solving this problem is one of the greatest challenges to the Spanish universities. This will surely imply a redefinition of the teaching career model.
- **Degree reform:** one of the major changes underway in Spanish universities is the degree reform, including embodiment of new degrees and curricula modification of the existing ones. The process has been developed during the last seven years and is reaching completion. However, most of the early changes need revision and readapting, to take into account corrections suggested by experience.

In recent years, some universities and institutions have established postgraduate courses (the so-called *masters*), focused on fields with a relatively high job offer, such as business, marketing and publicity, environmental impact, mostly with the objective of earning money, and sometimes without suitable control. One way of arranging this situation would be a reform of the third cycle, so that it includes both postgraduate training for high professional specialisation, and research training via doctoral thesis.

- **Research:** the National R&D Plans are very useful tools for a fruitful and well organised scientific policy. However, science funding had slowed down in the 1993-96 period and is now approaching the 1992 level. Maintaining and increasing science funding is a great challenge, as is the preservation of the balance between basic and applied research. Major involvement of enterprises in S&T funding will help to lighten the weight of S&T on the state budget, but it should never replace it.

- **Science diffusion:** apart from data or events directly concerning human or social progress (e.g. advances in health sciences, electronics, climatology, anthropology and a few others), scientific results and progress are generally absent from mass media. This leads to a popular lack of interest for scientific matters, which does not concord with the huge amount of budget allocations to science, and does not contribute to a sufficient understanding of the importance of science for the cultural and economic development of the country. Scientists, mass media and policy rectors are challenged to change this situation.

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## SWEDEN

*Prepared by E. Forsse, Delegate to the Group on the Science System (1996)*

Swedish higher education is characterised by its uniformity, joining within one and the same system both traditionally academic and non-academic education and training. A number of different institutions are included in this system – from large universities to small colleges – and they are dispersed over the whole of Sweden.

Undergraduate education and training is the same all over the country as far as degrees and other framework regulations are concerned. The system permits variations in terms of locally or individually designed courses or programmes. The permanent resources for research and postgraduate training, however, have until now been concentrated in the universities and some specialised colleges, such as the technical institutes in Stockholm and Göteborg.

Since the beginning of the 1960s there has been a difference in the functions of various academic posts. Professional chairs are focused on research. University lecturers have teaching as their main function. Teaching is also carried out by PhD students.

The colleges without faculty grants are permitted to employ a professor after a quality assessment has been undertaken by the National Agency for Higher Education. All colleges in Sweden will be given permanent resources for research as of 1997 if Parliament accepts the proposal in the Government's latest Budget Bill. Some of them will – if Parliament permits – be able to call themselves universities before the year 2000.

The Government has appointed a Commissioner to elaborate a new teaching and research structure, where the differences in functions and responsibilities between professors and lecturers are to be abolished or at least considerably diminished. The relationship between teaching and research should also be diminished in other ways, for example by using more research-like methods in undergraduate teaching. Such a development is already taking place, not at the traditional universities but rather at the newer colleges, which have concentrated their research on specific subject areas and where interaction with business, industry and other parts of society is often well developed.

### **I. Evolution of the university research budget**

In Sweden, most publicly-funded research is performed at universities and colleges. Universities and colleges account for nearly 90 per cent of all publicly-funded research when research for defence purposes is excluded. This is true for both basic and most of the so-called sectoral research (mission-oriented research). Public research funds are provided for by the approval in Parliament of the Government's budget proposal and are allocated both as untied resources for basic operations of faculties and via a large number of expert bodies such as research councils and sectoral agencies.

According to a recent review of Swedish research funding the total volume of research in Sweden has been increasing steadily within universities but especially within business and industry. The proportion of external funding (on average 45 per cent in 1994/95) of university research is increasing, mainly as a result of more non-government funding. This fact has raised some concern about the independence of universities, but has not yet triggered any measures from the Government other than a statement in the 1997-99 Research Bill that universities should avoid interaction on conditions which may interfere with their main tasks of education and research.

### ***Evolution of non-government funding both for research and education***

Non-government funding accounts for most of the increase both of total R&D and of university research funding. Industry may not fund regular undergraduate training programmes in Sweden, but does however purchase in-service training from universities. An important new development is industry's involvement in graduate schools, although this is still limited.

### ***Changes observed in the balance between training and research***

According to Statistics Sweden, university research has increased on average by about 5 per cent during the first half of the 1990s (counted on a per-year basis). The number of students in undergraduate training has increased by more than 40 per cent during the same period. Government funds for research and funds for undergraduate training are independently allocated to universities. According to the review of Swedish research funding, resources for university research have increased by about 12 per cent (real terms) between 1989/90 and 1994/95, including both direct government funding and external sources.

### ***Broad policy and budget trends affecting university***

Research and training are important as part of overall policy to promote economic development and fight unemployment. The expansion of undergraduate training is especially targeted to colleges, to stimulate regional development, and to science and technology programmes. The rapid expansion of undergraduate programmes obviously raises concerns as to the quality of undergraduate training. Therefore, elaborate programmes for quality assessment are being developed at universities and colleges. Both research and higher education have been relatively protected against budget cuts, despite the general budgetary constraints. Now a point has been reached, however, when all sectors of society have to contribute. Reforms have to be funded by reallocation within the sector, to a large extent.

## **II. Existing and or planned knowledge transfer mechanisms**

A number of more institutional forms of interaction between universities and colleges, and business and industry have been developed since the beginning of the 1970s. Among these are science parks, liaison offices, technology bridge foundations to support patenting etc., facilitate industry's access to sources of information within universities, develop co-operative industry-university research and encourage interaction between SMEs in common projects. Material consortias and competence centres, the latter with active involvement by industry, are two structures for interdisciplinary research of industrial relevance. Some of these programmes are fairly recent and will run to the year 2000 or later. A number of reviews have been carried out to evaluate the different models of interaction.

*Relative success of policies and mechanisms*

It is difficult to quickly assess and present the different models. According to a recent review (NYFOR, SOU 1996:70), many different forms for interaction between universities and the business sector exist. Lack of funding is a common problem and some forms of interaction were recently established and therefore cannot yet be evaluated. A general judgement is that temporary (five to ten years) concentration of financial and human resources in a university environment, focusing on a particular area of industrial relevance and with a strong involvement from industry (50 per cent), seems promising. A factor of decisive importance is that both models facilitate movement of students and researchers between university and industry and vice versa.

*Policies to promote knowledge transfer*

The Swedish government puts strong emphasis on knowledge transfer in the Research Bill for 1997-99. Changes to the legislation governing universities are proposed in order to clarify the role of universities in the transfer process. Traditionally, the main tasks of universities have been education and research. Universities have also been expected to provide information about their research activities. According to the Bill, the interaction between universities and society must develop beyond a one-way information flow. A third main task of universities shall, according to the Government's proposal, be to interact more closely with society. Universities must assume greater responsibilities as mediator of knowledge and at the same time acquire experience and research projects from society. Education and research must develop in response to this interaction while the freedom of research is maintained. Small and medium-sized enterprises located in the region are important counterparts. Inversely, society (business and industry, governmental and non-governmental organisations, and the public) must learn to use universities and seek information about recent developments within education and research.

A specific form of knowledge transfer is the commercialisation of research results and innovations. According to the Research Bill, universities shall give advice to scientists in this process, e.g. concerning patent applications. The individual researcher keeps the rights to his/her research results. The relationship between the researcher and the university shall be negotiated and regulated in a contract between the two parties. The universities shall negotiate fair compensation for public resources spent on innovations. An obligation for the researcher to inform the employer (university) about patentable innovations should be included in the contract.

**III. Relationships between national university research systems and other public research systems, policies and schemes to improve the effectiveness of those relationships – relative success of those policies and schemes**

As mentioned earlier, most of the publicly-funded research in Sweden is carried out at universities and colleges. There is, however, a system of so-called Industry (Branch) Research Institutes which receive 40 per cent of their basic funding from the Government and the rest from industry. This system has undergone review by a Commission which also had a mandate to negotiate restructuring and strengthening of the institutes. The final report from the Commission was due in November 1996. An interim report contained some preliminary proposals; a programme of industrial graduate studentships and post-docs, new models for funding of the institutes, and a special programme for SMEs.

#### **IV. Mobility**

Several reviews of the Swedish university system have pointed to the fact that geographic mobility of university teachers is very low. A review of the Swedish academic career structure is now under way. Mobility of university teachers is an important issue for this Commission. A final report with proposals was due in December 1996.

##### ***Schemes to promote mobility***

The Swedish research councils, academies and various research foundations have post-doc scholarship programmes, primarily for international mobility (about 380 scholarships in 1994/95 including the Swedish Institute). An increase is expected as a consequence of political decisions and, for example, research co-operation within the EU (TMR).

The question of mobility between universities and the public/private sector is receiving increased attention. Interdisciplinary graduate schools and industrial postdoc grants are fairly recent measures to promote this kind of mobility.

##### ***Barriers to mobility***

###### ***Family, local recruitment policies***

Estimates of numbers of graduate students and post-docs from each country who study/work in another country (OECD and non-OECD).

We have detailed data on undergraduate students, but nothing comprehensive so far on graduates or PhDs. It is generally less common (and there is less financial support) for doctoral students to spend a period abroad than it is for PhDs.

Data on education of foreign students in each member/observer country (OECD and non-OECD)

According to Statistics Sweden, about 17 per cent of PhD students had foreign citizenship (data from the autumn of 1993). Thirty-two per cent of these were women. The proportion of foreign doctoral students was less than 14 per cent in 1998 and about 10 per cent in 1978.

Most (about 46 per cent) of foreign doctoral students came from a European country. Nearly 29 per cent of foreign doctoral students came from Asia. The largest proportion of foreign PhD students at Swedish universities and colleges in the autumn of 1993 came from the People's Republic of China (19 per cent as compared to 1 per cent of Chinese students in undergraduate programmes). The opposite is true for citizens of Iran; 3 per cent in doctoral studies and 14 per cent in undergraduate programmes.

According to a report from the Foundation for International Co-operation in Research and Higher Education there were some 650 grants for visiting scientists in Sweden in 1994/95 (about 350 non-targeted and about 300 bilateral grants). A report from the Swedish Natural Science Research Council accounts for their visiting scientists programme from 1990 to 1993. A majority of visiting scientists came from the United States. The number of visitors from Central and Eastern Europe was larger than from Western Europe. Only 3 per cent of the visiting scientists were women. Nearly 50 per cent stayed for less than four months while about 20 per cent stayed for almost a year.

## SWITZERLAND

*Prepared by R. Forclaz, Delegate to the Group on the Science System*

### 1. The Swiss university system: trends and prospects

Higher education in Switzerland is characterised by a federal and decentralised structure; because of the cantons' autonomy in the field of education, they are responsible for higher education institutions (universities and *hautes écoles*), except for the Federal Institutes of Technology of Lausanne and Zurich. Since the University Support Act (LAU) of 1969, the Confederation has contributed to funding the operating and development costs of cantonal universities, but its role has essentially been limited to a subsidiary one of providing funds. The LAU is based on the principle of "co-operative federalism" and university policy is the joint responsibility of the Confederation and those cantons that have universities. However, given the magnitude of the funds provided since the end of the 1960s, this federal assistance to universities is an important aspect of Swiss science policy. The University Support Act does not simply regulate funding; it also contains provisions on the co-ordination and organisation of universities that make it possible to implement a nation-wide university policy based on the principles of co-operative federalism. Furthermore, it enables the Confederation to make special grants to achieve university objectives of national scope, such as developing data processing and engineering sciences and promoting continuing education, student mobility in Switzerland and Europe and the renewal of university staff. In this way, the Confederation can provide funding for a limited period for projects that meet pressing nation-wide needs.

One of the objectives of the Confederation's science policy during the 1996-1999 period is to ensure that **the funds provided are used more productively**. The federal education authorities attach great importance to implementing an effective system of evaluating university education and research and to improving current funding mechanisms. The Confederation is currently preparing a reform in this field aimed at ensuring that funding is better adapted to current and future needs. The main shortcoming of the current system is its excessive rigidity, which provides little incentive to undertake reform. In order to ensure that education better meets society's needs, grants would not be based just on universities' expenditure, but would also take into account the results achieved ("output"); the criteria for making grants would be based primarily on the relationship between the "input" (the funds provided) and the "output" (the results achieved). In addition, funding of universities must be made more transparent by earmarking grants more specifically to certain objectives. In particular, the share of grants devoted to implementing the major projects of Swiss university policy (for example, renewal of teaching and research staff, the allocation of tasks and co-ordination among universities and the creation of electronic data transmission networks) is likely to be increased. The planned amendment of the University Support Act will make this legislation a more effective university policy tool.

**The strengthening of Switzerland's position in university research and education** is another objective of the Confederation's science policy for the 1996-1999 period. The steps taken in this area include setting priority topics through "targeted" resource allocation in the framework of priority programmes and

national research programmes, promotion of interdisciplinary co-operation, a better allocation of tasks among universities and a strengthening of co-operation between university research and private research.

With the coming of “globalisation”, universities will be required to develop in new ways and rise to new challenges (greater openness to the outside world, increased co-operation with business and industry and a more interdisciplinary approach). But they will only be able to meet these challenges if they are given greater scope for action, increased powers and fuller responsibility for carrying out their tasks; they should have greater **autonomy**, including in the financial sphere. The new legislation on universities being prepared in most of the cantons with universities is in fact designed to give them greater autonomy.

The creation of **specialised higher schools** (*hautes écoles spécialisées*, HES) marks the beginning of a fundamental reform in university policy; following approval by Parliament of the Specialised Higher School Act and the order governing the creation and management of HES, the first ones were due to open in the autumn of 1997. From now on a “bipolar” higher education system will be promoted, which will embrace both universities (including Federal Institutes of Technology) and specialised *hautes écoles*. Unlike universities, the HES will focus teaching and research on occupational practice and the use of scientific methodologies; these schools will provide highly specialised training that is directly oriented towards specific occupations and meets the increasingly high standards required. With these “vocational universities”, Switzerland should be able to reduce the shortage of graduates whom the economy badly needs.

