

# **RESEARCH AND TECHNOLOGY REPORT 2001**

**Report, in accordance with §8 ROA, on federally subsidised  
research, technology and innovation in Austria**

## **FOREWORD**

This report on the "State of research, technology and innovation in Austria" presents the legislature with a sound account of the Austrian innovation system. It serves as the basis for continued research- and technology policy consultations and the legal resolution of future budget formulation.

Based on an account of Austrian research capacities with the help of national and international indicators in the public sector (above all at universities) as well as in the business enterprise sector, the most important fields of research and technology policy are analysed with particular regard to the further internationalisation of Austrian research and the actual instruments of research and technology promotion used to reach a 2.5% research expenditure share of the gross domestic product. The importance of information and communication technology is also specifically examined.

The report offers ample information for parliamentary debate as well as for the interested public. The joint presentation to the Austrian Parliament by both responsible ministers expresses the reciprocal integration of basic scientific research with application-oriented technology research bearing in mind the responsibility for a national innovation system.

Elisabeth GEHRER  
Federal Minister of Education, Science and Culture

Dipl.-Ing. Dr. Monika FORSTINGER  
Federal Minister of Transport, Innovation and Technology

# TABLE OF CONTENTS

<b>1</b>	<b><u>INTRODUCTION</u></b> .....	<b>5</b>
<b>2</b>	<b><u>RESEARCH CAPACITIES IN AUSTRIA: FINANCING OF RESEARCH AND EXPERIMENTAL DEVELOPMENT IN 2001 AND RESEARCH PERSONNEL IN 1998</u></b> .....	<b>7</b>
2.1	<u>TOTAL R&amp;D EXPENDITURES 2001</u> .....	7
2.2	<u>FEDERAL R&amp;D EXPENDITURES 2001</u> .....	8
2.2.1	<u>Analysis of the "Faktendokumentation 1999"</u> .....	9
2.3	<u>R&amp;D EXPENDITURES OF THE PROVINCES 2001</u> .....	10
2.4	<u>RESEARCH AND DEVELOPMENT IN THE BUSINESS SECTOR</u> .....	11
2.4.1	<u>Research and development activities of the service sector</u> .....	13
2.5	<u>TOTAL AUSTRIAN PERSONNEL COMMITMENT FOR R&amp;D 1998</u> .....	15
2.5.1	<u>R&amp;D employees by scientific fields 1989, 1993 und 1998</u> .....	15
2.5.2	<u>R&amp;D staff by business sectors 1998</u> .....	15
2.5.3	<u>Personnel capacities of university research 1998</u> .....	16
2.5.4	<u>Summary of the 1998 personnel commitment for R&amp;D by executing sectors</u> .....	17
<b>3</b>	<b><u>RESEARCH AND DEVELOPMENT IN INTERNATIONAL COMPARISON</u></b> .....	<b>19</b>
3.1	<u>GROSS DOMESTIC EXPENDITURE ON R&amp;D (GERD)</u> .....	19
3.2	<u>INTERNATIONAL COMPARISON OF R&amp;D FINANCING</u> .....	20
3.3	<u>INTERNATIONAL COMPARISON OF R&amp;D EXPENDITURES</u> .....	21
3.4	<u>RESEARCH AND DEVELOPMENT IN THE BUSINESS SECTOR (INTERNATIONAL COMPARISON)</u> .....	22
3.5	<u>BASIC RESEARCH IN INTERNATIONAL COMPARISON</u> .....	24
<b>4</b>	<b><u>INTERNATIONALISATION OF AUSTRIAN RESEARCH AND DEVELOPMENT</u></b> .....	<b>26</b>
4.1	<u>AUSTRIAN PARTICIPATION IN THE 4<sup>TH</sup> EU FRAMEWORK PROGRAMME (FP)</u> .....	26
4.1.1	<u>Austria's presence in the 4<sup>th</sup> FP</u> .....	26
4.1.2	<u>Determinants of participation</u> .....	27
4.1.3	<u>Cost – benefit analysis</u> .....	28
4.1.4	<u>Short- and mid-term effects of participation</u> .....	29
4.1.5	<u>Additionality</u> .....	30
4.2	<u>AUSTRIAN PARTICIPATION IN EUREKA</u> .....	31
4.2.1	<u>Benchmark figures of Austrian participation</u> .....	31
4.2.2	<u>EUREKA and the Framework Programme</u> .....	33
4.3	<u>AUSTRIAN PARTICIPATION IN COST</u> .....	35
4.3.1	<u>COST - an overview</u> .....	35
4.3.2	<u>Austria's participation in COST</u> .....	36
4.3.3	<u>COST and the EU framework programme</u> .....	36
4.4	<u>THE INTERNATIONALISATION OF RESEARCH AND DEVELOPMENT IN THE BUSINESS SECTOR</u> .....	38
<b>5</b>	<b><u>PUBLIC SUPPORT FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT IN AUSTR.</u></b> .....	<b>41</b>
5.1	<u>DIRECT SUBSIDY</u> .....	41
5.2	<u>TAX INCENTIVES TO R&amp;D</u> .....	42
5.3	<u>QUANTIFICATION OF THE AGGREGATED LEVERAGE EFFECTS OF PUBLIC SUBSIDIES</u> .....	43
5.3.1	<u>Econometric estimation of the effect of public support to R&amp;D</u> .....	44

<b>6</b>	<b><u>THE TECHNOLOGICAL EFFICIENCY OF THE BUSINESS ENTERPRISE SECTOR</u></b>	<b>47</b>
6.1	<u>STRUCTURE AND EFFICIENCY BY TYPE OF INDUSTRIES</u>	47
6.1.1	<u>The WIFO taxonomy</u>	47
6.1.2	<u>Structural characteristics: productivity, growth and quality competition</u>	48
6.1.3	<u>An Austrian peculiarity: good performance in traditional structures</u>	49
6.2	<u>BUSINESS FOUNDATIONS IN AUSTRIA</u>	52
6.3	<u>THE TECHNOLOGICAL SPECIALISATION PROFILE: PATENT REGISTRATION</u>	54
<b>7</b>	<b><u>INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT): THE TECHNOLOGICAL BASIS OF THE KNOWLEDGE-BASED ECONOMY</u></b>	<b>56</b>
7.1	<u>STRUCTURE AND DEVELOPMENT OF THE AUSTRIAN ICT SECTOR</u>	56
7.2	<u>DEVELOPMENT OF ICT DIFFUSION IN INTERNATIONAL COMPARISON</u>	59
7.3	<u>CONCLUSIONS</u>	67
<b>8</b>	<b><u>THE AUSTRIAN UNIVERSITY SYSTEM</u></b>	<b>70</b>
8.1	<u>BUDGET</u>	71
8.2	<u>PERSONNEL RESOURCES</u>	73
8.2.1	<u>University annual accounts 2001</u>	74
8.2.2	<u>Teaching staff and the share of women</u>	75
8.3	<u>STUDENTS AND COMPLETED COURSES OF STUDY</u>	76
8.3.1	<u>Complete overview</u>	76
8.3.2	<u>Completed courses of study by faculty</u>	77
8.4	<u>INTERNATIONAL MOBILITY OF AUSTRIAN STUDENTS</u>	78
8.4.1	<u>Subsidy programmes for up-and-coming scientists</u>	80
8.5	<u>SCIENTIFIC PRODUCTION AT UNIVERSITIES</u>	82
8.5.1	<u>Teaching and supervision</u>	82
8.5.2	<u>Publications</u>	83
8.5.3	<u>Project activities</u>	84
8.6	<u>INTERNATIONAL COMPARISON OF PUBLICATION OUTPUT</u>	85
8.7	<u>COOPERATION BETWEEN UNIVERSITIES AND INDUSTRY IN AUSTRIA</u>	90
	<b><u>REFERENCES</u></b>	<b>95</b>

# 1 Introduction

In compliance with § 8 ROA 2000, the Federal Ministry of Education, Science and Culture (BMBWK) together with the Federal Ministry of Transport, Innovation and Technology (BMVIT) must present the Austrian Parliament a report on the state of federally subsidised research, technology and innovation in Austria by June 1<sup>st</sup> of a given year in correspondence with § 8 of the Research Organization Act.

For the first time, the previously separate reporting on the state of research (annual research reports from the BMBWK) and Austria's technological capabilities (tip-technology reports 1997 and 1999) have been combined into one uniform document. With this, the two ministries responsible for the promotion of research, technology and innovation, BMBWK and BMVIT, account for the mutual integration of basic scientific research on the one hand and application-oriented technology research on the other hand as well as their promotion in the form of unified reporting; this position report is differentiated from previous reports by its analytically descriptive style.

The basis of this report is formed by contributions from the ministries (not only the BMBWK and the BMVIT but also the BMWA), from Statistic Austria and above all from comprehensive analyses of the tip<sup>1</sup> "Technology, Information and Policy Consulting", an initiative of BMVIT and BMBWK. Finally, special thanks go to the Austrian Universitätskuratorium, which also made data available.

Great efforts and coordinated initiatives by the different players on the research and technology policy scene are necessary to reach the Federal Government's goal of raising the research quota in Austria to 2.0% of the GDP by the year 2002 and to 2.5% by 2005<sup>2</sup>. For this reason the need for information is accordingly high. This report contributes to this need as part of its comprehensive coverage.

Moreover, the European Council at Lisbon has formulated an ambitious strategy of change. By 2010 the European Union "shall become the most competitive and most dynamic knowledge based economic area in the world"<sup>3</sup>. Prerequisites for the design and the conversion of such a strategy are the comprehensive inventories and comparisons (benchmarking) of the scientific and technological capabilities of the separate member states as well as the corresponding policies. This report serves as an Austrian contribution to these inventories and benchmarking initiatives.

The research and technology report is based on the most up to date, national and international data available and is oriented towards the international state of the art of innovation research. It...

- presents the Austrian research capacities with the help of basic indicators of research financing and active R&D personnel (chapter 2),
- puts the Austrian research and technology system to international comparison (chapter 3)
- describes the process of the internationalisation of the Austrian innovation system and analyses Austrian participation in the 4. EU framework programme and in EUREKA (chapter 4),

---

<sup>1</sup> tip, the consulting programme for the research and technology policy of BMVIT and BMBWK, is a network of expert researchers from WIFO (administration), JOANNEUM RESEARCH, ARCS and Technopolis. The analyses for this report come from a tip-group consisting of W. Polt (coordinator), B. Badger, H. Gassler, A. Geyer, G. Hutschenreiter, N. Knoll, H. Leo, M. Paier, M. Peneder, S. Pohn-Weidinger, D. Scharinger, A. Schibany, G. Streicher.

<sup>2</sup> Explanation of the Federal Government on current issues in research and technology policy from 11 July 2000

<sup>3</sup> Information from the commission: „Exploit the entire potential of the Union: consolidation and expansion of the Lisbon strategy“. KOM(2001) 79. Part 1. Brussels 2001)

- goes into the current debate on effective instruments of research and technology subsidy (chapter 5),
- describes different aspects of the technological capabilities of the Austrian business sector (chapter 6),
- presents current trends in the information and communication technology sectors and discusses Austrian catching-up potential (chapter 7)
- and finally, provides an overview of the Austrian university system and its output (chapter 8).

## 2 RESEARCH CAPACITIES IN AUSTRIA: FINANCING OF RESEARCH AND EXPERIMENTAL DEVELOPMENT IN 2001 AND RESEARCH PERSONNEL IN 1998

### 2.1 Total R&D expenditures 2001 (Tables 1 and 1a in the statistical appendix)

According to the latest estimate by Statistic Austria (end of April 2001)<sup>4</sup>, altogether 54 billion ATS will be spent on research and experimental development (R&D) in Austria in 2001. Most important are the contributions of governmental institutions (federal government, provinces, other public institutions: 40.3%) and the business sector (40.1%). 19.3 are funded by foreign entities as well as 0.8% by other sources. In comparison to 2000, the grand total of Austrian research expenditures increased by around 6.4% thus reaching 1.83% of GDP.

Thus altogether 21.8 billion ATS (40.3%) are borne by public authorities in 2001 – federal government - 18.4 billion ATS (34.1%), provinces - 3.1 billion ATS (5.7%), other public sources of financing (communities, chambers, social security providers) 250 million ATS (0.5%). Twenty-one point six billion ATS (40.1%) are financed by the business sector, 10.4 billion ATS (19.3%) from foreign sources and only 185 million ATS from the private, non-profit sector.

In the 2001 federal budget (see annex, table 3, "VA-Ansatz 1/5182 12"), 7 billion ATS are designated for the "R&D offensive" programme. Based on the information available to Statistic Austria in April (provided by the Austrian Council for Research and Technology, Federal Ministry of Finance) it was assumed however that of these 7 billion ATS only approximately 2 billion would be spent in 2001. The use of the remaining 5 billion ATS for R&D expenditures was planned for the years to follow (2002 and 2003). Therefore, in reference to the share of federal financing - deviating from attachment T/part b of the federal budget - only those 2 billion ATS which should flow into research in 2001 are incorporated into the R&D expenditure estimate available from Statistic Austria. The estimate for the year 2000 also incorporates the other reserves from the "Technologiemilliarden" from 1997 and 1998, amounting to approximately 839 million ATS, these funds were used for research projects in 2000.

The R&D survey by Statistic Austria carried out in enterprise sector for the 1998<sup>5</sup> reporting year, which not only examined the manufacturing sector but for the first time also the service sector, produced new insights with respect to the structure of financing of research in Austria. As a matter of course, these found their way into the estimation of R&D expenditure for 2001: according to this, research activity in Austria in 2001 will also be financed from abroad to a substantial degree (19.8%). The dominant share of those resources stem from the R&D activities of Austrian subsidiaries of multinational enterprises. To a certain degree this may also have been the case before 1993. Within the scope of previous R&D surveys in the Austrian manufacturing sector (most recently via the Austrian Chamber of Commerce during the 1993 reporting year) this could not however be verified. Still, European integration has undoubtedly made the essential contribution, that international groups exploit the advantages of Austria as a research location and perform their research activities to increased dimensions in Austria.

---

<sup>4</sup>The 2001 complete survey and results of the 1998 R&D survey by Statistic Austria on research personnel only became available at the beginning of May 2001. The data in some sections are therefore based on conditions in 2000.

<sup>5</sup> See „Forschung und experimentelle Entwicklung (F&E) im firmeneigenen Bereich 1998“. In: Statistische Nachrichten, number 2/2001, pages 89 – 103.

By definition, financing from abroad also includes the proportionate returns to Austrian research institutions within the framework of the respective EU framework programme for research, technological development and demonstration. As of April 2001, altogether about 1.6 billion ATS were approved from the 5th framework programme, which is currently running. Of those, approximately 450 million ATS are expected to flow back to Austrian research institutions in 2001.

The grand total of Austrian research expenditures in 2001 is around 70.3% above the level of 1993 and around 14.2% over that of 1998. The research expenditures grew (in spite of a marked slowdown in growth at the end of the 1990s) accordingly, somewhat faster than the gross domestic product (GDP). It rose nominally between 1993 and 2001 about 36.2%. Between 1998 and 2001 it rose around 12.5%.

An overview of all R&D expenditures in 2001 is contained in *Table 1* in the statistical appendix. This table presents the financing of research and experimental development executed in Austria. *Table 1a* in the appendix provides additional information on the share of financing from the separate sectors as a percentage of the gross domestic product.

## **2.2 Federal R&D Expenditures 2001** (Tables 2 to 8 in the statistical appendix)

Federal expenditures for R&D carried out in Austria will reach about 18.4 billion ATS in 2001. With that, they lie around 12.4% above the level from the previous year, around 18.5% higher than in 1998 and around 40.0% above the level of 1993 (see *Table 1* in the appendix).

According to the underlying method, *Table 1* shows the federal expenditures for R&D carried out in Austria in 2000 and 2001 based on Bundesvoranschlagswerte. For the year 2001 the estimate of the federal share of financing from Statistic Austria however (deviating from the 7 billion ATS estimated in the federal research budget for 2001 under the VA-base 1/5182 12 for the R&D offensive programme) only 2 billion ATS were allowed for, as the remaining 5 billion ATS for federal R&D financing is planned in the following 2 years. The full allowance in the year 2001 would greatly distort the estimate of the federal share of financing for both 2001 and for the following years. In addition to the expenditures for R&D executed in Austria, in 2001 the federal government will effect contributions in the amount of 602.6 million ATS to international organizations which have research and research subsidy as targets.

The whole of federal expenditures for research and research subsidy (including the research-effective quotas of the contributions to international organizations) are summarised in "supplement T of the official guide to the federal finance act, parts a and b" (see *Table 3* in the appendix); the values from the Bundesrechnungsabschluss 1999 also include the utilised research-effective resources from the "technology and export offensives of 1998 and 1999" (about 643 million ATS).

*Table 2* of the statistical appendix presents the federal expenditures for research and research subsidies in 2001 in accordance with the Bundesfinanzgesetz 2001 (supplement T) including the estimated reservable resources of the "research and technology offensive" in the amount of 7 billion ATS from chapter 51 of the budget. The total volume of estimated resources therefore reaches about 24 billion ATS. Since the assignment of resources available in 2001 from the "research and technology offensive" to each responsible ministry takes place in several steps and in light of the recommendations of the Austrian Council for research and technology development, a report can be only issued regarding the actual total amount of 2001 federal expenditures and their proportions by ministries in the following year.

For the Bundesrechnungsabschlussdaten 1999 and the Voranschlagsdaten for 2000 and 2001 Statistic Austria functionally categorized the federal expenditures for research and research subsidies (in-

cluding the research-effective shares to the contributions to international organizations) by socio-economic objectives (see *Table 4 in the statistical appendix*).

Without regard to the resources of the "research and technology offensive", whose allocation and division among the ministries in the years 2001 - 2003 is based on recommendations from the Austrian Council for research and technology development, the following emphases are yielded for the year 2001 for the promotion of R&D by the federal government (see *Table 8 in the statistical appendix*):

- 35.5%: promotion of the general expansion of knowledge
- 22.9%: promotion of health services
- 14.4%: promotion of trade, commerce and industry
- 6.9%: promotion of social and socio-economic development
- 5.1%: promotion of exploration of the earth, the oceans, the atmosphere and of space
- 4.3%: promotion of agriculture and forestry
- 3.7%: promotion of environmental protection
- 2.7%: promotion of shipping, transportation and communications

In comparison to the year 2000, the strongest growth is seen in the categories "promotion of trade, commerce and industry" (+10.3%), "promotion of the national defence" (+17.9%) and "promotion of health services" (+9.0%). The largest category with a share of 35.5%, "promotion of the general expansion of knowledge" shows a slight decline (-0,5%) in comparison to 2000.

Breakdowns of the annual values by socio-economic objectives for 1998, 1999, 2000 and 2001 are also available by ministries (see *Tables 5, 6, 7, and 8 in the statistical appendix*).

### **2.2.1 Analysis of the "Faktendokumentation 1999"** (Tables 9 to 14 in the statistical appendix)

Since 1976, the research subsidies and research assignments of federal authorities are recorded in a database of the federal ministry for education, science and culture. Statistic Austria evaluates this database annually by various criteria. The following evaluations are available for the year 1999:

- a) by subsidy recipient or contractor,
- b) by socio-economic objectives as well as
- c) by scientific field.

As in previous years, itemized evaluations were also issued for 1999 including the "large" i.e. institutional, general subsidies (FFF, Ludwig Boltzmann-society, Austrian Academy of Sciences, Austrian Research Centre Seibersdorf). The evaluations "without large, general subsidies" include research contracts awarded to institutions or individuals as well as basic subsidies to small research institutions. (The general subsidy from the BMWA to the FFF not included in the 1999 Faktendokumentation has been based on data from the Bundesrechnungsabschluss 1999). Taking these resources into account, in 1999 more than three quarters (76.8%) of all research subsidies and research contracts were applied to the "large" (institutional) general subsidies.

*Essential results of these evaluations are:*

Of all resources recorded, (i.e. including the "large" general subsidies) 73.7% were paid from BMWV, 22.7% from BMWA as well as the remainder (3.7%) from the other departments.

Without the "large" general subsidies, 81.4% of the resources were given out by BMWV, 5.4% from BMLF, 4.4% from BMUJF, 2.8% from BMWA, 2.2% from BKA and the remainder (3.9%) from the other ministries.

The evaluation of the total subsidies by subsidy recipient or contractor (*see Table 9 in the statistical appendix*) resulted in – apart from the subsidies distributed by the other two research subsidy funds (FWF: 25.9%; FFF: 22.3%) – 20.5% of the 1999 instalments going to subsidy recipients or contractors in the higher education sector, 14.3% to the business sector, and 13.1% to government institutions. Including the subsidies awarded via the FFF in 1999, 36.6% of resources disbursed went to the business sector.

If one does not take the "large" general subsidies into consideration (*see Table 10 in the appendix*), 35.8% of research contracts and subsidies in 1999 were awarded to contracted partners in the higher education sector, 28.3% to such in the government, 16.1% to contractors in the business sector and 15.4% to the private, non-profit sector.

The results of the evaluation by socio-economic objectives including the "large" general subsidies (*see Table 11 in the appendix*) were such that in 1999 the "promotion of the general enhancement of knowledge" had the greatest weight with 31.9%. Twenty-four percent of the subsidy resources were attributable to the category "promotion of commerce, industry and industry". If "large" general subsidies are not taken into consideration (*see Table 12 in the appendix*), 31.7% of all subsidy resources went for the "promotion of the general enhancement of knowledge", 22.8% for the "promotion of social and socio-economic development" and 8.7% to the "promotion of trade, commerce, and industry"

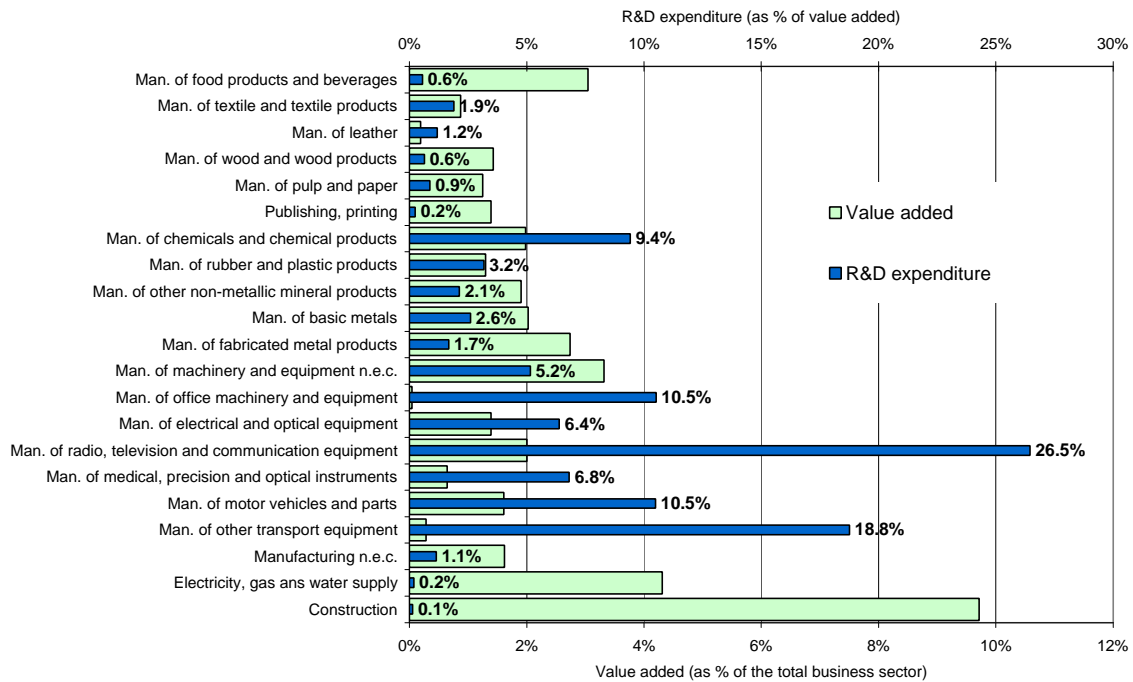
The results of the evaluation by scientific branch including the "large" general subsidies (*see Table 13 in the appendix*) were such that in 1999 the largest shares of the subsidies went to the technical sciences (33.4%) and the natural sciences (31.2%). Eliminating the "large" general subsidies (*see Table 14*), 35.0% of disbursed subsidies went to the social sciences, 27.9% to the natural sciences and 17.2% to the technical sciences.

### **2.3 R&D expenditures of the provinces 2001**

The provincial R&D expenditures are estimated by the Statistic Austria to be 3.064 billion ATS based on the reports of the provincial governments (the R&D expenditures of the provincial health clinics are included in this estimate). Therewith, they are about 4.4% above the level of 2000 and about 71.7% above the survey results from 1993 (*see Table 1 in the appendix*).

## 2.4 Research and development in the business sector

Figure 2-1: Research intensity and value added by industry of the Austrian business sector, 1998



Source: Statistic Austria (2001)

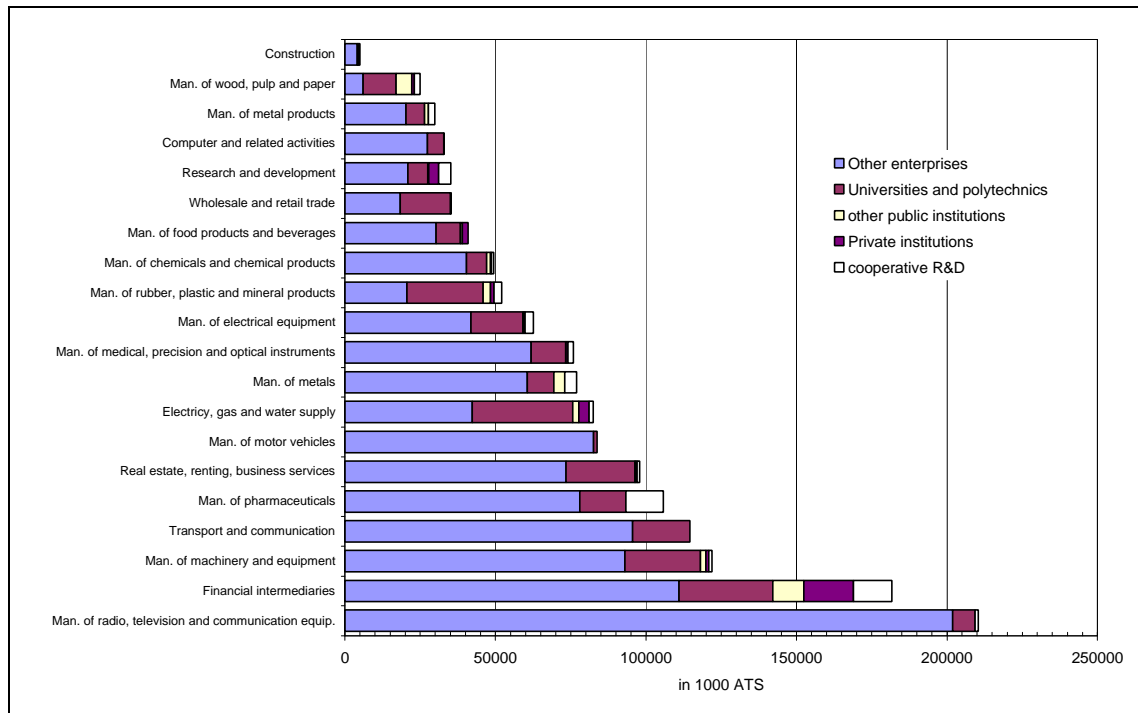
The share of the business sector performing R&D at the sectoral level can be further broken down. R&D intensity in the entire business sector reached 1.82%

Manufacturing, however, to which 84% of all industrial R&D is attributed, amounted to 4.78% in 1998. In comparison to that, the figures for 1995 by Statistic Austria showed an intensity of 4.2% indicating a slight escalation in the research intensity in Austrian manufactured goods production in recent years.

International comparison show that high economy-wide R&D intensity can mainly attributed to high R&D expenditures by the respective business sector. However not all sectors are research-intensive to the same degree. Isolated, particularly research-intensive sectors are able – given an appropriately high share of the economy of a country – to decisively influence the economy-wide R&D intensity.

Particularly research-intensive sectors are seen at the branch level (see Figure 2-1): manufacturers of radio, television and communication equipment, manufacturers of motor vehicles and other transport equipment, business machines, computers and chemicals and chemical products (including the pharmaceutical industry). As the Austrian technology report 1999 has already demonstrated, the low share of R&D intensive – in comparison to the OECD – is a reason for the lower R&D intensity as compared to the OECD average. In recent years, little has changed in regard to these findings. While some of the research-intensive sectors show growth rates higher than the overall economy and thereby averaged gains, these increases are however too small to substantially raise the overall research intensity.

**Figure 2-2 : Expenditure of the business sector for extramural R&D, 1998 in 1,000 ATS**

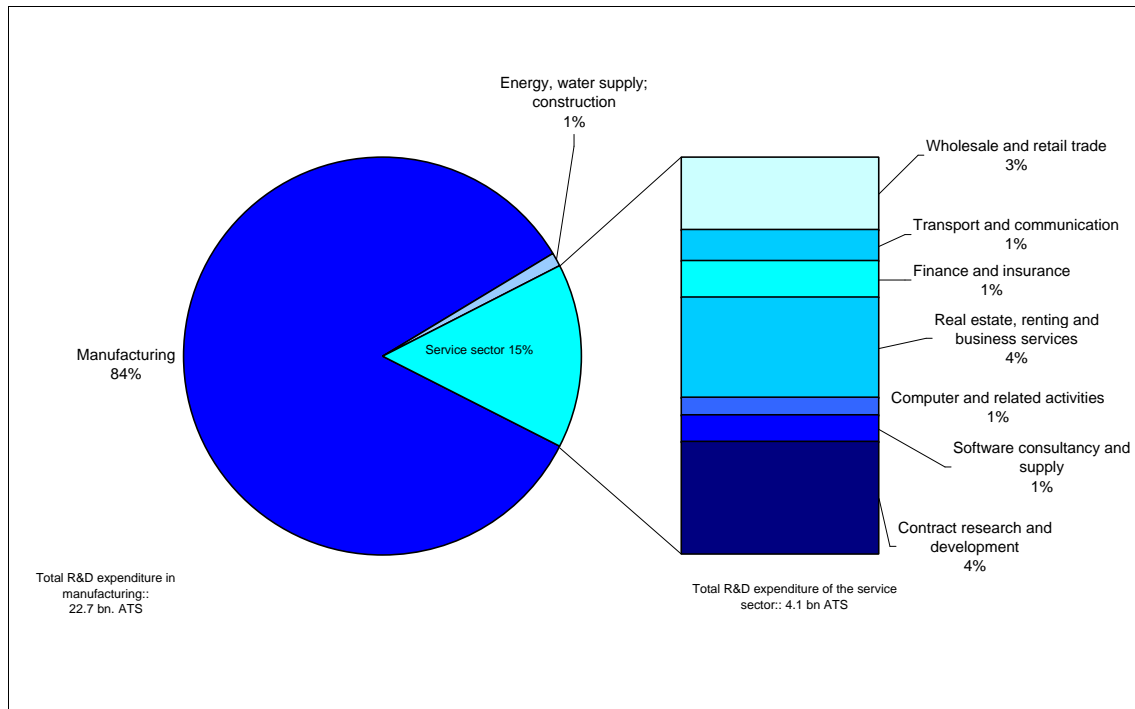


Source: Statistic Austria (2001)

Innovations are increasingly the result of cooperation and knowledge flows within networks of businesses and academic research institutions. A part of these integrations can be demonstrated by the financing flows for externally awarded research and development. The source of financing in this case is the business sector, which spent 1.6 billion ATS domestically for external R&D in 1998. As Figure 2-2 shows, the greatest share of these resources goes to other enterprises. In comparison, the relations between the Austrian business sector and universities are of far less significance in terms of financial scope. Universities receive only about 20% of the research resources awarded to third parties whereby even research-intensive sectors like the manufacturers of radio, television and communication equipment or the pharmaceutical industry are not spending extensively. The evident lack of integration between the Austrian business sector and other parts of the national innovation system, above all with universities, has already been mentioned in previous technology reports. In contrast, the external research capacity of the service sector is relatively high. With 507 million ATS in external R&D, the respective businesses achieve about half of the benchmark value of the manufactured goods industry with substantially lower research intensity. This points to the highly complementary character of externally awarded R&D for those enterprises, which generally do not have their own R&D departments.

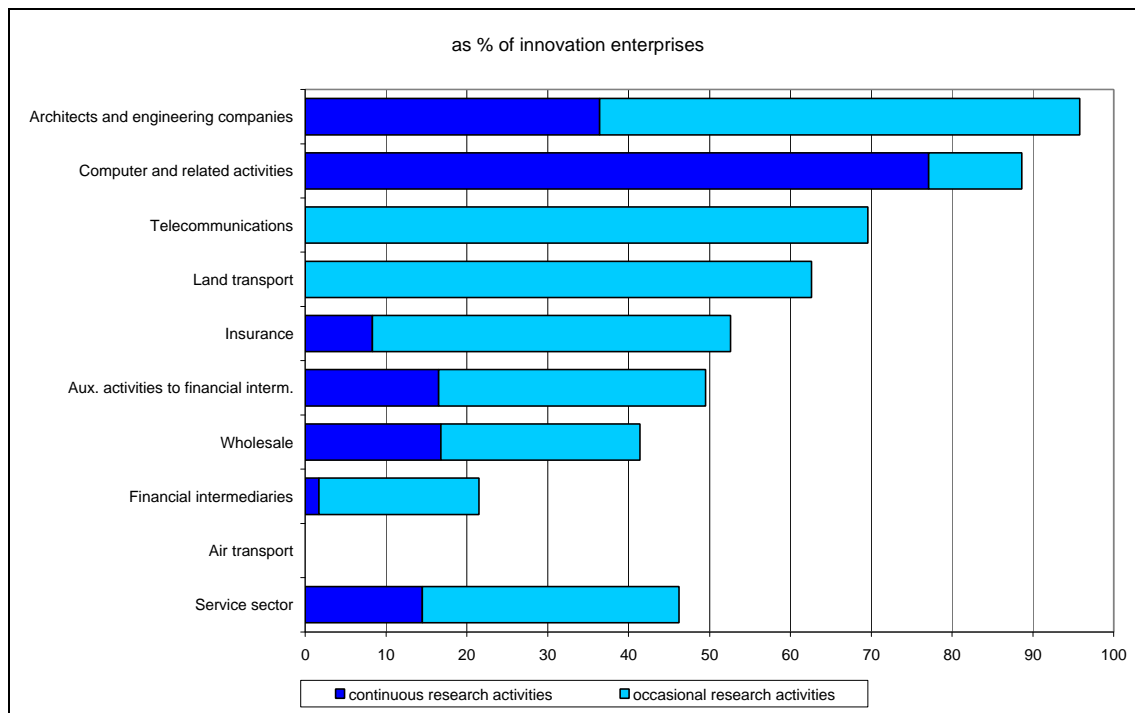
### 2.4.1 Research and development activities of the service sector

Figure 2-3: Service sector's share of R&D expenditures of businesses, 1995



Source: Statistic Austria (2001)

Figure 2-4: Share of enterprises performing research in the Austrian service sector, 1994-96



Source: Community Innovation Survey, WIFO.

The picture of the service sector with respect to technology and innovation policy has changed in recent years. Technology-oriented, dynamically growing sub-sectors like telecommunications and data processing have forever changed the handed-down image of the service sector as a labour-intensive field of the economy with slowly developing productivity. The first-ever consideration of the corresponding sectors in the official statistics relates to this change in attitude. Accordingly, the 1998 internal research and development expenditures of Austrian service companies amounted to 4.07 billion ATS or 15% of the R&D expenditures in the Austrian business sector. This share complies with the OECD-average for 1995 (see OECD, 2000).

The expansion of R&D in the service sector, which international statistics have overlooked for several years, cannot be attributed to a single cause. In many cases it is closely related to growing division of labour and cooperation in the innovation process. Knowledge-intensive service providers establish themselves more and more as organisers of innovation in manufacturing or other sectors of the service sector. The tight relationships and networks between these providers of specialised knowledge and innovative businesses are signs of an increasingly complex innovation process. The most important R&D-related sectors in this group are business consultants and engineers (NACE 74; 1 billion ATS in R&D expenditures), software companies (NACE 72; 455 million ATS) and commercial R&D institutions<sup>6</sup> (NACE 73; 1.14 billion ATS). Organizational integration quite often exists beyond cooperations. It is, for instance, the result of outsourcing (for instance in pharmaceutical research) and spin-offs.

Research and development increasingly finds itself serving as a basis for new products or processes in other sectors of the service sector closer to actual consumption: wholesale and real trade (NACE 50-52; 763 million ATS), transportation and telecommunication (NACE 60-64; 315 million ATS) or the financial sector (NACE 65-67; 374 million ATS). However, the connection between R&D and innovation in the service sector is substantially less distinct than in industry. Fewer than half of the enterprises (manufacturing: 60%) having achieved innovations between 1994 and 1996, also performed research activities (see Figure 2-3). The share of businesses having applied for patents is even less (see Dachs, Leo 1999). Research activities by service providers are organized more informally and based on need. They are often not long-lasting. Only in the rarest cases they have their own R&D departments. Research is mainly performed as an accompanying activity (Sundbo, Gallouj 1998). The research intensity in the service sector, measured by expenditures per staff member or unit of value added, is therefore substantially less than in manufacturing.

Since an important portion of the technologies used in the service sector is not developed by the companies themselves, technology diffusion in the form of tangible and intangible capital expenditures (e.g. software) is substantially more important to service innovations than internal research. A previous tip study (Hutschenreiter, Kaniovski 1999) has shown, that the service sector incorporates significantly more technology in the form of investment goods than does manufacturing. Innovation processes in the service sector are hence in many ways characterised by close relationships between suppliers and clients (Hipp, 2000), whereby the purchasers also build up considerable technological competences. In this context, modern information and communication technologies are of particular significance. In many sectors, like the financial sector or trade, they open up great technological possibilities for innovation. The ICT investments of the financial sector and of telecommunication exceed those of manufacturing by double. Research in the service sector is therefore often related to the adaptation and

---

<sup>6</sup> ARCS, Arsenal Research and Joanneum Research also belong to the ÖNACE 73, research and development. In the quoted survey however, these institutions are not listed under the business sector but in the "cooperative area", see Statistic Austria 2001.

further development of external technologies. A fundamental part of the R&D, within, but also outside the data processing sector, is thereby ICT-oriented.

## 2.5 Total Austrian personnel commitment for R&D 1998 (Tables 19 und 20 in the statistical appendix)

In a summary of all surveyed areas, *Table 19* shows the distribution of personnel commitment to R&D in the executing sectors by number of persons and by full-time equivalents for R&D. Beyond that, *Table 20* identifies the distribution of human resources by gender.

The *total results of the 1998 surveys* by Statistic Austria on the personnel commitment in R&D corresponded to 31,308 full-time equivalents (see *Table 19*). Of these 27.7% were active in the higher education sector (1993: 29.2%), 6.7% in the public sector (1993: 8.6%), 0.5% in the private non-profit sector (1993: 0.4%), 6.0% in the cooperative area and in the area of civil engineers (1993: 5.5%) as well as 59.2% in the area of company-internal research (1993: 56.3%). In total, 65.1% of R&D employees work in the business sector (1993: 61.8%).

By functional categories of employment, 59.8% are allotted to *scientific personnel* (1993: 52.4%; 1989: 38.1%), 25.3% to *highly qualified non-scientific personnel* - engineers, A-level graduates and equivalent manpower (1993: 26.2%; 1989: 36.5%) as well as 14.9% to *other supporting staff* (1993: 21.4%; 1989: 25.4%). With this, the trend toward better-educated personnel observed in 1993 also continued in 1998.

30.4% of *scientists* active in R&D in Austria work at universities (30.1%) and universities of arts (0.3%); 5.1% are at other government institutions, 0.5% in the private non-profit sector and 62.6% in the business sector (including the company-internal area 58.4%).

### 2.5.1 R&D employees by scientific fields 1989, 1993 und 1998

In a summary of all surveyed areas, *Table 26 in the statistical appendix* shows the number of R&D employees by scientific fields with which their R&D activities can be associated (the company-internal area is omitted here as such an assignment would not be consistent with goals). The distribution on the whole has not changed since 1989: about three quarters of the resources provided benefited natural and technical science research including human medicine as well as agriculture and forestry and veterinary science, about a quarter, social science and academic research. Still, since 1985 a slight and continuous shift in the relationship between the scientific fields has taken place in the years between the surveys. About a 1 percentage point shift to the natural sciences can be observed.

### 2.5.2 R&D staff by business sectors 1998

*Table 27 in the appendix* shows the distribution of R&D personnel and R&D expenditures by business sectors for the company-internal area, which has been documented by Statistic Austria since the 1998 R&D survey. In accordance with the modified guidelines of the Frascati-manual, revised in 1993, the ISIC system of economic classes, Rev. 3 was used to make the assignments. It is practically identical to NACE, Rev. 1, or the ÖNACE. The table shows that approximately 15% of the R&D resources go to the services area, which is documented for the first time (R&D employees: 15.6%; R&D expenditures: 15.2%).

### **2.5.3 Personnel capacities of university research 1998 (Tables 16, 17 und 18 in the statistical appendix)**

In Austria as a whole, the potential for scientific specialisation in research and experimental development is traditionally heavily concentrated in university departments. The scope of the personnel research capacities actually employed can be found in the statistical research surveys from Statistic Austria. These are performed every few years.

The 1998 survey revealed altogether 5,687 full-time equivalents directly involved in research and experimental development (R&D) at the universities and the universities of the arts. The overall staff research capacity including non-scientific personnel at universities was altogether 6,814.1 full-time equivalents (1993: 5,605.2) in 1998; this means an increase in the university-based research capacity of 21.6% in comparison with the 1993 survey. At the universities of the arts, altogether 66.9 full-time equivalents were employed in R&D in 1998 (1993: 57.4, that is +16.6% in comparison with 1993).

Classified by qualification and activities, scientific staff at the university institutes and clinics was represented with altogether 5,623.5 (1993: 4,555.9) full-time equivalents. In this case, scientific staff includes professors, lecturers (within the scope of the 1998 R&D survey they were removed from the "assistants" personnel category and recognised separately for the first time), assistants, scientific support personnel including study assistants and demonstrators, clerks of the scientific service, as well as staff of similar stature. The 1998 survey indicated 1,190.6 (1993: 1,049.3) full-time equivalents for qualified non-scientific staff (A-level graduates, engineers, laboratory technicians) and 1,426.9 (1993: 1,132.7) full-time equivalents for other support staff. The personnel capacities employed in R&D have therefore increased by 23.4% in comparison with 1993 in terms of scientific staff. The increase is around 13.5% for non-scientific staff.

If one compares the division of labour among professors in the overall average (see Table 17), it can be determined that in 1998 generally more time was spent performing R&D (44.8%) than for teaching and education (42.1%).

If one considers however the division of labour among professors by scientific fields, there is clear differentiation: particularly in human medicine and in the natural sciences, substantially more time is spent on R&D than on teaching and education. In contrast, the share of time spent on teaching and education in agricultural studies and veterinary science as well as in the arts is somewhat higher than that of R&D. In the technical sciences and the social sciences, the shares of time spent for R&D and for teaching and education are about the same.

The division of labour of the assistants in 1998 also shows a particularly distinct tendency toward research activity (40.9% of their time) in comparison to teaching activities (30.4% of their time). Other activities consume about 13% of professors' time on the overall average. For assistants, about 29%. At clinics however, this value (above all because of the service of the sick) is more than twice as high.

## 2.5.4 Summary of the 1998 personnel commitment for R&D by executing sectors

- **University sector** (Table 21 in the appendix)

In comparison to 1993, the total personnel commitment for R&D (measured in full-time equivalents) has increased by about 21.5%. The greatest increase was noted in institutes in the field the agriculture and forestry and veterinary science (+39.0%), followed by clinics (+33.2%), those active in institutes in the field of technical sciences (+26.0%) as well as in the area of the natural sciences (+25.3%).

- **Public sector** (Tables 22 und 23 in the appendix)

In comparison to 1993, the personnel commitment for R&D in this sector (measured in full-time equivalents) has decreased by around 0.1%. Particularly large decreases were noted in the agriculture and forestry area (-33.2%), in the area of human medicine (-11.7%) as well as in the area of the technical sciences (-7.4%). In contrast, R&D institutions in the humanities and the social sciences showed clear growth with +34.2% and +15.0% respectively.

If one compares the personnel commitment of R&D institutions for research by legal entity in this area (*table 24*), it can be seen that in the institutions assigned to these executing sectors, only the personnel commitment in the federal R&D institutions controlled by the government showed marked decreases (-14.0%). In contrast, there were clear increases in personnel commitment for R&D in the institutions of the chambers (+45.2%), the communities (+44.9%), the private non-profit institutions predominantly financed or monitored by the public sector (+31.5%) and the provinces (+3.6%).

- **Private non-profit sector** (Table 24 in the appendix)

Within the scope of the 1993 R&D survey this national executing sector, to date always the smallest, showed marked decreases in personnel commitment for R&D and in R&D expenditures. This was based on the exclusion of the R&D institutions of the Ludwig Boltzmann-society and the "public" private non-profit institutions from this sector<sup>7</sup>. Between 1993 and 1998 however the full-time equivalents for R&D in this sector increased altogether about 47.8%, whereby the personnel commitment within the scope of the separate scientific fields shows very differentiated development: very high growth was noted in the personnel commitment of the R&D institutions in the natural sciences (+163%) and the social sciences (+134.3%). In contrast, the personnel commitment within the scope of humanities research and the technical sciences decreased by about 71.9% and 26.1% respectively.

- **Business sector** (Tables 25 and 27 in the appendix)

In comparison to 1993, the personnel commitment for R&D (measured in full-time equivalents) has increased about 37% in the areas documented by Statistic Austria excluding the company-internal area. It should be noted that the cooperative area showed an increase of around 41.3%.

The data on personnel commitment in the company-internal area for 1993 and 1998 are not completely comparable since within the scope of the 1998 R&D survey, the R&D institutions of the service sector were documented. The increase of personnel commitment by 34.7% in the company-internal area since 1993 is therefore to be judged taking these facts into consideration.

The data from the 1998 survey in the company-internal area come from the 1998 R&D survey by Statistic Austria in the company-internal area. They were aggregated according to the recommendation of

---

<sup>7</sup> Review of the "Frascati handbook" of the OECD

the Frascati-manual by the system of scientific classes ISIC, Rev. 3. which is practically identical with the NACE, Rev. 1, or the ÖNACE.

*Table 27* in the appendix shows the distribution of personnel commitment and the expenditures for R&D by the economic groups served by R&D. There it is shown that in 1998 (as in 1993) the greatest share of R&D resources went to manufactured goods production (employees 83.2% and expenditures 83.6%)<sup>8</sup>.

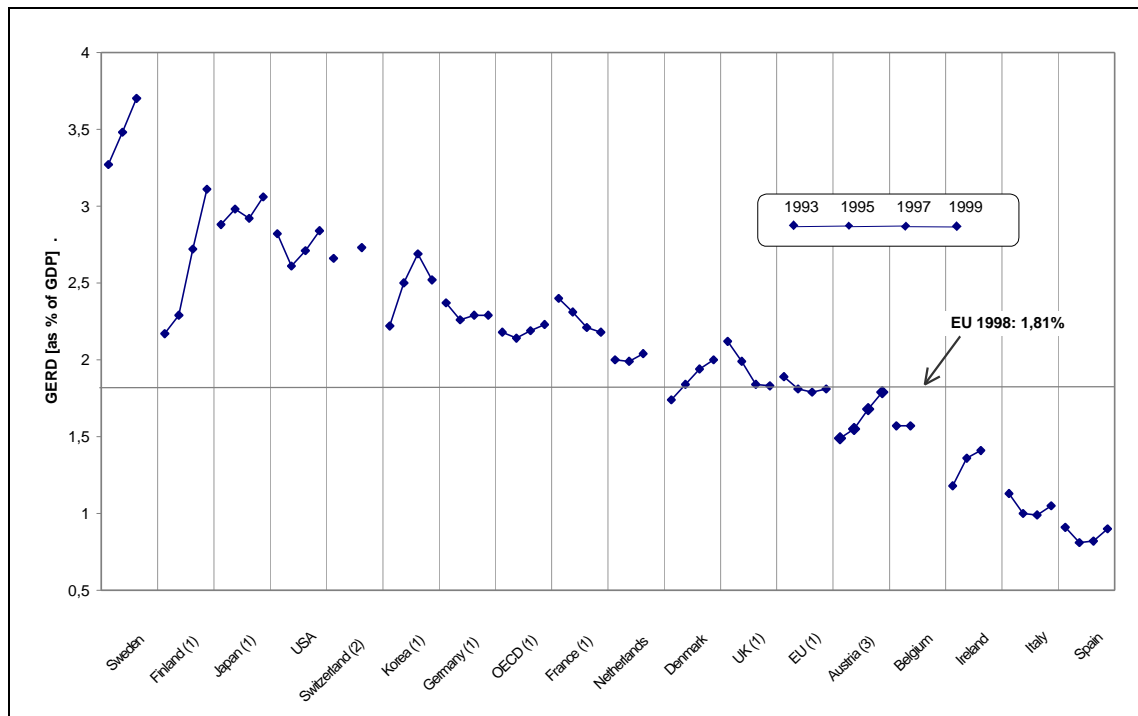
---

<sup>8</sup> For detailed results see "Forschung und experimentelle Entwicklung (R&D) im firmeneigenen Bereich 1998". In: Statistische Nachrichten, edition number 2/2001, pg. 89 – 103.

### 3 Research and development in international comparison

#### 3.1 Gross domestic expenditure on R&D (GERD)

Figure 3-1: Development of gross domestic expenditure on R&D in selected countries, 1993, 1995, 1997, 1999



Source: OECD-MSTI (2000), Statistic Austria (2000a); (1) most recent figures 1998, (2) only 1992 and 1996 available, (3) most recent figures 2000.

Expenditures on research and development (R&D) are one of the central indicators used to assess the technological efficiency of an economy. Simple international comparisons between the R&D inputs of the different countries are made using the gross expenditure on research and development (GERD), i.e. the share of gross expenditure on R&D measured against the gross domestic product (GDP). Figure 3-1 shows the development of this indicator for Austria and some comparable countries since 1993. An overview of the OECD-area – in reference to 1998 – can be seen in Table 27 in the statistical appendix.

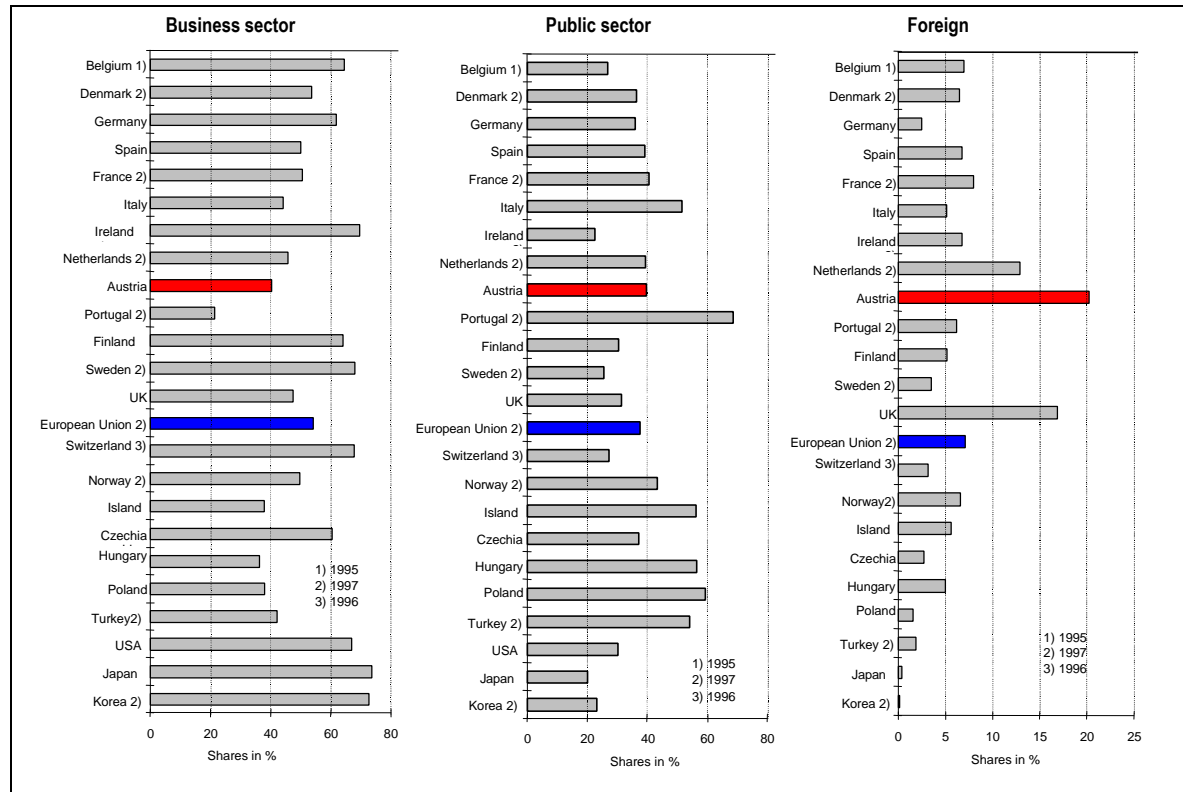
Both in the EU as in the OECD there has been an international trend towards a stagnation of GERD. Only a few small countries like Sweden, Finland, Denmark and Ireland have raised their R&D expenditures considerably and were therefore partially able to move in amongst the international leaders. Finland's technological catching-up process deserves special note. It began in the 80's at the same level as Austria and by 1998 - despite a tough economic crisis at the beginning of the 90's – reached a value of 2.89%.

In Austria, GERD of recent years have been corrected upwards by Statistic Austria within the scope of the GERD estimate from the year 2000 – following a review of the R&D statistics from 1999. Given this, Austria was able to catch up to the EU average in its own catching-up process (1998 Austria: 1.81%; EU: 1.81%). In comparison to the average of the OECD members (1998: 2.18%) Austria is still

clearly behind. This is particularly due to the weighting of the USA and Japan within the OECD. In its declaration of 11 July 2000, the Austrian Federal Government affirmed its goal to increase GERD to 2.5% of GDP by the year 2005.

### 3.2 International comparison of R&D financing

Figure 3-2: International comparison of R&D financing by sector, 1998



Source: OECD- MSTI, Statistic Austria.

The share of the domestic businesses financing R&D is clearly below the EU average and is about at the level of Italy, the Netherlands, Hungary or Poland. In countries with dynamic development or a high level, domestic businesses contribute significantly more to the total financing volume.

In Austria, the public sector's share of R&D financing is about at the EU average. Highly developed and technologically dynamic countries usually exhibit a low share of financing from the public sector and simultaneously a high share of financing from the business sector. The majority of R&D expenditures financed by the public sector are devoted to R&D activities at universities. Part of the public R&D expenditures is used to finance R&D promotion schemes (see Figure 3-2).

The portion of the R&D expenditures financed from abroad encompasses research activities of multinational enterprises in Austria which are financed by the mother company, research contracts from foreign countries awarded to Austrian institutions and businesses, as well as research funds from the RTD programmes of the European Union.

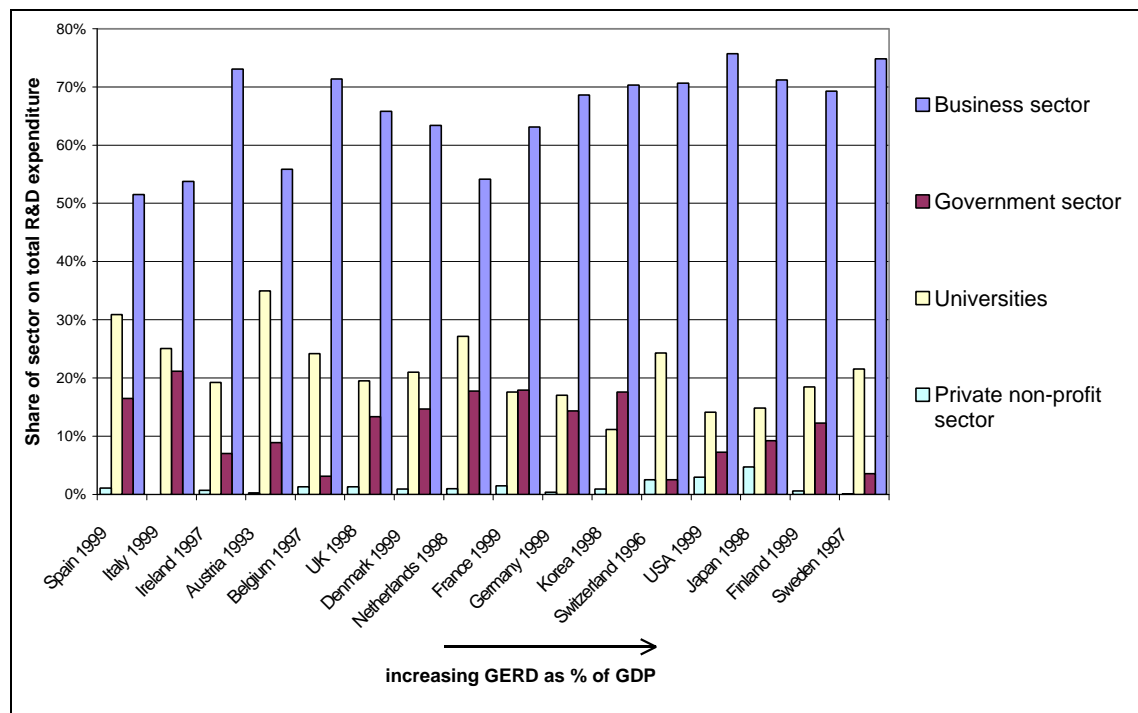
Austria has by far the highest share of R&D financed from abroad in the OECD area. Since the definitions for collecting figures on R&D financed by foreign sources have changed since the last R&D survey in 1993, there is no directly comparable value which allows for an unequivocal interpretation.

While the return from the European RTD programmes increased substantially in the second half of the 1990s this only accounts for a small fraction of R&D financing from abroad.

Assuming that the predominant portion of R&D expenditures financed by sources abroad is performed by the business sector suggests that the share of R&D performed by the business sector should have increased since 1993. Unfortunately the breakdown of R&D expenditures by performing sectors was not yet available as this report was being prepared. For further interpretation and analysis of R&D spending pattern this figures is essential.

### 3.3 International comparison of R&D expenditures

Figur 3-3 : R&D expenditures by performing sectors



Source: OECD-BSTS (2000)

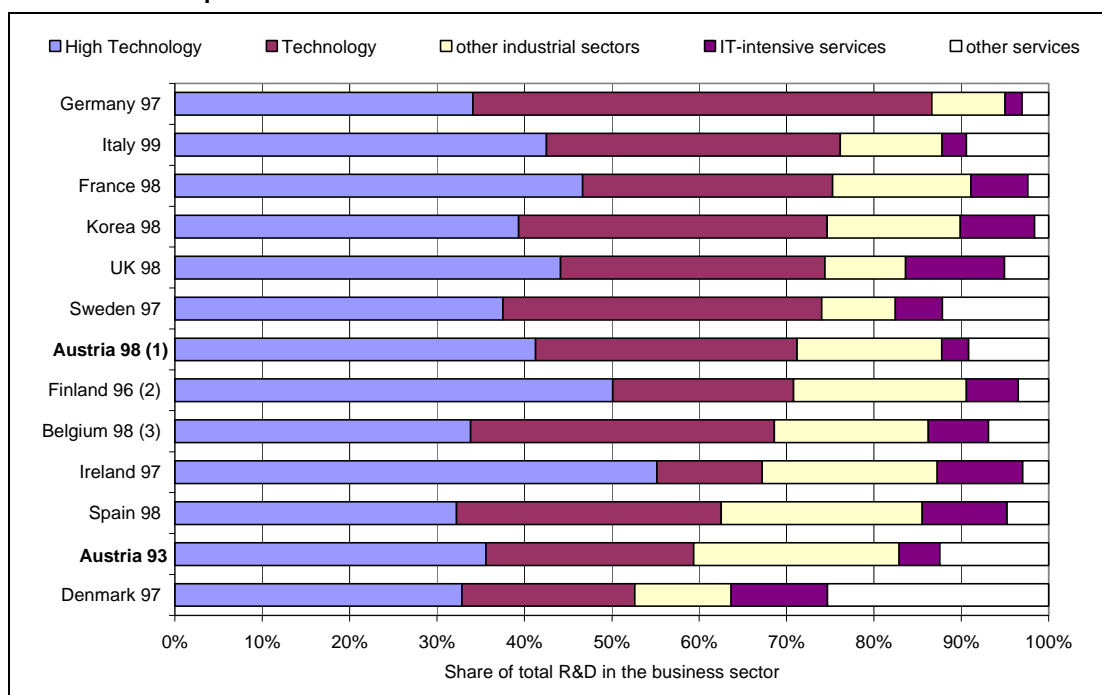
It is noticeable that in international comparison, countries which rank high in terms of GERD as % of GDP, this standing is above all due to a clearly over-proportionate share of R&D in the business sector. The level of the overall economic research intensity therefore correlates to the extent of R&D activities in the business sector. On the other hand, the shares of the public and higher education sector are generally less despite higher R&D intensity. The GERD as % of GDP of a country is therefore not just determined by the sectoral organization of its research activities.

The highest shares of the business sector compared to the total research expenditures belong to the USA with 76% (1999), Sweden with 75% (1997), as well as Ireland with 73% (1997). The EU average share for business sector R&D is about 62%, in the OECD over 68%. In Austria, however, despite recent indications of a catching-up process, the industry share of R&D performed is still clearly below average. The last fully available R&D survey in Austria (base year 1993), indicates an industry share

of 56%. The higher education share is consistent with the international value. It is 35% of all Austrian R&D expenditures<sup>9</sup>.

### 3.4 Research and development in the business sector (international comparison)

Figure 3-4: Research and development in the business sector (BERD) by industry in international comparison



Source: OECD-BSTS (2000), Statistic Austria (2001), calculations from tip. Delimitation of the sectors by classification *ISIC rev. 3*<sup>10</sup>. (1) 92. (2) 83% of the total industry R&D included. (3) 95% of the total industry R&D included.

An international comparison of the structure of research expenditures in the business sector is difficult due to the differing data surveys in individual countries. If, however, one condenses the separate branches into 5 groups, namely high-technology, technology, other industrial sectors, information technology (IT)-oriented services and other services, the following picture can roughly be drawn (see Figure 3-4). The predominant share of business sector research in all comparable countries is carried

<sup>9</sup> In Austria, the executing sectors are distinguished as follows: business sector (company-internal area including energy suppliers, and the cooperative area including Austrian Research Centre Seibersdorf, Joanneum Research as well as civil technicians); State sector (federal institutions (excluding those documented under the college sector), national-, local-, chambers as well as institutions of social security providers, museums and provincial health care organisations); College sector (university departments and clinics, universities of the arts, Austrian Academy of Sciences as well as testing and research laboratories at polytechnic schools); as well as the private non-profit sector: private institutions without commercial characteristics, and comprised of private or legally private, confessional or other non-public status, as long as it is not completely or predominantly funded by public resources.

<sup>10</sup> For the following representation the sectors were grouped according to the International Standard of Industrial Classification (ISIC) rev. 3 :  
 high-technology: 19 (pharmaceuticals), 28 (business machines, computers), 30 (electronic hardware), 33 (instruments), 37 (aircraft-construction); technology: 16 (crude oil processing), 18 (chemicals without pharmaceuticals), 27 (engineering-machinery), 29 (electric appliances), 34 (construction-of-motor-vehicles), 36 (shipsvessels), 38 (other vehicle construction); Other production sectors: *ISIC rev. 3*-sectors 1 to 44 without high-technology and technology; IT-services: 48 (transport), 49 (communication), 54 (computer-related services); Other services: 46 (trade), 47 (hotel trade), 52 (financial services), 57 (research and development), 58 (others business activities), 59 (personal services etc.).

out in the technology and high-technology sectors. On average, in the countries surveyed, the common share is 71% with the majority share held by high-technology.

Some countries, which were able to dramatically increase their R&D efforts in recent years, distinguish themselves through a dominance of R&D expenditures by high-technology sectors. In Ireland, they account for 55% of BERD. In Finland it is over 50%, whereby the pharmaceutical industry, which is particularly research-intensive, is not surveyed separately, and thus is not valid for comparison. Only in Germany are the expenditures focussed on (middle) technology with 53%; in contrast, Germany brings up the rear by the high-technology with a share of 35 %.

According to new data from Statistic Austria (2001)<sup>11</sup> in comparison with 1993, the technology-orientated enterprises in Austria were able to markedly raise their common share of the total industry R&D compared to 1993. By 1998, they achieved a share of 71%, consistent with the average of the countries surveyed. This in spite of the fact, that the technology sector is not completely documented in the available comparison, and in reality should be somewhat better positioned<sup>12</sup>. Still, Austria's position behind forerunners like Finland or Ireland must be pointed out, with regard to high-technology's share of all industry R&D (41%).

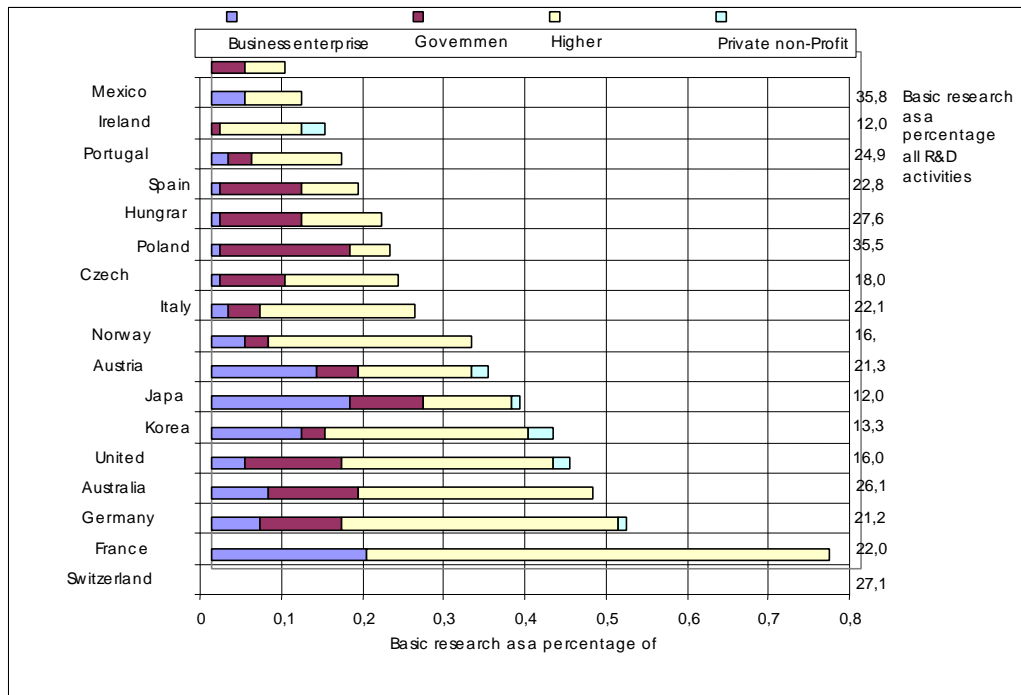
---

<sup>11</sup> For Austria, partial results of the first R&D survey by Statistic Austria from 1998 exist. With this, For the business sector (with exception of the cooperative area and the civilian technicians) it is the first time that results are also available for the service sector.

<sup>12</sup> Due to the low number of businesses in the individual branches, the branch total is confidential.

### 3.5 Basic research in international comparison

**Figure 3-5: Share of basic research by sector of performance and country 1997**  
(as a % of GDP and as a % of all R&D expenditures)



Source: OECD (1999)

#### Basic research by sectors of performance

Within the OECD countries the expenditures for basic research vary between about 0.1% (Mexico) and more than 0.7% (Switzerland) of GDP. With 0.32% of GDP, Austria lies in the middle of the pack in this comparison. Compared with the early 80's, the share of basic research measured by GDP clearly rose in most OECD countries.

The shares of expenditures for basic research also vary widely when measured by the total R&D expenditures. While countries like Mexico and Poland have values over 30%, the share of basic research by total R&D expenditures in east Asian countries like Japan and Korea is at 12-13%. Austria is with Germany (21.2%), France (22%) and Italy (22.1%) with 21.2% (1993) in the middle of the pack.

Within the OECD, the largest portion of basic research is conducted in the higher education sector and/or in the public sector. This picture is characteristic of most EU countries while in Switzerland, the USA, Korea and Japan, basic research in the business sector clearly plays a more significant role. The higher education sector also dominates the basic research performance in Austria. In comparison, the public sector and the business sector are comparatively less important.

## Expenditures of higher education research in international comparison (HERD)

**Table 3-6: Research expenditures in the higher education sector (as a% of GDP)**

	1989	1993	1995	1997	1998	1999
Germany	0.41	0.43	0.41	0.41	0.4	0.41
France	0.35	0.38	0.39	0.38	0.37	-
U.K.	0.33	0.36	0.38	0.36	0.36	-
Italy	0.24	0.28	0.25	0.26	0.25	0.26
Austria	0.44	0.52	-	-	-	-
Sweden	0.9	0.84	0.76	0.8	-	-
EU	0.34	0.39	0.38	0.37	0.37	-

Source: OECD-MSTI (2000)

Table 3-6 presents the development of expenditures for higher education research (HERD - *Higher Education Expenditure on Research and Development*) in the largest EU countries, the EU and Austria since 1989. The international comparison of the HERD share of GDP reflects the status of higher education research in the respective countries. In Austria, in 1993 - the year of the last complete survey – the value was 0.52%, clearly above 0.37% which the OECD specifies as the average for the EU-states in 1998. Austria's higher education share is only topped by Sweden (1997: 0.8%).

All in all, the significance of higher education research appears to have receded slightly. While in the first half of the 90s (just as in the 80s) the HERD share of GDP markedly rose within the European Union, a slight decrease in HERD quotas is apparent in the second half, from 0.39% of GDP in 1993 to 0.37% 1998. This development is reflected in all of the countries mentioned with the exception of Sweden.

## 4 Internationalisation of Austrian research and development

### 4.1 Austrian participation in the 4<sup>th</sup> EU Framework Programme (FP)

In April 2001 the evaluation of Austrian participation in 4th EU framework programme, commissioned by the BMBWK, was completed (Schibany et al. 2001). Within the scope of this study, a self-conducted survey was carried out in addition to the assessment of the status of the Framework Programme within the European research area. This survey supplies important conclusions regarding the effects of the framework programme on cooperative, precompetitive and applied research in Austria.

#### 4.1.1 Austria's presence in the 4<sup>th</sup> FP

**Tab. 4.1: Austria's presence in the 4th FP (Activities 1-4)**

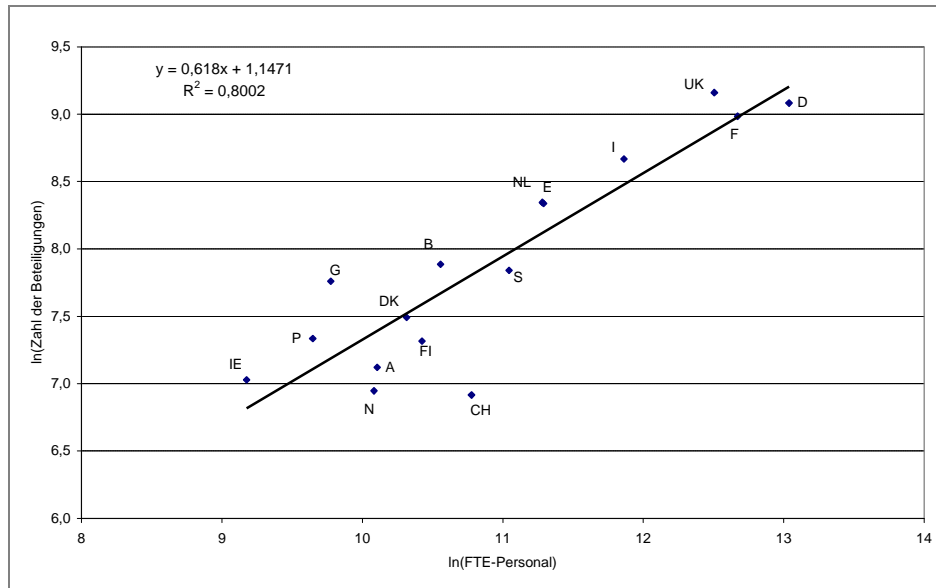
	In projects submitted	In successful projects
Participations	7,164	1,923
Projects with Austrian participation	5,680	1,444
Coordinators	1,124	270
Organisations	2,320	1,009
Returns		192.627 million EUR

Source: BIT

- Membership in the EU has resulted in a quantum leap for Austria's participation in the framework programme: the number of participations in the 4th framework programme quadrupled in comparison to the participation all previous FP's combined.
- In the entire 4th framework programme, 2,320 Austrian organizations participated in submitted proposals. Of those, 1,009 organizations were part of successful applications with altogether 1,444 projects and 1,923 participations. On average, there were 1.33 Austrian participations in projects with Austrian presence.
- All returns from participation in 4th framework programme amounted to over 192 million EURO (~ 2.65 billion ATS) and represent a share of 1.99% of all resources planned for indirect activities.
- Of the 1.009 Austrian organizations participating in the 4th framework programme 50% are from industry, 28% from universities and 13% from non-university research institutions. If however one looks at the distribution in reference to successful participations one notices very clear differences. This is due to the fact that the average number of participations per organisation clearly varies between the different types of organisations. Industry averages 1.5 participations, university departments 2.1 and non-university research institutes average 2.3 participations.

## 4.1.2 Determinants of participation

Figure 4-1: Relationship between R&D staff and the number of successful participations

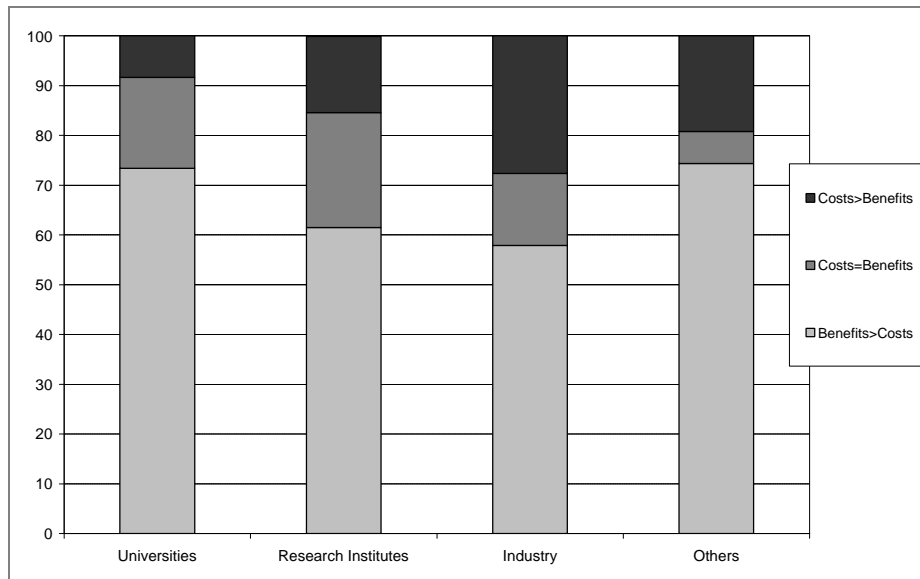


Source: Schibany et al. 2001

- Participation by member states and the number of RTD personnel show an impressive and explanatory relationship. The existing absorption potential in the form of human resources explain 80% of the variance in relation to the number of participations of a country. The remaining 20% are then due to other factors. The trend line shows if a country has the expected number of participations given its size (measured in RTD-staff). Countries below the trend line therefore have “too few“ participations. This is clearly noticeable in non-EU member states Norway and Switzerland.
- Despite the rapid increase in Austrian participation in 4th framework programme, there still appears to be unexhausted catching-up potential. This is also the case in the other new member states Sweden and Finland, but Austria is clearly below the trend line.
- An analysis of the patterns of participation further shows that the framework programme has an (absolutely intended) effect towards European convergence: the structure of participation in the individual countries is essentially determined by the structure of the framework programme and thus exhibits a pattern of high correlation between the participating countries. Varying national specializations only come through to a small extent.