As the federal advisory body for all science policy issues, the Swiss Science Council is responsible for laying down the **broad policies for the development of universities**, taking into account research policy objectives. In the report it prepared for 1996-1999, it mentioned the most urgent needs, priorities and requirements of a co-ordinated university policy. It recommends in-depth reforms of higher education and in particular supports the more rapid development of specialised *hautes écoles*. The Science Council believes that it is necessary for the Confederation and the cantons to develop jointly an overall plan for the allocation of tasks among universities and specialised *hautes écoles* in the field of education, research and development and knowledge transfer. It recommends making universities more effective teaching and research institutions, and giving them a higher profile as “research universities”; it also proposes some guidelines for the action of the Confederation, such as promoting an allocation of tasks and specialisation among universities that would foster competition between universities, and applying a new concept of the link between federal funding and incentives to research, since funding should increasingly promote project-based research.

## 2. The mission of universities and budget trends: the position of research

At the threshold of the third millennium, the university’s mission of education through teaching and research has lost none of its relevance; the linkage of teaching and research and the dialogue between the sciences are the guiding ideas of the modern university. In future universities will play a major role as **science communication and research centres**. The quality of universities will largely be determined by their ability to open up rapidly to new research fields. Given the levelling off of the funds available, these new fields will have to be developed, if necessary at the expense of current research fields. Thus, universities will face new challenges of co-operation and interdisciplinarity, and in particular they must become more actively involved with the economic and social world around them. The **promotion of economic and social innovation** is another of their tasks; by training managers and researchers, universities increase a country’s capacity to generate social innovations and to maintain its economic competitiveness. The economy’s capacity for innovation is largely the result of the knowledge produced

by both free and targeted research, to which universities and specialised *hautes écoles* make a major contribution.

As a rule, there is no special budget for research within university budgets, and it is not possible to provide accurate data on the current trends of appropriations for research in universities. It can merely be said that the observation made in 1989, at the time of the OECD review of science and technology policy in Switzerland, remains valid: funds for research are levelling off and even declining in real terms. A significant share of research is carried out in universities and specialised *hautes écoles* (including the research institutes attached to Federal Institutes of Technology); according to the most recent available statistics, which date from 1992, the share of university research in overall research expenditure is 25 per cent (SF 2.27 billion out of a total SF 9.09 billion). Of this amount, approximately 55 per cent (SF 1.240 billion) is provided by the Confederation, while the cantons' share is 37 per cent (SF 840 million); the remainder (roughly SF 200 million) comes from various sources (non-profit organisations, universities' own funds, the private sector). Two-thirds of the funds provided by the Confederation are for applied research and targeted research (subsidies granted by the Commission for Technology and Innovation, research contracts from the federal government, European research programmes), while the remainder is devoted to basic research: subsidies from the National Scientific Research Fund (approximately SF 250 million) and aid to universities under the University Support Act (the share devoted to research is estimated at SF 130 million). Figures breaking down research expenditure by type of research (basic or targeted research) are not available. Although the federal government influences the kinds of topics selected for university research in the case of targeted research – a sector in which the topics or fields of research are laid down by the government or Parliament – the same is not true of free research; because of the autonomy of universities, university research is not directly influenced by the Confederation. It exercises its influence indirectly through the National Scientific Research Fund (FNRS) via the research projects it supports; under the Research Act, the FNRS is required to promote research that is in line with the government's research policy objectives and to monitor the execution and results of the research it funds, in particular by evaluating their scientific impact.

It should be pointed out that the Swiss Science Council plays an important role in the field of research policy. Firstly, in accordance with its terms of reference, it makes proposals for the Confederation's research policy objectives. Next, through its FER programme (Advance Warning in Research Policy), the Science Council identifies promising areas for research and the economic and social problems that research should help to solve. Lastly, its evaluations have called attention to certain gaps in university research, in particular in the social sciences. The Science Council therefore recommended developing research and promoting renewal of research staff, which led to the launching of a priority programme in the social sciences ("Switzerland Tomorrow") for the 1996-1999 period, which is intended in particular to promote research in the social sciences with practical applications.

The Confederation's aid to cantonal universities amounts to approximately 15 per cent of operating expenditure and ranges between 35 and 60 per cent of investment. Federal subsidies – and consequently the Confederation's support for university research – will not change in real terms during 1996-1999; there is a similar levelling off of FNRS grants. As a rule, the contributions provided by third parties, in particular by the private sector, only account for a small part of universities' resources (5-10 per cent), but efforts are being made to increase them. Despite these unfavourable economic circumstances, the cantons with universities are nevertheless making major efforts to continue to maintain the same funding levels as previously.

At a time of budget restrictions, the constant increase in the number of students is the main problem facing Swiss specialised *hautes écoles*, which must ensure a high quality education for a continually increasing

number of students. Despite the levelling off and even the decline of the funds available for research, **maintaining the quality of university research** is one of the challenges that specialised *hautes écoles* must face over the coming years. Not only does research play an important role in ensuring the quality of teaching, but it should also be able to contribute to strengthening Switzerland's position as an industrial and economic power. As soon as the Research Act entered into force in 1984, the Federal Council asked those responsible for higher education policy in the cantons to give greater consideration to research in university planning and to focus research more directly on the needs of the economy, society and government. This recommendation was taken into account in university planning for 1996-1999. The Swiss University Conference, which is responsible for planning, admittedly refuses to divert an additional share of federal aid to research and is opposed to universities becoming "research universities", as the Science Council proposes. However, the multi-annual plan for Swiss universities and specialised *hautes écoles* for 1996-1999 does place considerable importance on research and stresses the co-ordination and allocation of tasks between specialised *hautes écoles* through "networking" and the pooling of resources. Although basic research is of primary importance to universities, they are also concerned to make available their experience and research staff potential to solve social and economic problems. It is for this reason that the multi-annual plan defines a number of interdisciplinary topics (approximately 15), most of which involve research and call for a co-ordinated approach as projects of nation-wide scope. What is more, universities are interested in their staff having full access to European research programmes; all Swiss universities and specialised *hautes écoles* currently have a "Euro info centre", which is an information centre for all questions involving European programmes. However, the University Conference is opposed to the federal authorities' position in this regard, since it argues that the Swiss financial contribution to European research and education programmes should not lead to a reduction either in grants to universities or in grants by the National Fund to support basic research; participation in international programmes cannot, in its view, produce satisfactory results unless Swiss universities first have well-trained researchers and adequate infrastructure.

### 3. Promotion of knowledge transfer

Technology transfer is a research and technology policy objective that the Confederation pursues mainly by promoting targeted and applied research, primarily through bodies such as the Commission for Technology and Innovation (CTI), the action programmes of the Federal Office for Current Economic Issues, national research programmes and priority research programmes. The **Commission for Technology and Innovation** (formerly the CERS) is the key actor in the Confederation's technology transfer policy and promotes applied research aimed at producing results that will be of direct use to industry. The CTI primarily supports joint research projects between private firms and non-profit research institutions (universities, engineering schools, etc.); industrial partners generally cover half of project costs and the CTI makes federal grants to the non-profit research centres. Among the "**action programmes**" of the Federal Office for Current Economic Issues, we can mention the CIM programmes in integrated computerised manufacturing and MICROSWISS in microelectronics; these programmes have made it possible to create CIM regional "competence centres" and a "national knowledge network" for microelectronics designed to meet the needs of industry, including a number of MICROSWISS centres. These centres were set up jointly with engineering schools and the research institutes of universities and industries. Both action programmes are aimed at promoting research projects carried out by "competence centres" and partner institutions; priority is given to projects undertaken in co-operation with commercial and industrial firms. Lastly, **national research programmes** and **priority programmes** are the two main vehicles for promoting multidisciplinary projects oriented towards technological and socio-economic issues. The national research programmes call on the research potential of specialised *hautes écoles* and non-university research centres to help solve problems of national importance; given

the goals of these programmes, researchers work in close co-operation with practitioners. As for the priority programmes, their purpose is to encourage “targeted” research in fields of strategic importance to the economy and society, as well as helping to create “competence centres” in specialised *hautes écoles*; one of its major objectives is to promote collaboration between research in universities and in the private sector.

As a rule, universities are trying to develop their relations with business and industry and to work more closely with the private sector. A series of measures to strengthen their ties with the private sector have been adopted and implemented to varying degrees, such as setting up “contact bodies” for technology transfer, promoting mobility of researchers and creating joint posts in specialised *hautes écoles* and firms, developing contractual research (joint financing by industry of research in specialised *hautes écoles*) and promoting the creation of technology parks. Universities have become much more aware of the important regional role they play in promoting a dynamic economic environment in the broad sense. In recent years, cantonal universities and Federal Institutes of Technology have created various structures that act as liaison bodies with the private sector. Their ultimate aim is to develop research by providing information, identifying potential partners and promoting co-operation and support for initiatives (setting up partnerships, drawing up contracts, advising on patents and intellectual property rights, etc.). These structures have been developed in particular in Federal Institutes of Technology (the Scientific and Technological Support Centre at the Federal Institute of Lausanne and the Centre for the Support and Application of Research at the Federal Institute of Zurich). In addition, the special measures taken by the Confederation to promote continuing education, and participation in the European Union’s COMETT Programme, have made it possible to develop relations between the university and the private sector, and University-Enterprise Associations for Training (AUEF) have been created for this purpose. The future specialised *hautes écoles* will have a strong practical orientation and will emphasize co-operation with industry and business, as well as knowledge transfer.

Improving co-operation and knowledge transfer between the specialised *hautes écoles* and industry is also a matter of concern to research policy bodies. As part of its FER programme, the Science Council has launched an initiative aimed at studying the integration of research, science and training in the socio-economic system. Furthermore, in 1994 the Science and Research Group created, in co-operation with the *Fondation Latsis Internationale*, a government/university/industry “think tank” to provide a forum for ongoing dialogue among researchers, engineers, scientists, academics and science policy officials. As the body responsible for overall strategic thinking, the Science Council plays a decisive role in this forum. The annual meetings, known as “Bavois Seminars”, have addressed in particular the issue of strengthening co-operation between specialised *hautes écoles* and firms. Initial concrete results have been achieved and it has been possible to promote active co-operation between two spheres that had been separate until now; for example, certain ideas suggested at these seminars were taken into account to restructure knowledge and technology transfer at the University of Basle.

#### **4. Relations between the university research system and other public research systems**

Unlike some OECD Member countries, Switzerland has little public sector R&D capacity outside its universities. The Confederation has created its own research centres for agriculture, national defence and sports. There are also a number of non-university research centres in specific fields such as biology, medicine, education, etc. (for example, the Swiss Institute for Experimental Cancer Research, the Swiss Institute for the Tropics, the Swiss Institute for Allergy and Asthma Research and the French-speaking Institute for Pedagogical Research and Documentation). Four establishments connected with Federal Institutes of Technology which have a specific mission in fields such as materials, forestry, snow, the countryside and water planning, purification and protection, should also be mentioned; the most

important one, the Paul Scherrer Institute, is a multidisciplinary national research establishment in natural sciences and engineering. These research laboratories specialise in fields in which the Confederation has special responsibilities, such as energy and the environment; since they are attached to Federal Institutes of Technology, they are under the supervision of the Council of the Federal Institutes and cannot be considered extra-university research institutes in the strict sense. Consequently, there is no general policy governing the relationship between university research and public-sector research outside the university, but only individual arrangements in specific fields.

## 5. Student mobility

There have been major efforts in Switzerland to promote mobility of students and researchers, at both national and international levels. Mobility of university students is currently quite high and is promoted through three policies: 1) encouraging mobility inside Switzerland; 2) encouraging student exchanges in Europe based on the European Union's ERASMUS Programme; 3) developing student exchanges through bilateral co-operation schemes (co-operation and exchange agreements with selected universities, mainly in the United States, countries of Central and Eastern Europe and Asia). In addition, the FNRS has entered into a number of co-operation agreements with foreign institutions that provide for exchanges of researchers.

A **federal programme to promote mobility**, set up in 1991 and covering a four-year period (1992-1995), launched initiatives aimed at facilitating student mobility. For example, the "mobility centres" funded by the Confederation help students with the formalities involved in transferring temporarily from one specialised *haute école* to another, and give advice and information. A number of national agreements governing each subject matter provide for mutual recognition of studies, and "mobility grants" to students have eliminated, at least in part, obstacles of a financial nature. These opportunities to study in other schools have been perceived as being highly positive, especially when they are in different linguistic regions, and contribute significantly to fostering a better understanding among linguistic communities.

**Switzerland's participation in the European Union's ERASMUS Programme** enables Swiss students to study in a university of an EU Member country, and these studies are recognised upon the student's return to Switzerland. There are also reciprocal arrangements, since there are grants which enable students from an EU member country to study in Swiss universities or specialised *hautes écoles*. ERASMUS having been replaced by the SOCRATES programme, co-operation between Switzerland and the EU expired at the end of the 1995/96 academic year. Pending Switzerland's full participation in EU education programmes once bilateral agreements have been signed, the Confederation has adopted temporary measures providing funding for student exchanges between Switzerland and the EU member countries. These experiments have been highly positive: since the 1992/93 academic year, the number of students participating in these exchanges has grown regularly (cf. Tables 1 and 2). The countries chosen by most Swiss students (nearly two-thirds) are France, Germany and Great Britain; the largest number of students who come to Switzerland are from Germany, Italy and France.

**Table 1. Swiss participation in the ERASMUS Programme**

1992/93	1993/94	1994/95	1995/96	1996/97
353	677	727	1212	1228

Source: Author.

**Table 2. ERASMUS students in Switzerland**

1994/95	1995/96	1996/97
688	924	1122

Source: Author.

Looking at the total number of Swiss students studying abroad and of foreign students enrolled in Swiss specialised *hautes écoles*, it is difficult to draw relevant conclusions regarding mobility since a number of Swiss students study abroad either for reasons of convenience or because they were born abroad. According to the estimates of the Federal Office of Statistics, this is the case of roughly one-third of Swiss students abroad; of the 7 000 Swiss students studying in foreign universities (the vast majority in OECD Member countries, with nearly one-fourth in the United States), slightly more than 4 500 can thus be considered truly mobile. Moreover, it is not possible to distinguish between the different levels of study (undergraduate, doctoral or post-doctoral), for data on this subject are not available. The same holds true of foreign students: the proportion of foreign students enrolled in Swiss specialised *hautes écoles* was approximately 20 per cent in the winter semester of 1995/1996 (17 517 out of a total of 88 243). Of this figure, approximately one-fifth (approximately 3 200 students) were already living in Switzerland before beginning their university studies (i.e. foreigners born in Switzerland, refugees, etc.) and do not qualify as “mobile” students. As for their countries of origin, although few Swiss students study in non-OECD countries, nearly one-fifth of the foreign students in Switzerland (slightly over 3 100 students in the winter semester of 1995/96) do not come from an OECD Member country.

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## UNITED STATES

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### **Preface**

The Group on the Science System (GSS) of the Organisation for Economic Co-operation and Development (OECD) has undertaken a cross-national study on the changing character of research in the systems of higher education of the OECD countries. The study was initiated in response to a request by the OECD Ministers of Science at their 26-27 September 1995 meeting “to reassess the role of universities and the balance between their traditional knowledge production (research) and knowledge-transmission (training) functions, and the relatively novel knowledge-transfer function.” They made this request while reaffirming “the central importance of national science systems to the knowledge-based economies of all OECD countries,” and recognising that universities comprise the core of national science systems in most countries. Ministers also took note of the increasing international character of science systems resulting from factors such as international mobility of scientists and the emerging importance of information technologies.

The OECD study, tentatively entitled *Science and Higher Education: University Research in Transition*, will be based on papers submitted by GSS Delegates containing information on academic research in their respective countries. The sections which follow represent the contribution of the US Delegation to the study. They were organised according to an outline agreed on by GSS members:

1. Research in the national higher education system.
2. Policy and budget trends.
3. Universities and knowledge transfer.
4. Parallel, non-academic national research systems.
5. International mobility.

This paper is not meant to be an exhaustive treatment of research in the US higher education system. Nor is it an authoritative statement of the US government. Rather, the principal objective is to provide non-US readers with an introduction to our academic research system and to place that system in the context of the broader US system of higher education. However, the paper may also be of some interest to US readers. For that reason, comments and criticisms would be welcomed.

### **I. Overview**

#### ***Do the 1990s mark an era of transition for US universities?***

Undoubtedly, since it is unlikely that there have been many decades since the founding of Harvard College in 1636 that would not have been characterised by at least some contemporaries as times of

transition – if not crisis – for higher education in the United States. More recently, in the late 1960s and early 1970s, many of the country's institutions of higher education, including its principal research universities, were buffeted by vehement student protests about the alleged complicity of university research in the war in Vietnam. Concurrently, President Lyndon Johnson presided over the beginning of a reduction in federal research support to universities because of the open opposition of many academic scientists and engineers to provide sufficiently vocal support for his Vietnam policy. Yet by the end of the 1970s, both crises had passed. Student hostility had largely evaporated, and federal research support was increasing.

More benignly but more unsettling for the long-term, beginning in the 1970s employment opportunities in the academic sector began to exhibit signs of constraints in some fields of science, leading to concerns about whether the research-centred PhD offered by leading universities was adequate to the demands of the country's expanding knowledge-based economy. These concerns have not diminished.

*Is the character of the end-of-the-millennium transition for academic research in the United States fundamentally different from previous transitions?*

Perhaps, since there are indications that the character of the entire US research enterprise may be changing. For almost a half century, universities have been regarded as the core of whatever research system may be said to exist in the United States. What is unique about the current transitions is that universities could be in danger of losing the financial and human resources they require to continue to occupy that core position.

Viewed in the context of both the total US research enterprise and the overall US system of higher education, the role played by academic research appears at first glance as relatively minor. For example:

- the academic sector ranks as a distant second behind the industrial sector, and only slightly ahead of the government sector, in terms of research performance;
- the overwhelming majority of research performed in the academic sector is accounted for by approximately 220 institutions, or 6 per cent of the approximately 3 600 institutions that comprise the US system of higher education; and
- research at these 220 institutions accounts for less than 20 per cent of their total expenditures, which in 1995 were estimated to have been approximately US\$ 74 billion.

Despite these data, US research universities have come to be recognised as essential to both the total US research enterprise and the US economy more broadly. They have retained their position at the core of the research system both because they are the only institutions capable of conducting sustained, long-term research, and because they have been able to link performance of research with advanced training for scientists and engineers.

Support from the federal government remains critical to the ability of US universities to perform research and provide advanced training in science and engineering; likewise, the federal government continues to emphasize support for research universities as an essential component of its science policy. For example *Science in the National Interest*, a 1994 policy document which appeared under the signatures of President Clinton and Vice President Gore, refers to research universities as “the heartland of fundamental science and engineering research and advanced education.” This privileged status, as has frequently been noted, is a direct result of post World War II policies that provided substantial federal support for

scientific research and education (primarily graduate education) to research universities, consistent with Vannevar Bush's 1945 dictum that:

*"The simplest and most effective way in which the Government can strengthen industrial research is to support basic research and to develop scientific talent."*

(SEF, p. 21)

Phrases such as the "university-industry partnership" or the "science-government contract" are repeatedly invoked to describe the strong dependence of research universities on federal research support and, reciprocally, the dependence of several federal agencies on universities as justification for their claims as major participants in the US research enterprise. Private industry, too, has recognised the essential contribution of the academic sector to the US research enterprise. For the past two decades, its financial investments in university research have grown more rapidly than those of the federal government. More recently, as industry has focused increasingly on short-term, applied research in its own laboratories, industrial leaders have become among the strongest advocates for sustained federal support for research in universities. Yet, tangible support from both government and industry has been levelling off.

Regardless of the character or outcome of the current transition, it cannot be characterised as an unanticipated crisis. On the contrary, it is the result of a number of converging trends that have been evident for some time. A December 1992 report of the President's Council of Advisors on Science and Technology (PCAST) entitled, *Renewing the Promise: Research-Intensive Universities and the Nation*, rehearsed a litany of problems, as follows:

*"The relationship between the American public and institutions of higher learning is showing serious signs of stress. Despite their success, universities are losing public confidence. The many partners in the overall enterprise – students and parents, the federal and state governments, foundations and industry, and faculty and scientific communities – increasingly are expressing discontent with the enterprise's current state and direction."*

(PCAST, p. xi)

The body of the PCAST report contains substantial anecdotal information in support of these contentions, in addition to recommendations to government, academia, and industry aimed at rectifying some of these problems so that the "promise" might be renewed. In particular, the report urged research universities themselves to "adapt quickly and responsibly to a constrained resource environment."

*"So that research-intensive universities may continue to function productively in an environment of limited resources, PCAST urges them to adopt more highly selective strategies based on a realistic appraisal of the future availability of resources and a commitment to meet world class standards in all programs that are undertaken."*

*Such strategies would include, elimination or downsizing of some departments and specialties within departments rather than sustaining less than world-class activities in every area of science and engineering."*

(PCAST, pp. 11-12)

Many of the trends noted in the PCAST report have persisted and even intensified, as documented in the body of this paper. The more important include these:

- recognition that since basic research – the mainstay of the research performed in universities – does not automatically translate into socio-economic benefits, the post-World War II focus on universities as the principal instrument to carry out federal science policies is probably inadequate;
- continued public questioning about the uniformly beneficent character of science and technology;
- realisation that federal support for academic research will remain inadequate to fund even a sizeable fraction of research opportunities;
- limitations in the availability of industrial support, particularly for long term research;
- competition for public and private funds from other parts of the higher education system;
- rising costs of undergraduate tuition, from which research universities derive an increasing fraction of their operating expenses;
- perceptions that the quality of university instruction, particularly undergraduate instruction, may be suffering because of too strong a faculty emphasis on research;
- persistence of a steady-state job market for PhD scientists, a factor that may be limiting the number of US students seeking advanced degrees in some science and engineering fields;
- concerns that the research-based PhD degree offered by many universities may comprise too narrow a preparation for scientists on the threshold of the 21st century; and, of course
- the much discussed end of the Cold War and the subsequent quest for a non-defence rationale for science policy.

Although US universities may not be in a state of crisis, there are legitimate grounds for concern about the continued vitality of the academic research sector. Realistic projections indicate that the budgets of the principal federal agencies that support university research are likely to be highly constrained, at least during the next five years. Industrial contributions are unlikely to rise substantially, and the costs of tuition even at many public universities have become so high that further substantial increases that might permit universities to invest more of their own resources in research are also unlikely. Additionally, in the absence of a significant expansion in the employment market for PhD scientists, the proportion of US students who elect to pursue graduate study in many fields of science and engineering is unlikely to increase. In view of the essential role they play in the US academic research enterprise, insufficient numbers of graduate students would constitute a resource constraint on the ability of universities to conduct research almost as significant as direct financial resource constraints.

Although the US academic research sector faces serious problems, the fact that none are of particularly recent origin suggests that most universities should be able to deal with them, while considering necessary adjustments in the ways they fulfil their research (knowledge production), teaching (knowledge transmission) and knowledge-transfer functions. Indeed, many are already doing so by downsizing or merging academic departments, actively seeking patents and royalties on discoveries made by their

faculties, encouraging research faculty to teach more undergraduate courses, and broadening and otherwise modifying the character of the PhD degrees they offer.

But whereas many, perhaps most individual universities and the US system of research universities as a whole will no doubt weather the current transition as well as those that are almost certain to follow in the next century, there remains a real danger that the academic sector itself could become marginalised. While federal investments in research and development (R&D) have been levelling off and will probably decline during the next five years at least in inflation-adjusted terms, industrial investments are continuing to rise, although not at the rate that many critics regard as desirable. A substantial share of federal R&D has been devoted to academic research. In contrast, industry invests a negligible amount for that purpose. Moreover, the character of industrial research has changed considerably. As recently as a decade ago, several large US firms performed long-term, basic research in their own laboratories. Today, virtually all industrial research is targeted toward specific short-term ends. Thus, academic research has become even more unique and essential at the same time that it is experiencing both financial and human resource constraints.

What would be the consequences, for the US economy, of a research system dominated by the short-term needs of industry, with the supply of long-term basic research results and well-trained people envisioned half a century ago as the vital core of the enterprise continuing to shrink? In other words, what would be the consequences of a marginalisation of the academic sector?

These questions have yet to be adequately addressed.

## II. Research in the US higher education system

### A. *Status of the system*

Although the term “US higher education system” is used throughout this paper as a convenient shorthand, it qualifies as a serious contradiction since it obscures the fact that there *is* no national system of higher education in the United States. Rather, there are a large number of colleges, universities, and specialised schools supported and governed by a variety of private organisations and state and local governments. Among the 3 611 US institutions that were designated as institutions of higher education in 1993 by the Carnegie Foundation for the Advancement of Teaching<sup>8</sup>, 2 045 are supported primarily from private sources, while 1 566 are publicly supported, deriving a substantial fraction of their operating revenues from state and local governments (*S&EI 96*, Chapter 2<sup>9</sup>). State government appropriations for higher education in 1994 amounted to US\$ 42.9 billion (*III*); no comparable figures are available for total support from private sources or from local governments.

Two points need to be emphasized from the outset in any consideration of research in the US higher education system:

**First**, although the federal government provides substantial support to the science and engineering research and related training functions of many US universities, in **no** case does it provide direct operational support to any institution of higher education.

**Second**, as detailed presently, the large majority of the science and engineering research is performed in only 200 or so US universities; by far the largest fraction of the expenditures of even these universities are for purposes other than research.

The US higher education system is remarkable in its diversity. The approximately 3 600 institutions which comprise this system include two-year colleges offering the associate degree in a variety of technical subjects, four-year baccalaureate degree granting institutions – or colleges – which provide instruction to undergraduate students, and universities which award the masters and doctoral degrees in addition to the four-year undergraduate or baccalaureate degree. Also included among these 3 600 institutions are a range of specialised schools such as medical colleges and law schools, schools of business and management, schools of art and music, and bible colleges. Some of these specialised schools are components of comprehensive university systems; others are self contained, free standing entities.

While admission to the baccalaureate programmes of perhaps 100 or so elite colleges and universities is highly competitive, the US higher education system as a whole has a non-elite, almost populist character. In 1993, its 3 600 institutions enrolled a total of 14.7 million students, more than double the number enrolled in 1967. The system touches a sizeable fraction of the US public who either attend or have attended one of these institutions, as well as the families who support students enrolled in these institutions. Indeed, participation in higher education has come to be regarded as almost a right by many middle- and upper-income Americans, despite the expenses involved in financing an undergraduate education which, in 1996 were estimated to average over US\$ 18 000 annually at private institutions (US\$ 12 800 tuition and US\$ 5 400 living expenses) and over US\$ 7 000 annually at public institutions (US\$ 3 000 tuition and US\$ 4 200 living expenses). (*College Board*) Although substantial financial assistance is available in the form of government guaranteed loans and outright scholarship awards which are usually based on need, a significant fraction of undergraduate students and their families pay for all or most of their education.

A restricted subset of the 3 600 institutions of higher education in the United States account for the training of a large majority of scientists and engineers as well as for most of the science and engineering research performed in the US academic sector. Although in 1993 1 440 institutions awarded the baccalaureate degree in science and engineering, almost 60 per cent of the natural science baccalaureates and 80 per cent of the engineering baccalaureates were granted by the approximately 220 doctorate-granting universities which qualify as Research I or Research II institutions according to the Carnegie classification scheme. Among these universities, approximately one-third are privately supported and two-thirds are publicly supported. These 220 universities also account for well over 95 per cent of all PhDs awarded in the natural sciences and engineering. Not surprisingly, in view of the traditionally close coupling between academic research and training at the PhD level in the United States, they also accounted for over 95 per cent of the US\$ 19.5 billion expended for academic research and development (R&D) in 1993. Within this set of 220 universities, 100 account for the bulk of the PhDs awarded in science and engineering, and also for 80 per cent of total US academic R&D performance. (*S&EI 96*, Chapter 2).