### 4.1.3 Cost – benefit analysis

Figure 4-2: Cost/benefit comparison by type of organisation [%]

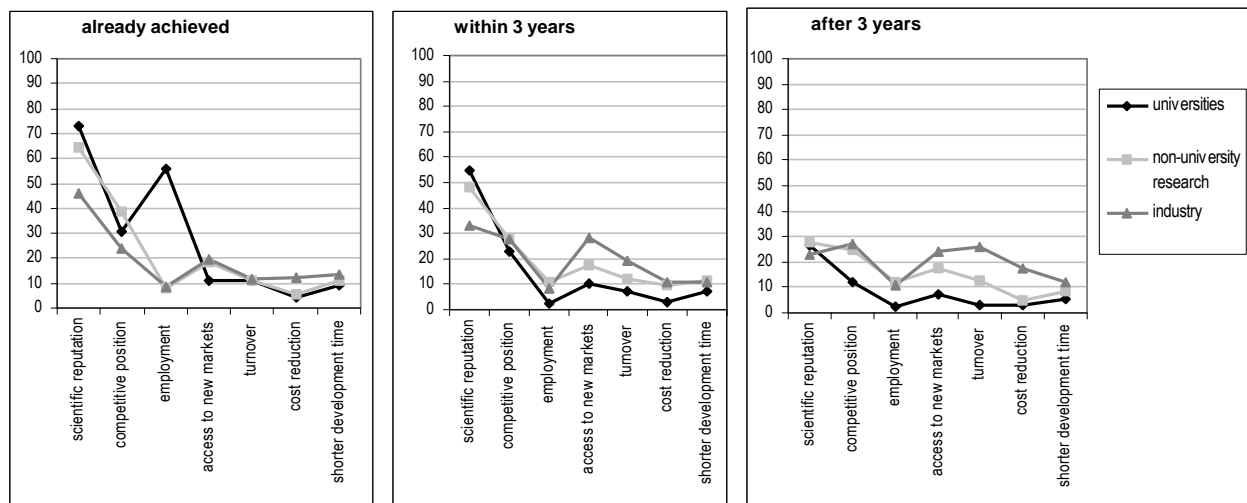


Source: Schibany et al. 2001

- The general assessment of the benefits of participation in 4th FP is absolutely positive: 66% of the participants estimate the benefits of their participation to be higher than the costs. 17% see a balanced relationship between benefits and costs and only 17% judge the relationship negatively.
- The universities and the category “others” were the most positive in rating their participation. This is most certainly due to industry’s heightened awareness of the costs of participation. The opportunity costs of participation in the FPs plays a lesser role for the universities as for companies.
- *Newcomers* estimate the general benefits to be positive as well: over two thirds estimate the benefit/cost relationship to be positive. Their assessment was slightly more positive than that of the group that had already participated in earlier FPs.
- The research activities in EU projects are precompetitive. This influences the status of an EU project within the context of research strategy. The FPs make it possible for industry to carry out cooperative research activities which could be of future strategic significance. Such knowledge is increasingly developed in larger consortia and contributes to the building of competence. For the majority of participating companies, participation in FPs supports other innovation activities. Universities and non-university institutions however attribute substantially higher strategic significance to EU projects – demonstrating a causal relationship with scholarly research.

#### 4.1.4 Short- and mid-term effects of participation

Figure 4-3: Short- and mid-term impact of participation in EU FPs (% of answers in the category strong positive effect)

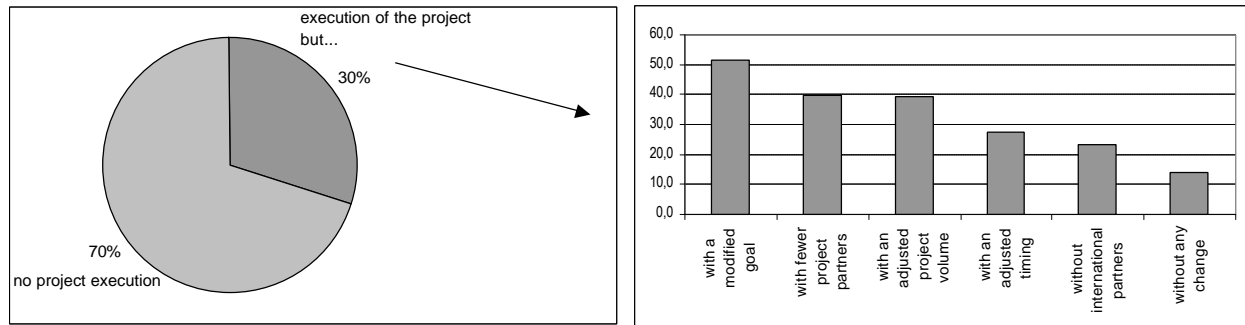


Source: Schibany et al. (2001)

- With respect to the effects of participation in the EU- framework programme, technological and/or scientific reputation takes first place. Obviously, participation is already an important tool for universities (73% indicated highly positive effects on reputation) and non-university research institutions to express their scientific/technological capabilities to the outside world.
- In regard to the short-term effects on employment, university research institutes have the highest share (56%), indicating highly positive effects. This is not too surprising since within the scope of university projects doctoral students as well as post-docs generally work in addition to the project-related, permanent staff. The motivation to increasingly involve up and coming academics in EU projects is at least partially due to the fact that EU subsidies for universities refer to the marginal costs. Permanent staff is not financed. The results show that at the university level participation in EU FPs plays an important role for the academic up and coming. In non-university R&D institutions as well as in industry, the projects are however carried out by permanent staff. Therefore the direct effects during as well as shortly after project execution are mentioned correspondingly less.
- The mid-term effects show that participation in EU FPs is also used as a mid-range offensive tool for new market development. Although the FPs are generally organised to be precompetitive, direct (in part even short-term) economic effects are visible. This is further confirmed by the fact that 28% of companies expect their competitive position to improve within the next three years. Also, industry's expectations are clearly rising in regard to increasing turnover. This indicates a general difference between the types of organisations. While universities assess the effects to be particularly strong in the short-term (i.e. during or shortly after the project) followed by decreasing future expectations, the exact opposite is true for industry. While the "hard" effects (like development of new markets, increased sales or cost reduction) have a limited response at the outset (effect already occurred) they rise sharply in regard to future expectations.

## 4.1.5 Additionality

Figure 4-4: Additionality of participation in EU FPs



Source: Schibany et al. (2001)

The concept of additionality is of central importance to the European context and essentially presents the analysis of the motivational effects of public subsidy of research activities. The reason why public subsidy sources are interested in the concept is a fear that public subsidy monies represent a substitution for private investment, which would have been made by the subsidised companies in any case. This would counteract the government's intentions, namely correcting potential market failure.

Existing studies regularly demonstrate very high values for the additionality of the framework programme, reflecting the characteristics of a European project (multinational, several partners, etc.). In this regard, Schibany et al. (2001) posed the question as to whether or not the project would have otherwise been carried out without EU funds.

- In Austria 70,1% of those questioned said, that they would not have continued with the relevant research project in the case of a project rejection. This favours the very high additionality of the EU FPs. One cause of this high additionality is certainly the fact that because of the complex project organisation, the amount of work associated with the execution of the project without EU subsidy is considered to be too high and that without the subsidy the consortium would forego the whole project.
- Of the 30% of respondents that would have continued the project without EU subsidy only 14% say that they would have done so without any adjustments. This further underlines the great extent of additionality that can be achieved through the EU FPs. All those that would have continued the project with modifications list above all modified goal orientation (52%), a reduced number of project partners and different project volume (each 40%). The average change in project volume, is – 47%. So, without EU subsidy the project would have only been continued in a very reduced form.

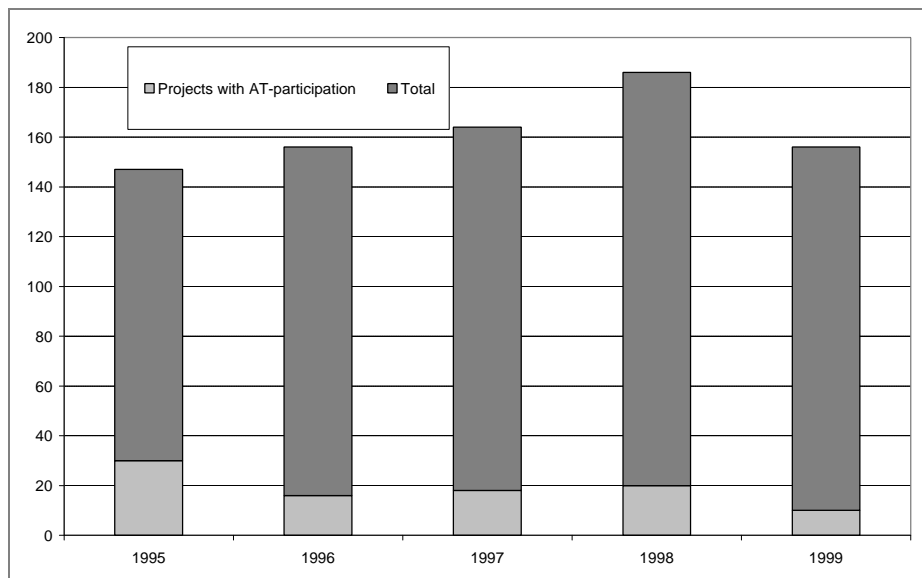
## 4.2 Austrian participation in EUREKA

### 4.2.1 Benchmark figures of Austrian participation

In 1985, 17 western European countries and the European Union founded EUREKA. Today, a majority of the Eastern European countries along with the EU and EFTA states comprise the 29 EUREKA members. Still, EUREKA's general goal has remained unchanged: the strengthening of the competitive capacity of European industries on civilian, international markets.

Since the beginning of the EUREKA Programme, Austrian partners have participated in 249 projects. This number includes completed, current as well as aborted projects. In total, Austria has participated in approximately 12% of all EUREKA projects. Figure 4-5 shows the number of Austrian projects in relation to the total number all EUREKA-projects for the period from 1995-99. Of the 803 projects begun in this time period, Austria is or was participating in 89. It shows the highest share of all projects started in 1995, the year Austria joined the EU. In subsequent years, that share drops to about 10% of all initiated projects.

**Figure 4-5: Number of EUREKA projects, 1995-99**



Source: BIT

According to recent figures<sup>13</sup>, Austrian participation is still somewhat more than 10%. That is consistent with the performance of Finland (113 project participations) and lies somewhat above the EUREKA mean. In addition, there are great differences between the EUREKA-countries: in the last 5 years, 11 countries (out of 29) have generated more than 80% of all EUREKA projects<sup>14</sup>. Austria belongs to this group of very active countries.

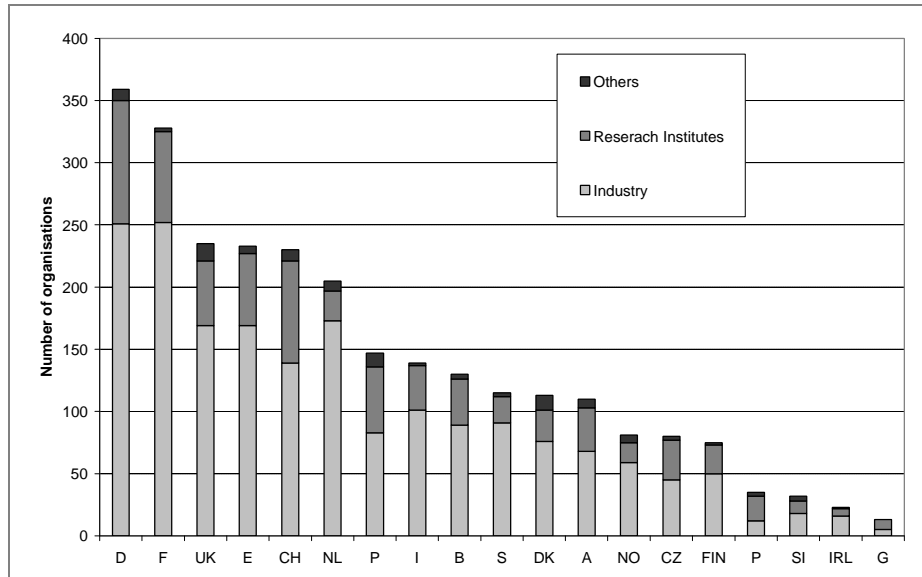
In recent years the weighting of projects has shifted from strategic, large-scale projects – with high costs and long duration - on average ATS 523 million / 70 months – to market-oriented, shorter and smaller projects with average costs of ATS 27,5 million and an average length of 24 months. This reflects the increasing participation of SMEs in the recent past.

<sup>13</sup> As of 4/2001; Source: EUREKA Intranet

<sup>14</sup> EUREKA Document E/N3-3a,S.2 Spanish Chairmanship, NPC-Meeting Nr.3, 4-5 April 2001

Figure 4-6 shows the number of organisations, participating in projects in 1998. They are broken down by type. It shows that EUREKA appeals above all to industry. Of the nearly 3.000 participants (companies and research institutions), two thirds were from industry. Sixty one percent were SMEs (i.e. 42% of all participants). Further, almost 25% of all participants are from two of the largest countries (Germany, France), followed by the U.K., Spain, Switzerland and the Netherlands. Altogether these countries account for about half of participants.

**Figure 4-6: Number of organisations in the EUREKA projects [1998]**



Source: EUREKA annual report 1999

In 1998, Austria was represented in EUREKA projects by 110 organisations, of which 68 were companies (of them 44 SMEs) and 35 research institutions (of them, 24 were universities). An essential characteristic of EUREKA is the “bottom-up” approach. It allows the project participants the choice of project content and scope, to set the date the project begins as well as the selection of project partners. Along with initiation of project ideas by companies as well as researchers themselves, the subsidy process also differs from the FP. EUREKA projects can be subsidised with national R&D subsidies. Requests for financing take place according to national R&D subsidy procedures. In Austria, the EUREKA budget of the FFF covers approximately 80% of the subsidy volume. Since 2000, the FFF commands a separate EUREKA budget with approximately 80 million ATS available for grants and loans to subsidise Austrian EUREKA participation.

The average Austrian EUREKA subsidy volume currently amounts to 8.7 million Euro annually; that finances around 30 Austrian project participations annually. With an average financing volume of EUREKA projects at the level of 2.5 million Euro,<sup>15</sup> the 30 Austrian projects constitute a total capacity of 75 million Euro. That is a subsidy quota of about 1:8.

<sup>15</sup> EUREKA document E/N3-2c, page 9

## 4.2.2 EUREKA and the Framework Programme

Table 4-2 offers a comparison of participation in EUREKA and in the framework programme in recent years:

**Table 4-2: Austrian participation in EUREKA and the 4th framework programme in comparison**

	EUREKA* (1995-1999)	4th framework programme (1994-98)
Total number of projects	803	21,715
Number of projects with Austrian partners	89	1,444
Share in%	11	6.6
Number of Austrian project coordinators	44	270
Share in%	5.4	1.2
Ø Number of participations per project (with AT participation),	6.1	8.3**
Ø Number of participating countries per project (with AT participation)	3.3	5.2**

Source: For EUREKA: Documents E/N3-3a, E/N3-2c Spanish Chairmanship, NPC-Meeting Nr.3, 4-5 April 2001; For FP-4: see Schibany et al. 2001, Key figures of DG Research, BIT; RP including Euratom

\* Without cluster- and umbrella projects, N=64

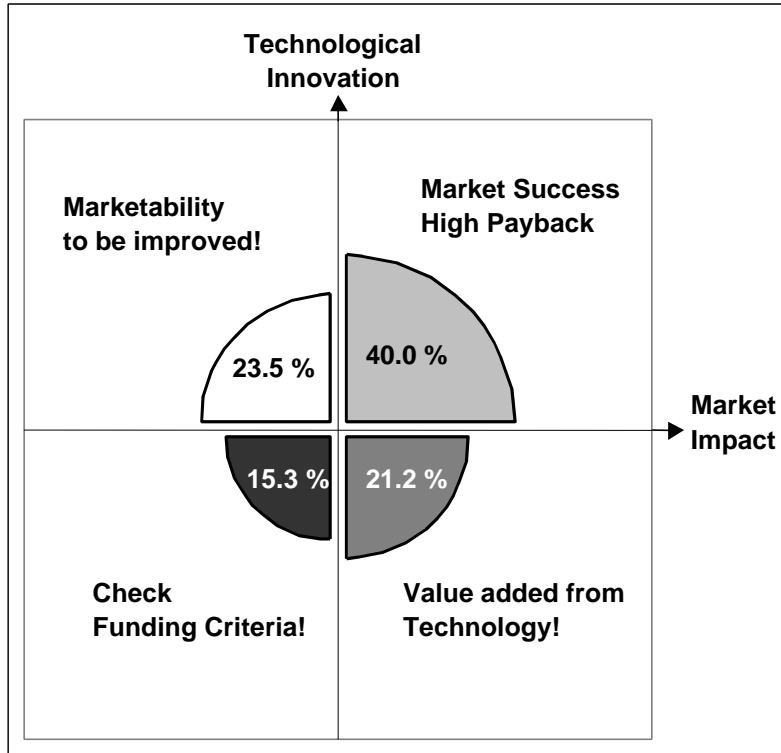
\*\* Only research projects (shared cost actions), N=812

The indicators of Austrian participation in EUREKA are quite comparable to those of participation in the 4th framework programme; in some aspects, Austrian performance in EUREKA is clearly better:

- Austrian partners participate in 11% of all EUREKA projects (FP 4: 6,6%), 5,4% of all EUREKA projects are coordinated by an Austrian partner (FP 4: 1,2%). It must be noted that in this comparison, the Austrian percentage share of EUREKA is calculated with a higher population of 29 countries.
- A comparison of EUREKA and the 4th framework programme also shows, that while in the parameter "average number of participations per project" EUREKA projects lie below the average participation level in the 4th FP, it still commands a relatively broad base of participation. This is even more remarkable, in that despite EUREKA projects' proximity to market, a significant number of competences cooperate thus indicating a high degree of research dynamic and learning effects.
- On average, partners from 3.3 countries participate in EUREKA projects. In contrast, this average is more than 5.2 countries in 4th framework programme. This provides interesting inferences about the quality of EUREKA projects since the subsidy decisions take place at national levels. Consequently, on average 3.3 national subsidy bodies are involved, each with an independent evaluation. At the same time, the national subsidy bodies cannot limit their evaluations to the parts of the projects performed by the domestic project partner, rather the subsidy bodies naturally must examine the quality of the project as a whole. Additionally the awarding of EUREKA status for an R&D project comes after examination of the relevant criteria based on the proposals of the national project coordinators.

Of late, the EUREKA office produces a so-called “Competitiveness Matrix”<sup>16</sup>, in which, based on an ex-ante evaluation, the project proposals are assessed according to 2 parameters (technological level of innovation and economic capability). Specific criteria were evaluated for both parameters by means of a point system. Figure 4-7 shows the results of the evaluation of projects with Austrian participation and the assignment to the respective quadrants.

**Figure 4-7: Competitiveness matrix of projects with Austrian participation**



Source: BMVIT, tip calculations

Of the sample of 85 project approvals, a mere 15.3% exhibit a clearly below average degree of innovation as well as below average market opportunities. The remainder are distributed across the other three quadrants. Measured against both criteria, 40% of all EUREKA projects with Austrian participation are technologically advanced as well as economically utilisable.

In summary, the present interaction of purely national criteria of assessment and selection methods works well. This is further confirmed when the competitiveness matrix is viewed at another level: the majority of projects subsidized in EUREKA are technologically demanding and market-oriented R&D projects.

<sup>16</sup> EUREKA document E/N3-2c, page 8

## 4.3 Austrian participation in COST<sup>17</sup>

### 4.3.1 COST - an overview

Austria has been a member of the COST European research initiative since 1971. COST is made up of 32 member states (15 EU and 17 non-EU members) as well as Israel. At the same time, COST establishes cooperations with research institutions from third countries like Russia, Japan, Australia, Canada and the U.S.A. It is also an important forum for collaboration with the Danube district. 40,000 scientists work together in COST as one network. COST is especially important for junior scientists accessing international cooperation and short-term researcher exchanges within the scope of Short Term Scientific Missions. The research volume achieved within COST amounts to 2 billion Euro per year.

The number of member states has grown continuously since its founding:

1971	COST founded	19 member states
1991	Minister conference of Vienna	25 member states
1997	Minister conference of Prague	28 member states
1999	COST resolution of Sliema, Malta	32 member states
2000	COST resolution of Helsinki	32 + Israel (special status)

COST promotes scientific-technical research in the precompetitive area based on common coordination, yet based on national funding. The projects encompass a spectrum from basic research to industrial application, where multiple- and interdisciplinary fields are particularly addressed.

The “variable geometry“ of COST collaboration enables the member states to participate according to the “à la carte principle“: they have free choice of participation in the various research activities. The interest expressed by the member states and the lively scientific cooperations are impressively demonstrated by the continuous growth in the number of research activities.

At founding in 1971, 7 COST projects were approved. In 1990, 42 projects were executed and in the year 2000, the number was about 150.

COST provides an infrastructure, which allows scientists across Europe to exchange their expertise and cooperate efficiently. This is particularly attractive to teams of young researchers as COST’s flexibility offers them decisive advantages: openness to new impulses (bottom-up approach), workshops, “Short Term Scientific Missions“ and increasing numbers of worldwide cooperations.

---

1 <sup>17</sup> COST - Coopération européenne dans le domaine de la recherche scientifique et technique - European cooperation in the area of scientific and technological research

### 4.3.2 Austria's participation in COST

Austria's continually increasing participation in COST is higher than in any other research programme (in%): (Source: COST-annual reports, released from BMVIT)

1996/97:	51%
1997/98:	52%
1998/99:	70%
1999/2000:	90%

The important role of Austrian scientists in the nano-sciences and the strong participation in activities in the medical and chemical / pharmaceutical areas, in telecommunications, transportation and the woodworking and the paper industries deserve special emphasis.

To Austria, successful COST cooperation means a decisive increase in national innovation potential at favourable terms as well as access to the commonly acquired research results relevant to all of Europe. With this, COST proves to be a particularly valuable instrument for Austria, with special importance for collaboration with Central and Eastern European countries.

In Austria, there is no single budget for COST activities, like in some other member states (e.g. Switzerland or the Czech Republic). Project costs related to COST activities are presently covered by:

1. Internal resources of the research institutions (especially university departments)
2. Research subsidy funds: above all FWF, FFF
3. Funding by businesses
4. Contracted research commissioned by ministries
5. Other resources

### 4.3.3 COST and the EU framework programme

The top-down-oriented framework programme and the bottom-up COST cooperation are complementary. COST supports the European Research Area (ERA) with its flexible working method. There is no single budget for COST in the EU budget but the COST infrastructure is funded via INCO of the EU framework programme. The integration of a research cooperation extending beyond the boundaries of the union into the INCO activity, has not proven successful due to different structures and objectives. Austria is recommending a separate budget for COST within the 6<sup>th</sup> framework programme.

The financial resources for COST in the 5th EU framework programme have been cut although the association agreement with the MOEL countries has come into effect. Therefore, COST has proportionately fewer resources available from the 5th FP. It is now necessary to raise the financial resources for COST through a moderate raise in resources in the 6<sup>th</sup> FP, so that this shortage is again balanced and a suitable and efficient management is secured.

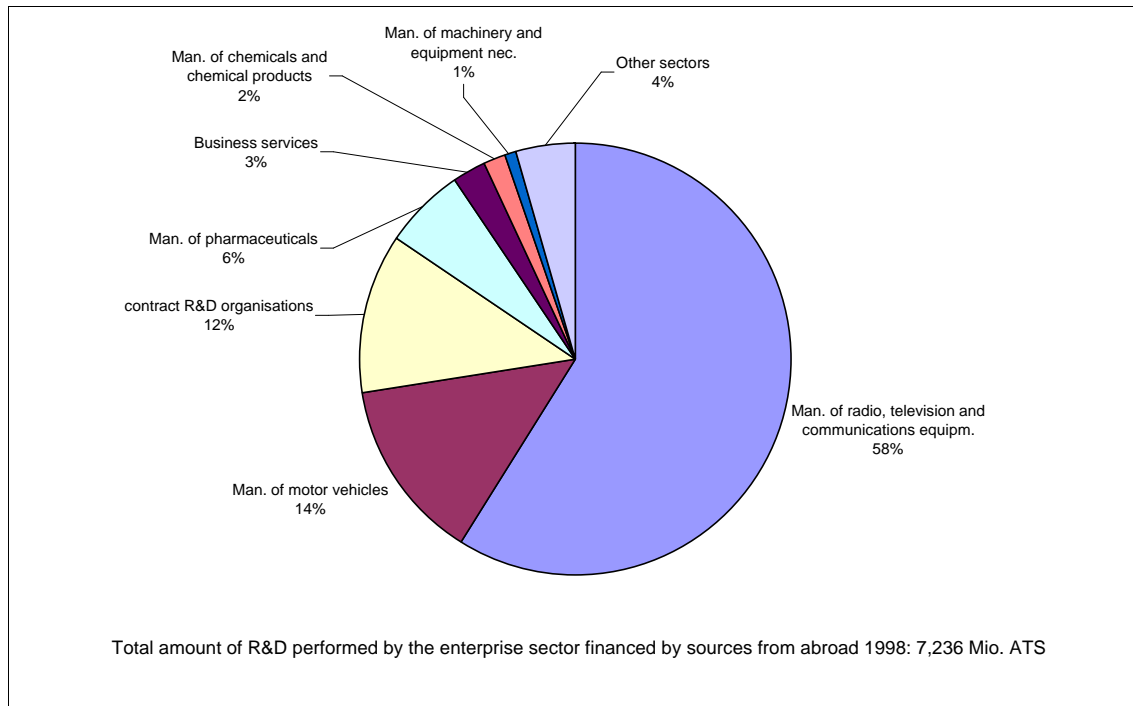
To secure the synergies between framework programme, EUREKA and COST, there is support for the retention of an office in the European Commission. The EC has overtaken this work since COST's founding and shall therefore not be released of this responsibility. In the end, member states would be responsible for other forms of financing.

COST also has model characteristics for new cooperations in Europe's relations to other parts of the world. Recent developments have shown that above all Canada, the USA and Australia are intensifying their relations to COST and are cooperating at the project level, increasingly to the mutual benefit of those involved. With this, COST projects produce essential impulses for further developments in

EUREKA and the framework programme, especially as COST projects are positioned above all in the precompetitive area, in particular in basic research. Faced with the objectives of the future European research area, COST represents a good instrument for making use of the existing national potential at the European level. The COST cooperation is therefore in the interest of the whole of European innovation and simultaneously serves the preservation of Austrian interests in this process.

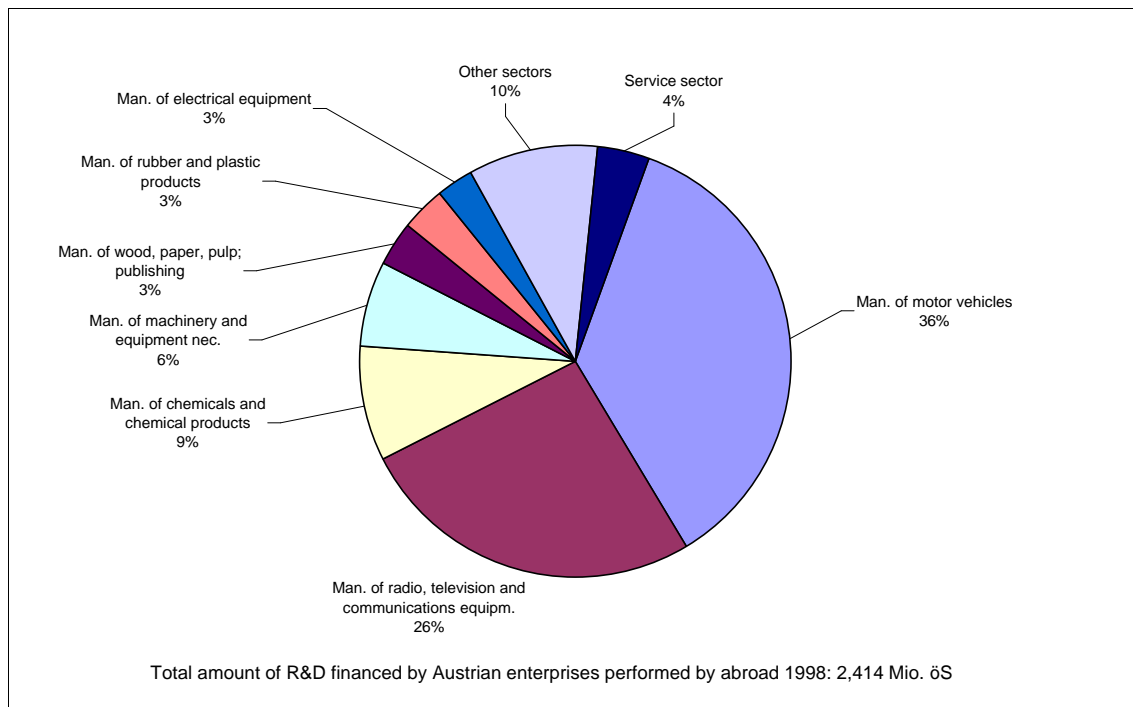
#### 4.4 The internationalisation of research and development in the business sector

Figure 4-8: Financing of business R&D from abroad by receiving sector, 1998



Source: Statistic Austria (2001)

Figure 4-9: Financing of R&D abroad by Austrian business by sector performing, 1998



Source: Statistic Austria (2001)

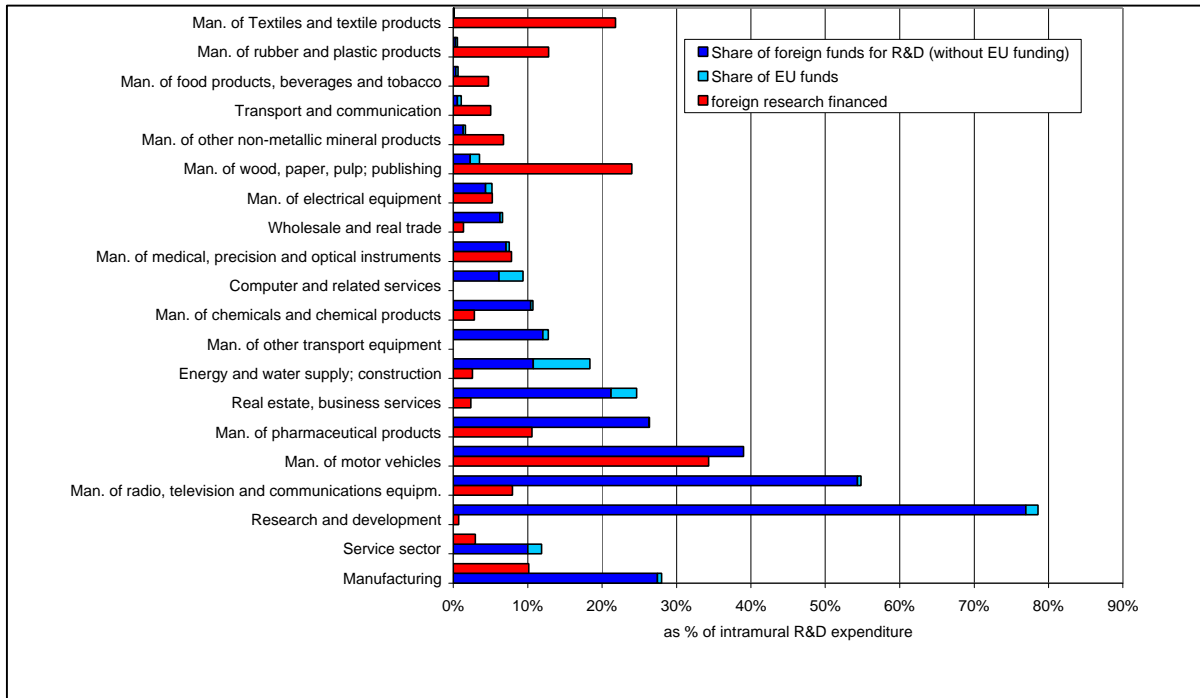
The rise in the share of foreign financing of domestic research shows that the Austrian innovation system is part of a development toward the increased internationalisation of industrial research. This development has already been recognized in the other OECD countries for some time (for an overview, see OECD 1998). Based on current results reported by Statistic Austria, Austria would actually clearly exceed all other OECD-states with regard to the foreign share of domestic R&D financing. At the same time, in 1998 Austrian companies financed R&D activities worth 2.4 billion ATS by foreign institutions.

At the financial flow level the internationalisation of the Austrian innovation system can clearly be ascribed to the increasing decentralisation of the R&D activities of transnational companies. In contrast, more intense international contacts between companies and universities or the returns from the EU framework programme only play an ancillary role financially. Foreign companies, having chosen Austria as their research location, financed R&D expenditures of 7.2 billion ATS in 1998 in the domestic business sector. The recipients of these resources were restricted to a relatively small group of particularly research-intensive sectors (see Figure 4-8). In recent years, Austria has been able to establish itself as an attractive location for R&D institutions of transnational companies in these fields. Many of these are the result of direct investments in existing companies. Research in commercial R&D institutions (ÖNACE 73) is, for instance, almost exclusively financed from internal resources as well from abroad.

Transnational companies can decentralise their research activities for a number of reasons. These might be advantages of location like the access to research capacities, proximity to particular universities, research institutions, business clusters or “communities“ (e.g. in the fields of IT and biotechnology), the existence of qualified scientists, advantageous legal and subsidy conditions or “soft factors“ (e.g. high quality of life). The high concentration of research-intensive sectors can – particularly in light of the small size of the Austrian market and the proximity to Germany – be seen as an indication, that the foreign share of domestic industry research is less due to adaptation of products to the local market but rather represents an important complement to the R&D competences of the parent company.

Also, the financial flows from Austrian companies to foreign countries which account for 2.4 billion ATS are predominantly financed by research-intensive sectors (see Figure 4-9). The predominant share goes to subsidiaries and related companies. The automobile industry and manufacturers of radio, television and communications equipment are sectors which are not only important recipients but also important financiers of R&D. The share of mid- or less research-intensive sectors like the textile industry or the paper- and cardboard industry is also conspicuously high. Based on the financing flows, the degree of international integration of the service sector (without respect to commercial R&D institutions) is substantially less than that of manufactured goods production (see Figure 4-10).

**Figure 4-10: Degree of interconnection of selected sectors with foreign countries, 1998**



Source: Statistic Austria (2001)

## 5 Public support for research and technological development in Austria

Public support for research and technology has been and still is a central element of Austrian technology policy. Other instruments of technology policy such as regulation, public procurement, provision of research infrastructure (public research institutions) do not enjoy the same status in Austria as in other countries.

The total impact of the Austrian system of public support is hard to assess. Previous attempts to evaluate the Austrian system of public support for technology are - despite some positive examples (see, e.g. the activities of the platform "Technology Evaluation") - still incomplete and seen, also from an international perspective, as in need of improvement (OECD, 1998). On the one hand, important elements of the system have not been evaluated to this point. On the other hand, reforms are often local, disregarding the overall system. However, the effectiveness of instruments of public support - as shown by the OECD (Guellec, van Pottelsberghe 2000) - is not independent of the other components of the support system.

Some reasons for the great significance of public support to technology are, on the one hand, the fact that innovation is very dynamic on an international scale and the resulting new tasks facing innovation policy and, on the other hand, the fact that in the EU framework of control of state aid R&D subsidies are preferred in comparison to other forms of aid. Furthermore, the number of agents increased internationally, nationally and also regionally because of the expansion of the field.

### 5.1 Direct subsidy

The state aid database of the Federal Chancellory (FINKORD) reveals, among other things, present values of subsidies for federal "business-related technology subsidy". The share of these technology-oriented subsidies (including, among others, the promotion of technology diffusion, technology transfer and provision of infrastructure) which is actually used for the promotion of research and development in a narrow sense, cannot be exactly determined. This is due to the fact that, among other reasons, the classification is based on the supporting institution and not on the type of support.

When measured by this indicator, at the beginning of the 90s, direct support to R&D in Austria corresponded to the OECD average (Polt et al., 1999). After a falling trend in the present value of technology-related subsidies was identified in the mid-90s (1996: 1,334 million ATS), this value rose sharply in the second half of the decade (1999: 2,456 million ATS). Thus, in 1999 technology-related subsidies were only slightly exceeded by regional aid. The latter was unusually high as the EU structural fund period came to an end in 1999.