Despite the heavy concentration of US academic research performance in approximately 220 universities, research accounted for only US\$ 11.9 billion, or 16.2 per cent of their approximately US\$ 74 billion expenditures in 1994, with the remainder apportioned among such categories as instruction, public service, scholarships and fellowships, and construction and maintenance of facilities. Of the US\$ 74 billion expended by these institutions, approximately US\$ 12 billion (16.2 per cent) came from federal sources and was devoted primarily to research and related purposes, US\$ 14.9 billion (20 per cent) came from state and local government appropriations, US\$ 7.1 billion (9.5 per cent) came from private sources, and US\$ 13.7 billion (18.5 per cent) from tuition and related fees. (*NCES*)

State and local government appropriations accounted for US\$ 14.2 billion or 30 per cent of the US\$ 46.9 billion in 1994 expenditures by the approximately 150 publicly supported universities in the

Carnegie Research I and II categories. This US\$ 14.2 billion represented only about one-third of the US\$ 42.9 billion appropriated for higher education by state governments during that year. (*III*)

Paradoxically, perhaps, the essentially non-elite character of the US higher education system may be one important reason why a small number of institutions have been able to maintain their decidedly elite status as research universities. Most US citizens regard education – meaning undergraduate education – as the principal function of the system so that the availability of undergraduate education in good institutions that are not among the elite research universities has no doubt reduced the pressure on those institutions to devote even greater resources to undergraduate instruction at the expense of research. On the other hand, mounting financial problems experienced by the system as a whole due to restricted state government appropriations, reductions in private support, and the unlikelihood that tuition costs can continue to rise as sharply as they have during the past few years, are likely to have an effect on the elite character of the research universities, over and above the effects of budgetary constraints on the individual universities themselves.

### ***B. Evolution of the system***

Two related characteristics of the US higher education system are worth reiterating: first, it is highly dispersed and decentralised; second, it is highly diverse and generally non-elitist. Both characteristics are the result of numerous, disconnected decisions and actions taken by private, often church-related organisations and, later, by state and local governments which began during the early colonial era, and accelerated after the United States became an independent nation following the Revolutionary War (1775-83). A few significant actions by the federal government, starting with the Civil War era (1861-65), have also been instrumental in shaping the character of the system. Despite the individualised character of these decisions and actions, most were driven by the ideal expressed by Thomas Jefferson in the late 18th century that the proper functioning of a democracy depends on well informed citizens.

Harvard College, the oldest institution of higher education in the country, was established in 1636 in Cambridge, Massachusetts, just seven years after the Massachusetts Bay Colony was chartered. William and Mary College in Williamsburg, Virginia, St. John's College in Annapolis, Maryland, and Yale College, in New Haven, Connecticut, were founded in 1660, 1696, and 1701, respectively. All of these institutions were established as four-year baccalaureate institutions offering instruction to an elite, restricted set of students in what then qualified as a somewhat standardized liberal arts curriculum, which included studies in classical languages, theology, mathematics, and some natural philosophy. At the time of the Declaration of Independence in 1776, there were approximately a dozen such institutions in the 13 English-speaking colonies on the Atlantic seaboard which in that year established a confederation known as the United States of America. Several of these institutions were destined to evolve into comprehensive universities and number themselves among the group of approximately 220 institutions which currently account for the bulk of the science and engineering research and graduate education carried out in the US academic system. Although many, including Harvard, Yale and Princeton, originally had close ties with specific Protestant sects, by 1776 most had become almost wholly secularised, although even today many continue to offer courses of study in theology.

From the first years of the United States as an independent nation, access to higher education in some form has been regarded by many citizens as integral to personal advancement and regional prosperity. In the last decade of the 18th and first decades of the 19th century, settlers began to move into the territories between the Atlantic seaboard and the Mississippi River which had been acquired from Great Britain as a result of the treaty of 1783 which ended the Revolutionary War. As the population density in these territories increased, they were organised into a number of new states, including Ohio, Wisconsin,

Indiana, Kentucky and Tennessee, for example. Colleges were established even prior to the organisation of these new states, frequently by religious organisations. Although modelled after the pre-Revolutionary colleges in the 13 colonies, they were modified to suit the differing character of the new territories. In particular, many were considerably less elitist, consistent with the fact that they were established by pioneers and sought to offer practical skills required in the new territories in preference to, or at any rate in addition to, the standardized liberal arts offerings. This pattern persisted with the acquisition (in 1803) and subsequent settlement of the Louisiana territory beyond the Mississippi River, and in the western territories extending to the Pacific Ocean that were acquired between 1803 and 1848.

Private organisations continued to be important in establishing and nurturing US colleges. However, with the westward expansion of the country, territorial and state governments began to play an important and ever increasing role, consistent with the conviction that access to higher education was in the public interest and should therefore be supported in part with public funds. Inevitably, the involvement of state governments led to the further popularisation of what had been, in the 17th and 18th centuries, a highly elite system. In 1820, for example, the State of Indiana established a college that was destined to evolve into the University of Indiana. Wisconsin followed suit in 1836. Public support for higher education, which began somewhat hesitantly and evolved slowly in the Middle Western states, was to become almost routine further west. Thus, for example, the University of Colorado was established in 1861, the same year that the Colorado Territory was organised and 15 years before that territory was admitted to the union as a state. Likewise, the University of California was established as a full-fledged university in 1868. Although state governments were dominant in the creation of higher education institutions in the far western states, private organisations and occasional individual philanthropists continued to pursue their own vision by founding new colleges. As a case in point Stanford University, which was established in Palo Alto, California, in 1885, was destined to become one of the leading 100 research universities in the country.

The first action of the federal government to have a significant impact on US higher education was the passage of the Morrill Act, which was signed into law in 1862 during the Civil War by President Abraham Lincoln. The Morrill Act transferred control of a portion of the federally owned land to the states in which it was located, on the condition that proceeds from its sale would be used to establish what came to be known as “land-grant” colleges of agriculture and mechanics. Many state “A&M” colleges were established as a result, most of which eventually expanded their curriculum and substituted the word “State” for “A&M” (e.g. Colorado State University in Ft. Collins, Colorado was originally established in 1870 as Colorado A&M, with the intention to provide what was deemed to be more practical instruction than what was offered at the University of Colorado at Boulder).

The Morrill Act was significant in articulating, in a new form, the vision that although higher education should be controlled and largely financed by state governments and private organisations, it should also be nurtured as a national enterprise. Notably, the vision was a highly applied one, with education in the practical pursuits of agriculture and mechanics emphasized. Two related actions taken during the Civil War articulated a related vision. The first was creation of the Department of Agriculture which, during the 1880s, began to apportion modest funds for agricultural research to state land-grant colleges. The second was the creation, in 1863, of the National Academy of Sciences on the initiative of a handful of individuals who regarded recognition of the importance of research as essential to the maturing nation.

Although the first PhD in the United States was awarded by Yale University in 1861, the transformation of a few of what were still largely four-year colleges into genuine research universities which offered training beyond the undergraduate level did not commence until the last quarter of the 19th century. Although based in part on European, particularly German models, US research universities developed their own unique characteristics – in part because many already had traditions more than a century old,

and in part because of the absence of any federal support which might have obliged them to develop in a similar manner. The Johns Hopkins University, founded in Baltimore, Maryland, in 1876, was the first institution established at the outset as a comprehensive university offering the PhD degree in several scientific fields and possessing facilities for advanced scientific research. At about the same time, several long established colleges throughout the country began to pursue research and offer advanced education in several fields, including science and, later, engineering. While a handful of private institutions with access to philanthropic funds led the way in transforming themselves into research universities, a number of state universities soon followed suit.

By World War I, the United States had perhaps a dozen universities where what could be regarded as world class research was being conducted. Although they offered PhD degrees in various scientific fields, until World War II it remained the case that, with some exceptions, advanced training and research experience in Europe was virtually a necessity for anyone aspiring to a career as a university scientist. The academic research enterprise continued to expand and prosper in the decade following the war as links with European institutions were strengthened. Despite setbacks during the years of the Great Depression, by 1939 academic science was poised to make major contributions to the pursuit of World War II.

According to a 1945 estimate, in 1939 there were approximately 125 US institutions of higher education where some research was conducted. Total expenditures for research at these institutions amounted to approximately US\$ 21.8 million. However, ten institutions among this group accounted for US\$ 9.3 million or 43 per cent of those expenditures, while 35 accounted for US\$ 16.6 million or 76 per cent. In 1939, the entire academic sector qualified as a bit player in terms of its research performance, with approximately US\$ 200 million worth of research performed in industrial laboratories, and a total of US\$ 65 million in laboratories supported by the federal government and all state governments combined. (*SEF*, p. 122) No comprehensive information is available about the character of the research conducted in US universities on the threshold of World War II. However, there is no doubt that a good deal of the research conducted at the leading institutions qualified as what is now called basic research. *None* of this basic research was funded by the federal government. Rather, it was supported by private philanthropic organisations, by state government appropriations and, to some extent, by private industry.

World War II marked the turning point for the US higher education system. Prior to that time, as already emphasized, the federal government provided virtually no support for university research or education. The only exceptions were the case of agricultural research for which some federal funds were apportioned to state land grant colleges, and instances in which a federal agency would contract for a special study or project, usually of a specific, applied nature, or retain the services of a university scientist as a consultant. This situation changed markedly after 1945. As a result of the wartime contributions made by university scientists, academic leaders were able to argue, successfully, that federal support for academic research in science and engineering, particularly basic research, was in the national interest. The most famous and articulate case for such federal support was made by Vannevar Bush, President Franklin D. Roosevelt's wartime science adviser, in *Science – the Endless Frontier*, which was transmitted to President Harry S. Truman in July 1945.

By the time the National Science Foundation was created by Act of Congress in May 1950, several federal agencies, most notably the Department of Defense, the Atomic Energy Commission (absorbed into the Department of Energy in 1977), and the National Institutes of Health, were already providing substantial support for academic research. The magnitude of that support continued to increase dramatically until the early 1970s. In the process, the US academic research enterprise moved from a position on the periphery of the US research system in 1939 to occupy the centre of that system. Although federal support became essential to the academic research system, the strength of the tradition that denied any role in higher

education to the federal government was such that research support was almost always provided on a project-by-project basis rather than by means of direct funding of academic institutions. With some exceptions, that mode of support persists today.

Another federal action in the immediate aftermath of World War II had unanticipated consequences for higher education which may have been of more fundamental importance than the availability of federal support for academic research. The GI Bill of Rights, enacted in 1946, provided numerous benefits to veterans of the war, including low-cost loans for home purchases and federally subsidised college expenses. One result was a rapid increase in undergraduate enrolments in both public and private colleges throughout the United States by veterans returning from service in the war. These increased enrolments led, in turn, to the creation of many new faculty positions in US universities which, coupled with the availability of federal funding for science and engineering research, provided the basis for the pre-eminence of the US academic research system.

A second, perhaps more fundamental and certainly longer lasting consequence of the GI Bill of Rights was to reinforce the non-elite character of US higher education which had resulted, in part, from earlier federal actions, including the Morrill Act of 1862. Because so many World War II veterans were given access to higher education, increasing numbers of US citizens came to regard access to higher education in some form almost as a right, albeit a right for which they and their families are often expected to make substantial financial contributions to exercise.

### **III. Policy and budget trends**

#### **A. *University research and federal science policy***

Beginning in the late 1940s and continuing, with occasional lapses, into the 1980s, support for academic research (including research in government laboratories managed by universities and consortia of universities) qualified as one of the principal foci of the US government's non-defence science policy, and an important component of defence science policy as well. Certainly support for academic research was - and remains - the most consistent and non-controversial component of the changing science policies of successive presidential administrations and, by 1980 if not earlier, had come to enjoy broad support across the political spectrum.

Academic research achieved this privileged status partly by default, since the US government, arguably, lacked any other broad, consistent non-defence science policy. This is not to say that support for academic research was ever the dominant component of the federal research budget. On the contrary, more substantial funds by far were appropriated over the years for specific missions such as nuclear reactor research, energy independence, and space exploration. Each of these missions was supported by a specific agency so that in an important sense much of federal science policy was in reality an amalgam of the programmes and policies of these agencies. On the other hand, university research and graduate education was supported not only by mission agencies such as the Atomic Energy Commission (and after 1977 the Department of Energy), the National Institutes of Health, and the Department of Defense, but also by the National Science Foundation which was explicitly chartered by Congress to support basic research in universities and other non-profit organisations. Additionally, with the notable exception of health-related research, enthusiasm for most agency-specific missions turned out to be relatively short lived. It is worth reiterating that a not insignificant fraction of the funds devoted to such missions went to support research in universities. In particular, for many, 30 per cent or more of successive federal budgets for health-related research has been expended in the form of project grants to medical schools, most of

them closely associated with major research universities. This situation still persists, as discussed in Section III D below.

Adoption by successive presidential administrations of what might be called a minimalist approach to science policy was no accident. Rather, it was consistent with the prevailing post-World War II US *laissez faire* economic philosophy that viewed any government interference with private industry – no matter how well intentioned – as anathema. Certainly any science policy that involved direct support for industrial research would have fallen into that forbidden category. By extension, federal interference in university governance – no matter how well intentioned – was also anathema. In 1945 Vannevar Bush articulated the implications of this perspective for US science policy:

*“The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research, and to aid in the development of scientific talent.”*

(SEF, p. 7)

Bush reasoned that if an adequate supply of basic research results continued to be forthcoming, then US industry would be able to exploit those results for its own benefit and that of the nation. According to this *laissez faire* view, scientists and scientists alone were capable of determining what lines of research to pursue, and how; industry and industry alone was capable of determining which basic research results should be exploited, and how. If so, the role of government should be restricted to providing adequate support for academic research and to assuring that an adequate supply of new scientists and engineers would continue to be available to academia and industry.