In the Austrian system, direct subsidies traditional instruments like direct grants and subsidised loans dominate. In recent years, however, support to technology in Austria was complemented by truly innovative elements, which address a variety of dimensions of the innovation process processes. In particular, in accordance with new insights of research regarding technology and innovation they address several dimensions recognised as important problems in the context of the Austrian innovation system. In some programmes

- the problem of lacking information and awareness concerning technological developments and the innovation potential – especially in SMEs – was given attention (via the financing of consulting services - Austro-BUNT, certification of the consultant),
- technology transfer and technology diffusion – again with a focus on SMEs – was supported (in the ITF-programmes FlexCIM [Flexible Computer-Integrated Manufacturing] and Technology Transfer – with an evaluation of these programmes (see Geyer et al., 2000, or Jörg et al, 2000),
- the strengthening of co-operation between science and industry<sup>18</sup> was the goal. The competence centre programmes included here were:  $K^{plus}$ ,  $K^{ind}/K^{net}$ , the impulse programme for co-operative research institutes, the contact projects between science and the economy (for an overview of these programmes see Schartinger, Schibany, Gassler, 2000 as well as Polt, 2000),
- the formation of industrial clusters was supported via various initiatives - above all at the state level – to create "critical masses" (among others, the automobile-cluster in Styria<sup>19</sup> and Upper Austria and the biotechnology-cluster in Vienna)
- the formation of technology-orientated businesses was supported: Business Angels, Seed-Financing, Spin-Offs from academia - "A[cademia]plusB[usiness]" (on the development of the formation of technology-oriented businesses see Almus et al., 2000; on the concept of academic Spin-Off promotion see Sturn, 2000).

Some essential innovations are also apparent in the "subsidy design: following international examples, support to competence centres through the Kplus programme were awarded via a competitive process administered by the "Technologie Impulse GmbH" (TIG). This process should enable the selection of "the right" projects even given incomplete information.

## 5.2 Tax incentives to R&D

Rather less attention is paid to tax incentives to R&D. The R&D tax allowance, which was increased and redesigned with the 2000 tax reform, is the most significant indirect R&D subsidy instrument in Austria<sup>20</sup>.

Until the 2000 tax reform came into effect, a tax allowance of 12% could be claimed for the development or improvement of "economically valuable inventions" in accordance with §4 para.4 EstG (Income Tax Law), over and above the immediate deduction of R&D expenditures as business expenses. An increased deduction (18%) was granted if the results of the research were mainly used within the company (the returns from the use of the invention did not exceed 25% of the research expenditures for the given financial year).

The reform of the R&D tax allowance with the 2000 tax reform included the following crucial points:

- The R&D tax allowance was generally increased to 25%.
- "Additional" R&D expenditures (i.e. beyond the average of the last three years) earn a R&D tax allowance of up to 35%.

---

<sup>18</sup> Also see chapters 7 and 8 for the cooperation between science and industry in Austria

<sup>19</sup> For an evaluation, see Adametz et al., 2000.

<sup>20</sup> Schneider, 2000 offers an overview of the system of fiscal incentives to R&D.

- The differentiation in the level of benefits based on the criterion of internal or external exploitation was lifted.

According to the report of the Federal Ministry of Finance on state aid in 1999, the tax revenue foregone due to the R&D tax allowance and beneficial treatment of donations for science and research are listed was 1.1 billion ATS (before the 2000 tax reform). When the reforms take effect, a substantial increase in tax revenues foregone is expected. In relation to the other research and technology subsidy instruments, the R&D tax allowance is certainly not of a negligible magnitude. In an international comparison, the fiscal incentives to R&D are relatively well-developed in Austria but need improvement in some aspects: current regulations are disadvantageous to, among others, technology-oriented start-ups which usually show no profit in the early phase.

### 5.3 Quantification of the aggregated leverage effects of public subsidies

#### Effects of public subsidies on internally financed R&D expenditures of the business sector - the OECD study (2000a)

A new empirical study of the OECD (OECD 2000a, based on Guellec, – van Pottelsberghe, 2000) attempts to quantify the influence of different forms of public R&D expenditures on the internally financed R&D expenditures of the business sector by use of econometric estimations. The following influencing factors were considered:

- direct public support to R&D in the business sector,
- indirect support to R&D (based on an index of the "generosity" of the tax incentives),
- the R&D expenditures of the public sector (public research institutions) and
- the R&D expenditures in the higher education sector.

Value added and industry R&D expenditures of the previous period were included as additional variables.

The study is supported by data for 17 OECD countries between 1981-1996. A particularly interesting aspect of this study was that the influence of the factors listed above was determined simultaneously and not, as mostly, in isolation (e.g. influence of only the tax incentive or only the direct R&D subsidy on the R&D expenditures of the business sector).

The main results of the study ("the average" of those countries concerned, not for any individual country) are as follows:

- Both direct and indirect support to R&D stimulates internal R&D financing by the business sector. One ATS in direct subsidies raised the average R&D expenditure by around 1.61 ATS in total in the short term.
- Direct subsidies are more permanent than tax incentives since they impact on business R&D expenditures over a longer period.
- Direct and fiscal support to R&D act as substitutes: an increase in the intensity of one decreases the effect of the other.
- The R&D expenditures in the public sector and higher-education R&D appear to crowd-out business R&D expenditures. In this regard however it should be noted that the time lags in the OECD model are much too short to adequately represent the influence of university research.

The study contains important statements about the effectiveness of public support to R&D:

- Neither direct subsidies that are "too low" nor "too high" are optimal. Up to a subsidy intensity of 13%, the stimulating effect increases, beyond this threshold it declines. Beyond a 25% subsidy intensity, public subsidies appear to substitute for private financing.
- Industry's uncertainty as to future subsidy policy (e.g. due to frequent changes in the subsidy

requirements, the subsidy intensities etc.) reduces its effectiveness. This result confirms the results of earlier studies. For this reason a long-term orientation or the stability of support policy is recommended.

- The effectiveness of an instrument depends on the use of the other components of public R&D expenditure.

The following conclusions can be drawn from the OECD study. They are relevant to the current goals of Austrian research and technology policy:

- Public support to R&D (whether direct or indirect) actually stimulates additional business-sector R&D investment.
- The subsidy intensity however cannot be arbitrarily increased without a decrease in efficiency. Therefore, there are limits to the ability to influence business-firm's R&D investment decisions in the short run.

The study offers a strong argument for smoothing and co-ordinating support policy. Short-term stop-and-go policies (resulting from budgetary restrictions) are inefficient. Reforms to individual instruments in the R&D support system should – for reasons of effectiveness – take the overall support system into account.

### 5.3.1 Econometric estimation of the effect of public support to R&D

Recently, WIFO made a first attempt to quantify the influence of various policy instruments on the R&D expenditures in Austria financed by the business sector (FUNT). In this study, commissioned by the BMVIT, an econometric approach was used (see Hutschenreiter, Polt, Gassler, 2001)<sup>21</sup>. Along with the business-sector R&D expenditures of the previous period, explanatory variables include:

direct technology-related subsidies - DIR (cash values according to FINKORD and WIFO calculations),

tax incentives to R&D measured by an index of the generosity of the R&D tax allowance - B (WIFO calculations),

higher education R&D expenditures - UNI (Statistic Austria),

gross physical investment of industry (based on the WIFO investment survey).

The period of observation covers two decades, namely 1980-1999. The econometric model was estimated in logarithmic differences (growth rates). Specifically, the estimated R&D investment model takes the following form:

$$\Delta FUNT_T = C + I \Delta FUNT_{T-1} + \mathbf{b}_{DIR} \Delta DIR_{T-1} + \mathbf{b}_{UNI} \Delta UNI_{T-1} + \mathbf{b}_B \Delta B_T + \mathbf{b}_{INV} \Delta INV_T + \mathbf{e}_T$$

Delta ( $\Delta$ ) is the log-difference-operator:  $\Delta x_T = \log x_T - \log x_{T-1}$  and  $\log$  the natural logarithm.

The comparatively long intervals between Austrian R&D surveys limited the analytical possibilities. The results of the econometric study for Austria are nevertheless consistent with the OECD results (Guellec, van Pottelsberghe 2000) in several respects. However, the comparison of the estimated results with those of the OECD-study ought not be overstretched since the analyses not only differ with respect to data and period of observation but also in the econometric approach. The goal was to obtain an idea of the magnitude of the effects of policy instruments, in particular the effect of subsidies on R&D expenditures financed by the business sector in a relatively short-term context (increase of the ratio of R&D over GDP to 2.5% by 2005).

<sup>21</sup> Jointly with S. Kaniovski (WIFO)

The main result is that direct technology-related support has a highly significant influence on the R&D expenditures financed by the business sector in Austria (at the 1%-level). The calculations provide an idea as to the magnitude of this effect.

The elasticity defines the number of percentage points by which the dependent variable (in this case the R&D expenditures financed by the business sector, FUNT) changes, when the value of the respective explanatory variable, e.g. direct technology-related subsidies (DIR), are increased by 1%. The marginal effect of an increase of the variable DIR on FUNT is yielded by multiplying the elasticity by the (average) relation FUNT/DIR.

In the basic variant, the result is that 1 additional ATS of direct technology-related subsidies induces 0.59 ATS of R&D expenditures financed by the business sector (table 5-1). The effect of one ATS of subsidy on all R&D expenditures therefore amounts to 1.59 ATS. In comparison, the OECD study's basic variant reaches a short-term effect of 1.61 ATS on all R&D expenditures (long-term 1.70). If one considers that these calculations assume a somewhat broader definition of subsidies in Austria, these results can certainly be termed similar.

**Table 5-1: Effect of an increase in direct subsidies by 1 schilling**

	Austria	17 OECD countries
Elasticities	0.06	0.07
FUNT / DIR	9.82	8.71
Marginal effect on R&D expenditures financed by industry (FUNT)	0.59	0.61
Marginal effect on total R&D expenditures	1.59	1.61

Source: OECD (2000), WIFO

Tax incentives to R&D were represented by an index of the generosity of the R&D tax allowance. Within the observed period, the "generosity" of the R&D tax allowance changed three times: once directly due to the increase of the R&D tax allowance and twice due to changes to the corporate income tax rate. The coefficients are less robust than for direct support, but as a rule they have the correct sign. That means, according to our results, an increase in the generosity of the tax incentive for R&D (through an increase in the R&D tax allowance or the corporate income tax rates) leads, as expected, to an increase in the R&D expenditures financed by the business sector.

In international research, a cost/benefit ratio is often calculated in connection with the quantification of the effects of fiscal incentives to R&D. This shows the relationship between the R&D expenditures induced in companies by the tax incentives and the corresponding tax revenue foregone (and is therefore approximately comparable to the total effect of the direct support on total R&D expenditure). The highest estimates published to date are in the range of 2. The majority of estimates performed in the 90s are in the range of 1.3 to 2.0 (see Hall, – van Reenen, 2000).

The elasticity of R&D expenditures financed by the business sector in relation to higher education R&D expenditures is negative in all respects. In the basic variant, an increase in higher education research expenditures of one ATS leads to an increase in total R&D expenditures of 0.72 ATS. The OECD study (2000) showed similar results for this relationship. Here as well, the crowding-out-effect apparently dominates the stimulating effect. In both models, the time lags appear to be much too short to adequately represent the influence of university research.

In summary, based on the available results, the OECD findings with respect to the leverage effects of subsidies appear to be useful as working hypotheses. Expectations that an expansion of subsidies would, in the aggregate, entail additional R&D expenditures financed by the business sector in the same amount appear – at least in the short term – rather optimistic. All the more this is true for claims, sometimes circulating in the public sphere, of "leverage effects" of multiple size. This of course does not mean that individual instruments cannot have a stronger effect on research financed by the business sector than the averages estimated here.

## 6 The technological efficiency of the business enterprise sector

### 6.1 Structure and efficiency by type of industries

#### 6.1.1 The WIFO taxonomy

International comparisons of patterns of specialisation in production and foreign trade are aimed at measuring the efficiency of an economy in light of the actual *achieved economic results given the economic acquisition of technological knowledge*. An economically interpretable basis is required. It must allow conclusions to be drawn as to the relative strengths and weaknesses as they relate to the determining factors, which make the difference between business success and failure in competition. The use of classifications meets the purpose of summarising the different sectors of production or product lines under common analytical viewpoints.

On behalf of the European Union, WIFO has recently developed three new classifications of economic sectors (table 6-1). Since their development, they have become a firm component of the commission reports on the competitive capacity of European industry<sup>22</sup>; results which are positively looked upon from the Austrian perspective.

The fundamental idea behind Taxonomy I is based on the distinction between location-based competitive advantages due to varying factor costs like capital and labour on the one hand, and competitive advantages created by the business itself due to strategic investments in immaterial assets like marketing and research on the other hand. Taxonomy II uses data on the relative shares of employment of highly or less qualified labour. Taxonomy III divides the sectors of the manufacturing sector by their different types and intensities of demand for external services.

As with the development of any taxonomy, the new classifications from WIFO are also based on the reduction and condensing of information and must therefore be interpreted carefully. Naturally the economic sectors summarised in the models are still very heterogeneous. Based on statistical test procedures it is possible to demonstrate that a majority of the observable variation between the sectors - e.g. in the capital-, research- or advertising intensity – could be isolated through successful classification within the respective type of industry (Peneder, 2001).

---

<sup>22</sup> European Communities (1998), The Competitiveness of European Industry: 1998 Report, Luxembourg; European Communities (1999), The Competitiveness of European Industry: 1999 Report, Luxembourg; European Communities (2000), European Competitiveness Report 2000, Luxembourg.

Table 6-1: The WIFO branch taxonomies

<b>Taxonomy I (Factor use models)</b>				
Mainstream manu- facturing (TS)	Labour-intensive industries (AI)	Capital-intensive industries (KI)	Marketing-driven industries (MGI)	Technology-driven industries (TGI)
<b>Taxonomy II (Types of qualification)</b>				
<i>Sectors with an espe- cially ...</i>	.. low-skill labour force (NQ)	.. medium-skill `blue- collar´ labour force (MBC)	.. medium-skill´ white- collar´ labour force (MWC)	.. high-skill labour force (HQ)
<b>Taxonomy III (External service inputs)</b>				
<i>Sectors with a high share of inputs from ...</i>	... knowledge- intensive services (IWDL)	... marketing and retail services (IM&V)	... transport services (ITR)	Other

Source: Peneder (2001)

### 6.1.2 Structural characteristics: productivity, growth and quality competition

Table 6-2 summarises the reasons why patterns of specialization within the given categories are significant to the assessment of the techno-economic efficiency of a country. It establishes systematic differences between the separate economic sectors in reference to their average growth performance, the qualitative differentiability of the goods and services offered as well as labour productivity as a direct contribution to the economic development of income.

Take the European Union, Japan and the USA together and the average growth in consumer demand between 1990 and 1998 was by far the highest in technology driven sectors (+3.75% p.a.). Above average growth rates of consumption also favoured development in sectors with a high share of qualified labour, in industries with great demand for marketing- and sales-oriented services as well as industries with a high amount of input from knowledge-intensive services. The lowest by far was the change in demand in the group of capital-intensive sectors (+1.48% p.a.). Still, the group of mainstream manufacturing (+3.22% p.a.) proves that high growth in demand is not necessarily limited to "modern" sectors of industry.

Labour productivity rises with the efficiency and quantity of additional production factors like investment in the physical plant, research, advertising or the qualifications of employees (human capital). Altogether, in 1998 labour productivity was highest in the technology-supported industries. The capital-intensive sectors were next as well as industries with a high share of knowledge-intensive services. By far the lowest level of labour productivity was in the group of labour-intensive industries. They are characterized by the lack of any pronounced reliance on additional production factors.

**Table 6-2: Growth, productivity and unit values by type of branch: EU-Japan-USA**

	Con- sump- tion (1990- 1998)	Value added	Employ- ment	Labour productiv- ity		Export- Unit- Values	Import- Unit- Values
	<b>EU+Japan+USA</b>				<b>EU</b>		
	Average annual change			1998	1999		
	1985-1998 in%			1.000 €	€/kg		
Mainstream manufacturing (TS)	+3.22	+3.71	-0.17	+3.89	62.1	3.87	3.36
Labour-intensive Industries (AI)	+2.50	+3.28	-0.85	+4.17	46.5	2.65	2.41
Capital-intensive Industries (KI)	+1.48	+3.54	-1.49	+5.11	102.0	0.56	0.55
Marketing-driven Industries (MGI)	+2.47	+4.22	+0.08	+4.14	72.0	1.52	1.33
Technology-driven Industries (TGI)	+3.75	+4.74	-0.95	+5.74	104.6	16.26	15.78
Industries with especially high shares of . . .							
. . . low-skills (NQ)	+2.16	+3.32	-1.01	+4.38	61.4	1.13	1.10
. . . medium-skill 'blue collar' labour (MBC)	+2.92	+4.38	+0.01	+4.37	60.4	4.10	3.41
. . . medium-skill 'white collar' labour (MWC)	+2.83	+4.37	-0.48	+4.88	89.9	1.24	1.11
. . . high-skill labour (HQ)	+3.22	+3.93	-0.58	+4.54	85.5	19.43	17.19
Manufacturing sectors with high demand for . . .							
. . . knowledge-intensive services (IWDL)	+3.07	+4.55	-0.53	+5.11	91.5	2.63	2.05
. . . marketing and retail services (IM&V)	+3.24	+4.53	-0.16	+4.70	79.1	4.62	4.49
. . . transport services (ITR)	+2.37	+3.71	-0.31	+4.03	67.2	0.86	0.80
Other	+2.24	+3.22	-1.08	+4.35	60.5	1.90	1.73

Source: WIFO

If one compares the average annual growth rates in value added, employment and labour productivity between 1985 and 1998, high growth rates in value added are confirmed above all for marketing- and technology-driven industries as well as for those sectors of manufacturing, whose external service inputs are marked by particularly high shares of knowledge-intensive and marketing- or retail services. In both the technology-driven sectors as well as those sectors of production with a high share of knowledge-intensive services, the advances in productivity prevent positive development in employment.

"Unit values" are a measure of vertical differentiation and quality competition and are calculated by dividing the nominal market value by the physical quantity of goods (measured for instance by unit weight or number of units). In a comparison of industry types, the groups of especially technology-supported industries as well as those with particularly high shares of highly qualified workers command significantly higher unit values than all other groups.

### 6.1.3 An Austrian peculiarity: good performance in traditional structures

The observation of persistent deficits in the specialisation of modern, growth-oriented and technologically demanding sectors of production dates back to a series of structural analyses undertaken at the end of the 80s. In the 90s it was referred to under the heading of an Austrian "technology gap". finally

leading to the controversial debate about the Austrian Paradox of 'old' structures but high macroeconomic performance. (Hutschenreiter and Peneder 1997, Peneder 1999)<sup>23</sup>. The new branch classifications permit a fresh glance at these findings (Table 6-1).

When delimiting by typical factor inputs, the Austrian patterns of specialization deviate from those of the European Union, especially in two groups: a markedly higher share of labour-intensive industries (20.13% versus 15.55% in the EU) faces a markedly lower share of value added in the group of technology-driven sectors of production (14.16% vs. 20.92%) in Austria. The structural deficit is similarly distinct with respect to those taxonomies, which differentiate sectors by type and amount of services purchased. The conspicuously low share of sectors with marked demand for knowledge-intensive services (12.40% vs. 19.32%) is alarming. At the same time the share of sectors with great demand for transport services (32.39%) is clearly above the EU average (23.57%). The structural deficit by type of qualification is less distinct. Nevertheless, the share of industries with particularly high shares of highly qualified workers (13.11%) is below the EU value (16.67%).

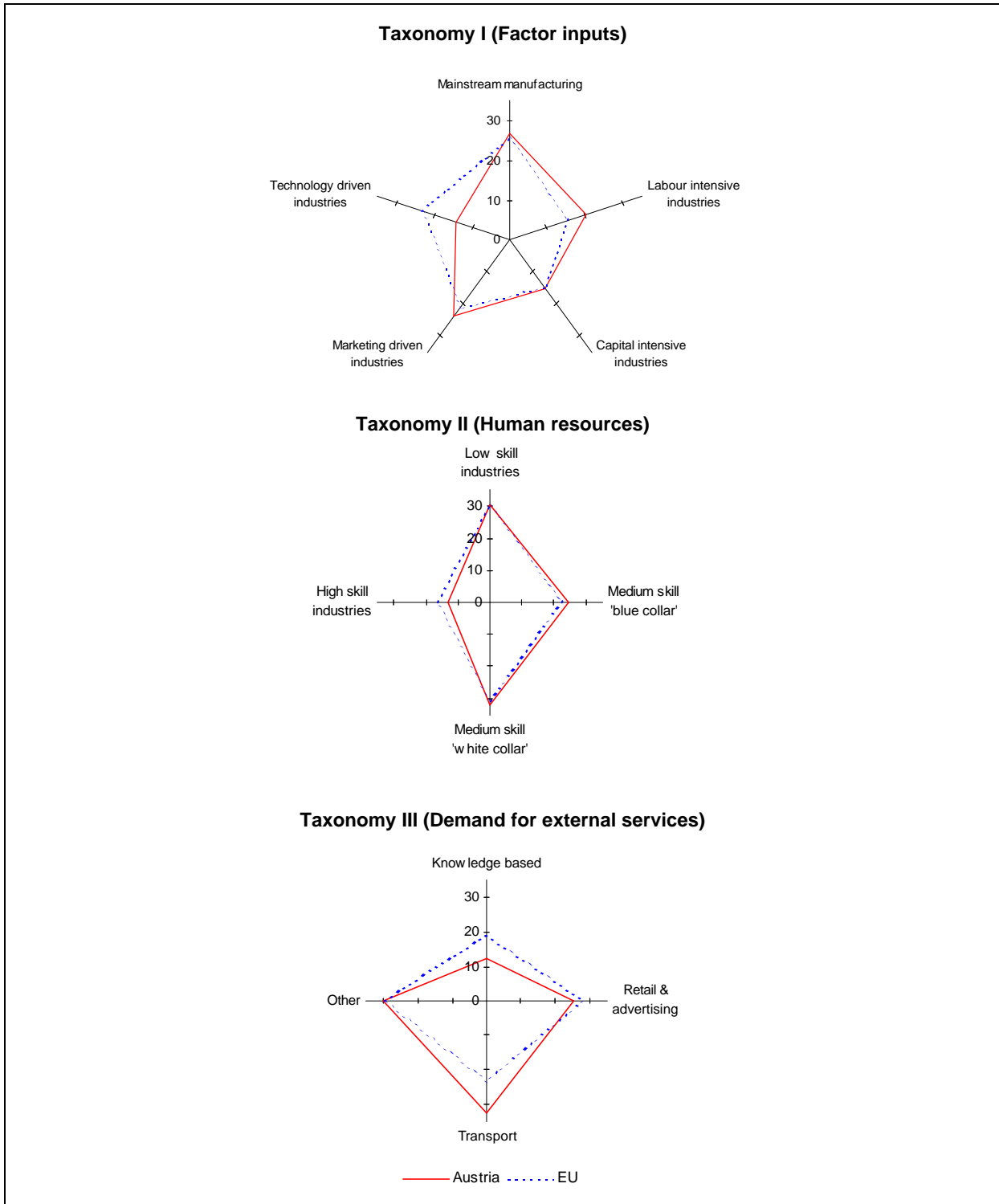
Despite these clear structural deficits, a look at the overall economy shows that in the 90s, Austria grew about 0.4% faster than the EU at an average of 2.2 p.a. And with an average +3.6% p.a. the manufacturing sector was able to increase its real production values by nearly half. In comparison with the other EU countries, this is the 4<sup>th</sup> highest growth within the last decade. Industrial output only grew faster in Ireland (+10.8% p.a.), Finland (+5.2% p.a.) and Sweden (+4.2% p.a.). In contrast to the growth in Austria, the growth in these three countries was tied to marked structural changes.

In summary it can be said that the Austrian production of manufactured goods is carried out in traditional sectors with average to little technological sophistication. Positive macroeconomic findings do however show, that it sustains itself in these markets. The possible long-term consequences of these findings for Austria deserve more attention than they have received to date in economic- and technology policy discussions.

---

<sup>23</sup> The "(structure-) Performance paradox" refers to the fact, that in the international comparison Austria's presumed 'technology gap' opposes the positive, long-term macroeconomic performance of the Austrian economy. Recently, Tichy suggested an additional "user paradox". In short, the "user-paradox" refers to the fact, that the user may be most aware of new innovative needs and accordingly are behind the most important innovations; at the same time, they steer the innovation process toward the improvement of existing products at the expense of newer approaches thus preventing radical innovation. Result: "Behind the slow, technical progress in Austria stands the business man timid before greater, if not radical innovations" (quoted from Tichy 2001, page 224).

Figure 6-1: Shares of value added in manufactured goods production in 1998 in%

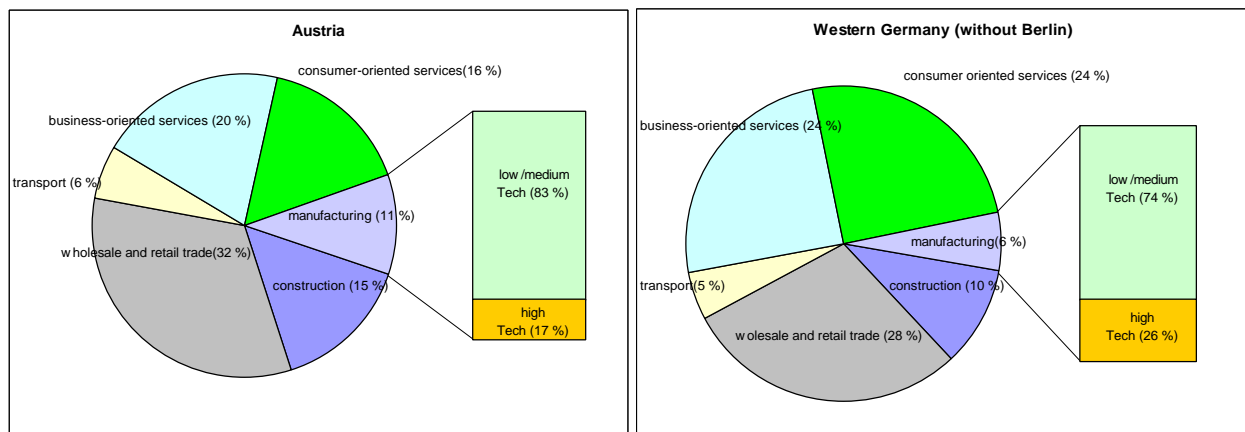


Source: WIFO

## 6.2 Business foundations in Austria<sup>24</sup>

In comparison to reference regions like West Germany and Bavaria (where comparable data is available) Austria still generally exhibits a weakness in foundations. Compared to *all foundations*, Austria shows a lower foundation-intensity (number of new foundations per 10,000 inhabitants capable of gainful employment). In the course of the 90s, no decrease in the gap to the reference regions can be observed. Still, the foundation deficits in the R&D-intensive sectors of the manufacturing industry were made up. In the R&D-intensive sectors of the business services industries, the existing deficits have continued to decrease since 1993 due to the steadily increasing number of foundations.

**Figure 6-2: Structure of Austria's business foundations (1997/98) in comparison to Germany (old provinces)**



Source: Foundation monitoring ZEW/ARCS (Almus et. al 2000)

One cause for Austria's general weakness in foundations can be found in the unchanged *industry-laden structure*. In the 90s, the number of foundations actually tended toward an increase in the sectors of the manufacturing industry while they declined in West Germany and Bavaria. At the end of the 90s (1997/98) the share of Austrian industrial foundations is nearly double that of the comparable German regions (see Figure 6-2). The share of new companies in the service sectors is still relatively low despite a high foundation intensity. While the share of business services increases slightly, that of the consumer-oriented services stagnates at a low level.

The *technology orientation* of the foundations in the manufacturing industry is somewhat lower than in the comparable German regions. However, since the share of industrial foundations in Austria is, as mentioned, clearly higher than in West Germany, the share of R&D-intensive foundations from *all* Austrian foundations (approximately 1.8% in 1997/98) is slightly higher than in West Germany (1.5%)

Despite these industry-laden foundations, the structure quota (calculated as the relationship of the share of a branch's foundations compared to the corresponding share in enterprise assets) of the manufacturing industries is less than one. Therefore, the manufacturing industry's share of foundations is less than its share in total stock of enterprises. The business services' structure quota is substantially greater than one. Therefore the foundations contribute to a *structural change* in the Austrian economy toward modern services.

<sup>24</sup> This short overview is based on the summarised discussions from the foundation monitoring by ZEW/ARCS (Almus et al., 2000).

Newly founded businesses contribute significantly to employment growth. Still, the predominant portion of young companies exhibits little or no growth. Contributions to growth come from a few businesses, which however exhibit considerable employment growth rates (so-called “high flyers” or “gazelle companies”). Here, the R&D-intensive sectors tend to demonstrate better growth performance. Varying growth rates in the sectors in the first years are the result of sector specific minimum efficiency size (MES). These different sizes can be attained with varying speed.

Based on data from the Association of Social Security Providers it is possible to analyse the extent to which foundations (or closings) or rather employment changes in existing companies determine the development of employment on the whole. Between 1994 and 1997, employment in Austria’s private sector grew slightly at 0.9% (see table 6-3). From this, 0.85% of this employment growth comes from business foundation activities (the balance between market entries and exits). A mere 0.05 percent come from employment changes in existing companies. All told, the employment balance of market entries and exits outweighs employment change in the existing structure. This relationship is however the exclusive result of the situation in the manufacturing industry, where a strong decline in employment was recorded in existing companies. This forces the total change downward. The service sector was able to record marked increases in employment in the observed time period, whereby more growth was due to change in existing structures than foundations. Especially advanced services (business services and above all R&D-intensive services) recorded double-digit employment growth despite the relatively short time period.

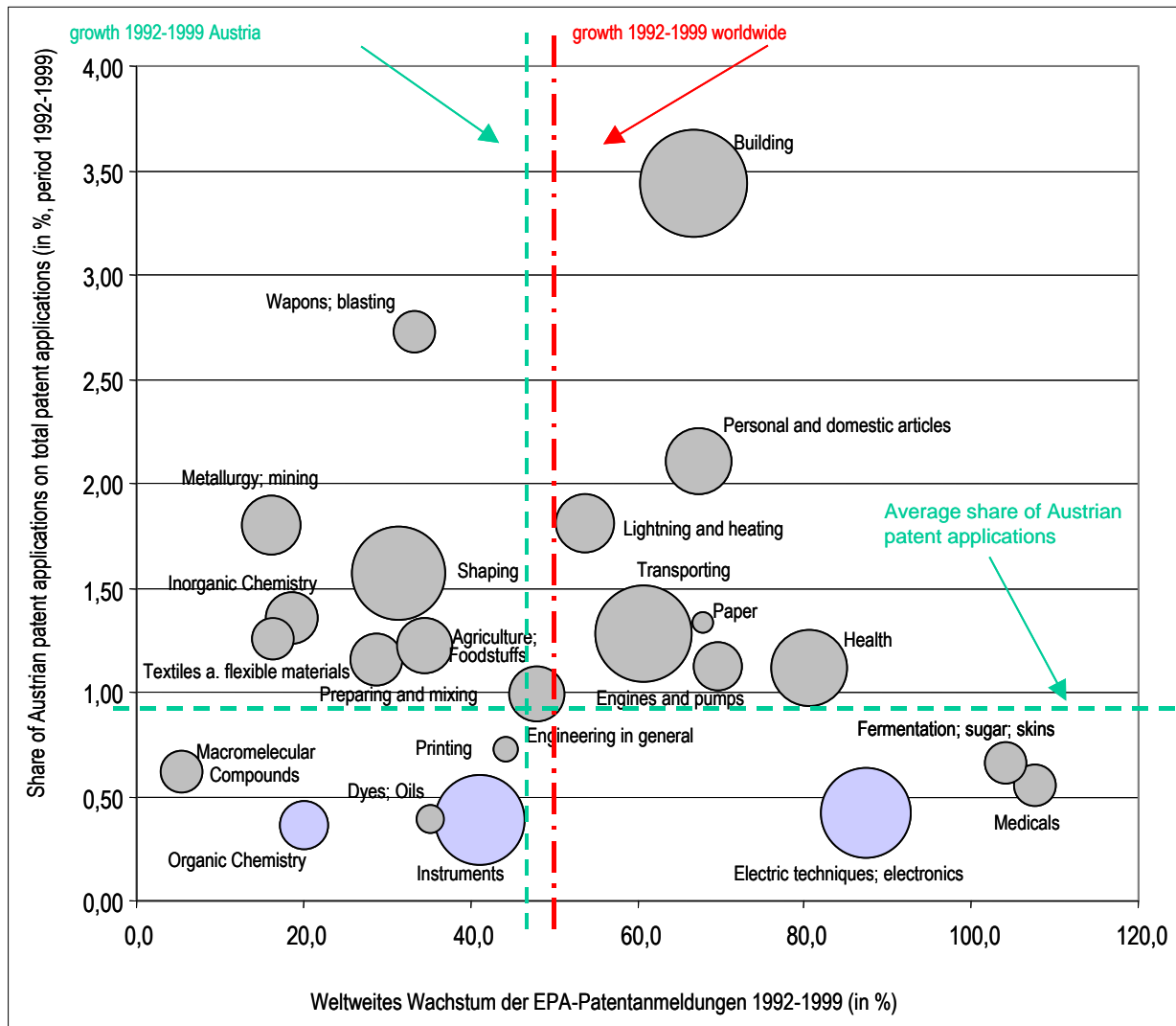
**Table 6-3: Change in established employment from 1995 to 1997 by sector**

	Total change (in %)	Due to market entry and exit (in %)	Through change in existing assets (in %)
<b>Manufacturing sector</b>	<b>-4.31</b>	<b>-0.52</b>	<b>-3.79</b>
Manufacturing industries	-5.33	-0.64	-4.69
<i>of those, R&amp;D-intensive</i>	-3.89	0.34	-4.23
Construction	-1.58	-0.18	-1.40
<b>Distribution sector</b>	<b>1.23</b>	<b>0.39</b>	<b>0.84</b>
Trade	2.40	0.46	1.94
<b>Services</b>	<b>8.9</b>	<b>3.56</b>	<b>5.34</b>
Business services	20.43	8.56	11.87
<i>of those, R&amp;D-intensive</i>	40.82	17.27	23.55
<i>of those, consulting</i>	18.73	7.65	11.09
Consumer-related services	4.74	1.75	2.99
<b>Total assets of the private sector</b>	<b>0.90</b>	<b>0.85</b>	<b>0.05</b>

Source: Austrian Association of Social Security Providers, ZEW Mannheim calculations.

### 6.3 The technological specialisation profile: patent registration

Figure 6-3: Austria's patent portfolio at the European patent office in international comparison



Source: European patent office; tip calculations

Note: The size of the circles corresponds to the absolute number of Austrian patent applications in 1999 (sum = 794).

The circles with the checkerboard patterns denote the three most significant areas of technology worldwide (in reference to the absolute number of patent applications).

Austria's patent applications at European patent office (EPA) during the 90s are internationally positioned in Figure 6-3. The findings can be summarized as follows:

- With a growth rate of 46% between 1992 and 1999, Austria is somewhat below the general increase in patent applications at the EPA (increase in registrations of around 52%). Nevertheless a continuous increase in the importance of European patent applications is apparent in Austria during the 90s. Still, because of the low growth rate, Austria loses "market share" in the international market for patent-able inventions.
- The structure of patent applications follows the familiar pattern (see the 1997 and 1999 technology reports): in those areas of technology with the most registered European patents worldwide, (instruments; electrical engineering/electronics; organic chemistry), Austria is comparatively less rep-

resented (i.e. the shares in these areas of technology are below Austria's general share which is approximately 0.9%).

- Simultaneously, Austria is markedly under-specialised in fields of rapidly increasing significance (disproportionate increase in patent applications) (fermenting; sugar; skins; medical compounds; electrical engineering/electronics).

Altogether, the patent applications profile points to failings in Austria's technological specialization. This corresponds to the known deficits in the Austrian industry structure, namely the strong orientation toward traditional sectors with leanings toward low to moderate levels of technology.

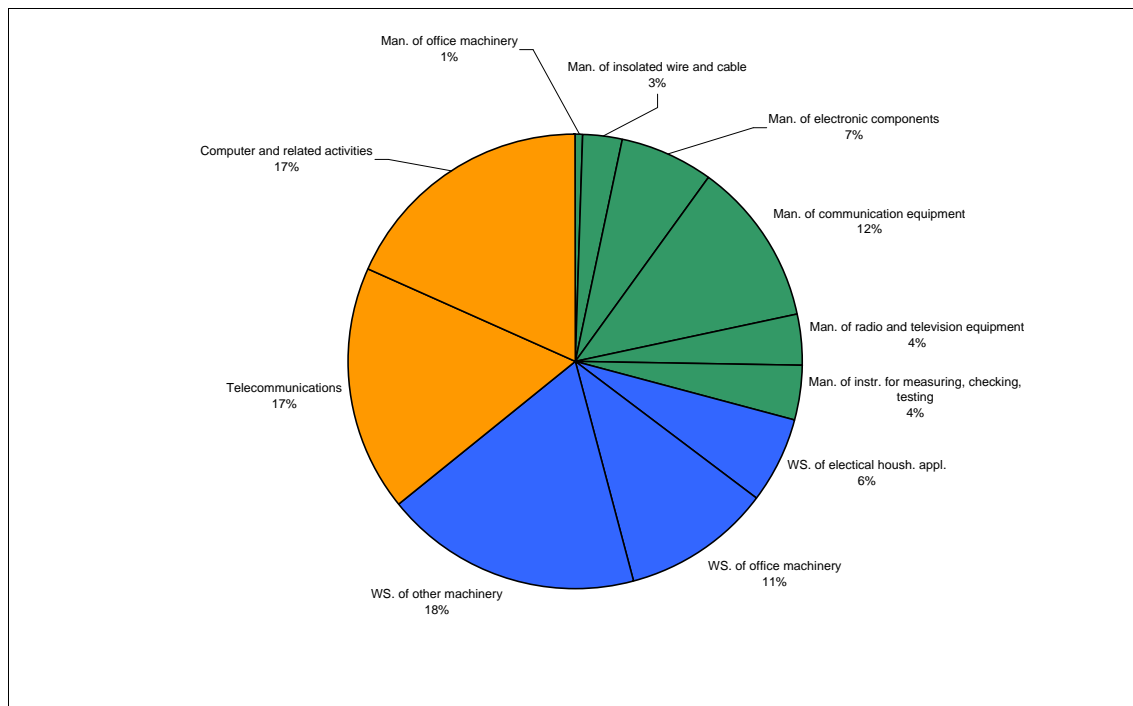
## 7 Information and communication technologies (ICT): the technological basis of the knowledge-based economy

In the 90s, the process of economic and social transformation within the context of rapid technological change was explained partly by competing, partly by overlapping concepts like the digital economy, information society, learning economy, network economy, new economy and knowledge-based economy. In two respects, ICTs form a common reference point for attempts to explain economic transformation processes in industrialized countries and for the formulation of national strategies to increase productivity, employment and growth. On the one hand products and services from the ICT sector distinguish themselves through high knowledge intensity – measured by the requisite research input and the qualifications of the research personnel – as well as above average dynamics in growth and productivity. On the other hand, ICTs are considered to be general-purpose technologies, whose use in the creation of goods and services spurs transformation processes in all sectors of the economy.

Beginning with a short presentation of the Austrian information and communication technology sector, this chapter continues by concentrating on ICT diffusion in Austria.

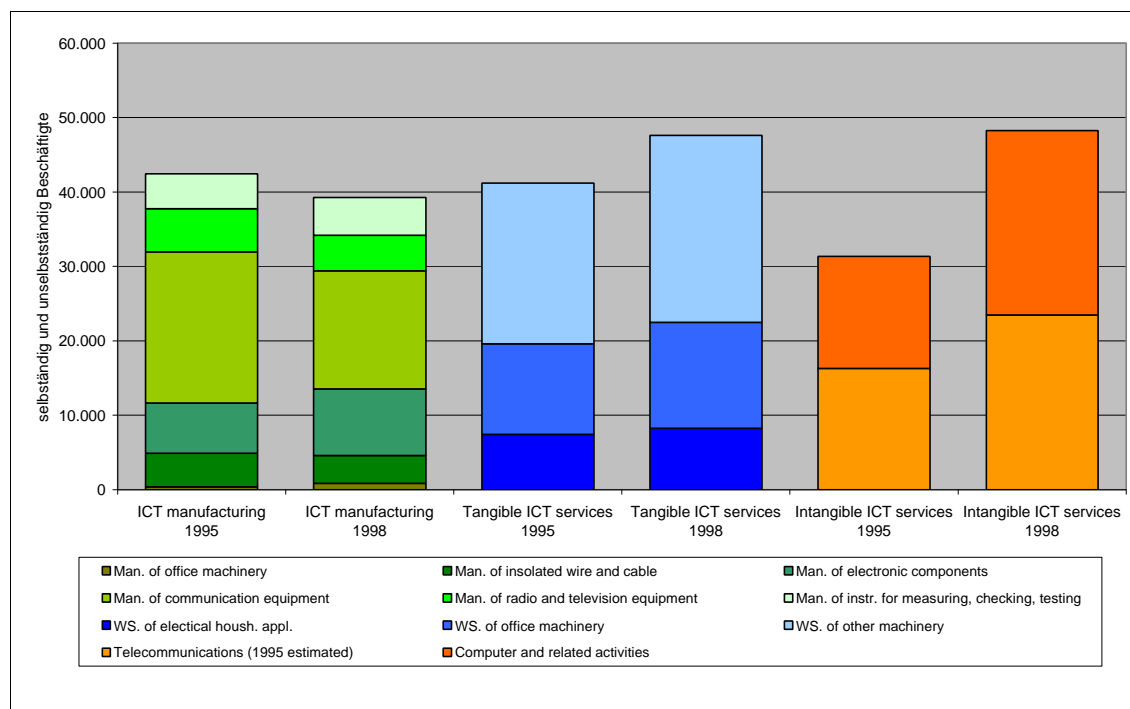
### 7.1 Structure and development of the Austrian ICT sector

Figure 7-1: Employment structure of the Austrian ICT sector by the OECD definition, 1998



Source: Statistic Austria, structure and performance survey, 1998, tip calculations

Figure 7-2: Development of employment in the Austrian ICT sector 1995-98



Source: Statistic Austria, structure and performance survey, 1995 and 1998, tip calculations

In 1998 the Austrian ICT sector<sup>25</sup> had more than 135.000 employees in about 11.000 enterprises. With a value added share of 8.4% and an employment share of 6% of the entire business sector (excluding agriculture) the sector plays a quite substantial role in the Austrian economy. Essentially, a distinction must be made between three groups of products and services in the sector. (see Figure 7-1):

- The ICT industry (share of employees 29%) includes not only the producers of components but also of telecommunications equipment and machinery.
- The goods-oriented ICT services (share of employees 35%) mainly include wholesale activities or trade activities of international ICT companies without considerable production in Austria.
- The data processing and the telecommunications (communications services) sectors, which exhibit particularly strong growth, make up the group of intangible ICT services (share of employment 36%).

Altogether, the sector is particularly dynamic. Its growth between 1995 and 1998 is above average at +48% measured by the number the businesses and +17% measured by number of employees. Nevertheless, clear differences are apparent in the sub-sectors (see Figure 7-2):

- Data processing and telecommunications experienced a delightfully high level of employment expansion<sup>26</sup>. Furthermore, both sectors exhibit an extraordinarily high number of new enterprises - an increase in the number of companies of about 90% each.

<sup>25</sup> The delimitation of the ICT sector used below meets the definition of the OECD. See OECD (2000c).

<sup>26</sup> The data from statistic Austria only provide accurate data on the telecom sector starting in 1998. Until then, the business areas postal services and communication services were combined under Post and Telekom Austria AG. Therefore the employee data for communication services, ÖNACE 64.20, also included the employees from what is now Post AG and Postbus

- The domestic ICT manufacturing recorded a clear reduction in the number of those employed (-7%) with a moderate increase in value added. Thus, it supplied weak growth impulses to the overall economy in comparison to ICT manufacturing in the Nordic states and the USA. Still, certain areas of ICT production (e.g. electronic components) exhibit a growth dynamic similar to that of the intangible ICT services.
- The expansive development in ICT wholesale, which includes the Austrian subsidiaries of multinational enterprises, reflects the increasing need for ICT in the private sphere as in the economy<sup>27</sup>.

Altogether, the structural shift is clearly identifiable in the development of the domestic ICT sector between 1995 and 1998. Employment development shows a shift from ICT manufacturing to ICT services. Differences in the development of productivity as well as tradability also play a role (intensity of international competition, opportunities to relocate production).

---

AG. The employees who according to the 1995 PTA annual report made up 37,412 of 55,720 employees were subtracted from the total number of employees in communications services.

<sup>27</sup> The development of ICT manufacturing and ICT wholesale can also be traced in the expansion of the trade deficit through the sectors. See also OECD (2000c).

## 7.2 Development of ICT diffusion in international comparison

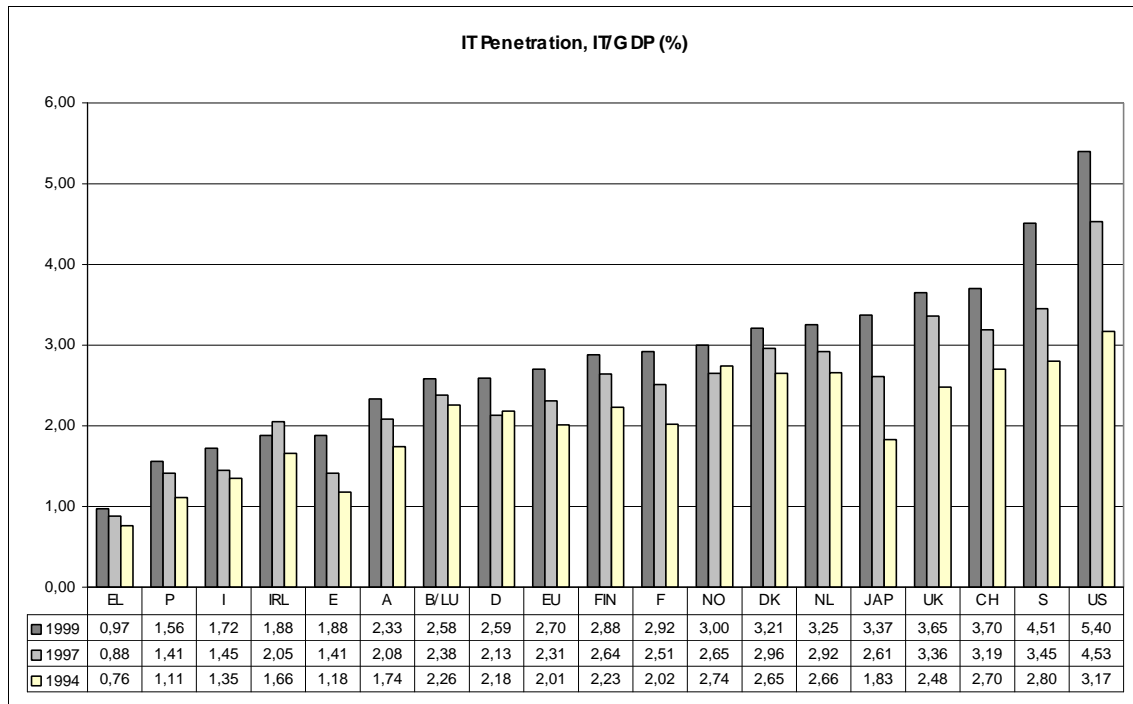
As a result of its dynamic growth and simultaneous rapid technological change, the ICT sector directly contributes to the development of a knowledge-based economy. Indeed, significant effects also result from the increasing use of ICT in the production of goods and services as well as for the initiation and execution of commercial transactions in other sectors (for more, see the section on the diffusion of CIM technologies in Austria).

Today, products and applications like computers and the Internet are tools, which are taken for granted. ICT have the essential attributes of generic technologies or general-purpose technologies. Increasing IT intensity – measured for instance by IT-expenditures as a percent of gross domestic product – is a phenomenon common to all evolved, industrial nations and is an indication of the increasing diffusion of ICT. A marked rise in this indicator can be seen in the 90s. In advanced countries like the USA, there is no identifiable saturation to date (see Figure 7-3). Beyond this, an international comparison shows that Europe has not been successful in catching up in comparison to the USA, at least until the end of the 90s. Further, the situation within the European Union continues to be characterised by strong disparities (regional north-south slope).

Austria's position in terms of IT diffusion has hardly changed in the country ranking. The country's IT intensity is still inferior to that of the leaders - the Nordic countries, Switzerland and the Netherlands. Since the mid-90s, Austria remains below the European Union average (roughly the same level or slightly less). It can be assumed that a general catching-up process has not taken place until now, despite the limited validity of this aggregated indicator on the diffusion of IT applications in the business sector.

The development of PC-density (see Figure 7-4) is a concrete example of Austria's lagging IT diffusion catching-up process in the 90s. In a comparison of 24 predominantly Western European OECD countries, in 1999, Austria heads up the bottom third of those countries surveyed with 256.8 PCs per 1,000 inhabitants. With that, Austria is behind many EU states and only negligibly higher than the comparable value for the entire European Union (248.6). Still, it should be pointed out, that until 1994, Austria was below the EU average. Only in 1995 did it exhibit a PC-density value above the EU average. The situation at the beginning of the 90s (or in the 80s) was that of a "latecomer". In this light, this catching up to or joining the "average" is noteworthy if somewhat modest.

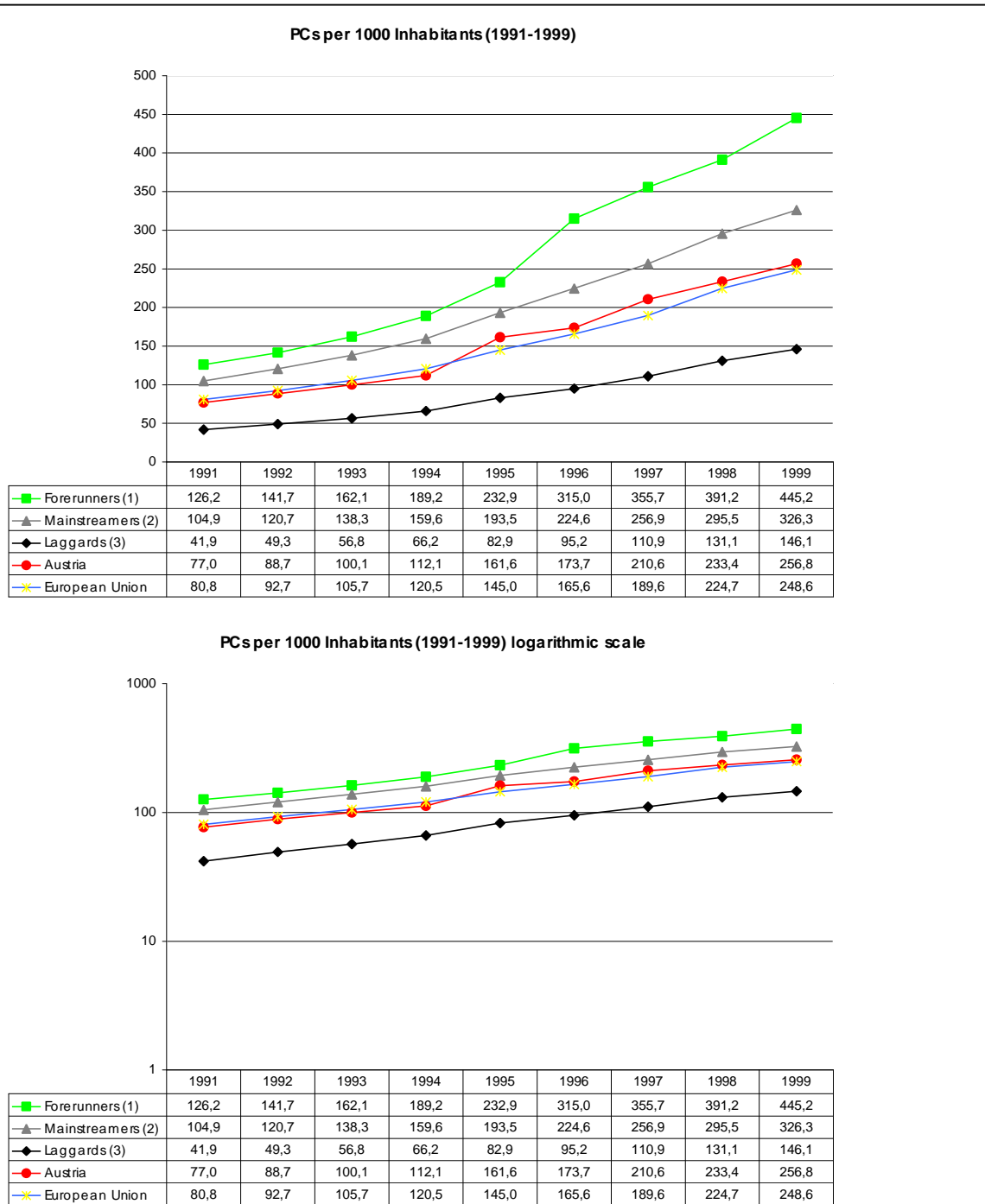
Figure 7-3: Development of IT intensity in international comparison



Source: EITO

“Catching-up” cannot be observed in the growth dynamic between 1991 and 1999. The nearly parallel progression of time (in logarithmic scaling) is an indication of the failure of the catching-up processes for the groups of countries. The same can be derived from a direct comparison of growth rates (see Figure 7-4). With a share of 16.3%, Austria is above the comparable values of both the European Union (15.1%) and the middle third (15.2%) when measured by the average annual growth rate (CAGR 1992-1999). Still, both the lower (16.9%) and upper thirds (17.1%) exhibit higher average growth rates. Consequently, Austria has been lagging behind the top flight for numerous years and catching these leaders in the short term will be quite difficult given these growth rates.

Figure 7-4: Development of PC density in international comparison



- (1).. Average growth rate for Australia, Denmark, Ireland, Luxembourg (from 1996), Norway, Sweden, Switzerland and USA.  
 (2).. Average growth rate for Belgium, Canada, Germany, Finland, Great Britain, Japan, Netherlands and New Zealand.  
 (3).. Average growth rate for Austria, France, Greece, Italy, Korea, Mexico, Portugal and Spain.

Source: ITU, WIFO calculation for the 24 selected OECD countries.

A European opinion poll<sup>28</sup> shows that the comparatively low PC density in Austria cannot be attributed to a weakness in private use alone. Rather, it is also tied to low usage intensity in business. The survey finds that only 42.5% of the domestic workforce uses a computer at work. Austria is just below the comparable value for the entire European Union (45%), behind Germany (46.0%) but clearly behind the Nordic countries (Sweden: 74.3%; Denmark: 67.3%; Finland: 56.9%) and the Netherlands (67.5%). This low PC use for job-related purposes confirms the PC-density findings. However, these results must be seen against the backdrop of the respective economic structures. In comparison particularly to the Nordic countries (especially Sweden and Denmark), Austria, like Germany, still exhibits a relatively large manufacturing sector. Since PC use is generally higher in the service sector than in manufacturing, there must be a lower usage density. Certain business services exhibiting particularly high PC-usage densities are still underrepresented in Austria in comparison to countries like Sweden or Switzerland.

Despite lagging diffusion in comparison with the leading countries (confirmed by indicators like IT intensity and PC density), the indications that the Austrian economy is developing into a knowledge-based economy are unmistakable. One clue as to the structural change is the business sector's increase in software investment. Software can be regarded as a form of codified knowledge created on the one hand through the use of highly qualified human capital. On the other hand, the degree of its use as a universal tool for acquiring, processing and storing information is also an indication of the information intensity of sectors or businesses.

The growth in software investment in Austria is considerable. Data (Statistic Austria) reveal that the investment in software between 1988 and 1999 tripled with an increase from 4.2 billion to 13.2 billion ATS. With that, software investment is the fastest growing part of capital investment.

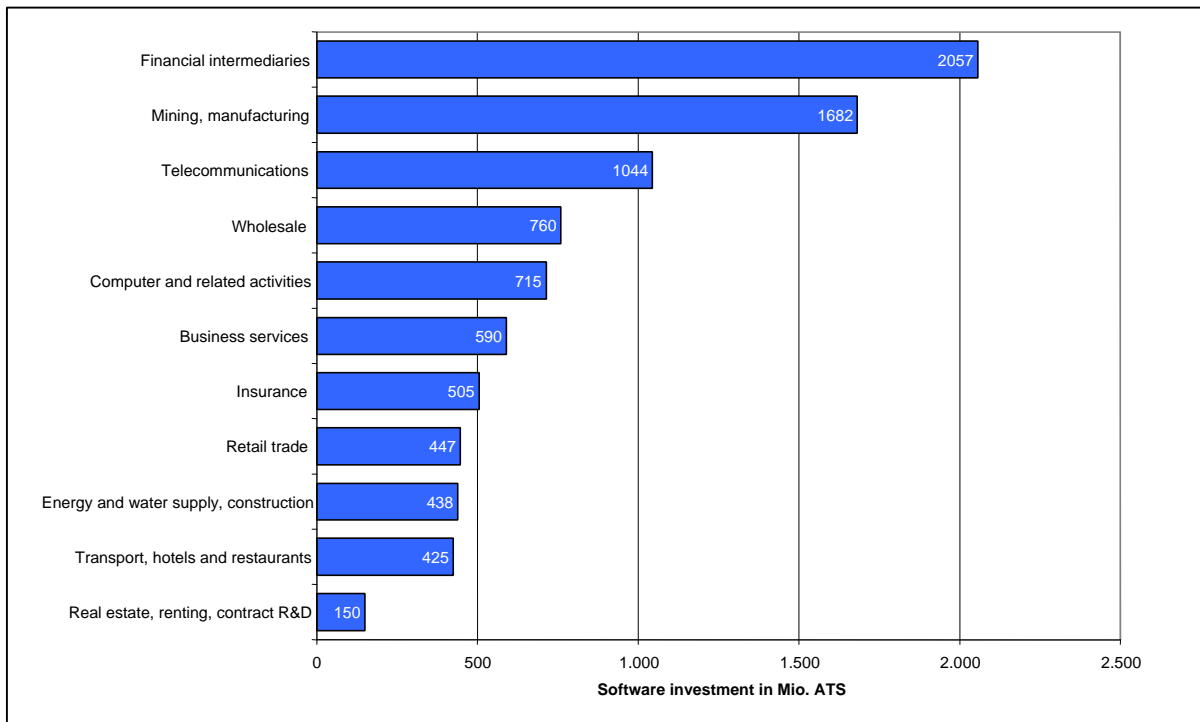
A closer look at software investment reveals great disparities when sectors are compared both with regard to software intensity per employee as well as software's share of gross investment. The majority of investment activity occurs in the business enterprise sector with software investment of about 8.8 billion ATS (see Statistic Austria 2000a, 2000b). Software investment play an important role in all sectors. Still, as with research and development expenditures, an uneven distribution between the sectors is unmistakable. This is particularly apparent given the concentration in the service sector (while R&D expenditures are dominated by industry). For instance, software expenditures in the banking sector at 2.054 billion ATS surpass the software investment of the entire manufacturing sector (1.66 billion ATS)<sup>29</sup>. Alongside the group of research-intensive sectors of industry, banks and insurance companies, data processing, telecommunications and business services make up the second core area of a knowledge-based economy. With a share of employment at 17%, they account for 56% of the entire software investment in the Austrian business sector.

---

<sup>28</sup> Eurobarometer, November 2000

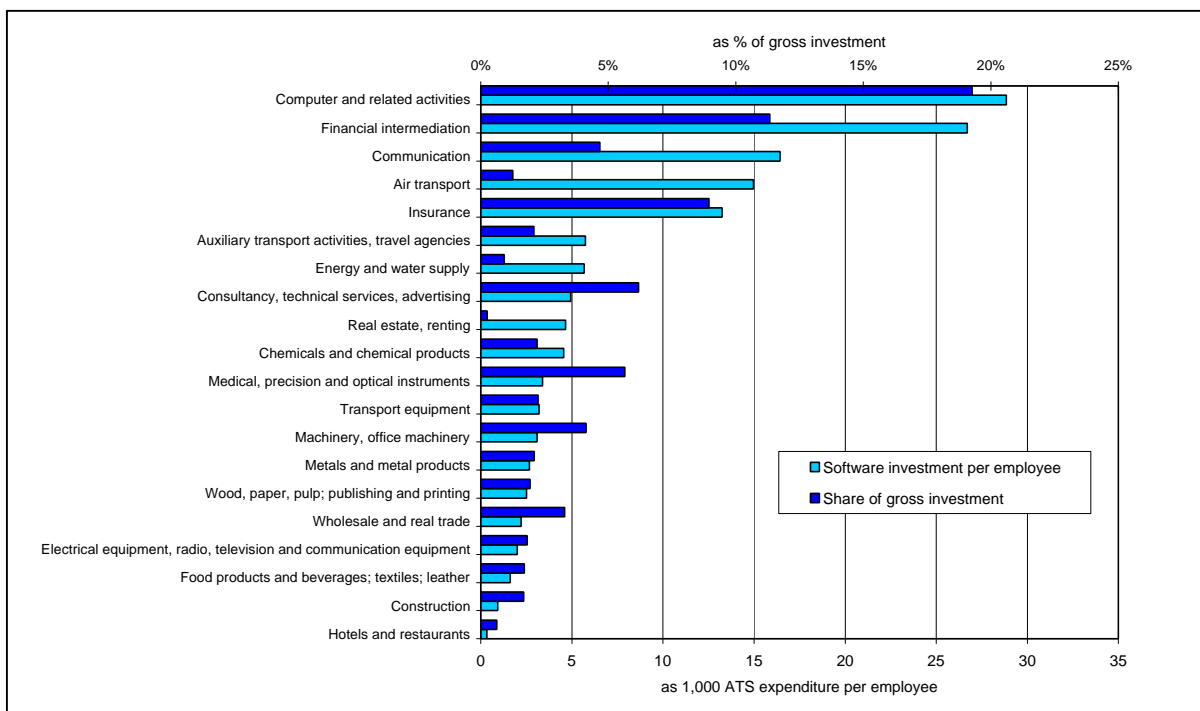
<sup>29</sup> 1998 values

**Figure 7-5: Structure of the software investment of the Austrian business sector, 1998**



Source: Statistic Austria.

**Figure 7-6: Software intensity in the Austrian business sector, 1998**



Source: Statistic Austria

Disparities in the software intensity or in the strong position of some particularly knowledge-intensive services can mainly be explained by application possibilities and existing forms of usage (front- and back-office uses, client databases, etc.). Furthermore, software is often incorporated into other capital investment (e.g. machines and equipment) and does not specifically appear as an investment. At the

same time, it becomes clear that software investment – with respect to the modernisation of processes (process innovations) – in the service sector are comparable to equipment investment in the manufactured goods industry.

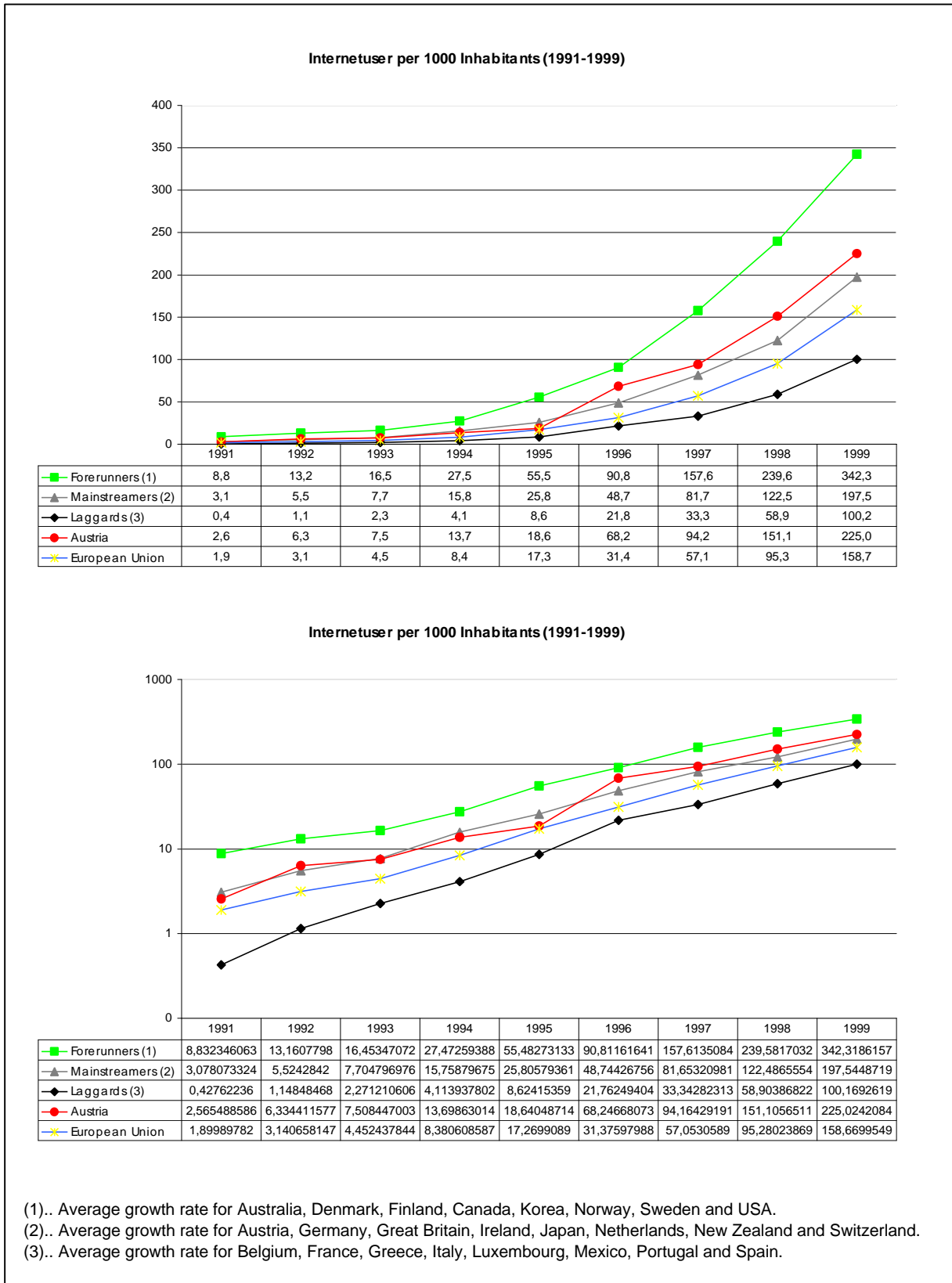
The ICT sector extends beyond hard- and software and also includes telecommunications services along with communications machinery and equipment. The former comprise an important part of the infrastructure of a knowledge-based economy. Increased competition as well as the acceleration of technological change (digitization, convergence etc.) has led to an accelerated structural shift in the telecom sector during the 90s. The diffusion of telecom services has received strong impulses – unlike in the IT-area – due to the liberalization of the Austrian market. These impulses come from reduced prices, the accelerated modernisation of the network infrastructure and newly-offered services. In terms of low costs and market penetration, Austria is now among the leading European countries in mobile communications. With this, the first steps toward building a universal, mobile infrastructure are complete. This is even more noteworthy given that Austria started the process from a rather unfavourable position (late liberalization, low usage density and high prices at the beginning).

The diffusion of telecom applications is considered strategically important from both societal and economic perspectives. There are high expectations for the Internet – the bridge between IT and telecommunications, a general-purpose technology with innovative impulses for business applications. Further, the Internet acts as technical platform for eCommerce applications. Lastly, an expansion of digital communications has implications ranging from the requisite individual capabilities to re-organisational needs in business to shifts in the balance of power between market entities.

In comparison to the PC density, Austria exhibits clear, positive developments in terms of Internet use. When measured by the number of Internet users per 1000 inhabitants, Austria ranks in the middle third of 24 selected OECD-countries (see Figure 7-7). Austria is clearly above the total EU average – in terms of time – and it is merely one year behind the leading group of countries. The growth dynamic of this indicator points to a catching-up processes between the groups of countries. For example, Figure 7-7 (in logarithmic scaling) shows slight convergence over time. The average growth rates from the 90s point in the same direction (CAGR 92-99). The countries with a lesser starting position show stronger growth rates the majority of the time.

No accurate assessment of Austria's position, with respect to the use of electronic media for business communications, can be derived from the Internet user density. A well-grounded assessment is hindered by difficulties in measuring use and a lack of quantitative analyses with a sufficient degree of representation. An indicator, which is also often used by the OECD, is the density of "secure web servers" (number per million inhabitants). It is used to estimate the degree of Internet use for commercial purposes and is provided by various private Internet research organizations (e.g. Netcraft). Here, Austria is in the upper half of the European middle (based on 1999 data from Netcraft), about even with Norway and Great Britain (Switzerland, Sweden and Finland are in the lead group). Non-European English-speaking countries (USA, New Zealand and Canada) exhibit a much higher density than the European countries.

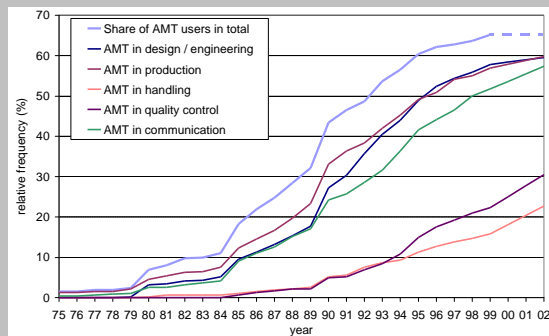
Figure 7-7: Development of the Internet user density in international comparison



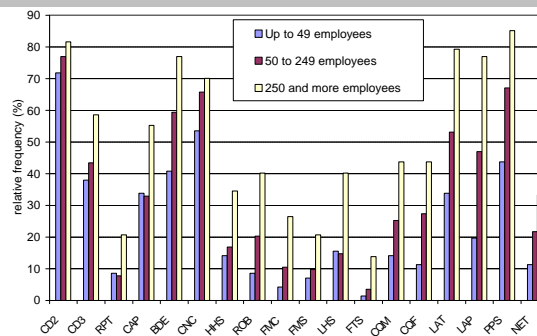
Source: ITU, WIFO calculations for 24 selected OECD countries

## Adoption and trends in the use of Advanced Manufacturing Technologies (AMT) in Austrian manufactured goods production

### Time profile of AMT adoption



### AMT adoption in 1999 by size of production site<sup>30</sup>



Source: FlexCIM survey 1999, ARCS calculations

The diffusion of advanced manufacturing technologies (AMT) is an important indicator of an economy's abilities in process innovation. Austrian manufactured goods production is traditionally more strongly orientated toward process innovation than that of other countries. Nevertheless, with regard to AMT-adoption Austria's manufactured goods production sector was lagging behind countries like Germany and Switzerland in the 80s.

Rapid growth of AMT-use set in in the early 90s. By 1999, approximately 65% of Austrian manufactured goods production sites (ÖNACE-sections 10 till 36) with more than 20 employees have adopted AMT (Geyer et al. 2000). The most prevalent use of AMT is for design and planning (above all CAD) and in production (most frequently used AMT element: CNC and digital firm data recording). In both of these areas of application, the diffusion curve is already flattening.

In the coming years strong growth in the use of inter-company computer networks can be expected. The diffusion of ATP elements for the application area handling (automated storage and retrieval systems, transport systems) will continue to stay comparably low, since the adoption of those AMT elements is only sensible at certain production sites.

The diffusion rate and the intensity of AMT use in Austrian manufactured goods production is clearly dependent on the size of the production site. Whereas the differences in the diffusion rate between large and small sites is comparably low in "old" CIM technologies (e.g. CD2, CNC), the differences are particularly pronounced with advanced AMT elements (e.g. RPT, FMC, FMS).

The data from the 1999 FlexCIM-survey show that in 1998 the share of Austrian production sites which make more than 80% of their sales with products produced using AMT was about 17%. The survey indicates that this share is likely to grow rapidly to 32% by 2002 (Geyer et al. 2000).

30 BDE: Digital firm data representation; CAP: Computer-aided (manufacturing) planning; CD2: Computer-aided design and/or engineering (two-dimensional); CD3: Computer-aided design and/or engineering (three-dimensional); CNC: Computer-numerical controlled machines including materials working lasers; CQF: Quality control on final products; CQM: Quality control on material / goods in production; FMC: Flexible manufacturing cells; FMS: Flexible manufacturing systems; FTS: Transport systems; HHS: Pick and place robots (with three or fewer degrees of freedom); LAP: Local area networks for factory use; LAT: Local area networks for technical data; LHS: Automated storage and retrieval systems; NET: Inter-company computer networks; PPS: Production planning systems; ROB: Complex robots; RPT: Rapid prototyping / simulation

### 7.3 Conclusions

The growth expectations of a “New Economy“ driven by a strong ICT sector have only been partially met in Austria as in most European countries. At the same time, clear deficits exist in comparison to the leading countries in terms of both diffusion and use of ICT. Since the leading ICT-using countries also show the highest growth in ICT expenditures, there is no trend toward convergence in international comparison. Therefore it should not be expected that Austria would not “automatically“ catch up to the leaders in the short-term. The empirical evidence is inconsistent; partial catching-up processes (like in mobile telephony or less so in Internet density) contrast with unchanged deficits in other fields (e.g. IT investment). Altogether, it is clear that technology policy initiatives are still necessary.

Technological change initiates the need for action in two respects: on the one hand, the ICT sector makes direct and indirect contributions to growth and competitiveness (from the company level to the overall economic level). Therefore, its growth should be supported. On the other hand, it is necessary to avoid a “digital divide“ resulting from differing opportunities to access and use of ICT.

Both strengthening competitiveness and avoiding a digital divide are the basis of the European Commission’s “eEurope“<sup>31</sup> initiative formulated at the Lisbon summit. The main components focus on securing an economically competitive telecommunications infrastructure available to all segments of society, the capacity to work with the Internet and new media as well as the promotion of the spread of e-commerce and other Internet applications in different areas including the public sector.

Nevertheless, the eEurope initiative does not claim, either with respect to type or scope, to replace national technology policy. EU members, who are well on their way in the information society, have worked hard in recent years on the development and execution of ICT-oriented technology policy strategies; in sub-sectors, the national initiatives extend well beyond the “eEurope“ initiative (see the following box).

The EC’s eEurope initiative has also contributed to a noticeable intensification of activities toward the information society in Austria. Based on of the general-purpose character of ICT, a variety of ministries are involved:

- Within the scope of its ICT strategy<sup>32</sup>, the Federal Ministry of Education, Science and Culture promotes eight programmes. Emphasis is on the ICT infrastructure in schools, the improvement of the communications network of universities and other educational institutions as well as the adaptation of educational content and the advancement of training opportunities.
- The Federal Ministry of Transport, Innovation and Technology promotes ICT-based research in six K-plus competence centres as well as initiatives in the area of transportation (e.g. logistics). The BMVIT is also the regulative authority for the telecom market. Here, it plays an essential role in lowering the cost of access to the telecom infrastructure.
- The Federal Ministry of Economics and Labour has prepared recommendations on various aspects of e-business. These recommendations will be acted on over the course of the year. The work was done in seven working groups<sup>33</sup>. Within the scope of the K<sup>ind</sup>/K<sup>net</sup> projects, three competence centres are subsidised in the area of e-business.