Until the 1970s, the minimalist science policy advocated by Bush appeared to be spectacularly successful, as the US academic research enterprise grew and prospered, while science-based industries flourished. However, these success rested in part on a rather transparent sleight of hand: although the US government did not provide direct, broad subsidies for industrial research, it did so indirectly by means of substantial contracts to the defence and aerospace industries, for example.

Additionally, in the aftermath of World War II and for approximately two decades, US industry had very little competition internationally. When, beginning in the 1970s, the global pre-eminence of US industry began to falter, questions about the efficacy of the minimalist non-defence science policy that had been pursued as an article of faith for a quarter of a century began to emerge. At the same time the Vietnam War and the emerging environmental movement led to questions about whether the outcomes of scientific research were uniformly beneficial. Although support for academic research was rarely an issue, the assumption that support for any and all meritorious university research could provide the principal basis of an effective national science policy was increasingly questioned.

One response to this questioning was to provide some direct, though limited federal support for research in industry. A few such programmes, begun somewhat hesitantly during the administrations of Ronald Reagan (1983-89) and George Bush (1989-93), were expanded and given more visibility during the early years of the Clinton administration (1993-present). These, however, remain controversial.

Another, less controversial response which began in the 1970s and has expanded significantly since that time has been to encourage and facilitate closer co-operation between academic and industrial research, with the expectation that academic research conducted under the terms of such partnerships will be more consistent with the needs of industry and that knowledge will thereby be transferred more effectively. More recently, there have been suggestions that federal agencies that support academic research should

establish priorities, favouring basic research disciplines that underlie so-called “strategic” areas of the economy. At the very least, there is a reasonable consensus that university research should be subject to some type of priority setting, although details how this should be accomplished are rarely spelled out.

Very few policy makers and perhaps relatively few academic scientists continue to subscribe to the idealised vision that support for university research will automatically yield socio-economic benefits. On the other hand, research universities are generally recognised as a valuable national resource in their own right. How to make effective use of that collective resource to address national needs while allowing universities to maintain the autonomy they require in the effective exercise of their multiple functions has emerged as an important if unresolved science policy issue.

### **B. Recent policy statements**

Support for university research remains an important component of federal science policy, although it can no longer be regarded as the principal focus of that policy. The 1994 presidential policy statement entitled *Science in the National Interest* echoes the contention of Vannevar Bush that government funding of the academic sector is essential to the vitality of US industry:

*“The underlying purpose of industrial and industrially-sponsored research is to stimulate innovation and thereby to create new business opportunities. The principal determinants of success are the quality of the scientists and engineers available to industry and the knowledge base and core competencies which permit both informed decision-making and technological innovations. Thus, the continued health of our major research universities is of utmost importance to our science and technology-based industrial sector.”*

(*Science in the National Interest*, p. 21)

Official government policy documents make frequent reference to a partnership with universities, noting that problems faced by universities are, to some extent, of concern to government agencies as well. According to the National Science Foundation’s 1995 publication entitled, *NSF in a Changing World*:

*“NSF’s longest-standing partners – the Nation’s colleges and universities – are facing an era of reduced growth in resources and major changes in the demographics of their enrolments. These shifts and their impact on the continued health and vitality of the academic enterprise will lead to modifications in the character of its partnership with NSF.”*

(National Science Foundation, p. 6)

While such references to a special partnership between universities and the federal government persist, they are often accompanied by emphasis on broader partnerships involving industry and state governments, for example.

Non-government sources also stress the partnership theme. For example, the April 1996 report of the Competitiveness Council entitled, *Endless Frontier, Limited Resources* opens as follows:

*“The Council’s central finding is that R&D partnerships hold the key to meeting the challenge of transition that our nation now faces. Partnerships are defined here as co-operative arrangements engaging companies, universities, and government agencies and laboratories in varying combinations to pool resources in pursuit of a shared R&D objective.”*

(Competitiveness Council, p. 1)

### **C. Trends in the performance and support of academic research**

Rhetorical emphasis on partnerships between universities and other institutions indicates not only widespread recognition of the importance of the academic sector to the overall US research enterprise, but also realisation that federal support for university research is unlikely to increase substantially in the foreseeable future, and may actually experience a decline, at least in inflation-adjusted terms.

In 1995, academic R&D accounted for an estimated 12.6 per cent of total R&D performance in the United States, compared with about 11 per cent in 1990, 10 per cent in 1980, and about 9 per cent in 1970. By far the largest proportion of these expenditures were for research rather than development. During the 1970-95 period, the proportion of total US research expenditures in academic institutions was around 25 to 29 per cent, while the proportion of total basic research expenditures fluctuated between 40 and 50 per cent, making the academic sector the largest performer of basic research. (*S&EI 96*, Chapter 5). Academia is the only R&D-performing sector in the United States which has not experienced a constant dollar decline in R&D performance since 1990. However, the annual real rate of growth has been falling steadily over the past ten years, dropping from a nearly 10 per cent increase in 1985 to a less than 1 per cent increase estimated for 1994-95 (*S&EI 96*, Chapter 4).

In 1990, the academic sector moved into second place as a performer of research, well behind the industrial sector but ahead of the government sector. The academic sector now accounts for more than a quarter of the total research performed in the United States – approximately 50 per cent of all basic research and about 14 per cent of all applied research (*S&EI 96*, Chapter 4).

In 1995, the federal government provided an estimated 60.2 per cent of the funding for R&D performed in academic institutions. This percentage has decreased from 70.5 per cent in 1970 and 67.6 per cent in 1980. Institutional funds (that is, funds from the performing institutions themselves) constitute the second largest source of academic R&D funds. From 1980 to 1991, the institutional share grew from 13.8 to 19.1 per cent of all academic R&D expenditures. Academic institutions are believed to have continued to commit a substantial amount of their own resources to R&D. Estimates for 1995 are approximately US\$ 3.9 billion or 18 per cent of total academic R&D. Institutional support for R&D from public institutions was greater (at 22 per cent) than from private institutions (at 9 per cent) (*S&EI 96*, Chapter 5).

Funds from the industrial sector for academic R&D grew faster during the past two decades than funds from any other source. Industry increased its share of support from 2.6 per cent in 1970 and 3.9 per cent in 1980 to an estimated 6.9 per cent in 1995. Industry’s contribution to academia represented about 1.5 per cent of all industry-funded R&D in 1995, compared with 0.8 per cent in 1980 and 0.6 per cent in 1970 (*S&EI 96*, Chapter 5).

By far, the largest fraction of academic R&D expenditures in 1993 went to the life sciences, which accounted for 54 per cent of total academic R&D expenditures, 53 per cent of federal academic R&D expenditures, and 56 per cent of non federal academic R&D expenditures. Within the life sciences, the sub-field of medical sciences accounted for 27 per cent of total academic R&D expenditures and the sub-field of biological sciences accounted for 18 per cent. The next largest block of total academic R&D expenditures (16 per cent in 1993) was for engineering (*S&EI 96*, Chapter 5).

The distribution of federal and non-federal funding for academic R&D in 1993 varied by field and sub-field. For example, the federal government supported 76 per cent of academic R&D expenditures in the physics and atmospheric sciences sub-fields, but only 29 per cent of academic R&D in the agricultural and political sciences sub-fields. The federally financed fraction of support declined over the past two decades for all science and engineering fields except for computer sciences. The most dramatic decline occurred in the social sciences (from 57 per cent in 1973 to 38 per cent in 1993); the smallest decline was in the mathematical sciences (from 78 to 75 per cent). In the computer sciences, federal support was 70 per cent in 1973 and 71 per cent in 1993 (*S&EI 96*, Chapter 5).

#### ***D. Federal support for academic research, by agency***

For many years, six US government agencies have accounted for well over 90 per cent of all federal R&D expenditures: in descending order, the Department of Defense (DoD), the Department of Health and Human Services (HHS – primarily the National Institutes of Health (NIH) within that agency), the National Aeronautics and Space Administration (NASA), the Department of Energy (DoE), the National Science Foundation (NSF), and the US Department of Agriculture (USDA). These same six agencies also account for well over 90 per cent of federal research funds, although in a different rank order.

Among these agencies, three – the National Institutes of Health, the National Science Foundation, and the Department of Defense – provide approximately 80 per cent of federal support for academic research, including both basic and applied research. By far the largest proportion of these funds is provided in the form of research grants or contracts based on proposals submitted by individual investigators and groups of investigators. Proposals are evaluated according to some sort of peer review process, which differs in detail among the three agencies and even within each.

While the remaining three agencies (NASA, DoE, and USDA) also support university research to some extent, they devote the largest share of their R&D funds to work carried out in their own laboratories. Several of these, particularly those supported by the Department of Energy, provide user groups from universities with access to large scale facilities and are therefore an important supplement to direct federal support for university research. (See Sections VB and VC).

The National Institutes of Health (NIH) is by far the largest supporter of academic research among federal agencies, having provided approximately US\$ 5.78 billion to universities for basic and applied research in 1995. This amount represents approximately 53 per cent of the estimated US\$ 10.84 billion in federal support of academic research during that year. (*S&EI 96*, Chapter 5) NIH's support is overwhelmingly in the biomedical and life science fields, which accounts for the predominance of these fields in the federal academic research support portfolio. Additionally, the agency provides some support in certain behavioural science disciplines. Of the total US\$ 5.78 billion allotted by NIH for academic research in 1995, it is estimated that approximately 70 per cent went for research in medical schools, virtually all of them associated with major research universities.

In 1995 NSF, which supports research in all science and engineering disciplines with the exception of biomedicine, provided US\$ 1.82 billion for university research, or approximately 17 per cent of all federal support for that purpose. Of this amount, US\$ 1.59 billion is estimated to have gone to support basic research. DoD provided US\$ 1.11 billion for university research, or 10 per cent of the federal total, approximately US\$ 0.97 billion of which was devoted to basic research. (*S&EI 96*, Chapter 5)

Federal agencies emphasize different science and engineering fields in their funding of academic research. Several agencies concentrate funding in one field (e.g. Department of Health and Human Services and the Department of Agriculture in the life sciences and the Department of Energy in the physical sciences). Other agencies – the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Defense – have much more diversified funding patterns. (*S&EI 96*, Chapter 5)

#### ***E. Current and projected federal support for academic research***

Rhetorical support for academic research in government policy documents, particularly for basic research, has been translated into tangible form in the most recent federal budgets for which action had been completed by June 30, 1997 - i.e. those for fiscal years 1996 and 1997. Despite the widely reported, contentious struggles between the Democratically-controlled White House and Republican-controlled Congress over much of the government's fiscal year 1996 budget, basic research appropriations for the non-defence agencies were larger than what many observers had anticipated. This was due in part to the fact that there is strong bipartisan consensus about federal support for basic research in universities, in contrast with continuing contention about support for many applied research programmes, including those carried out at national laboratories and those involving private industry. Total appropriations for basic research for fiscal year 1996 are estimated at US\$ 14.4 billion, a 4.8 per cent increase over the US\$ 13.8 billion appropriated for fiscal year 1995. Among the three agencies that provide 80 per cent of federal support for university research, the basic research budget of NIH is estimated to have increased by 6.1 per cent between 1995 and 1996 and that of NSF to have increased by 0.2 per cent, while the basic research budget of DoD decreased by 2.4 per cent, this result being consistent with continuing reductions in the overall defence budget<sup>10</sup>.

Faced with a general election in November 1996, the Congress was in no mood for renewed confrontation with the White House over the fiscal year 1997 budget so that, again, basic research continued to be funded at what most observers agree is a reasonable level. Total appropriations for basic research are estimated at US\$ 14.8 billion, a 2.7 per cent increase over 1996. The respective basic research budgets of NIH and NSF increased by 6.4 and 2.5 per cent, while that of DoD decreased by 5.0 per cent.

The non-defence budget outcomes for fiscal years 1996 and 1997 were particularly gratifying, particularly in view of the fact that until January or February 1996, many agencies had braced themselves for substantial decreases in their research budgets. Nevertheless, the final budget levels continued the pattern of slow growth in federal funding for both total R&D and basic research that has been characteristic of the 1990s.

Projections beyond 1997 suggest that federal research budgets will be significantly constrained, at least until the early years of the next century, so that there may well be a decline in federal support for university research, at least in constant dollar terms. Both the Clinton administration and the Republican-controlled Congress continue to provide rhetorical as well as tangible, financial support to the principal federal agencies that fund academic research. For example, in February 1997, the conservative Republican Senator Philip Graham of Texas convinced the Congress to pass a non-binding resolution to double the federal non-defence research budget over the next ten years. Despite such demonstrations of

support, the administration and Congress are committed to eliminating the overall federal deficit thereby balancing the budget by fiscal year 2002, which will begin 1 October 2001, and this will almost certainly have an impact on federal research appropriations. Until May 1997 when the administration and Congress reached agreement on a broad approach to balancing the budget, the details of how each proposed to attain this objective differed considerably. Significantly, both the administration and the congressional proposals sought to balance the budget primarily by reducing spending in the so-called domestic discretionary category, which includes the budgets of all agencies involved with non-defence R&D. This remains true of the May 1997 agreement as well.

During the summer of 1996, the American Association for the Advancement of Science (AAAS) developed a set of detailed scenarios based on the alternative administration and congressional proposals to assess the most likely impacts of each on the budgets of the principal R&D agencies. (AAAS) This analysis suggested that:

- NIH's budget would remain approximately flat in current dollar terms according to both the administration and congressional budget scenarios.
- NSF's budget, according to the administration scenario, would decrease slightly in current dollar terms, resulting in a 9 per cent constant dollar decrease between 1995 and 2002; according to the congressional scenario, NSF's budget would increase somewhat in current dollar terms, the overall result being a 7 per cent constant dollar decrease between 1995 and 2002.
- Budgets of other non-defence R&D agencies would decrease more substantially: NASA would experience a constant dollar decrease of more than 20 per cent by 2002 under both scenarios. The Department of Energy, under the administration scenario, would face a 25 per cent constant dollar decrease by 2002, and a 44 per cent decrease under the congressional scenario.