---

<sup>31</sup> See European Commission (2000)

<sup>32</sup> see <http://www.bmbwk.gv.at/ikt-strategie/grundl.htm>

<sup>33</sup> see <http://www.bmwa.gv.at/ebusiness/index.htm>

- The Federal Ministry of Public Service and Sports is the federal IT coordinator and works on ICT applications in public administration (e-government).
- The Federal Ministry of Justice adapts legal standards in different areas (by carrying out the EU directive for electronic business) to meet the standards of new forms of communication.
- The ministries' supplemental funds (FWF, FFF, ERP) subsidise research, development as well as investment projects related to ICT within the scope of their general activities as well as in special programmes.

A common federal government strategy, which would unite these separate programmes under one strategy, is currently being formulated. A paper on this matter will be finished in 2001. It will be issued by the Federal Ministry of Public Services and Sports and will be a continuation of the federal government's 1996 action plan for the information society.

### International initiatives for the information society<sup>34</sup>

The national strategies of advanced countries like Denmark, Germany, Great Britain and the Netherlands extend well beyond eEurope in the use of technology policy instruments. Information and communication technologies (ICT) have a special place in the technology policy of these countries, and the instruments used to stimulate innovation and diffusion constitute a broad spectrum:

- The promotion of research and development refers to specific research programmes (e.g. LINK) or the creation of broadband communications infrastructures for research (e.g. Giga-Port).
- A boost in innovation activities should also be achieved through the creation of innovative environments at regional or local levels; examples of appropriate initiatives, which also – but not only – play a role in connection with ICT can be found in Great Britain (Innovative Cluster Fund) and Denmark (Digital Nordjütland).
- Innovation stimulation activities via ICT are not necessarily limited to existing companies, but include an increase in the number of “innovative” company foundations; approaches extending beyond providing venture capital can, for instance, be found in the Netherlands (Twinning) and Denmark (Innovationsmiljøer).
- A multitude of information deficits in non-users must be corrected in order to increase the diffusion of ICT usage (e.g. Internet, e-commerce). Campaigns, (free) initial consultations, seminars and awards are all proven methods in the countries studied. Just as in Great Britain, Germany has struck out on the path to the future through the build-up of regional competence centres.
- Administrators and authorities can contribute greatly to the diffusion of new communications services. For instance, in all four countries studied, efforts are being intensified to promote the electronic execution of procurement.
- Legal requirements for the use of ICT are currently less concerned with the regulation of the telecommunication sector than with the construction of a security infrastructure in the world of electronics. In 1998, the Danish government already started a significant technology policy initiative through pilot projects on the use of digital signatures in advance of legislation.

---

<sup>34</sup> See Dachs – Knoll (2001).

## 8 The Austrian university system

Universities are a central part of the Austrian innovation system. On the one hand, their significance comes from their great share of public research expenditures. On the other hand, it comes from their output. Their output is comprised of the education of qualified scientific academics and employees, their function as the largest institutions performing basic research and the scientific publications connected thereto and furthermore, input for the innovative processes of businesses (contract research, cooperation etc).

The following chapter presents an overview of the Austrian university system (financing, staff) as well as indicators of the scientific output and output relevant to innovation (graduates, publications, cooperation).

The data were collected at the department level wherever possible. Table 8-1 shows the distribution of the individual departments among the universities.

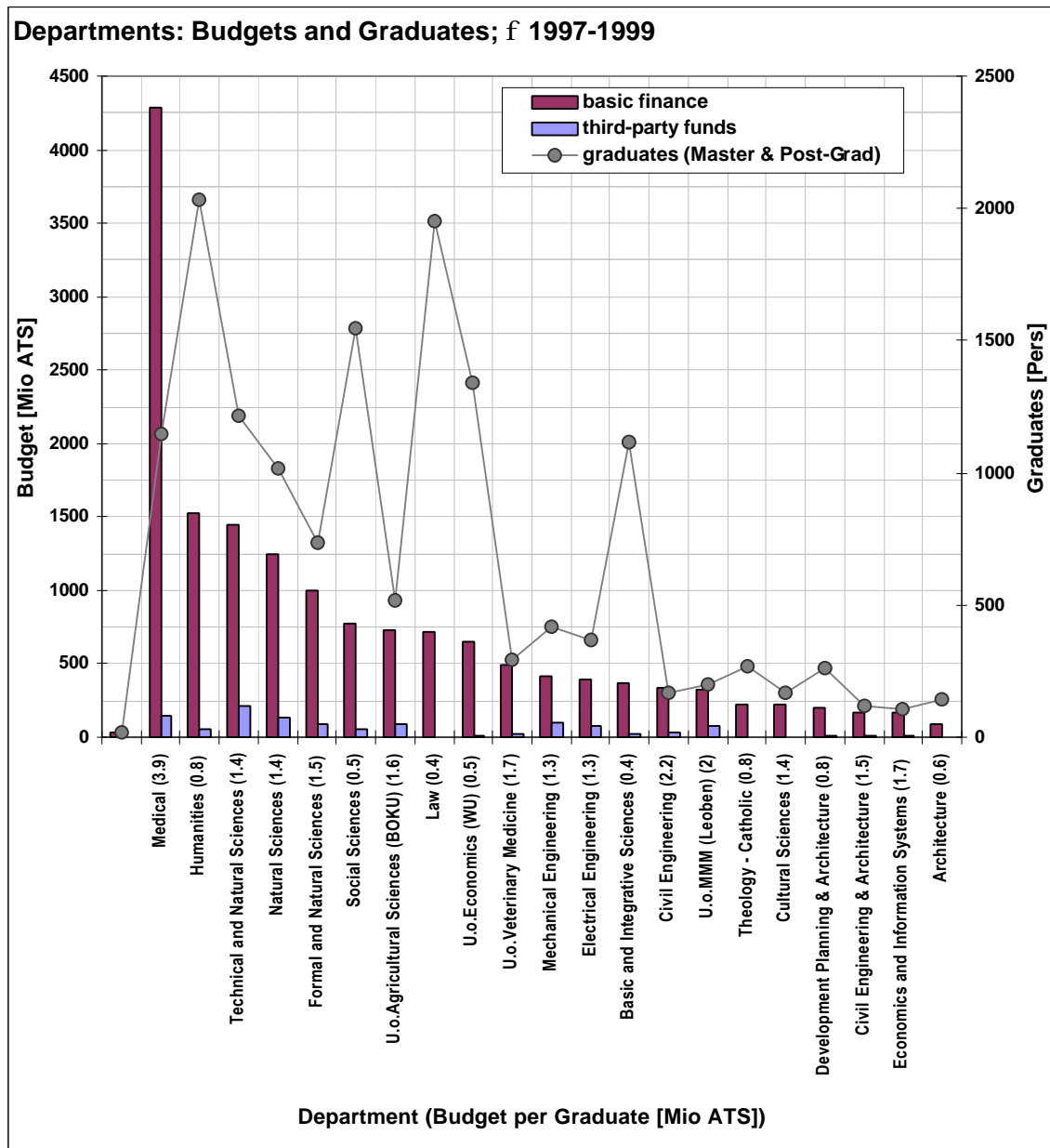
**Table 8-1: Department distribution**

Department distribution	Department code	University Code											
		A	B	C	D	E	F	G	H	I	J	K	L
Institutes without departmental affiliation	0												
Theological - Catholic	1												
Theological - Protestant	2												
Law	3												
Social- and economic sciences	4												
Medical	5												
Basic- and integrative sciences	6												
Humanities	7												
Formal- and natural sciences	8												
Natural sciences	9												
Civil engineering and architecture	10												
Development planning and architecture	11												
Architecture	12												
Civil engineering	13												
Mechanical Engineering	14												
Electrical engineering	15												
Technical-natural sciences	16												
Cultural sciences	17												
Economics and information systems	18												
University of Mining, Metallurgy, and Materials (Leoben)	99												
University of Agricultural Sciences (BOKU)	99												
University of Veterinary Medicine	99												
University of Economics, Vienna (WU)	99												

Source: BMBWK. The faculty labels correspond to the timing of the report. In the meantime, they have been somewhat altered.

## 8.1 Budget

Figure 8-1: Budget and graduates by faculties/universities

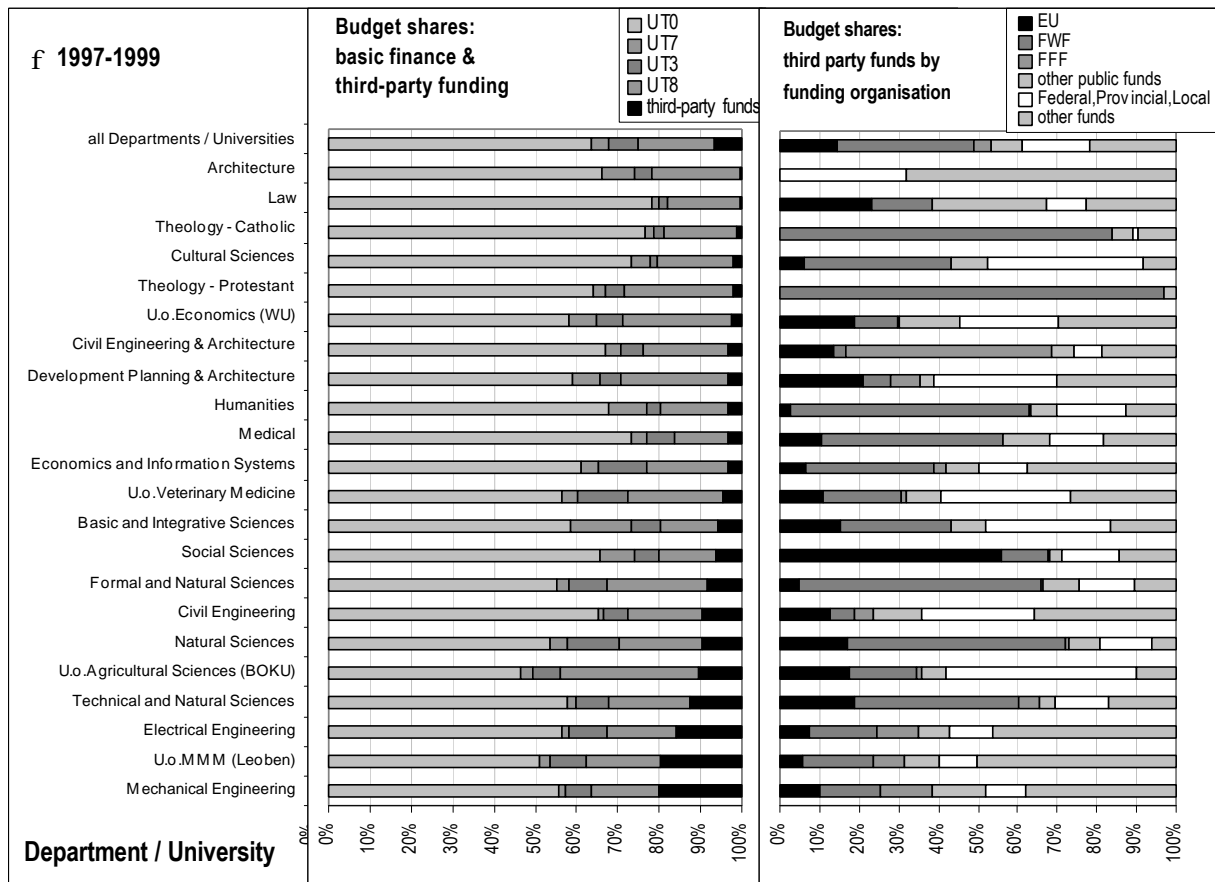


Source: BMBWK, tip calculations

The medical school has the highest budget<sup>35</sup> (but this includes the university clinics), followed by the humanities. The graduate-related values are more interesting than the absolute figures: medicine has by far the highest budget (again, including the university clinics, which provide a high measure of service), followed by civil engineering, the University of Mining, Metallurgy, and Materials (MMM) at Leoben and veterinary medicine (2.2, 2.2 and 1.6 million ATS per graduate). The basic and integrated sciences have the lowest budget per graduate along with law and the University of Economics Vienna (0.4 to 0.5 million ATS per graduate). Different ratios of budget per graduate are the result of diverging capital intensities. They cannot directly be interpreted as a “measure of efficiency”.

<sup>35</sup> Faculty resources vary by university and do not include non-apportionable costs

Figure 8-2: Budget structure by department/university, € 1997-99



Source: BMBWK, tip calculations <sup>36</sup>

The structure of the total budget shows a clear distinction between "hard" and "soft" sciences: the first group exhibits shares of third-party funding of 10-20% (the leaders are mechanical engineering and the University of MMM at Leoben); architecture (TU Graz) and law come last with a third-party funding share of less than 2%.

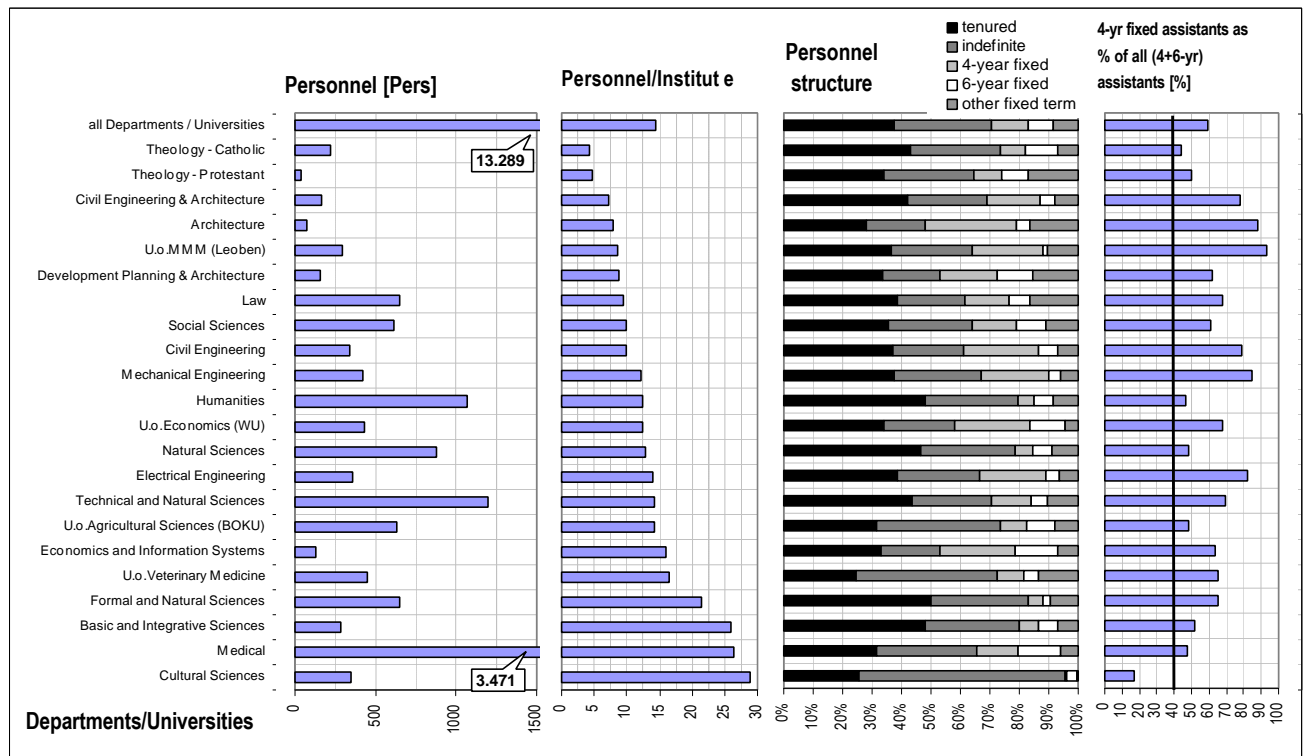
In terms of third-party funding, EU projects play the greatest role in the social sciences and economics (55%). It is no surprise that they play no role in the theological faculties or in architecture at the TU Graz. These however have the largest share of "other" (non-public) sources of financing. This mainly includes financing from the business enterprise sector, which offers research contracts to university institutes.

Private funding also play an important role in departments with high third-party shares. In the technical sciences like mechanical and electrical engineering or at the University of MMM Leoben, the business sector provides almost half of the third party funds. However, in summary it can be said that the share of third party funds in the budgets of most departments or universities plays a lesser role, constituting a maximum of 10% of the budget. On average, approximately 7% of the budget comes from the private sector.

<sup>36</sup> UT: non-allotted overhead is not included in the figure (UT0=Personnel; UT7= expenditures and legally required costs; UT3=investments; UT8=expenditures)

## 8.2 Personnel resources

Figure 8-3: Teaching personnel and personnel structure by faculty/university



Source: working report of the departmental administration, tip calculations

In 1999, 13,289 federal teaching personnel were employed at scientific universities. Measured by staff and in absolute numbers, the largest departments are in medicine, technical-natural sciences and the humanities. The faculties of the cultural studies, medical and basic and integrative sciences have the largest staffs; civil engineering, architecture and the theological faculties have the smallest.

Concerning the structure of personnel resources, it is important to note that the highest share of tenured and salaried staff can be found at institutes of the cultural studies faculties (95%), followed by the formal-natural sciences, the basic and integrative sciences, the humanities and natural sciences (quotas between 75 and 83%). Architecture, economics and information systems exhibit the lowest shares (about 50%).

The graphic on the right shows the share of 4-year salaried staff compared to the total number of assistant professors (4- and 6-year): if all 4-years would be extended to 6-year appointments, this share should be about 40% given a state of equilibrium; the higher the share of 4-year appointments, the lower the probability that these extensions would occur. This indicates that the technical faculties are likely to have the lowest extension rate (the leader is the Coal and Steel University Leoben: only 6% of all assistant professors are on the 6-year track). Since the total number of assistant professorships is limited, it can be assumed that a greater number of scientifically trained staff from institutes with a high share of 4-year assistants will move into the non-academic sector.

## 8.2.1 University annual accounts 2001

### Federal personnel at departments and clinics by scientific branch and categories (*Table 15 in the statistical appendix*)

Based on employment schemes, subdivided by institute (and/or clinic) for the scientific and non-scientific staff (with a deadline of 1.1.2001) and in consideration of the coefficients from the 1998 R&D survey (division of working hours), Statistic Austria established full-time equivalent values for the university sector in R&D, for teaching and education as well as for other activities by scientific branch (for federal personnel). Permanent positions at universities of the arts are not included in this evaluation.

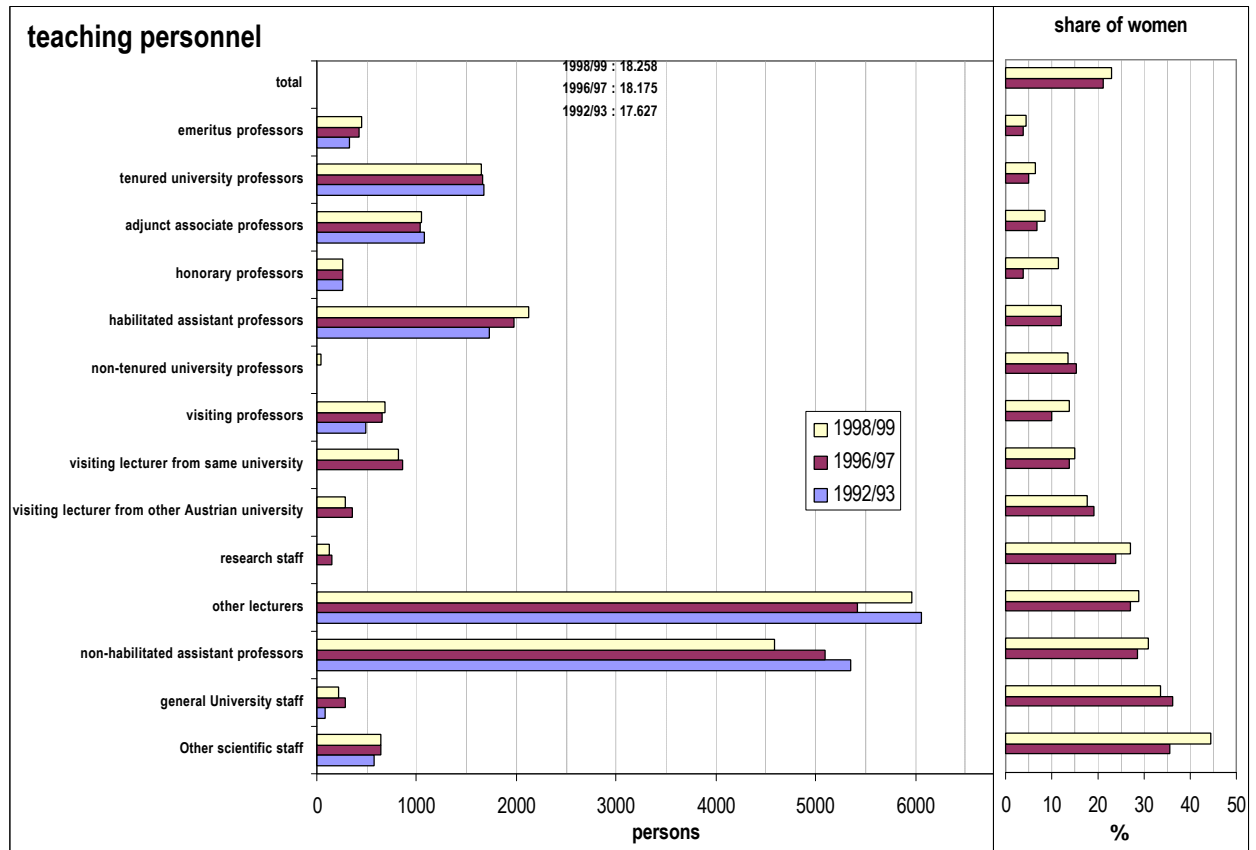
Given this, altogether 6,820.2 full-time equivalents for R&D were employed at Austrian universities by the 1.1.2001 deadline. They are distributed across the scientific fields as follows:

<i>Scientific fields</i>	<i>FTE for R&amp;D</i>	<i>in%</i>
Natural sciences	1 816.9	26.6
Technical sciences	914.9	13.4
Human medicine (incl. clinics)	1 886.2	27.7
Agriculture and forestry, veterinary medicine	340.1	5.0
Social sciences	1 132.8	16.6
Humanities	729.3	10.7
TOTAL	6 820.2	100.0

It should be noted that the underlying values for permanent positions, which of course include vacant posts, include the personnel from the institutes and clinics respectively, while central university administration staff is excluded. The non-financed staff as well as non-federal staff at the institutes (clinics) is also excluded.

## 8.2.2 Teaching staff and the share of women

Figure 8-4: Share of women by category of teaching staff



Source: BMBWK, von tip calculations

The personnel categories are ranked by share of women in 1999. This ranking truly reflects the hierarchy of teaching personnel as well as the historical development: the lowest share of women is among professors emeritus at under 5%; the highest share is among those not qualified as professors. The share of women<sup>37</sup> increases in practically all categories when comparing 1996/97 with 1998/99.

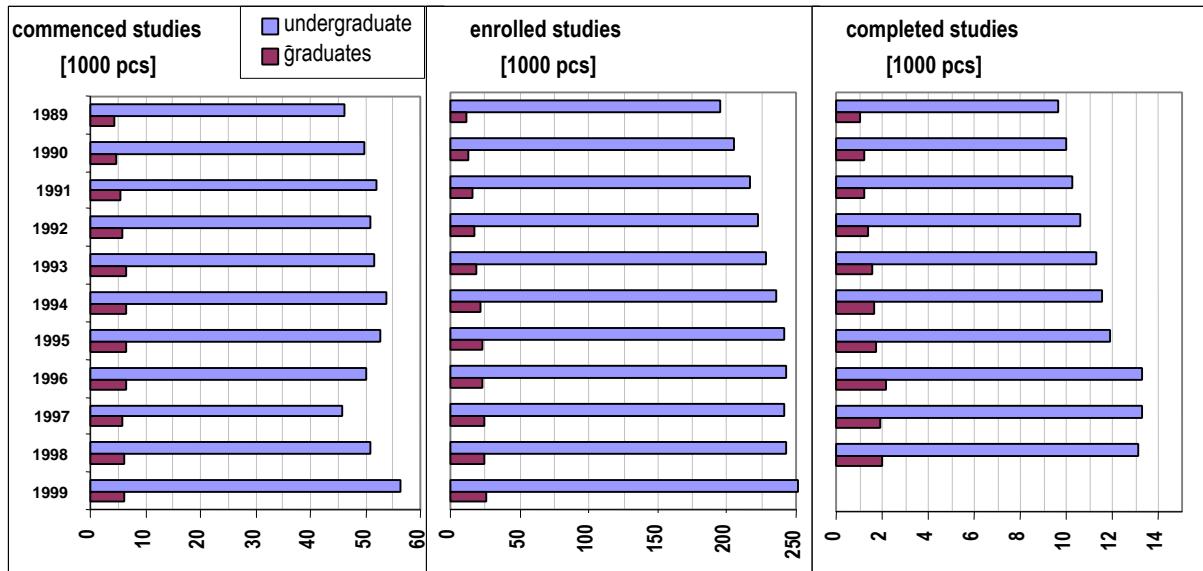
In summary, the share of women decreases the higher one looks in the academic hierarchy: undergraduate degree started – 55%, undergraduate degree completed – 50%, graduate studies begun – 45%, graduate studies completed – 35%, non-qualified university assistantship – 32%, qualified assistantship – 15%, professor – 7%, emeritus - 4%.

<sup>37</sup> The data are not differentiated by gender in the preceding years. Source: working reports of the department's managing board.

## 8.3 Students and completed courses of study: basis for the up-and-coming researchers

### 8.3.1 Complete overview

Figure 8-5: Development of studies begun/registered/completed



Source: BMBWK, tip calculations

Figure 8-5 shows the development of courses of study commenced, enrolled as well as completed between 1989 and 1999. They are separated according to undergraduate studies (diplomas and short courses of study) and graduate studies (post-graduate and doctoral work)<sup>38</sup>. The numbers represent studies begun, enrolled or completed by domestic and foreign students. They do not represent the number of students who have begun, finished or continued studies. Accordingly, multiple courses of study are counted, more than once. The annual figures denote the beginning of the respective academic years (year 1995 = WS 1995/96 + SS 1996).

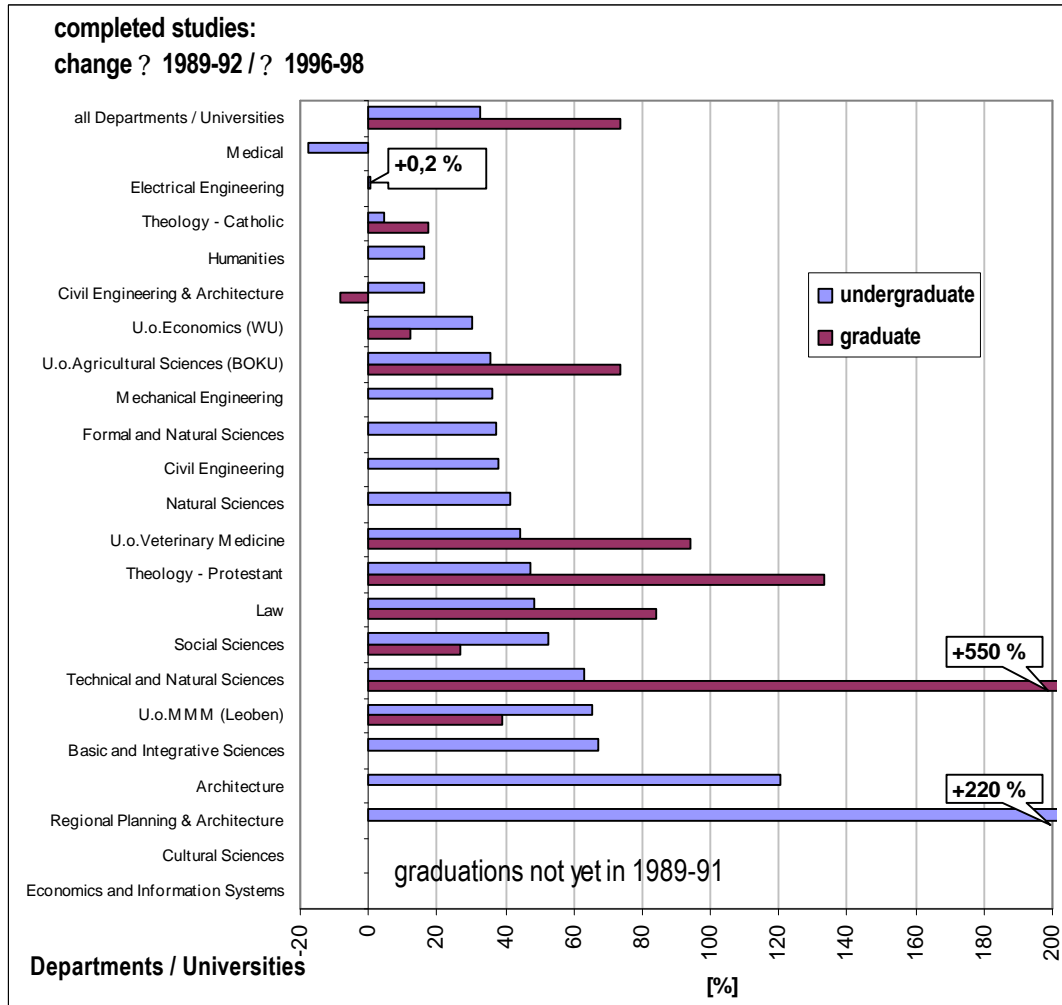
Following a decline between 1995-1997, the number of studies started both at the undergraduate and the graduate level exhibits a rising tendency. This tendency can also be seen to a lesser degree in documented courses of study (with a year delay) and studies concluded. Part of the drop in commenced studies can be explained by the introduction of a college system ("Fachhochschulen") in 1994. These absorbed about 3.000 new courses of study in 1998 and show a strong growth tendency. Still, the rising number of studies begun also proves that the increasing attractiveness of colleges is not (only) at the expense of the universities but also exhibits an expansion of the demand for tertiary education.

Graduate studies experienced stronger growth: in the period between 1989 and 1999, the number of graduate courses of study begun rose about 34% (in comparison: undergraduate studies +22%). Completed studies are almost double that at +91% (in comparison: undergraduate studies completed +37%).

<sup>38</sup> In 1999, no final data was available for courses of study completed

### 8.3.2 Completed courses of study by faculty

Figure 8-6: Change in studies completed 1989-92 / 1996-98

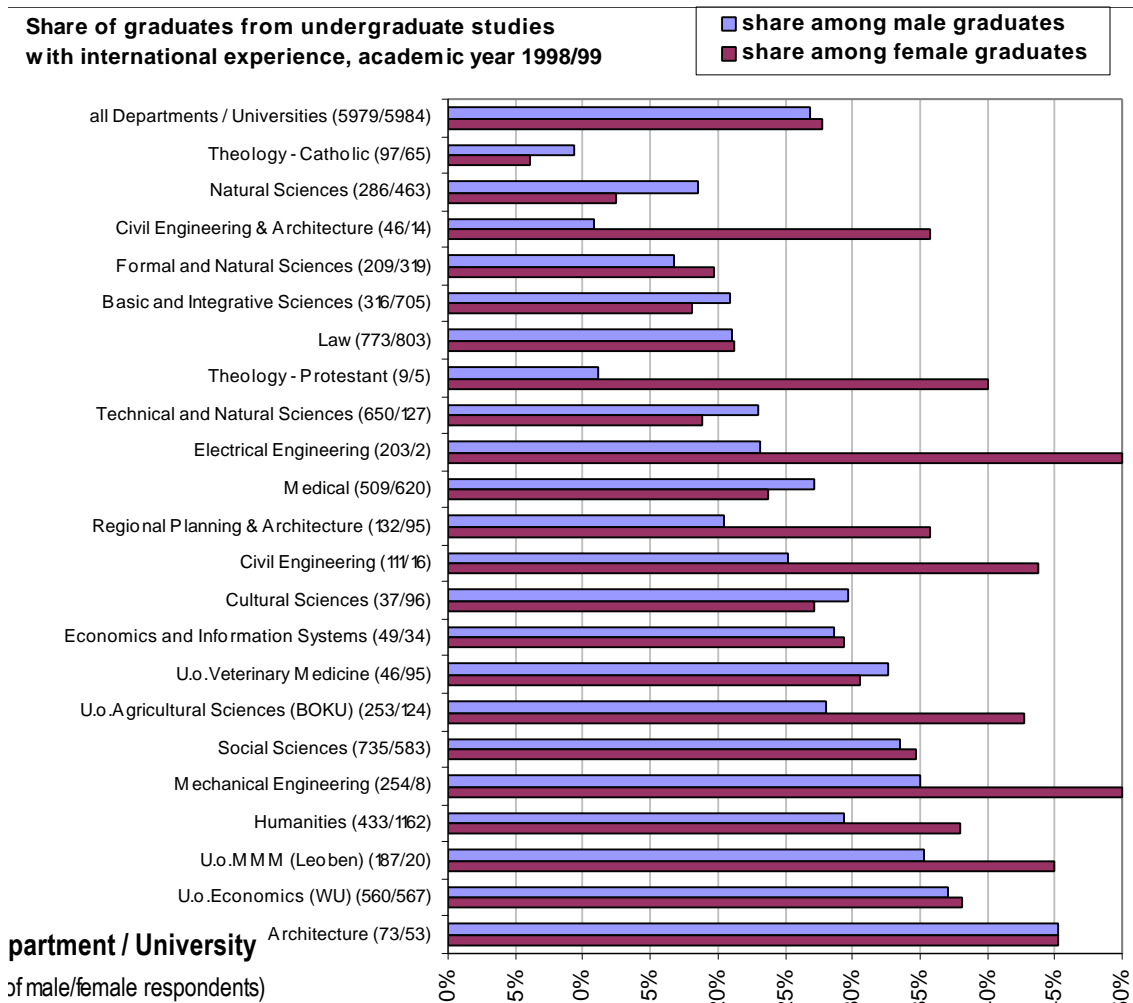


Source: BMBWK, tip calculations

In reference to studies completed, it can be said that all faculties show increasing graduation rates with the exception of medicine. "Regional planning & architecture" at Vienna's Technical University leads all others in the category of undergraduate studies completed with an increase of 220% during the period under investigation. The technical-natural sciences lead in graduate studies, followed by the protestant theological faculties and the school of veterinary medicine. With the exception of the University of MMM at Leoben, the engineering sciences show below average growth in completed courses of study.

## 8.4 International mobility of Austrian students

Figure 8-7: Study abroad among students in their undergraduate course of study



Source: STATISTIK AUSTRIA, tip calculations<sup>39</sup>

This figure shows the share of graduates who studied abroad at least once during their studies (the faculties are ranked according to total share, i.e. graduates).

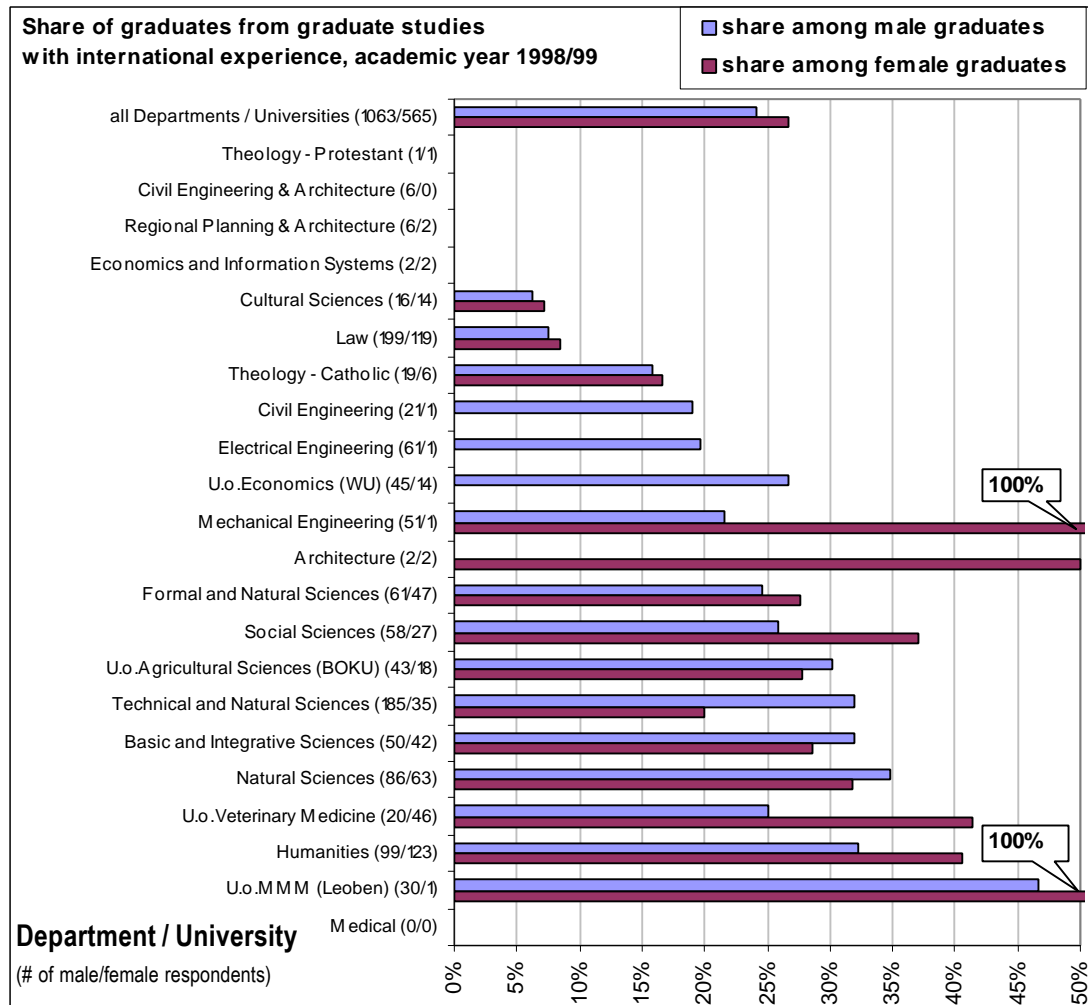
The TU Graz's school of architecture (45%) and Vienna's economics university (37%) have the highest shares of study abroad; the lowest

quotas belong to the catholic theological school (8%) and the natural sciences (15%).

The differences between male and female graduates is negligible in most cases; it is however striking that given greater gender-specific differences, the female graduates have a higher share of study abroad (extremes: civil engineering and architecture: 36 vs. 11%, electrical engineering: 50 vs. 23%).

<sup>39</sup> The numbers are based on an evaluation of the questionnaire, which Statistik Austria distributed to all graduates of Austrian universities. A comparison with the number of graduates reveals that the response rate is about 90% in the case of undergraduates and about 80% in the case of post grads.

Figure 8-8: Study abroad by graduates of graduate studies



Source: STATISTIC AUSTRIA, tip calculations

Figure 8-8 shows the share of graduates of post-grad studies who studied abroad at least once during their studies (the faculties are ranked according to total share, i.e. graduates).

In comparison to graduates of undergraduate studies, the ranking of departments here is quite varied: Vienna's economics university (WU) and architecture (TU Graz) no longer take the lead (only 27% of male graduates and no female graduate of the WU Vienna studied abroad; in contrast, at the school of architecture (TU Graz), neither of the 2 male graduates yet both female graduates studied abroad). Graduates of 4 faculties had absolutely no studies abroad (these 4 only have a very small number of graduates). Finally, for medicine there is no data (medicine has no special post graduate program).

The University of MMM at Leoben is the leader in the post-grad studies area (nearly 50% of the graduates), followed by the humanities (32%).

## 8.4.1 Subsidy programmes for up-and-coming scientists

**Table 8-2: Share of subsidy programmes for up-and-coming scientists**

Grant / award	funding organisation	Participants Σ 1998-2000 * Σ 1999-2000	f budget/grant [Tsd ATS]	participation criteria
Erwin Schrödinger-Auslandsstipendium	FWF	297	417	for post-grads/scientists, 10-24 months, ATS 290-500 k/year
Erwin Schrödinger-Rückkehrprogramm	FWF	1	1,700	for post-grads/scientists, max.ATS 4 Mio
Lise Meitner-Programm für AusländerInnen	FWF	50	408	for foreign postdocs under 35, 12 months, up to ATS 210 k
Charlotte Bühler-Programm	FWF	31	768	female academic teachers under 41, 12-24 months, ATS 530/year
Herta Firnberg-Stellen	FWF	35	1,891	female scientific "recruits" (Postdoc), resident of A, 3 years, ATS 662k/year
START-Programm	FWF	15		female scientists under 35, max 6.years, ATS 2-2,5 Mio/year
Wittgenstein-Preis	FWF	6	5,920	female scientists, ATS 20 Mio
APART (Aus.Progr.f.Advanced Res&Techn.)	ÖAW	55		for habilitation, 3 years, ATS 620 k/year
DOC (PhD-subsidies)	ÖAW	98	885	PhD-students, max.2 years, ATS 200 k/year
Öst.Progr.f.Techn.Doktoranden bei CERN	BMBWK	16*		max.24 months at CERN, avg. ATS 36k/month
Grant for scientific purposes	BMBWK	k.A.		in the university domain, sum 1999/2000: ATS 17 Mio
internships at internat/supranat.organisations	BMBWK	101	420	
Postgrad.Stipendien für das fremdspr.Ausl.	BMBWK	270*	182	
Kurt Gödel-Stipendien für d.Int.Space Univ.	BMBWK	19*	75	Postdocs/scientists, max.12 months, max ATS 12.500/month
Grant for the Inst.of Hist. at the ÖKI Rom	BMBWK	22*		ATS 12.000/month

Source: BMBWK, tip calculations

Table 8-2 provides an overview of the most important scholarship programmes for young researchers (two of them, the Charlotte Bühler programme and the Herta Firnberg fellowships are directed specifically at female researchers). In 2000, 264 scholarships or prizes were awarded. The total value of these awards was about 230 million ATS.

At a European level, the 4th EU framework programme and particularly the "promotion and mobility of scientists" (TMR) programme deserves special attention. It is specifically directed at colleges and promotes the international mobility of junior scientific staff. Applications from all fields of the natural and engineering sciences as well as the humanities, social sciences and economics could be submitted to the TMR programme according to the bottom-up principle as long as they met the general objectives of the framework programme. The target groups were above all graduates and graduated academics as well as research institutions willing to offer a seat to qualified academics. This activity was subdivided into 4 areas in the 4<sup>th</sup> framework programme (FP). In the 5<sup>th</sup> FP, it continued as a specific activity under the heading "expanding potential human resources in research".

**Table 8-3: Promotion of mobility in the EU framework programme**

4th framework programme		5th framework programme	
	Successful participations		Successful participations
Research networks (NW)	53	Educational networks	30
Access to large scale research facilities (LSF)	1	Scholarships	45
Research grants (RTG)	81	Conferences	34
Accompanying measures (AM)	5		

Table 8-4: Study abroad by groups

? 1997-1999 (2000)	Students				Outgoing by group				Incoming by group			
	Undergraduate studies begun	Undergraduate studies completed	Graduate studies begun	Graduate studies completed	Students/candidates	Doc/Post-doc	Scientific/teaching personnel	Of them, ERASMUS fellows	Students/candidates	Doc/Post-doc	Scientific/teaching personnel	Of them, ERASMUS fellows
University												
University of Ag.Sciences Vienna (BOKU)	900	442	229	78	145	23	15	120	86	45	5	73
University of Innsbruck	6.447	1.735	807	251	600	100	180	350	380	N/A.	180	250
University of Vienna	17.096	4.046	1.659	566	1.036	N/A	200	680	584	N/A	380	584

Source: Foreign study departments of the University of Innsbruck, Vienna and Bodenkultur; tip calculations

Note: the other universities were contacted but could not deliverer any appropriate data.

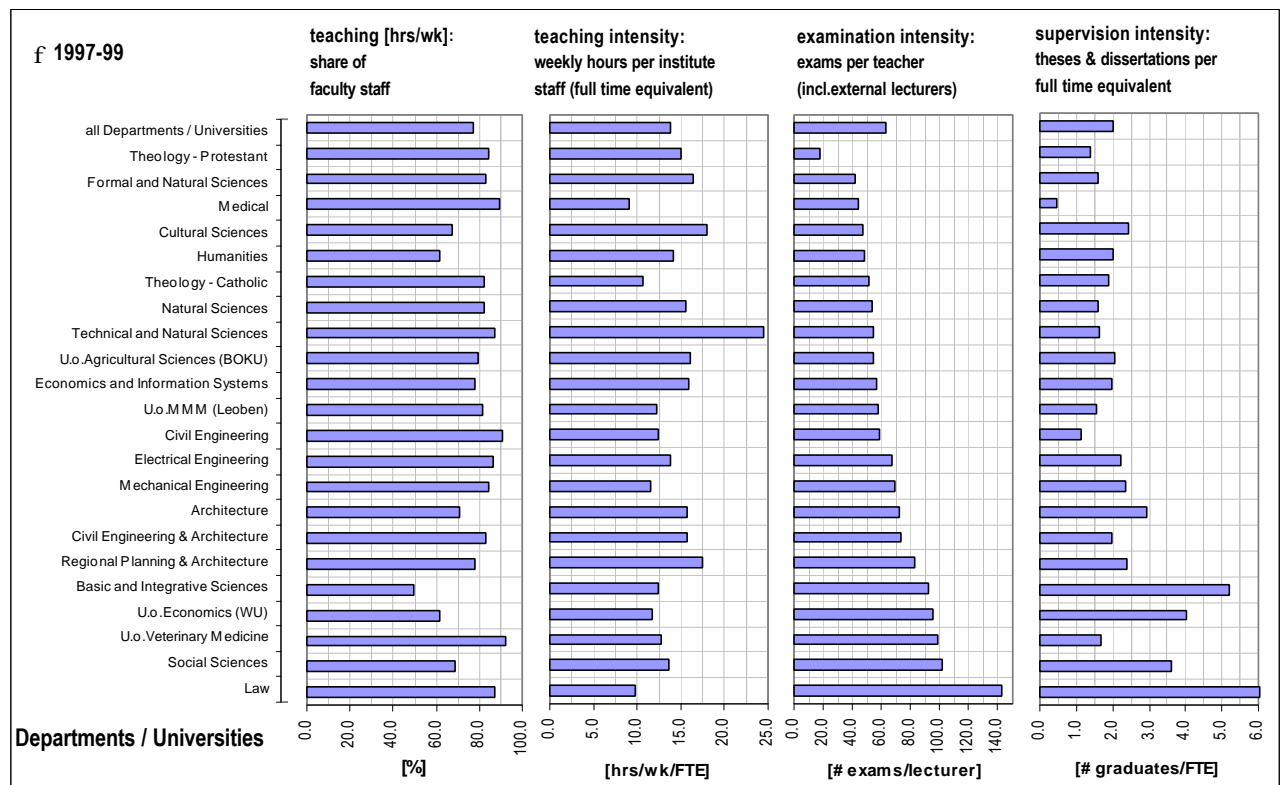
Table 8-4 shows that the ERASMUS fellowship is among the most important financial instruments in promoting the mobility of students and teachers. Other sources of financing are subsidies for short-term scientific work in foreign countries and joint study programmes (the most important after ERASMUS), CEEPUS, partnerships, cultural accords, etc. ERASMUS represents a part of the SOCRATES program in which Austria has been quite active since 1992/93. Within the scope of student exchanges, since 1992 11,000 Austrian students have gone to participating colleges.

The figures in table 8-4 represent the means for 1997-1999 (or 1996-1998 in the case of the number of graduates) or the most recent values (timelines did not exist for all categories). The mobility figures only include movement recorded by from the respective foreign study offices; in particular, they contain no data as to study abroad financed privately or via LEONARDO. Further, time spent abroad by scientific staff within the scope of project executions is not documented.

## 8.5 Scientific production at universities

### 8.5.1 Teaching and supervision

Figure 8-9: Teaching and supervision by faculty/university



Source: BMBWK, tip calculations

The first row shows the share of the entire course offering, carried out by employees of the institutes. The basic and integrative sciences faculty has the largest share of hours taught by external personnel (more than 50%). The highest share taught by “internal” staff belongs to veterinary sciences at over 93%. The remaining departments are between 60 and about 90%.

The highest teaching intensity, i.e. the number of required courses offered [hrs/week] per internal teaching staff member, is found among the technical-natural sciences faculty with nearly 25 hours/week per full-time equivalent (the total average of all departments is about 14 hrs/week); the lowest value, is 9 hrs/week in medicine.

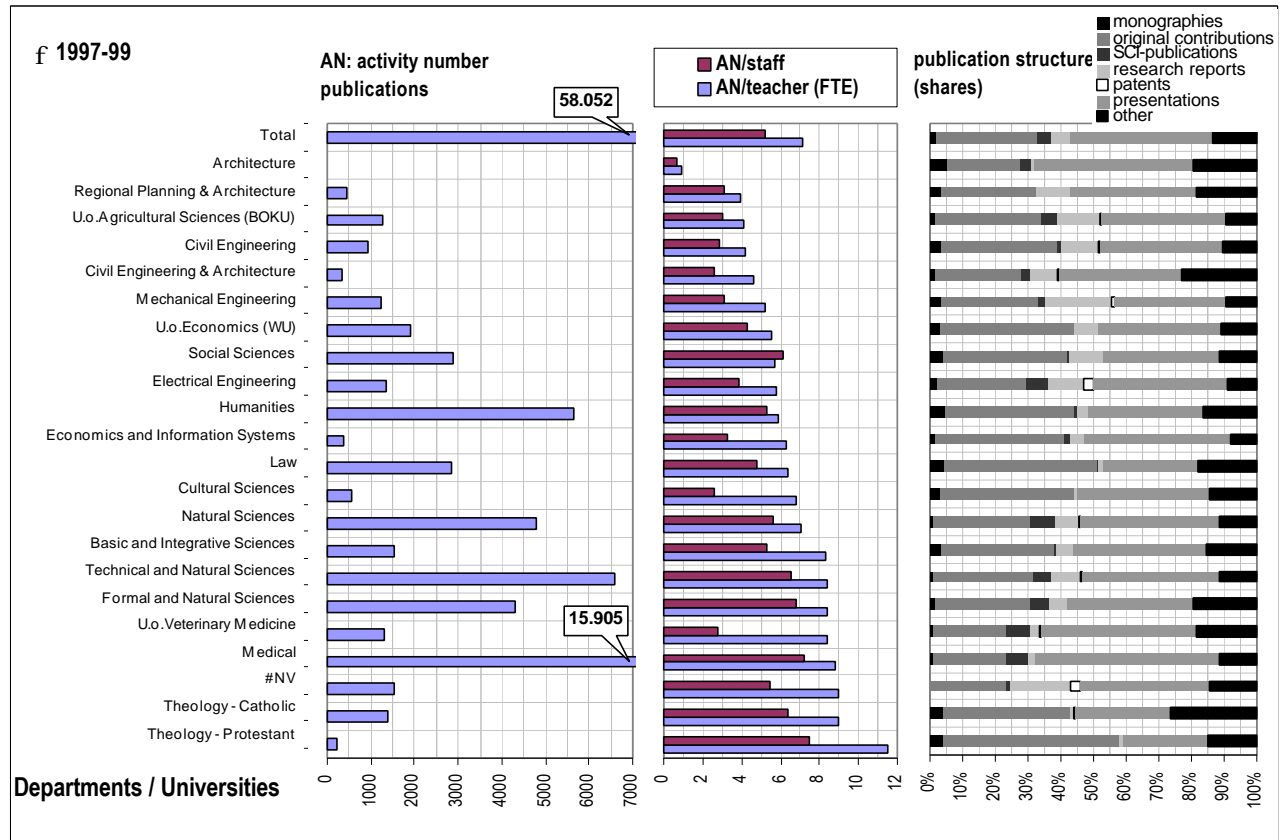
The different testing methods are subsumed as an activity figure<sup>40</sup>. The technical subjects are in the middle of the pack in regard to testing activities, oriented toward the (internal + external) teaching staff; the leaders are law, the social sciences and economics, veterinary medicine, the economics university, as well as basic and integrative sciences. With the exception of veterinary medicine, these departments are also the leaders in supervising intensity.<sup>41</sup>

<sup>40</sup> # examinations = (evaluations\*0.75) + (lecture exams\*1) + (individual exams\*2) + (exams by commission\*2)

<sup>41</sup> Activity figure, supervision = theses\*1 + dissertations\*2

## 8.5.2 Publications

Figure 8-10: Publication activities by faculty/university



Source: BMBWK, tip calculations

Publications are subsumed as an activity figure<sup>42</sup>. The highest publication rates, measured relative to scientific staff, are found in the theological faculties followed by the University of MMM Leoben (which in this respect is the "most productive" technical faculty/university) and human- or veterinary medicine. Architecture, area planning and the university of Bodenkultur bring up the rear.

In terms of the structure of publications it can be said that patents play a role in the technical faculties only; electrical engineering and the University of MMM Leoben also have noteworthy shares of scientific output.

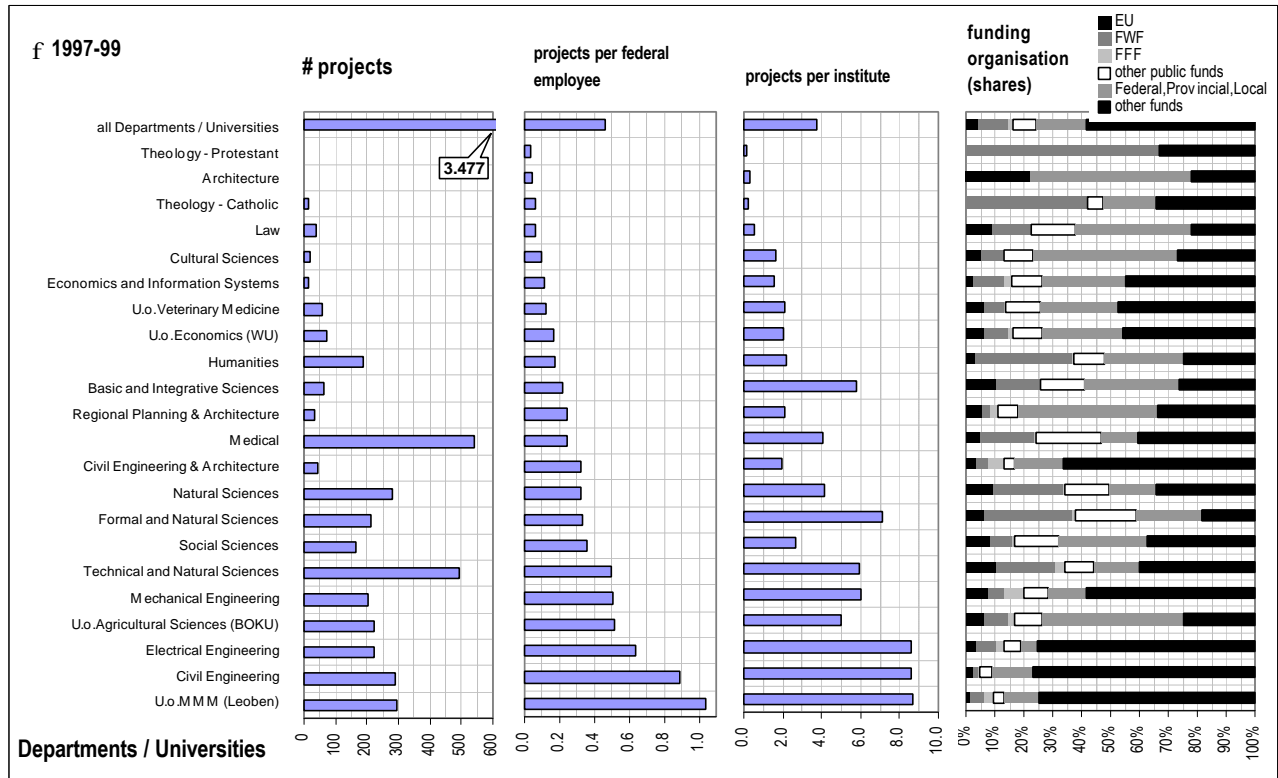
The highest publication quotas from all original contributions come from human- and veterinary medicine, the natural sciences faculty and electrical engineering. These are recorded in the "Science Citation Index."

Calculated across all faculties/universities, original contributions to professional journals and compilations have the highest share of the activity figure.

<sup>42</sup> AZ publications = (first edition monographs\*3) + (original contributions to professional journals and collaborative works\*1 (of those SCI/SSCI/AHCI publications\*3)) + (research reports\*1,5) + (patents\*2,5) + (lectures and presentations at scientific conventions\*0,5) + (other scientific publications\*0,5)

### 8.5.3 Project activities

Figure 8-11: Project activities by faculty/university



Source: BMBWK, tip calculations

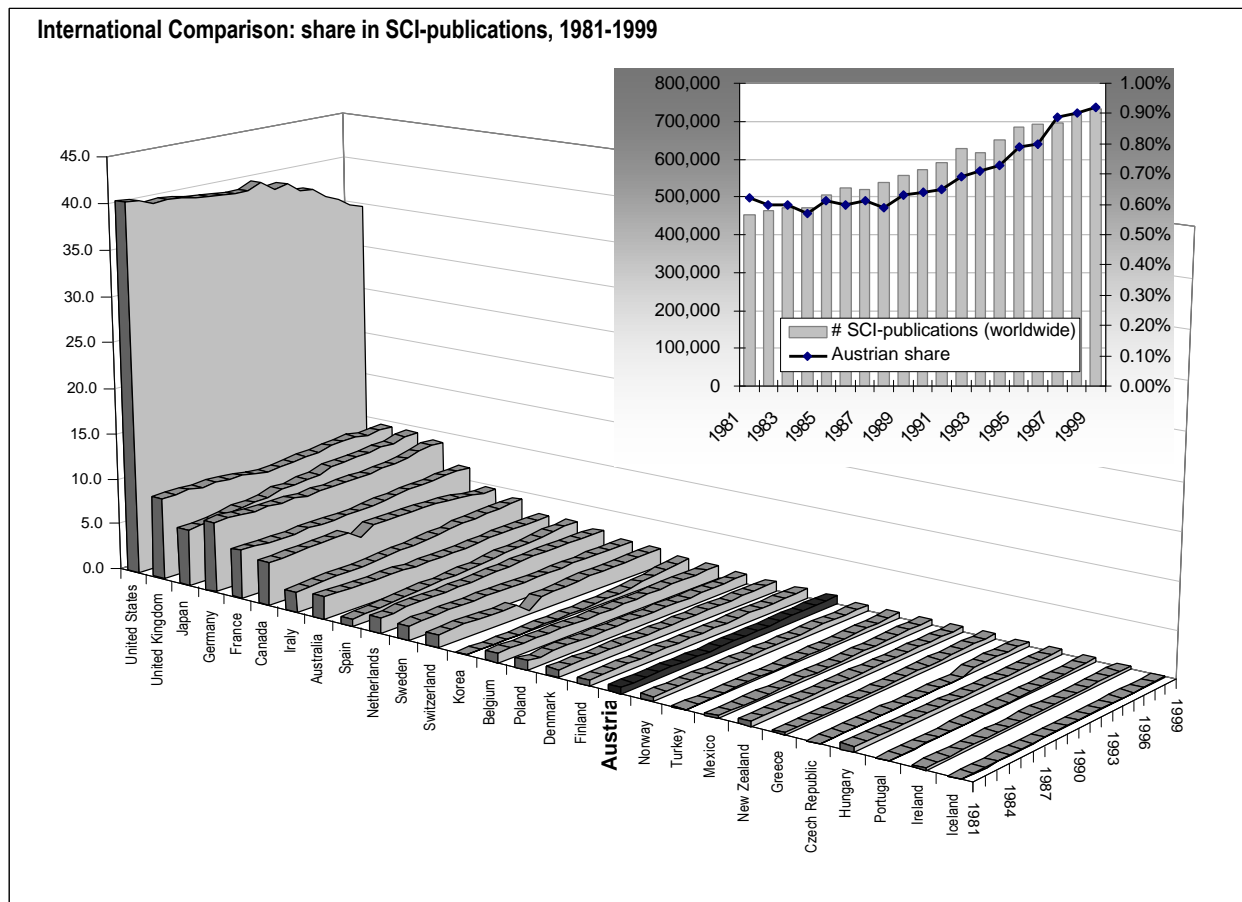
On average, between 1997 and 1999, 3,477 projects were executed; the highest shares belong to the medical and technical-natural science faculties (550 and 500 projects respectively). Both by projects per institute and per federal employee, the University of MMM at Leoben, civil engineering and electrical engineering have the highest values. This is not surprising since project work is generally a domain of the technical faculties. "Other" (non-public) contractors offer the highest shares of project structure (at about three quarters of all projects) in the three previously mentioned departments.

The low project intensity in law and at the University of Economics in Vienna (WU) affirms their position as primarily (and efficient) "institutions of vocational training".

It is interesting to note that in institutes with high project intensity, the private sector offers the highest share of contracts (University of MMM Leoben, civil engineering, electrical engineering). The FWF is most strongly represented in the catholic faculties (which have a very low overall project intensity) as well as in the natural sciences and humanities faculties.

## 8.6 International comparison of publication output

Figure 8-12: Development of the shares of SCI publications by country, 1981-1999



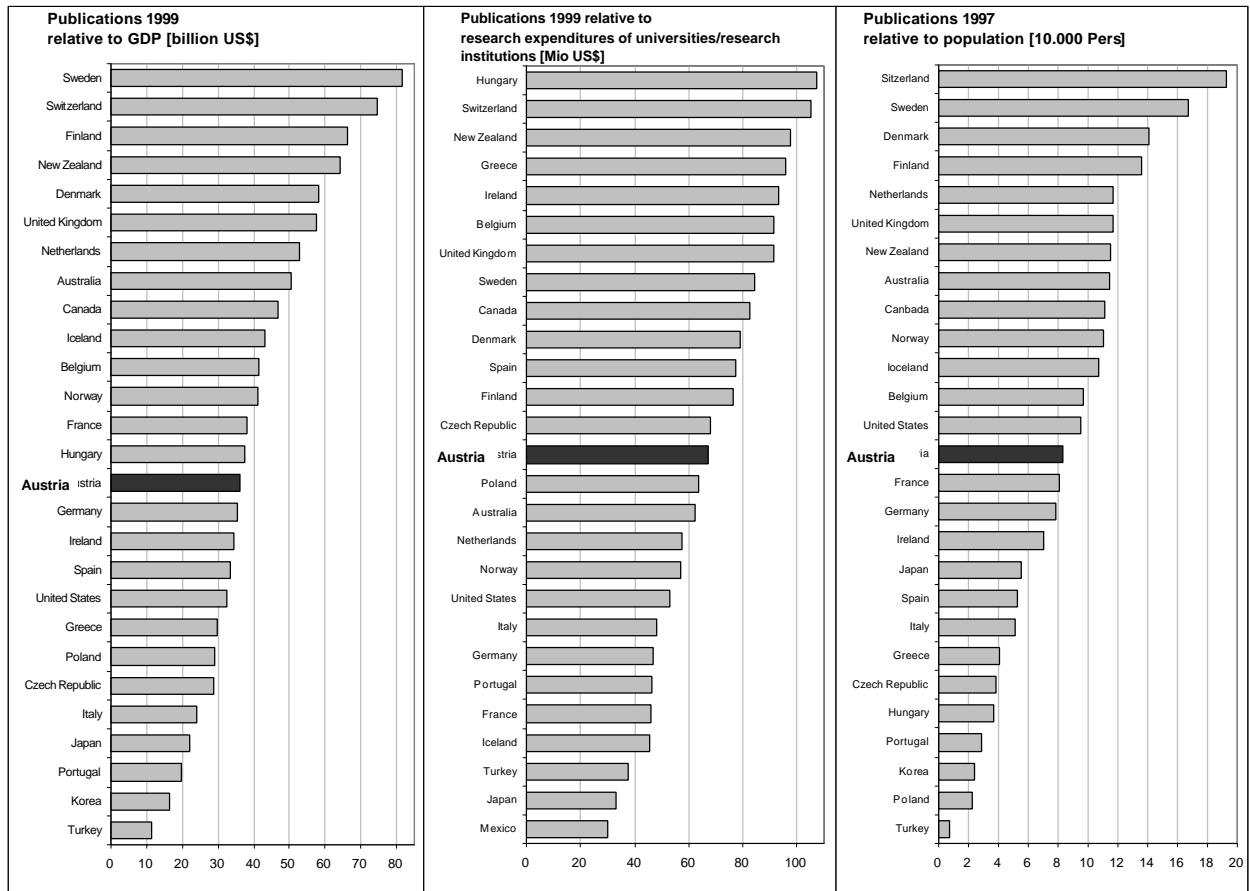
Source: Institute for Scientific Information, NSIOD 1981-1999, cited by The State and Quality of Scientific Research in Finland, 2000; tip calculations

The basis for this analysis is the "National Science Indicators" (NSIOD 1981-1999) of the Institute for Scientific Information. This database contains data on publishing and citations during the period between 1981-1999. It includes 5,500 journals on the natural sciences/technology, 1,800 on the social sciences and about 1,200 humanities journals. National associations are made given the details of the respective institute or work address of the author/co-author.

The diagram above shows the development of the shares in the total number of SCI-publications, per country, over time (the countries are arranged by their relative share in 1999). The share of publications by Austrian authors rose from 0.62 to 0.92% during the period studied and amounted to 6,718 publications in 1999; this represents a 48% increase in the relative share. In comparison, the same figures for Germany are +15% (from 7.61 to 8.79%), Sweden +31% (from 1.54 to 2.01%), Finland +64% (from 0.58 to 0.95%) and Switzerland +36% (from 1.38 on 1.88%).

The Austrian share stayed relatively constant during the 80s and then rose in the 90s. Given the worldwide increase in SCI publications during the entire period, the Austrian scientific system not only kept up with the general growth trend but also was able to improve its position.

Figure 8-13: Publications related to GDP, research expenditures and population

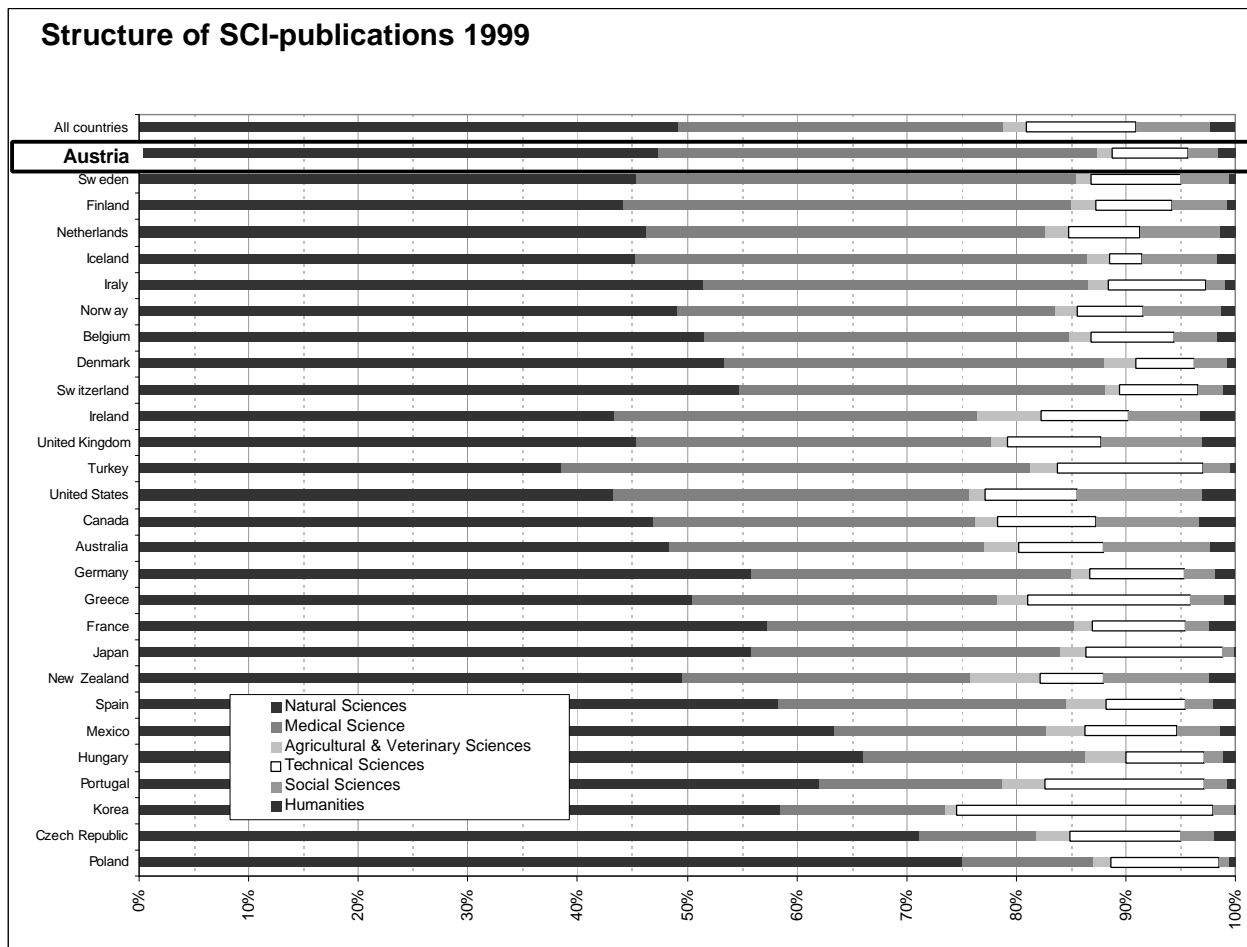


Source: Institute for Scientific Information, NSIOD 1981-1999, cited by The State and Quality of Scientific Research in Finland, 2000; tip calculations

Publications only represent a part of scientific output. Taken as a single indicator, they express little. Although somewhat limited, one possibility to compare countries is by relating publications to other relevant indicators. The figure above relates the number of publications to indicators like the gross domestic product, research expenditures of universities/research institutions and population.

Austria is in the middle of the pack with all three indicators, each (barely) ahead of Germany and (clearly) behind Sweden, Finland and Switzerland. These three occupy most of the leading positions. It is interesting that the USA is superior in absolute figures but only reaches the (lower) middle of the pack in these relative rankings.

Figure 8-14: Country-based comparison of the publication structure by scientific area



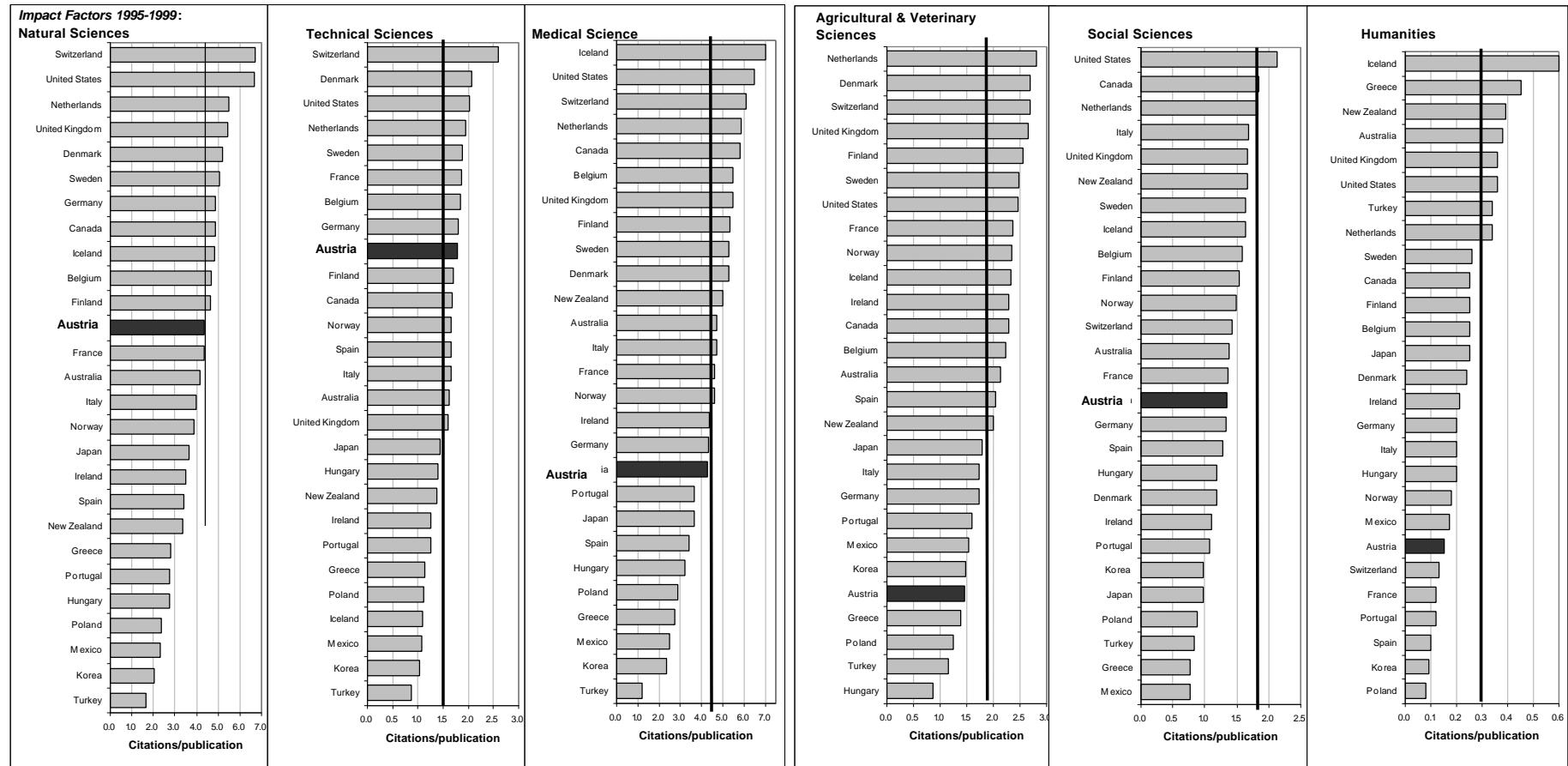
Source: Institute for Scientific Information, NSIOD 1981-1999, cited by The State and Quality of Scientific Research in Finland, 2000; tip calculations

The graphic shows the structure of publications, i.e. the shares of the total number, which apply to scientific areas<sup>43</sup>. The countries are ranked by their "structural similarity" to Austria<sup>44</sup>. The most similar publication structures are therefore in Sweden and Finland; roughly three groups of similarly large countries can be differentiated by decreasing structural similarity: small European countries; large or English-speaking countries; and the "remainder" (Mexico, Korea, Eastern European countries). In human medicine, Austria has the fifth-highest share of all 28 countries with 40% (the other rankings include: 19<sup>th</sup> in the natural sciences, 25<sup>th</sup> in agriculture and forestry, 22<sup>nd</sup> in the technical sciences, 18<sup>th</sup> in the social sciences as well as 13<sup>th</sup> in the humanities).

<sup>43</sup> Natural sciences, human medicine, agriculture and forestry including veterinary medicine, technical sciences, social sciences and humanities

<sup>44</sup> A quadratic distance measurement was chosen for the structural similarity; it measures the average difference in the shares of the scientific areas of the total number of publications.