The AAAS has not attempted to develop scenarios either for the total federal basic research budget, or for likely levels of university research support, since neither of these categories were explicitly broken out in the proposed administration and congressional budget scenarios. Nor did it develop scenarios for defence-related research. However, there is likely to be continued pressure to reduce the overall DoD budget, including its budget for the support of university research. Since NIH and NSF are the principal supporters of university research, with NASA and DoE also providing significant support in some fields, federal support for the academic sector would most probably decline, certainly in terms of constant dollars, and perhaps even in terms of current dollars. Because DoE funds the principal national laboratories housing large facilities that serve university user groups, the impact on scientific fields that rely on such facilities may well be magnified even further (see Sections VB and VC).

The AAAS has been careful to note that its analysis qualifies as a set of *projections* rather than a set of *predictions*. As such, the analysis is likely to become less reliable as a detailed guideline as one moves further into the future. Since, in the United States, federal budget decisions are made on an annual basis, precise budgets for any particular agency are impossible to predict even a year in advance.

The limits of the AAAS analysis are suggested by the budgets actually proposed by the Clinton administration for NSF and NIH for fiscal year 1998, scheduled to begin on 1 October 1997, as well as those finally agreed upon by Congress. These were more generous than the 1996 AAAS projections had anticipated. Nevertheless, the longer term trends anticipated by the AAAS analysis were eminently reasonable. In May 1997, the Clinton administration and Congress finally agreed on the broad outlines of

a plan to balance the federal budget by fiscal year 2002. According to this plan, overall research spending, measured in constant dollar terms, is slated to decline. Details, however, have yet to be worked out, and will no doubt be subject to annual adjustments. Senator Graham has insisted that he will continue to campaign to double federal non-defence research investments over the next ten years, while a statement signed by the presidents of the leading US scientific societies has called for minimum annual increases in the federal research budget of 7 per cent. But it is not at all clear where the money would come from to realise either objective.

In summary, it is virtually certain that total federal non-defence R&D will continue to decline into the foreseeable future, at least in constant dollar terms. While the impacts of this decline on federal support for academic research remain uncertain, these impacts are unlikely to be positive.

**F. *Research and teaching in research universities: the federal role***

By long-standing tradition tantamount to constitutional prohibition, the federal government is excluded from any direct role in the governance of US educational institutions, including training-related policies of institutions of higher education. With very few exceptions, *direct* capital and operating expenses for US colleges and universities are derived from non-federal sources: in the case of public universities, primarily from state and local governments; in the case of private universities, from endowment income and gifts; and from receipts from tuition and other student fees in both cases. Nevertheless, federal research support has a substantial impact on *all* functions of research universities, including their knowledge transmission (i.e. training) and knowledge-transfer functions. Most obviously, significant numbers of graduate students and post-doctoral fellows in science and engineering fields are supported by means of government fellowships or research assistantships financed by federal research grants and contracts. In addition, research universities derive substantial funds to maintain research facilities and for other research-related expenses ranging from library support to electric utility bills from overhead or indirect costs attached to grants from federal agencies. While these indirect costs are regarded as a legitimate and necessary part of doing research, questions of what should be chargeable as an indirect cost and at what rate continue to be subject to considerable contention.

**G. *Sources of support for graduate students***

Graduate students play an indispensable role in academic research in science and engineering as assistants or, better, apprentices to research faculty<sup>11</sup>. For this reason, the research productivity of a university department is determined not only by the funds available directly for the conduct of research (e.g. for experimental apparatus), but also by the availability of graduate students.

The number of graduate students in science supported primarily by federal agencies rose from 30 000 in 1983 to 43 000 in 1993, an annual increase of almost 4 per cent. In the physical sciences, however, the number of students supported by the National Science Foundation and US Department of Defense declined from 1988 to 1993. In fields of engineering, federal support increased from 11 000 students in 1985 to 17 000 in 1993, an average annual increase of 5 per cent. Non-federal sources of support for science students also continued to increase throughout this time, but at 4 per cent annually, the growth rate was lower than that for federal sources. After a decade of 5 per cent annual increases in the number of engineering students supported by non-federal sources, that number levelled off at approximately 30 000 from 1991 to 1993 (*S&EI 96*, Chapter 2).

The number of graduate students who were self-supporting increased 6 per cent annually from 1988 to 1993, reaching 30 per cent of graduate science and engineering students in 1993. Large variations exist across different fields. Only 7 per cent of the physical science students were self-supporting. In contrast, 44 per cent of graduate computer science students were self-supported, as were 43 per cent social science students, 37 per cent of civil engineering students, and 47 per cent of industrial engineering students (*S&EI 96*, Chapter 2).

#### **H. Federal programmes to improve education in mathematics, science and engineering**

Several federal agencies, including the Department of Energy (DoE), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF), have programmes that offer research experience in science and engineering to undergraduates at both four-year colleges and doctorate-granting institutions. These agencies have recently increased the visibility of their education-related efforts in response to explicit science policy goals of the Clinton Administration, as set forth in *Science in the National Interest*, for example. That report quotes the director of NSF as follows:

*“Science cannot live by science alone. Research needs education, just as education thrives when it is conducted in an atmosphere of inquiry and discovery. In fact, the separation of education and research makes no sense intellectually.”*

(*Science in the National Interest*, p. 11)

The National Science Foundation, which is explicitly mandated by Congress to support science, mathematics and engineering education at all levels, also provides substantial direct support for activities such as curriculum development and teacher training at the undergraduate as well as the precollege levels. NSF also supports projects to provide research experience to undergraduates, including those in four-year baccalaureate-granting institutions. The agency’s 1995 publication entitled, *NSF in a Changing World* states that the integration of research and education at all levels is to be one of four core strategies to further its support to the progress of science and engineering. To this end, NSF is providing grants of up to US\$ 500 000 for five years to a dozen research universities to facilitate model, innovative programmes to integrate research and education, primarily at the undergraduate level, but also involving local pre-college education as well. In February 1996 the National Science Board, which serves as the policy making body for NSF, recommended in its publication entitled *US Science and Engineering in a Changing World* that the integration of research and education should be extended to agencies besides NSF:

*“Integration of research and education is in the national interest and should be a national objective. To advance this goal, Federal science and engineering policies should strengthen efforts to promote the integration of research and education at all levels and should support innovative experiments in this area.”*

(NSB, p. 4)

#### **I. Balance between research and teaching at US colleges and universities**

Emphasis on integration of research and teaching reflects concerns expressed in recent years that science and engineering faculty in US research universities may “unduly” be focusing disproportionate time and effort on research at the expense of teaching, particularly at the undergraduate level that many US citizens

regard as the most important component of the US higher education system. A detailed snapshot for 1993 drawn from the National Survey of Post Secondary Faculty examined the question: "How do full-time doctoral science and engineering faculty with substantial research involvement allocate their time between teaching, research, and other functions? Results of the survey, summarised in *Science and Engineering Indicators 1996* (Chapter 5) indicate that:

- The average faculty member (in research universities as well as master granting institutions and four year colleges) spent about 44 per cent of his or her weekly work time on teaching and about 32 per cent on research. The typical faculty member taught an average of 69 students for seven credit hours per semester (a little more than two courses). Of these, five credit hours were devoted to undergraduate instruction (54 students) and the remainder to graduate-level courses.
- Faculty members whose major activity was research spent 59 per cent of their time performing research and 22 per cent teaching. They taught an average of one course involving 48 students (29 undergraduates and 19 graduate students, with the teaching load split fairly evenly between them). About 40 per cent of these faculty members, however, taught one or more undergraduate course in the fall of 1992; the others had no undergraduate teaching responsibility during that period.

It might be expected that the time budgets for research and teaching of faculty members at major research universities would differ from those of their colleagues in masters'-granting institutions and four-year colleges. Instead, surprisingly little difference existed across these institutional boundaries in the number of hours taught, size of undergraduate classes, and the number of graduate students. That is, research faculty also teach. A good many of them teach undergraduates. These patterns are not significantly conditioned by the type of academic institution. Almost all research faculty, regardless of institution type, taught some courses in the fall semester of 1992, with about one-third of them teaching undergraduate courses. However, the majority primarily taught graduate-level courses (*S&EI 96*, Chapter 5).

An analysis based on trends in enrolment, degree production, and faculty employment during the past 20 years also suggests that the teaching function has not suffered, even though academic institutions have employed more science and engineering faculty who view research as their primary responsibility. Indeed, half or more of all full-time faculty who regard research as their primary responsibility spend the next largest portion of their time teaching (*S&EI 96*, Chapter 5).

While the results of this snapshot suggest considerably more involvement in teaching, including undergraduate teaching, by faculty at research universities, it is useful to recall that even among the 220 research universities in the Carnegie Research I and II categories, research accounts for only about 20 per cent of expenditures. Furthermore undergraduate tuition, which continues to increase more rapidly than inflation, now accounts for almost 20 per cent of the revenues of these research universities. Given these conditions, the question of how science and engineering faculty at research universities should apportion their time will no doubt persist.

There has been considerable interest in the United States, as in other OECD countries, about the desirability and feasibility of modifying graduate training substantially so that PhD recipients will be better suited for a range of occupations other than working in the academic sector. The Competitiveness Council's report entitled, *Endless Frontier – Limited Resources* stated the issue forcefully:

*“The most vital mission of US universities is education; it is a mission that no other institution can perform. All other activities at universities should support or be subordinate to the education mission. To ensure that the United States has the human resources required for a healthy R&D system, universities should:*

*Restructure graduate study to open a broader spectrum of career opportunities to PhD students and to develop a credible practice-oriented master’s degree. Today’s students will have to keep up with rapidly changing technology and will have to solve multi-disciplinary problems. Education that is limited to a single sub-field does not equip these students adequately for either the academic world or the corporate world. Universities should work with industry to explore different emphases in graduate programs for students who prefer an industrial career to an academic one. Creating master’s degree programs geared to the needs of the workplace would be particularly valuable.”*

(Competitiveness Council, p. 7)

It is worth reiterating that among the functions of research universities, the council assigns the highest priority to knowledge transmission.

#### **J. Industrial support for the academic sector**

Industrial support for academic research, as already noted, has been the most rapidly growing component of total academic R&D during the past two decades, and now accounts for 6.9 per cent of the total. Support for graduate students is embedded within this total. Indeed, one of the principal reasons given for industrial support for academic research is the desirability of involving graduate students in problems of interest to industry with the expectation that some of them will be attracted to industrial research careers.

Preliminary results of a multi-year study of university-based engineering research initiated in 1992 by the Center for Technology Assessment and Policy at Washington University in St. Louis reveals that although industry has considerable involvement in university-based engineering research, close to 80 per cent of faculty desired even greater industry involvement. About 79 per cent of faculty reported support from industry while at their current university; some two-thirds reported an average of 5.8 years of experience in industry or government; and some 87 per cent reported having been a consultant to industry or government while a faculty member. Graduate students play a central role in university-based engineering research, primarily serving as associate or independent researchers. However, student interaction with industrial and government researchers was not strongly indicated. Engineering faculty involvement in research was roughly in balance with their involvement in teaching (*S&EI 96*, Chapter 5).

Despite the growth of industrial support for universities during the past 20 years, funds from academic institutions themselves account for a greater share of the total than do industrial funds, and there is a perception that federal policies should do more to facilitate industrial support to universities. For example, *Science in the National Interest* stated that:

*“The NSTC [National Science and Technology Council], with advice from PCAST [Presidents Council of Advisors on Science and Technology] and the broader scientific community, will advise on impediments to industry investment in fundamental research and recommend policies to encourage industry investment.”*

*(Science in the National Interest, p. 23)*

Although outside the scope of this paper, there is a relatively widespread perception that industry should also be performing more research in its own laboratories. *Endless Frontier, Limited Resources* recommended that:

*“Industry must increase its contribution to the US R&D enterprise. Although US industry has responded more swiftly and successfully than other sectors to the forces buffeting the post-1945 system, its role in R&D will have to grow if it is to continue interfacing productively with the other R&D stakeholders and to foresee from what direction new science and technology insights are coming. In 1994, industry provided 59 per cent of the nation’s total R&D expenditures, while performing 72 per cent of the nation’s R&D. Yet even under the most optimistic scenarios, the projected decline in federal support for R&D will weaken the US scientific and technological base unless the private sector augments its effort, not only by furnishing resources but by using them more effectively. Insufficient investment will weaken US industry.”*

*(Competitiveness Council, p. 4)*

Additionally, a significant change in the character of industrial research has been occurring during the past decade. Whereas industry itself once performed a reasonable amount of long term, basic research, there has been a pronounced trend toward short-term, results-oriented applied research. As a result, industrial spokespersons have emphasized the need for continued strong support for basic research in universities. For example, *Endless Frontier, Limited Resources* emphasized that:

*Government must maintain its research support of American universities. The federal government provided around 55.5 per cent of the funding for R&D performed in academic institutions in 1993 – down from over 67 per cent in 1980 and 70 per cent in 1970. Maintaining support to these US universities is especially critical because their endeavours contribute to long-term research in science and technology and act as a magnet to corporate laboratories and plants, as well as students, from the United States and around the world.*

*(Competitiveness Council, p. 6)*

A additional point about university-industry co-operation is worth noting: that is, the substantial expenditures by industrial firms for the continuing education of their research scientists and engineers, either by paying for their university tuition to allow them to pursue advanced degrees, or by means of special courses that the companies themselves offer.

#### ***K. Coda: the changing character of the US research system***

Two significant, long term trends highlighted in Section IIIC are the increasing share of research accounted for by the US academic sector, coupled with the declining fraction of that research financed by

the federal government. Federal funding, as already noted, is almost certainly to experience a further decline. Since alternative sources of support – primarily funds from academic institutions themselves and from industry – are unlikely to increase significantly, the prospect for an overall decrease in the support available for university research is very real.

A related trend has been the increase in the share of total US R&D expenditures accounted for by industry relative to the government share. In 1995, industry accounted for 59 per cent of the estimated total of US\$ 171 billion expended for R&D in the country, while the federal government accounted for 36 per cent. Federal R&D investments, measured in current dollars, have been virtually flat since the beginning of the decade. In contrast, industrial investments have continued to increase, although their rate of increase has declined since 1990 (*S&EI 96*, Chapter 4). Despite this trend, many critics believe that industrial R&D investments remain inadequate (see Section IIIJ). However, late in 1996 the Industrial Research Institute announced that, based on its survey of its members, industrial R&D investments were predicted to increase considerably in 1997. Most of the new research money contained in the total industrial R&D investments will no doubt continue to be devoted to relatively short-term research in company laboratories. However, some new funds might also be available for research in universities.

Beginning in the late 1940s, universities moved from the periphery to the core of the US research system. That situation came about and persisted in large measure because of the availability of federal funding. The implications for university research and thus for the entire US research enterprise of a situation in which industry rather than government provides the major fraction of funding for R&D and, perhaps, for research alone have yet to be explored in any detail.

It is worth reiterating that the multiple fiscal problems being experienced by US research universities cannot be regarded as unanticipated crises. Rather, they are the result of trends that have been apparent for several years. Many universities, encouraged both by federal agencies and private industry, have taken steps to broaden and balance their missions by establishing new partnerships, particularly with industry. Section IVA highlights the impacts on university research, education, and knowledge transfer of one NSF programme designed to support large scale, often multi-disciplinary research activities. Sections IVB and IVC provide data on cross-sectoral collaborations involving academic scientists and scientists working in industry and government laboratories, as well as data on patenting activities of universities.

Since the bulk of the research conducted in US universities qualifies as basic research, academia is usually regarded as the bastion of basic research in the country. In addition, several national laboratories – most of them administered by universities or consortia of universities – (Section V) conduct at least some basic research and, more to the point for purposes of this paper, provide access to their facilities to university user groups. However, the budget outlook for these facilities, regarded as essential for academic research in several disciplines, is not promising.

#### **IV. Universities and knowledge transfer: implications for the research function**

##### **A. A representative federal programme**

Knowledge transfer intended to yield tangible socio-economic benefits has become an important function of US universities. The 1992 PCAST report entitled *Renewing the Promise* asserted that:

*“For the nation’s economic interests, the issue is not simply how much new knowledge is being generated but also how fast it is being translated into economically and socially beneficial products and processes. This argues for a more deliberate effort to move information and, especially, people between universities and industry.”*

(PCAST, p. xxvii)

More recently, *Science in the National Interest* noted that:

*“While fundamental research is declining in much of industry, industrial leaders frequently speak of the value of “people transfer” and “idea transfer” with academic institutions.”*

(*Science in the National Interest*, p. 22)

Federal programmes to stimulate research co-operation between university and industrial scientists, which began modestly during the 1970s, have expanded considerably. For example, approximately 50 NSF programmes currently require or at least strongly encourage some type of industrial participation. Typically NSF, which only provides support to profit making organisations under very exceptional circumstances, funds a major share of the research of participating universities, with the industrial partners funding their own participation. Among these NSF programmes, the Engineering Research Centers (ERC) and Science and Technology Centers (STC) programmes are the most substantial. Both programmes provide substantial support to academic centres for up to ten years for research in areas of interest to industry which is frequently multidisciplinary in character and conducive to a team as opposed to an individual investigator approach. Both programmes require that undergraduate and graduate students be intimately involved in the research activities of the centres. Taken together, they account for less than 10 per cent of NSF’s research budget. While knowledge transfer is an explicit objective, the primary goal of both programmes is to facilitate the conduct of research that cannot easily be accomplished through the efforts of individual investigators or small groups of investigators.

The ERC programme, started in 1985, is the older of the two. As its name suggests, participation is limited to engineering departments at US universities. Centre awards are made on the basis of competitive proposals. At present, NSF is supporting six to seven new centres each year at an annual level of US\$ 2 to 3 million.

The STC programme was started in 1987 and awarded its first grants in 1989. Although modelled in part on the ERC programme, it is open to all scientific discipline and encourages, but does not require, multidisciplinary research work. New ERCs have been supported on a continuing basis. In contrast, there have been only two competitions for STC awards. The first set of awards was announced in 1989 and the second two years later. At present, 25 STCs are being funded at a total annual level of approximately US\$ 60 million. Some are based at a single university; others involve networks of more than one university. Most involve the participation of several industrial firms.

The STC programme is worth examining in further detail in part because the programme itself, as opposed to the individual centres, has recently been the subject of an independent evaluation. The three-fold objectives of the STCs are to: (i) pursue frontier research, (ii) improve science education, and (iii) transfer knowledge to industry. Among the questions raised in the early years of the STC programme was the extent to which these three objectives were compatible. In particular, concerns were expressed about whether the need to be mindful of the second and third objectives would permit the conduct of research judged to be of high quality by academic standards. With funding for the first set of STCs due to expire in 1998, NSF decided to determine whether the programme should be extended by announcing a competition for a new set of centres to be funded beginning in 1999 or 2000. To assist it in arriving at an answer, NSF commissioned an independent evaluation Committee on Science, Engineering and Public Policy (COSEPUP) of the US National Academy complex. Some of the principal conclusions of this study, completed in August 1996 are as follows.

Noting that the STCs were created to “address questions too complex for a single investigator to address,” the report went on to state that, “most of the research conducted would not have occurred absent the creation of a centre.” In particular:

*“They [the STCs] have produced research of high scientific quality with coherent intellectual themes that could only be addressed through centre-based research.”*

With regard to knowledge transfer:

*“Long-term stable funding . . . is the hallmark of the STC mode of support. The existence of stable clusters of expertise should also enable the nurturing of technology transfer pathways from many centres.”*

*“Considerable evidence exists that the STCs as a whole have done an excellent job of disseminating their results whether related to basic science or more applied fields.”*

One of the most significant conclusions of the evaluation was that the knowledge-transfer objective had not only realised in its own right, but that pursuit of that objective had a positive impact on the research conducted by the STCs:

*“The existing STCs have demonstrated that an active program of industrial co-operation and participation does lead to better research, new ideas, leveraged funding, improved faculty appreciation of the industrial sector, and students better prepared to join the workforce and respond to the challenges of the future. The scale of the STCs afford unique opportunities to set up industrial partnerships, and such opportunities should be strongly encouraged in future STCs.”*

Regarding the preparation of students:

*“STC graduates report being well trained for their subsequent careers – whether they be in academia, industry or a federal laboratory.”*

One of the principal recommendations of the COSEPUP report was that:

*“Research and the undergraduate and graduate programs linked to it should be the paramount goals of the STC program.”*

This recommendation, as well as other statements from the COSEPUP report noted above, is explicit in assigning a higher priority to research and teaching in these university-based STCs than to knowledge transfer, particularly since facilitating knowledge transfer is one of the stated objectives of the STC programme. Indeed, the recommendation is consistent with the often repeated observation that the best mechanism for knowledge transfer is to rely on the mobility of adequately trained people.

In November 1996 the National Science Board, the policy-making body for NSF, approved guidelines for a new STC programme to begin during 1999.

### **B. *Cross sectoral collaboration***

Leaving aside the pros and cons of government-supported programmes designed to facilitate knowledge transfer, there is strong evidence that such transfer is occurring. Substantial co-operation involving the academic, industrial, and government sectors has become an important characteristic of the US research enterprise, as evidenced by a steady increase in the number and proportion of articles with collaborators from multiple sectors. Just under one quarter (23 per cent) of all academic papers in 1993 involved collaboration with authors from one or more other sectors: 8 per cent each from the federal government and non-profit institutions, 5 per cent from industry, 3 per cent from laboratories funded by the federal government but managed by non-government entities, and 2 per cent from other sectors including state governments. Among academic articles, cross-sectoral collaboration rose from 20 to 23 per cent between 1981 and 1993 (*S&EI 96*, Chapter 5).

Academic authors were involved, as indicated by joint authorships, in well over half of all cross sectoral collaborations. Cross sectoral collaboration is highest in the combined biological and medical sciences and lowest in the physical sciences and in mathematics, although in both cases collaboration has increased since 1981 (*S&EI 96*, Chapter 5).

### **C. *Academic patenting and licensing***

Data on the patenting activity of universities and colleges suggest that academic institutions are giving increased attention to the potential economic benefits inherent in their research results and that they are seeking to capture some of these benefits. During the 1970s, the number of institutions receiving at least one patent grew slowly, but during the 1980s, the number more than doubled, from 80 in 1980 to 165 in 1994. During the 1980s, just as a growing number of academic institutions were receiving patents, the share of the 100 largest research universities (by volume of total research funds) increased from 75 to about 85 per cent (where it has levelled off) of all newly issued academic patents. At the same time, a composition shift took place within the top 100. The share of the largest 20 universities contracted, while institutions that rated below 50 per cent in research volume gained a slowly growing share of these patents (*S&EI 96*, Chapter 5).

The number of patents awarded to US universities (as opposed to the number of universities receiving patents) rose sevenfold in the past two decades. From an average of 200 to 300 patents a year issued in the late 1960s and early 1970s, the number rose to 350-400 a year in the early 1980s; it then increased fourfold to 1 761 in 1994. This growth is far steeper than that of all US patent awards, which roughly doubled in number. A change in US patent law in 1980, which allowed academic institutions and small businesses to retain title to inventions resulting from federally supported R&D, may have contributed to the continuing strong increase in academic patenting (*S&EI 96*, Chapter 5).

Universities increasingly are negotiating royalty and licensing arrangements based on their patents. A 1992 report by the US General Accounting Office (GAO), based on a survey of 35 universities, found that, as a group, they had granted 536 licenses in 1989–90. GAO reported that most of these universities had substantially expanded their technology transfer programmes during the 1980s. Typical licensees were small US pharmaceutical, biotechnology, or medical businesses. During 1989–90, the reported income flows based on these licenses were modest: a total of US\$ 82 million. However, just as patenting has expanded, so has licensing and the attendant revenue flows (*S&EI 96*, Chapter 5).

A more recent survey conducted by the Association of University Technology Managers reported gross revenues received by US universities of US\$ 242 million in 1993, compared to US\$ 172 million in 1992. Part of the increase is likely to be due to more extensive coverage and accounting. Nevertheless, while total reported revenue remains modest in comparison with the underlying R&D volume, its strong upward trend suggests a growing willingness on the part of universities to attend to the applications potential of the research conducted on their campuses and a growing willingness on the part of entrepreneurs and companies to recognise and invest in the market potential of this research (*S&EI 96*, Chapter 5).

## **V. National laboratories**

### **A. R&D performance in the federal sector**

The United States, in contrast with several other OECD countries, does not have a system of government-supported institutions roughly parallel to the universities where comparable research is performed. Rather, there exists a considerable number of laboratories that are either managed directly by a federal agency or by a private organisation under contract with an agency. Most of these facilities conduct applied, mission-oriented research and development. A few conduct research, both basic and applied, that is comparable to and/or of interest to academic scientists and engineers. Many, particularly those funded by the Department of Energy, are managed by universities or consortia of universities and make their facilities available to university-based user groups at no cost to those groups. The status of these is therefore pertinent to any exploration of academic research in the United States.

The National Institutes of Health (NIH) research complex near Washington, DC, in Bethesda, Maryland, comprises what are probably the premier group of quasi-academic research laboratories managed directly by a federal agency. Scientists working in this facility, like those in all other facilities managed directly by a federal agency, are government employees. Gauged in terms of its quality and character, the research conducted at the Bethesda campus is comparable to that of any first rate biomedical research facility in the world. The facility welcomes visiting academic scientists, including large numbers of visiting foreign scientists. The 1995 budget for this laboratory complex was about US\$ 1.6 billion, out of a total NIH budget of US\$ 10.8 billion, of which US\$ 5.2 billion was devoted to grants for research in universities.

The Federally Funded Research and Development Centres (FFRDCs) are of more direct interest to university researchers in the physical sciences and engineering. These are R&D-performing organisations administered by industrial firms, universities, or non-profit organisations which are financed either exclusively or substantially by a federal agency to meet particular R&D objectives or to provide major facilities for academic research and related training purposes. R&D obligations for the FFRDCs totalled US\$ 5.8 billion in 1995. The Departments of Energy and Defense (DoE and DoD) provide the majority of their funding (*S&EI 96*, Chapter 4).

In 1993, three university-administered FFRDCs had annual R&D funding levels exceeding US\$ 500 million. One of these, the Jet Propulsion Laboratory administered by the California Institute of

Technology in Pasadena, California, serves as NASA's principal centre for solar system exploration. Its 1993 R&D support from NASA totalled US\$ 742 million. The other two – Lawrence Livermore and Los Alamos – are national laboratories engaged primarily in nuclear weapons research. Both are administered by the University of California under contract with DoE. NSF sponsors four university-administered FFRDCs. The largest of these is the National Center for Atmospheric Research at Boulder, Colorado, with a 1993 R&D obligation of US\$ 56 million. The other three, with combined 1993 obligations of US\$ 65 million, are astronomical observatories (*S&EI 96*, Chapter 4).

### **B. Department of Energy laboratories**

The most well-known FFRDCs are often referred to as the national laboratories. These ten facilities are administered by the DoE. In 1993 these laboratories accounted for US\$ 3.4 billion of DoE's US\$ 6.26 billion R&D budget. Three of them (Oak Ridge, Lawrence Berkeley, and Los Alamos) were established during World War II specifically to design and build nuclear weapons. The six others were created in the decades immediately following the war originally to develop commercial applications of nuclear technology. The Lawrence Berkeley Laboratory has not engaged in weapons research since shortly after the end of World War II. All other DoE-supported FFRDCs, with the exception of the Los Alamos and Livermore nuclear weapons facilities, have broadened their capabilities to encompass energy-related R&D activities other than commercial nuclear technology.

Seven of the DoE supported national laboratories perform at least some basic research and provide facilities for university user groups: Argonne National Laboratory near Chicago; Illinois; Brookhaven National Laboratory on Long Island, New York; the Continuous Electron Beam Accelerator Facility at Newport News, Virginia; the Fermi National Accelerator Laboratory near Chicago; the Lawrence Berkeley Laboratory adjacent to the University of California, Berkeley, Campus; the Princeton Plasma Physics Laboratory administered by Princeton University; and the Stanford Linear Accelerator Center administered by Stanford University. Total DoE support for these seven facilities in 1993 was slightly over US\$ 1 billion, compared with US\$ 550 million in direct DoE support for research at universities (*S&EI 96*, Chapter 4).

The future role of the national laboratories in the US science and technology enterprise has been the subject of an ongoing debate, with the expectation that their R&D programmes have the potential to become more relevant to other sectors of the enterprise and to the US economy as a whole. Because many national laboratories were originally established to perform defence research and research related to commercial nuclear technology, they are facing the challenge of finding alternative activities in light of continuing reductions in military expenditures. As a result, several are attempting to redefine their missions by changing the focus of their research activities to include participation in science and technology projects likely to provide commercial benefits to the private sector. Recent laws have made technology transfer an official mission of the laboratories. Evidence of the impact of these laws is found in the growing number of Co-operative Research and Development Agreements (CRADAs), which have increased from approximately 100 in 1987 to a current level of over 1 000 (*S&EI 96*, Chapter 4). The growth in multi-institutionally authored papers has been particularly notable for researchers employed at FFRDCs. In 1981, 39 per cent of scientific and technical papers published by FFRDC researchers were authored with researchers in other sectors; in 1993, the share of FFRDC papers published with non-FFRDC co-authors had risen to 57 per cent (*S&EI 96*, Chapter 5).

C. *An assessment of the national laboratory system*

While much of the current reorientation in the mission of the national laboratories and other FFRDCs has been primarily in the direction of industrial R&D, there is also a perception that their potential to contribute to the US basic research effort in co-operation with the academic sector has not been fully realised. In *Science in the National Interest*, the Clinton Administration promised to undertake:

*“A cross-agency review of Federal laboratories [which] will give particular attention to their role in support of national goals and their effectiveness in performance and support of fundamental science, mathematics, and engineering.”*

*(Science in the National Interest, p. 21)*

The status of the DoE-supported national laboratories is particularly pertinent in this respect: first, because these laboratories account for approximately 50 per cent of DoE’s R&D budget; second, because many of these laboratories provide indispensable facilities for university user groups. In view of the likelihood that DoE’s total R&D will be reduced substantially during the next five years (Section III E), the impacts of such reductions on laboratories that serve university user groups is of particular concern.

In order to consider alternatives for the future of the national laboratories, the Secretary of Energy appointed an external task force chaired by Robert W. Galvin, Chief Executive Officer of Motorola, Inc., which submitted its report and recommendations in 1995. The report began by reasserting the importance of what it referred to as the “energy mission” to the security and prosperity of the United States, defining that mission broadly to encompass a related environmental mission. It went on to assert that rather than broadening or seeking new missions as several national laboratories have attempted, the laboratories should focus more sharply on the energy mission, avoid duplication of programmes among different laboratories, and effect cost savings by streamlining management practices and, in some cases, by privatising parts of the laboratories.

The Galvin report emphasized the unique research contributions made by the national laboratories:

*“The laboratories’ research role is a part of an essential, fundamental cornerstone for continuing leadership by the United States . . . Many of the least exploited investigative paths involve the need for extraordinary sophisticated multidisciplinary teams using sophisticated instruments and tools. It is that role for which the national laboratories are uniquely qualified. It is the case for – the justification of – the **existence** of the DoE laboratories.”*

*(Galvin, p. 139)*

*“The Task Force believes that the national laboratories serve a distinctive role in conducting long-term, often high-risk R&D, frequently through the utilisation of capital-intensive facilities which are beyond the financial reach of industry and academia, and generally through the application of multidisciplinary teams of scientists and engineers. We believe that an appropriate division of labour among the national laboratories, industrial research institutions, and research universities can be established but does not sufficiently now exist.”*

*(Galvin, pp. 140-41)*

The Galvin report's recommendations (p. 151) included several that are pertinent to the US academic research enterprise:

- The Department of Energy should move to strengthen its efforts in fundamental science and engineering, both at the laboratories and in the universities.
- The DoE should pay close attention to ensuring that a proper balance is maintained between the universities and the national laboratories of DoE-related basic research, both now and in the future.
- Basic research at the laboratories should be more fully integrated into the national and international research community.

## **VI. International mobility**

### **A. *US science and engineering students outside the country***

No complete or consistent data are available on the number of US science and engineering graduate students and post-doctoral fellows who carry out all or part of their training at research facilities outside the country. There is a perception that insufficient numbers do so, although it is difficult to make a strong case lacking firm data or some reasonable criteria for what would constitute sufficiency. Despite this, there is a good deal of anecdotal evidence that for a number of reasons, students are reluctant to spend too much time abroad: because they are insufficiently aware of opportunities for professional development, because they lack adequate language skills, or because they are concerned that their careers will suffer if they spend too much time away from the United States.

The National Science Foundation places a high priority on creating opportunities for new scientists and engineers to gain working experience abroad at early stages in their careers. It provides support through special programmes, including international post-doctoral fellowships and summer institutes for graduate students in Japan and Korea. The numbers of students who can be accommodated in these programmes are small, however. While other R&D supporting agencies also agree, at least tacitly, on the desirability of international working experiences for new US scientists and engineers, this sentiment has yet to be translated into a high priority, government-wide policy.

### **B. *Foreign students in US colleges and universities***

In contrast with the absence of good information on US science and engineering students studying and working outside the country, there is substantial data on foreign students in the United States. Approximately half of all foreign students in 1992–93 were enrolled in undergraduate levels: 50 000 in two-year associate degree programmes and 160 000 in four-year bachelor programmes. These students generally pay tuition—a high percentage of them have been recruited to private schools. An estimate of the total dollar amount paid by foreign students for tuition and living expenses (based on 1992-93 average amounts of US\$ 16 400 for tuition and living expenses for 365 000 foreign students) is US\$ 6 billion per year for their study in the United States. Another 193 000 foreign students were enrolled in graduate schools in 1992-93, approximately 100 000 of them studying science and engineering for a master's or doctoral degree. Foreign students within this pool, particularly at the doctoral level, account for those receiving university funds as their primary source of support (*S&EI 96*, Chapter 3).

Participation rates for foreign students in science and engineering degrees in US universities rise by level of degree. Thus, although foreign students obtain only a small fraction of science and engineering bachelor's degrees, they obtain 25 per cent of the master's degrees and 47 per cent of the doctorates (*S&EI 96*, Chapter 2).

In view of the often indispensable role that graduate students play in furthering the research of academic faculty, these foreign students make a significant contribution to the US research enterprise.

Foreign students accounted for a steadily increasing proportion of doctoral degrees in science and engineering from 1985 to 1992, especially in mathematics, computer science, and engineering. By 1993, foreign students on temporary visas obtained 44 per cent of mathematics and computer science doctoral degrees and 50 per cent of engineering doctoral degrees. If non-US citizens with permanent residence in the United States are added to foreign students on temporary visas, the percentage of doctoral degrees in engineering earned by non-US citizens would be 57 per cent; the percentage in mathematics and computer science would be 47 per cent. After a decade-long steady increase, however, fewer foreign students are entering US universities for advanced training in science and engineering fields (*S&EI 96*, Chapter 2).

There have been significant changes in the country of origin of foreign students over the years. The number of European students studying in the United States is modest compared with those from Asia. Students from Western and Central European countries combined received 658 doctoral degrees in science and engineering from US universities in 1992. That same year, students from China earned over 1 900 doctoral degrees in science and engineering at US universities (*S&EI 96*, Chapter 2).

Nearly half of the approximately 400 000 foreign students enrolled in 1991–92 were studying science and engineering fields. For some of the Asian countries, the percentage studying science and engineering is even higher. Two-thirds of the students from China and India enrolled in US universities concentrate in science and engineering, mainly at advanced levels (*S&EI 96*, Chapter 2).

Science and engineering doctoral degrees obtained by Asian foreign students more than tripled in the past decade, from 1 600 in 1983 to almost 5 600 degrees in 1993. The approximately 2 000 engineering degrees obtained by Asian foreign students represented 36 per cent of the total doctoral degrees awarded in US universities in 1993. The 2 800 doctoral degrees in natural sciences, mathematics, and computer sciences obtained by Asian foreign students represented more than one-quarter of all doctoral degrees awarded in these fields from US universities in that year. Japan is the exception. The majority of Japanese students come at the undergraduate level and study either business management or social sciences. Few Japanese study natural science or engineering fields in the United States (*S&EI 96*, Chapter 2).

US sources are the primary funding support of 80 per cent of all foreign science and engineering students at the doctoral level. More than three-quarters of foreign science and engineering doctoral students receive their primary funding support in the form of either research assistantships (including some research funds to universities from federal grants), teaching assistantships, or university fellowships. Only 3 per cent comes from federal fellowships or traineeships, which, for the most part, are not open to foreign students. About 20 per cent of foreign doctoral science and engineering students cite various forms of self-support (family, loans, earnings, and spouse's earnings) as their primary funding support. (*S&EI 96*, Chapter 2).

**C. Foreign-born scientists and engineers in the US workforce**

As of 1993, 23 per cent of science and engineering doctorate holders under age 76 and residing in the United States were foreign born. Slightly more than half of these (53 per cent) have US citizenship. Although a majority of foreign-born PhD level scientists and engineers in the US received their training from US institutions, 34 per cent received their degrees outside the United States. This percentage varied by field, from 12 per cent for the social sciences to 49 per cent for the life sciences (*S&EI 96*, Chapter 3).

During the 1980s, immigration of scientists and engineers was fairly stable, increasing slightly each year. However, in 1992, there was a large jump in admissions of scientists and engineers totalling 22 870, or a 62 per cent increase over immigration in 1991. The cause of this large increase is clearly related in part to the changes in the immigration law enacted in 1990, which permitted large increases in employment-based quotas for highly skilled workers. Despite an overall decline in immigration to the United States in 1993, the admission of scientists and engineers continued to rise. According to Immigration and Naturalization Service (INS) data, 23 534 scientists and engineers were admitted to the United States on permanent visas in 1993, representing a 3 per cent increase over 1992. The total immigration to the United States in 1993 is estimated at 904 292; scientists and engineers constituted 2.6 per cent of this total (*S&EI 96*, Chapter 3).

Data for 1993 show that most scientists and engineers admitted to the United States as permanent residents identify their country of birth as being in East and South Asia. In 1993, 58 per cent of all scientists and engineers admitted were from these regions. India was reported as country of birth for 17.5 per cent of all science and engineering immigrants, and China was reported by another 20.4 per cent of those admitted. Immigration from these two countries combined to account for 37.9 per cent of all science and engineering immigration, which is an increase from 1992, when 29 per cent of all science and engineering immigrants reported either India or China as their country of birth. Observation of INS data for previous years reinforce the conclusion that immigrants from East and South Asia constitute a large and growing proportion of all science and engineering immigration (*S&EI 96*, Chapter 3).

## APPENDIX: CARNEGIE CLASSIFICATION OF US HIGHER EDUCATION INSTITUTIONS

The following are brief descriptions (reproduced from *Science and Engineering Indicators – 1996*, Chapter 2) of The Carnegie Foundation for the Advancement of Teaching's categories of US institutions of higher education.

**Research I:** These institutions offer a full range of baccalaureate programmes, are committed to graduate education through the doctorate degree, and give high priority to research. They receive at least US\$ 40 million annually in federal support and award at least 50 doctoral degrees.

**Research II:** These institutions are the same as research I, except that they receive between US\$ 15.5 million and US\$ 40 million annually in federal support.

**Doctorate-granting I:** In addition to offering a full range of baccalaureate programmes, the mission of these institutions includes a commitment to graduate education through the doctoral degree. They award 40 or more doctoral degrees annually in at least five academic disciplines.

**Doctorate-granting II:** These institutions are the same as doctorate-granting I, except that they award 20 or more doctoral degrees annually in at least one discipline or ten or more doctoral degrees in three disciplines.

**Master's (comprehensive) universities and colleges I:** These institutions offer baccalaureate programmes and, with few exceptions, graduate education through the master's degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines, such as engineering or business administration. All of the institutions in this group enrol at least 2 500 students.

**Master's (comprehensive) universities and colleges II:** These institutions are the same as master's universities and colleges I, except that all of the institutions in this group enrol between 1 500 and 2 500 students.

**Baccalaureate (liberal arts) colleges I:** These highly selective institutions are primarily undergraduate colleges and award more than 40 per cent of their baccalaureate degrees in liberal arts and science fields.

**Baccalaureate (liberal arts) colleges II:** These institutions are primarily undergraduate colleges that award less than 40 per cent of their degrees in liberal arts and science fields. They are less restrictive in admissions than baccalaureate colleges I.

**Associate of arts colleges:** These institutions offer certificate or degree programmes through the associate degree level and, with few exceptions, offer no baccalaureate degrees.

**Professional schools and other specialised institutions:** These institutions offer degrees ranging from the bachelor's to the doctorate. At least half of the degrees awarded by these institutions are in a single specialised field. These institutions include theological seminaries, bible colleges, and other institutions offering degrees in religion; medical schools and centres; other separate health profession schools; law schools; engineering and technology schools; business and management schools; schools of art, music, and design; teachers colleges, and corporate-sponsored institutions.

## NOTES

7. The opinions expressed in this paper are those of the author and do not necessarily reflect the policies of the National Science Foundation or the US Government.
8. A summary of the Carnegie categories is appended.
9. Unless noted otherwise, cited passages throughout the paper from *Science and Engineering Indicators - 1996 (S&EI 96)* are quoted verbatim.
10. At the time of writing (June 1997), no estimates of total federal support for university research, nor of support by individual agencies, is available. It is worth reiterating that universities perform some applied research, even though the majority of their research qualifies as basic.
11. A comprehensive description of US graduate education appears in the OECD publication, *Research Training: Present and Future*, Paris, Organisation for Economic Co-operation and Development, 1995, pp. 159-191.

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