Figure 8-15: *Impact Factors by country and scientific area*



Source: Institute for Scientific Information, NSIOD 1981-1999, cited by *The State and Quality of Scientific Research in Finland*, 2000; tip calculations

Figure 8-15 shows the impact factors for the 6 scientific areas<sup>45</sup>; these factors are generated as the number of citations related to the number of the publications (i.e. how often an article is quoted on average); the average of all countries is shown as a line of reference.

Although the technical sciences are underrepresented in the structure of Austrian publishing activities, (see above), they exhibit the highest relative impact factor of all scientific fields (about 9% above the country average). Austria's relatively largest scientific field, human medicine, only attains a somewhat below average impact factor (about 10% below the country average). The impact of publications from the natural sciences is slightly above average (+1%). The remaining scientific fields are found in the lower middle of the pack with clearly below average impact factors.

In most cases, the countries compared, Switzerland, Sweden, Finland and Germany, are able to achieve (sometimes markedly) higher values (Switzerland is among the top 3 countries in natural- and technical sciences, medical sciences and agriculture and forestry. Only in the humanities is Switzerland 23<sup>rd</sup> and thus 2 places behind Austria); Finland is about even with Austria in the natural- and technical sciences, but is ranked higher in the remaining scientific fields. Germany is most similar to Austria in terms of the relative impact factors.

---

<sup>45</sup> Natural sciences, human medicine, agriculture and forestry including veterinary medicine, technical sciences, social sciences and humanities

## 8.7 Cooperation between universities and industry in Austria

**Table 8-5: The degree of interaction between universities and the business sector in various forms of interaction**

	Share of institutes	Natural sciences	Technical sciences	Human medicine	Agriculture	Social sciences	Humanities	Total
<i>Share of personnel</i>		23	11	31	3	19	12	100
Forms of interaction:								
Superv. Theses/Diss.	16	17	31	8	2	42	1	100
Lectures	14	7	20	4	1	60	8	100
3 <sup>rd</sup> party personnel	13	28	39	14	7	10	2	100
Researcher mobility	13	37	34	14	1	12	1	100
Common projects	12	21	45	17	3	13	0	100
Continuing education	11	6	24	15	1	46	8	100
Joint publications	11	28	38	14	5	14	0	100
New foundations	6	29	31	7	1	30	1	100
Sabbaticals	4	24	29	10	7	29	2	100
<b>Total</b>	<b>23</b>	<b>29</b>	<b>29</b>	<b>23</b>	<b>18</b>	<b>23</b>	<b>13</b>	

Source: 1999 department survey at the 12 universities, see Scharfetter et al. 2000. Figures in percent.

Table 8-5 provides an overview of the different forms of knowledge-intensive interactions between universities and the business enterprise sector in Austria. In the course of a complete survey from 1999, the university departments of the 12 universities were questioned as to the extent of their relations to the business sector in the following forms of interaction:

- Joint supervision of master's theses and dissertations with the business sector;
- Lectures held at universities by members of the business sector;
- Personnel financed by third party funds from the business sector;
- Movement of university assistants to the business sector;
- Joint projects with the business sector;
- Continuing education offered by the university institutes for members of the business sector;
- Common publications with the business sector;
- Foundations of firms from universities;
- Sabbaticals spent by university researchers in the business sector.

The survey concludes that between 1995 and 1998 at least 23% of all university institutes had at least one contact to the business sector in at least one of the forms of interaction listed above. The corresponding share of the institutes per scientific branch varies greatly. In the natural and technical sciences, the share of institutes with contact to the business sector in these forms is about one third. In human medicine and the social sciences it is roughly one quarter and under 20% in agriculture and the humanities.

With regard to the intensity of the interactions, the technical sciences, which employ over 11% of university personnel, perform 31% of all supervising activities (master's theses and dissertations) with the business sector. Given their size, they exhibit an above average interaction intensity in the "joint su-

pervision of scientific work“ as well as in all other forms of interaction. This scientific branch’s particular preference is however “common projects“ where its interaction intensity is especially high.

The natural sciences and agricultural studies also exhibit above average interaction intensity in a few forms of interaction. In the natural sciences this comes from a particularly intense flow of knowledge manifest as the mobility of university researchers into the business sector. In agricultural studies however the intensity is in the common supervision of contracted assistants financed by the business sector.

**Table 8-6: Business enterprise sectors and their relations to universities in various forms of interaction**

Economic branch	Nace	R&D Quota <sup>46</sup>	Joint publications	Joint projects	Mobility of univ. in industry	Spin-offs	Joint education
<i>Production sector</i>							
Nutrition industry	(nace 15-16)	0.56	0.82	0.27	1.42	0.00	1.09
Textile industry	(nace 17-19)	2.37	0.00	0.48	0.00	0.00	0.03
Wood industry	(nace 20)	0.80	0.00	0.00	0.42	0.00	1.24
Paper industry	(nace 21-22)	0.64	1.22	0.63	1.98	0.00	4.73
Chemical Industry	(nace 23-24)	12.66	2.38	3.69	2.66	0.22	1.68
Plastics	(nace 25)	1.61	0.99	25.60	1.25	0.00	0.59
Glass industry	(nace 26)	2.77	0.36	3.55	0.00	0.00	0.21
Metal industry	(nace 27-28)	1.53	2.58	3.98	0.81	0.00	1.49
Engineering	(nace 29)	3.91	0.95	1.17	0.92	0.43	0.66
Electronic industry	(nace 30-32)	16.71	0.37	0.40	0.17	0.06	0.22
Medical technology	(nace 33)	6.41	5.75	1.27	3.37	3.81	2.23
Auto industry	(nace 34-35. 50)	2.79	1.03	1.20	0.65	0.00	2.35
Furniture industry	(nace 36)	1.0	0.91	0.22	0.00	0.00	1.23
Waste disposal	(nace 37. 90)	0.85	5.39	1.24	1.94	0.00	3.64
<i>Service sector</i>							
Trade	(nace 51-52)	0.02	5.39	0.43	4.25	0.00	2.22
Transport services	(nace 60-63)	0.0	21.57	10.83	27.21	0.00	65.05
Telecommunication	(nace 64)	0.09	2.59	1.39	10.88	0.00	2.68
Finance services	(nace 65-67)	0.08	6.47	1.19	4.42	0.00	9.57
Software services	(nace 72)	3.88	0.86	0.17	4.06	5.33	1.05
R&D	(nace 73)	56.75	2.58	0.47	1.76	0.54	0.83
Business services	(nace 74)	0.14	23.73	2.82	43.20	199.70	50.64

Source: 1999 department survey at the 12 universities, see Scharfing et al. 2000.

Table 8-6 attempts to identify those business sectors with particularly strong ties to universities. To do this, it compares the number of interactions of a business sector with the “expected interaction intensity“ based on the size of the sector.<sup>47</sup> For clarity, the R&D intensity for each sector is shown in the left-hand column. (The different forms of interaction were partially aggregated: the interaction form “joint education“ comprises the joint supervision of master’s theses and dissertations with the business sector, lectures held at university departments by members of the business sector and the continuing education offered at university department for members of the business sector. “Mobility“ includes both sabbaticals and the continued movement of university researchers into industry.)

<sup>46</sup> Share of R&D employees of all employees

<sup>47</sup>  $(I_s/\Sigma I_s)/(S_s/\Sigma S_s)$ , where  $I_s$  is the number of interactions of a business sector  $s$  and  $S_s$  is the number of R&D employees in the given business sector.

The manufacturing sector shows that the most R&D-intensive business sectors do not necessarily have particularly high interaction-intensities in all forms of interaction: the electronic industry exhibits a significantly lower interaction intensity in all forms of interaction than would be expected based on its size and R&D intensity. The situation is different in medical technologies: this business sector exhibits above average interaction intensity in all forms of interaction in comparison to its size. Further, individual business sectors exhibit clear preferences for certain type of interaction: engineering and the glass industry maintain relationships to Austrian universities through common projects. In contrast, the nutrition industry does it via the mobility of university researchers and joint educational activities.

In the service sector, the "research and development" business enterprise sector, which by definition is the most R&D- intensive sector, maintains contacts to universities through joint publications and the mobility of university researchers. The "software services" sector exhibits a clear preference for mobility, spin-offs and common educational activities with universities. In total, three business sectors have a higher than expected (based on size) intensity of new business foundations from universities: medical technology, software services and above all the business services sector.

**Table 8-7: Business sector and its extramural R&D expenditures for universities**

Economic branch	Nace	ER&D_Univ/ BWS <sup>1</sup>	ER&D_total/ BWS <sup>2</sup>	A/B <sup>3</sup> (C)	ER&D_Univ/ ( $\Sigma$ ER&D_Univ) <sup>4</sup> (D)
Research and development	73	0.82	5.36	15.30	2.27
Medical technology	33	0.12	1.32	9.09	3.93
Electronic industry	31	0.08	0.63	12.70	5.85
Chemical industry	24	0.07	1.23	5.69	7.45
Glass industry	26	0.07	0.29	24.14	6.64
Energy/Water supply	40-41	0.05	0.13	38.46	11.32
Engineering industry	29	0.05	0.55	9.09	8.52
Wood industry	20	0.04	0.10	40.00	3.17
Data processing	72	0.03	0.18	16.67	1.87
Plastic industry	25	0.03	4.58	0.66	1.95
Radio; TV; communications	32	0.02	2.81	0.71	2.54
Financial services	65-67	0.02	0.15	13.33	10.58
Metal industry	27-28	0.02	0.22	9.09	5.08
Nutrition and tobacco industry	15	0.02	0.12	16.67	2.77
Business services; Real estate; leasing.	70-71. 74	0.02	0.08	25.00	7.73
Transportation/ communication	60-64	0.01	0.08	12.50	6.45
Jewellery etc.	36	0.01	0.12	8.33	0.93
Textile industry	17	0.01	0.43	2.33	0.30
Paper industry; printing	21-22	0.01	0.23	4.35	0.85
Trade	50-52	0.01	0.02	50.00	5.63
Automobile industry	34	0.00	3.95	0.00	0.37
Construction industry	45	0.00	0.01	0.00	0.02
Recycling	37	0.00	0.00	-	0.00
Tourism	55	0.00	0.00	-	0.00

Source: Statistic Austria; 1998 R&D survey. Data in%.

<sup>1</sup> Extramural R&D expenditures for universities as a percent of gross value added

<sup>2</sup> Extramural R&D expenditures total as a percent of gross value added

<sup>3</sup> Share of Extramural R&D expenditures for universities from the total extramural R&D expenditures of a sector

<sup>4</sup> Extramural R&D expenditures for universities per sector as a percent of the total external R&D expenditures for universities across all sectors

Table 8-7 shows the extramural R&D expenditures from the individual business sectors to universities. The research and development sector has the relative highest share of extramural R&D expenditures for universities at 0.82% of the gross value added. The medical technology, electronics and chemical industry sectors are clearly behind.

There are business sectors, which tend more than others to buy external knowledge and use it for innovation in the technological or organizational area. These sectors generally have a high share of extramural R&D expenditures of gross value added (Table 8-7, column B). They include the R&D sector, the plastics industry, the automobile industry and the radio, TV- and communications sector. Other institutions besides the universities also serve as sources of relevant external knowledge. They include other businesses and other government or private institutions. A comparison of columns A and B shows that of all of the business sectors listed which purchase a substantial amount of external knowledge, only the research and development sector accesses knowledge from universities to any significant degree (15.3% of all extramural R&D expenditures of the sector, column C).

However, the sectors, which spend the highest shares of their extramural R&D budgets on the universities (column C), are trade (50%), the wood industry (40), energy and water utilities (38.5%), the business services sector (25%) and the glass industry (24%).

Column D shows the share of extramural R&D expenditures for universities per sector against the sum of all extramural R&D expenditures for universities. It shows that quantitatively, universities receive the most third party funding from the energy and water utility sector (11.3%). It is followed by financial services (10.6%) and the engineering industry (8.5%).

## References

- Almus, M., Egelin, J., Engel, D., Gassler, H. (2000): Unternehmensgründungsgeschehen in Österreich bis 1998, ZEW Dokumentation, (00-06), Mannheim.
- Dachs B., Leo H. (1999): Innovationsaktivitäten der österreichischen Wirtschaft: Band 2: Dienstleistungssektor, WIFO, Wien.
- Dachs, B., Knoll. (2001): Screening eEurope. Technologiepolitik für die Informationsgesellschaft. Studie im Rahmen des TIP, Wien.
- DIW (Hrsg.) (2000): Die Ökonomie der Informationsgesellschaft, Vierteljahresheft 4/2000, Deutsches Institut für Wirtschaftsforschung, Berlin.
- DoC (U.S. Department of Commerce) (1999): The Emerging Digital Economy II, Washington, D.C.
- DoC (U.S. Department of Commerce) (2001): Digital Economy 2000, Washington <http://www.esa.doc.gov/de2k2.htm>.
- EITO (2001): European Information Technology Observatory 2001, Frankfurt am Main.
- Eliasson, G., Fölster, S., Lindberg, T., Pousette, T., Taymaz, E. (1990): The Knowledge-based Information Economy, Almqvist & Wicksell International, Stockholm.
- "Erklärung der Bundesregierung zu aktuellen Fragen der Forschungs- und Technologiepolitik", beschlossen im Ministerrat am 11. Juli 2000, Wien.
- Europäische Kommission (1994): Europe's Way to the Information Society: An Action Plan, KOM (94)347 final, Brussels.
- Europäische Kommission (2000): eEurope 2002: Eine Informationsgesellschaft für alle, Aktionsplan, vorgelegt am Gipfel von Lissabon, 23/24. März 2000.
- Gassler, H., Polt, W., Rammer, C. (1999): Erhöhung der österreichischen F&E Quote bis 2005: Modellrechnungen, Studie im Auftrag des BMWA, OEFZS--S-0032. Seibersdorf.
- Geyer, A., Rammer, C, Pointner, W, Polt, W., Hollenstein, Donzé, L., W, Arvanitis, S., (2000): Evaluierung des ITF-Schwerpunktes FlexCIM, ARCS Report OEFZS-S-0102, Seibersdorf.
- Guellec, D., van Pottelsberghe, B. (2000): The Impact of Public R&D Expenditure on Business R&D, STI Working Papers, 2000 (4). Paris
- Hall, B., van Reenen, J., (2000): How Effective are Fiscal Incentives for R&D? A Review of the Evidence, in: Research Policy, 29(4-5), S. 449-469.
- Harhoff, D. (1994): Zur steuerlichen Behandlung von Forschungs- und Entwicklungsaufwendungen. Eine internationale Bestandsaufnahme, ZEW Dokumentation (94-02), Mannheim.
- Hipp C. (2000): Innovationsprozesse im Dienstleistungssektor., Physica, Heidelberg.
- Hutschenreiter G., Kaniovski S. (1999): Embodied Technology Diffusion in the Austrian Economy. Studie im Rahmen des TIP, Wien.
- Hutschenreiter, G. (Koordination), Knoll, N., Paier, M., Ohler, F. (1998): Austrian Report on Technology, tip-study, Wien.
- Hutschenreiter, G. (1993): Neue Ansätze zu einer Industriepolitik der EG, in: WIFO-Monatsberichte, 66(5).
- Hutschenreiter, G. (1995): Intersektorale und internationale "F&E-Spillovers". in: Externe Effekte von Forschung und Entwicklung, in: WIFO-Monatsberichte, 68(6), S. 419-427.
- Hutschenreiter, G. (1998): Produktivität und Technologiediffusion, in: Wirtschaftspolitische Blätter, 45(1), S. 28-37.
- Hutschenreiter, G., Kaniovski, S. (1999): Embodied Technology Flows in the Austrian Economy, Studie im Auftrag der Bundesministerien für wirtschaftliche Angelegenheiten sowie für Wissenschaft und Verkehr, Technologie - Information - Politikberatung (TIP), Wien.

- Hutschenreiter, G., Leo, H. (1998): Technologiepolitik und -förderung, in: Bayer, K. (Koordination), Der Staat und seine Funktionen. Neue Formen der Erfüllung öffentlicher Aufgaben, S. 151-175, Bundesministerium für Finanzen, Wien.
- Hutschenreiter, G., Peneder, M., „Österreichs Technologielücke im Außenhandel“, in WIFO-Monatsberichte, 1997, 70 (2), S. 103-114.
- Hutschenreiter, G., Polt, W. Gassler, H. (2001): Möglichkeiten zur Erhöhung der österreichischen Forschungsquote – Abschätzung der Effekte öffentlicher auf private F&E-Ausgaben. Endbericht an die AG ‚Forschungsquote‘ im Auftrag des BMVIT, Wien.
- ITU (1995), World Telecommunication Development Report 1995: Information Indicators, Geneva.
- Jörg, L., Pointner, W., Polt, W., Zinöcker, K. (2001): Evaluierung des ITF-Schwerpunktes Tech-Transfer, Wien.
- Leo, H. (1999): Österreichs Innovations- und Forschungsleistung im internationalen Vergleich, in WIFO-Monatsberichte, 72(6), S. 435-443.
- Leyden, D.P., Link, A.N. (1992): Government's Role in Innovation, Kluwer Academic Publishers, Dordrecht.
- Lundvall, B. (1997): Information Technology in the Learning Economy: Challenges for Development Strategies, Communications & Strategies 28/4, pp.177-191.
- Mowery, D. (1995): The Practice of Technology Policy, in: Stoneman, P. (Hsg.), Handbook of the Economics of Innovation and Technical Change, pp. 513-557, Blackwell, Oxford.
- OECD (2001): Communications Outlook 2001, Paris.
- OECD (2000a): Science Technology and Industry Outlook 2000, Paris.
- OECD (2000b), A New Economy?: The changing role of innovation and information technology in growth, Paris.
- OECD (2000c): Measuring the ICT Sector, Paris.
- OECD-BSTS (2000): Basic Science and Technology Statistics (BSTS), Paris.
- OECD-MSTI (2000): Main Science and Technology Indicators (MSTI), Paris.
- OECD (1999): Science, Technology and Industry Scoreboard 1999. Benchmarking Knowledge-Based Economies, Paris.
- OECD (1998): Internationalisation of Industrial R&D. Patterns and Trends, Paris.
- OECD (1998): Technology, Productivity and Job Creation - Best Policy Practices, Paris.
- OECD (1997): Policy Evaluation in Innovation and Technology. Towards Best Practices, Paris.
- OECD (1996): The Knowledge-based Economy, Paris.
- Peneder, M. (2001): Entrepreneurial Competition and Industrial Location, Edward Elgar, Cheltenham, UK.
- Peneder, M. (1999), The Austrian Paradox: "Old" Structures but High Performance?, in: Austrian Economic Quarterly, 1999 (4), pp. 239-247, Wien.
- Polt, W. (Koordination), Gassler, H., Hutschenreiter, G., Knoll, N., Leo, H., Paier, M., Peneder, M., Schibany, A. (1999): Austrian Report on Technology, tip-study, Wien.
- Polt, W. (2000): Policy case study Austria. Report prepared for the OECD Focus Group on Innovative Firm Network, Wien.
- Polt, W., Daniel, H. D., Fritz, O. (2000), Evaluierung von F&E-Förderungen. Ein internationaler Vergleich am Beispiel Finnland, Wien.
- Schartinger, D., Gassler, H., Schibany, A. (2000): Benchmarking Industry – Science Relations, ARCS Report OEFZS-S-0099, Seibersdorf.

- Schibany, A., Jörg, L., Gassler, H., Warta, K., Sturn, D., Polt, W., Streicher, G., Luukkonen, T., Arnold, E. (2001): Evaluation of Austrian participation in the 4th EU Framework Programme for Research, Technological Development and Demonstration, Wien.
- Schibany, A. (1998): Co-operative Behaviour of Innovative Firms in Austria, tip-study, Wien.
- Schneider, H.W. (2000): Steuerliche Begünstigung von Forschung und Entwicklung, Linde, Wien.
- Scholtze, E. (2000): Finanzierung der Ausgaben für Forschung und experimentelle Entwicklung in Österreich. Globalschätzung 2000. In: Statistische Nachrichten 10/2000, S. 792-796.
- Shapiro, C., Varian, H. (1999): Information Rules: A Strategic Guide to the Network Economy, Harvard Business School Press, Boston, Massachusetts.
- Statistic Austria (2001): Forschung und experimentelle Entwicklung (F&E) im firmeneigenen Bereich 1998. In: Statistische Nachrichten 2/2001, S. 89-103.
- Statistic Austria (2000a): Finanzierung der Ausgaben für Forschung und experimentelle Entwicklung in Österreich. Globalschätzung 2000. In: Statistische Nachrichten 10/2000, S. 792-796.
- Statistic Austria (2000a): Produzierender Bereich 1998, Wien.
- Statistic Austria (2000b): Handel, Dienstleistungen 1998, Wien.
- Statistic Austria (1998a): Produzierender Bereich 1995, Wien.
- Statistic Austria (1998b): Handel, Dienstleistungen 1995, Wien.
- Sturn, D., Novacovic, M., Pointner, W., (2000), Unterstützung bei der Konkretisierung und Ausformulierung eines Förderungsprogramms "Akademische Spin-offs", Wien-Graz.
- Sundbo, J., Gallouj, F. (1998): Innovation in Services. SI4S Project Synthesis Report. <http://www.step.no/Projectarea/si4s/start.htm>
- Tichy, G. (2001): Das Nutzer-Paradoxon und seine Bedeutung für die europäische Innovationsschwäche. Neue Ansatzpunkte für die Technologiepolitik?, in: Fuchs, W. und Horvath, G. Hg. Wirtschaftsstandort Österreich. Von der Theorie zur Praxis, Wien: Bundesministerium für Wirtschaft und Arbeit, 207-30.
- WIFO, Forschungszentrum Seibersdorf, Joanneum Research (1996): Technologiepolitisches Konzept 1996 der Bundesregierung, Expertenentwurf, Wien.

Table 1:

**Overall estimate 2001: Gross Domestic Expenditures on R&D**  
**Financing of research and experimental development performed in Austria between 1981 -2001 (in million of ATS)**

Financing sector	1981	1985	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001
1. <b>Gross Domestic Expenditures on</b>	<b>12 332,1</b>	<b>17 183,2</b>	<b>22 966,9</b>	<b>31 694,2</b>	<b>34 943,5</b>	<b>36 876,9</b>	<b>39 291,0</b>	<b>42 450,2</b>	<b>47 258,1</b>	<b>49 533,9</b>	<b>50 740,6</b>	<b>53 967,6</b>
Financed by:												
A. Federal government	4 986,7	7 130,2	8 501,7	13 170,2	14 794,2	15 030,1	14 674,8	14 828,0	15 560,4	16 523,7	16 409,6	18 438,9
B. Provinces <sup>2)</sup>	658,6	979,7	1 229,9	1 784,3	2 183,6	2 117,5	2 188,7	2 302,8	2 582,6	2 744,1	2 934,8	3 064,4
C. Business sector <sup>3)</sup>	6 195,9	8 440,8	12 182,6	15 527,1	16 073,6	16 688,1	17 366,8	18 107,0	19 125,8	19 871,0	20 804,1	21 627,2
D. Abroad <sup>4)</sup>	305,0	425,2	741,3	821,4	1 466,0	2 602,0	4 616,7	6 559,2	9 447,4	9 842,8	10 058,8	10 401,9
E. Others <sup>5)</sup>	185,9	207,3	311,4	391,2	426,1	439,2	444,0	653,2	541,9	552,3	533,3	435,2
2. <b>Nominal GDP <sup>6)</sup> (in billion of ATS</b>	<b>1 081,7</b>	<b>1 369,1</b>	<b>1 699,1</b>	<b>2 159,5</b>	<b>2 276,1</b>	<b>2 370,7</b>	<b>2 450,0</b>	<b>2 513,5</b>	<b>2 614,7</b>	<b>2 712,0</b>	<b>2 833,9</b>	<b>2 941,4</b>
3. <b>Gross Domestic Expenditures on</b>	<b>1,14</b>	<b>1,26</b>	<b>1,35</b>	<b>1,47</b>	<b>1,54</b>	<b>1,56</b>	<b>1,60</b>	<b>1,69</b>	<b>1,81</b>	<b>1,83</b>	<b>1,79</b>	<b>1,83</b>

As of April 2001

Source: Statistik Austria

<sup>1)</sup> 1981, 1985, 1989 and 1993: survey results (federal government including resources from the two research subsidy funds and in 1989 and 1993 also including the ITF).

1990 - 1992 and 1994 - 2001: attachment T/part b (federal budget - research); 1990 additional special activities to promote R&D projects oriented toward foreign trade (50 million ATS). 2000: including any delimited funds from the Technology Billions from 1997 and 1998, used for research purposes in 2000 (not included in the federal estimate for 2000). 2001: 7 billion ATS are estimated in the federal budget for research in 2001 under the VA-approach 1/5182 12 for the R&D offensive program. Based on current information, it is assumed that only 2 of these 7 billion ATS will be spent in 2001. The remaining 5 billion ATS are for R&D expenditures in the following years. Therefore, only the 2 billion ATS which will flow into research in the year 2001 are included in the R&D expenditure estimate from Statistik Austria, deviating from attachment T/part b.

<sup>2)</sup> 1981, 1985, 1989 and 1993: Survey results (including estimates of the R&D expenditures from the provincial health authorities via Statistik Austria: 1981: 375.9 million ATS; 1985: 510.9 million ATS; 1989: 637.7 million ATS; 1993: 903.1 million ATS). 1990 - 1992 and 1994 - 2001: estimate from Statistik Austria in light of the R&D expenditure estimates of the provincial governments.

<sup>3)</sup> Includes funding from the business sector (including Jubiläumsfonds from the Austrian National Bank). 1981, 1985, 1989 and 1993: Survey results. 1990 - 1992 and 1994 - 2001: Estimate from Statistik Austria based on the results of the R&D surveys from the Austrian chamber of commerce (1989, 1991 and 1993) and from Statistik Austria (1989, 1993 and 1998 - Results of the R&D survey from Statistik Austria in the company-internal area).

<sup>4)</sup> 1981, 1985, 1989 and 1993: Survey results. 1990 - 1992 and 1994 - 2001: estimate from Statistik Austria taking into consideration the results of the 1998 Statistik Austria R&D survey in the company-internal area. 1995 - 2000 including the returns from the 4th EU framework programme for research, technological development and demonstration and including the returns from the 5th EU framework programme for research, technological development and demonstration from 1999 to 2001 (as of April 2001).

<sup>5)</sup> Includes financing via communities (without Vienna), via chambers, via social security providers as well as all other forms of public financing (also includes all construction projects in the college sector from 1989 through 1998 via ASFINAG, as well as 1993 through 2000 via BIG non-budgeted financing) and via the private non-profit sector.

1981, 1985, 1989 and 1993: survey results. 1990 - 1992 and 1994 - 2001: estimate from Statistik Austria.

<sup>6)</sup> 1981 - 1999: Statistik Austria; 2000, 2001: WIFO forecast (March 2001).

Table 2: **Federal expenditures for research and research subsidies from 1998 to 2001 by federal ministries**

Subdivision of attachment T of the official guide to the federal finance acts 2000 and 2001 (Parts a and b)

Departments <sup>1)</sup>	Achieved				Federal estimate			
	1998 <sup>2)</sup>		1999 <sup>3)</sup>		2000 <sup>3)</sup>		2001 <sup>3)</sup>	
	Million ATS	%	Million ATS	%	Million ATS	%	Million ATS	%
Federal Chancellor's Office	109,382	0,7	108,364	0,6	77,907	0,5	70,521	0,3
Federal Ministry of the Interior	2,358	0,0	2,235	0,0	1,994	0,0	1,994	0,0
Federal Ministry of Education and Cultural Affairs <sup>4)</sup>	529,690	3,2	585,471	3,4	.	.	.	.
Federal Ministry of Science and Transportation <sup>4)</sup>	11 839,041	72,5	12 474,876	72,0	.	.	.	.
Federal Ministry of Education, Science and Culture <sup>4)</sup>	.	.	.	.	12 546,775	76,3	12 957,420	53,9
Federal Ministry of Labour, Health and Welfare	1 890,951	11,5	2 041,780	11,8	.	.	.	.
Federal Ministry of Social Security and Generations	.	.	.	.	483,920	2,9	145,958	0,6
Federal Ministry of the Environment, Youth and Family	171,476	1,0	170,966	1,0	.	.	.	.
Federal Ministry of Foreign Affairs	24,035	0,1	25,069	0,1	27,570	0,2	27,570	0,1
Federal Ministry of Justice	1,050	0,0	1,000	0,0	0,850	0,0	0,850	0,0
Federal Ministry of Defense	3,188	0,0	2,611	0,0	3,267	0,0	3,547	0,0
Federal Ministry of Finance	398,825	2,4	415,705	2,4	429,933	2,6	7 442,947	31,0

Federal Ministry of Agriculture and Forestry <sup>4)</sup>	531,007	3,2	581,074	3,3	.	.	.	.
Federal Ministry of Agriculture and Forestry, Environment and Water Supply <sup>4)5)</sup>	.	.	.	.	731,108	4,4	725,487	3,0
Federal Ministry of Economic Affairs <sup>6)</sup>	884,603	5,4	940,299	5,4	.	.	.	.
Federal Ministry of Economics and Labour <sup>6)</sup>	.	.	.	.	89,063	0,5	93,855	0,4
Federal Ministry of Transport, Innovation and Technology	.	.	.	.	2 075,895	12,6	2 571,379	10,7
Federal Ministry of Public Service and Sports	.	.	.	.	-	-	-	-
<b>TOTAL</b>	<b>16 385,606</b>	<b>100,0</b>	<b>17 349,450</b>	<b>100,0</b>	<b>16 468,282</b>	<b>100,0</b>	<b>24 041,528</b>	<b>100,0</b>

**As of April 2001**

**Source: Statistic Austria**

<sup>1)</sup> According to the valid federal statutes for the given year 1986(1998, 1999: BGBl. I Nr. 21/1997; 2000,2001: BGBl. I Nr. 16/2000).

<sup>2)</sup> Official guide to the federal finance act 2000.

<sup>3)</sup> Official guide to the federal finance act 2001.

<sup>4)</sup> Including the VA approaches from chapter 64 for constructions expenditures for the federal R&D institutes controlled by the ministry.

<sup>5)</sup> Federal estimate 2000: Including the estimated expenditures for research and research subsidy on the environment in budget chapter 18.

<sup>6)</sup> Excluding the VA approaches from chapter 64 for constructions expenditures for the federal R&D institutes controlled by the ministry.

Table 20:

**RESEARCH AND EXPERIMENTAL DEVELOPMENT IN ALL SURVEY AREAS**

Sectors / Areas		Number of units surveyed, performing R&D	Per head					
			TOTAL		of them			
					Scientific staff (Academics and equivalent staff)		Highly qualified non-scientific staff (A-level graduates, technicians and laboratory staff)	
Male	Female	Male	Female	Male	Female	Male	Female	
<b>1.</b>	<b>Higher education</b>	<b>1 015</b>	<b>13 351</b>	<b>8 582</b>	<b>11 118</b>	<b>3 842</b>	<b>1 114</b>	<b>2 151</b>
	of these:							
	1.1 Universities	822	10 400	5 891	8 478	2 637	932	1 362
	1.2 University clinics	77	2 439	2 371	2 202	1 013	130	724
	1.3 Universities of the arts	56	149	90	145	65	3	6
	1.4 Academy of Sciences	56	354	228	286	126	47	58
	1.5 Experimental stations at HTLs	4	9	2	7	1	2	1
<b>2.</b>	<b>Government</b>	<b>358</b>	<b>3 283</b>	<b>2 451</b>	<b>1 560</b>	<b>730</b>	<b>618</b>	<b>546</b>
<b>3.</b>	<b>Private non-profit sector</b>	<b>53</b>	<b>161</b>	<b>188</b>	<b>117</b>	<b>71</b>	<b>30</b>	<b>62</b>
<b>4.</b>	<b>Business enterprise sector</b>	<b>1 317</b>	<b>21 103</b>	<b>3 837</b>	<b>12 708</b>	<b>1 258</b>	<b>6 658</b>	<b>1 335</b>
	of these:							
	4.1 Cooperative area	25	2 173	742	1 033	184	687	177
	4.2 Civilian technicians	20	80	50	41	11	25	8
	4.3 Gas and electric utilities <sup>1)</sup>	.	.	.	.	.	.	.
	4.4 Company-internal areas	1 272	18 850	3 045	11 634	1 063	5 946	1 150
<b>TOTAL</b>		<b>2 743</b>	<b>37 898</b>	<b>15 058</b>	<b>25 503</b>	<b>5 901</b>	<b>8 420</b>	<b>4 094</b>

As of April 2001

<sup>1)</sup> Since the 1998 R&D survey, the R&D institutions of this sub-sector are listed under the "Company-internal" sub-sector. In order to compare the business sector with previous R&D surveys, the "Gas and El

		Full-time equivalents for R & D							
		TOTAL		of them					
Other support staff				Scientific staff (Academics and equivalent staff)		Highly qualified non-scientific staff (A-level graduates, technicians and laboratory staff)		Other support staff	
Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
<b>1 119</b>	<b>2 589</b>	<b>5 570,0</b>	<b>3 100,1</b>	<b>4 611,2</b>	<b>1 344,0</b>	<b>450,1</b>	<b>792,0</b>	<b>508,7</b>	<b>964,1</b>
990	1 892	4 644,7	2 318,7	3 802,4	999,2	380,2	538,8	462,1	780,7
107	634	642,8	634,9	566,6	255,4	45,3	226,3	30,9	153,2
1	19	45,7	28,3	44,2	19,3	1,2	2,2	0,3	6,8
21	44	233,6	118,0	195,5	70,0	22,7	24,6	15,4	23,4
-	-	3,2	0,3	2,6	0,2	0,7	0,1	-	-
<b>1 105</b>	<b>1 175</b>	<b>1 255,3</b>	<b>849,1</b>	<b>665,0</b>	<b>289,0</b>	<b>159,3</b>	<b>166,2</b>	<b>431,0</b>	<b>393,9</b>
<b>14</b>	<b>55</b>	<b>74,0</b>	<b>74,4</b>	<b>57,7</b>	<b>31,7</b>	<b>9,6</b>	<b>23,2</b>	<b>6,7</b>	<b>19,5</b>
<b>1 737</b>	<b>1 244</b>	<b>17 471,9</b>	<b>2 912,7</b>	<b>10 754,2</b>	<b>961,8</b>	<b>5 309,2</b>	<b>1 009,5</b>	<b>1 408,5</b>	<b>941,4</b>
453	381	1 439,5	394,9	681,2	91,8	427,8	70,0	330,5	233,1
14	31	14,3	8,9	10,0	2,2	3,2	1,1	1,1	5,6
-	-	-	-	-	-	-	-	-	-
1 270	832	16 018,1	2 508,9	10 063,0	867,8	4 878,2	938,4	1 076,9	702,7
<b>3 975</b>	<b>5 063</b>	<b>24 371,2</b>	<b>6 936,3</b>	<b>16 088,1</b>	<b>2 626,5</b>	<b>5 928,2</b>	<b>1 990,9</b>	<b>2 354,9</b>	<b>2 318,9</b>

Source: Statistik Austria

Electric Utilities" are listed in the previous column. – Rounding difference:

Table 28:

## RESEARCH AND EXPERIMENTAL DEVELOPMENT (R&amp;D) 1998 in INTERNATIONAL COMPARISON

Country	Gross domestic expenditures on R&D as a percentage of GDP	Financing of the gross domestic expenditures for R&D via		R&D personnel in full-time equivalents	Gross R&D expenditures by the			
		Government	Industry		Industry	Higher education	Government	Private, non-profit sector
		in %			as a % of the gross domestic R&D expenditures			
Belgium <sup>11) 15)</sup>	1.84	24.9	69.4	39 080.0	71.4	24.2	3.1	1.3
Denmark	1.93 <sup>1)</sup>	36.1 <sup>15)</sup>	53.4 <sup>15)</sup>	34 083.0 <sup>1) 15)</sup>	62.6 <sup>1)</sup>	21.3 <sup>1)</sup>	15.2 <sup>1)</sup>	1.0 <sup>1)</sup>
Germany	2.31 <sup>1)</sup>	34.9 <sup>1)</sup>	62.3 <sup>1)</sup>	461 539.0 <sup>1)</sup>	67.9 <sup>1)</sup>	17.4 <sup>1)</sup>	14.7 <sup>1) 4)</sup>	. <sup>5)</sup>
Finland	2.89	30.0	63.9 <sup>14)</sup>	46 517.0	67.2	19.6	12.6	0.6
France	2.18	37.3	53.5	309 515.0	62.3	17.6	18.6	1.5
Greece <sup>15)</sup>	0.51	53.5	21.6	20 173.0	25.6	50.6	23.4	0.4
Ireland <sup>1) 15)</sup>	1.39	22.2	69.2	12 030.0	73.1	19.2	7.0	0.7
Italy	1.02 <sup>11)</sup>	51.1 <sup>11)</sup>	43.9 <sup>11)</sup>	141 737.0 <sup>15)</sup>	53.7 <sup>11)</sup>	25.0 <sup>11)</sup>	21.3 <sup>11)</sup>	.
Netherlands	1.95	37.9	48.6	85 486.0	54.2	27.1	17.7	1.0
<b>Austria</b>	<b>1.81<sup>1)</sup></b>	<b>39.2<sup>1)</sup></b>	<b>40.5<sup>1)</sup></b>	<b>31 307,5</b>	<b>55.9<sup>3)</sup></b>	<b>35.0<sup>3)</sup></b>	<b>8.9<sup>3) 14)</sup></b>	<b>0.3<sup>3) 14)</sup></b>
Portugal <sup>15)</sup>	0.62	68.2	21.2	17 999.0	22.5	40.0	24.2	13.3
Sweden <sup>15)</sup>	3.70	25.2	67.7	65 495.0	74.8	21.5	3.5	0.1
Spain	0.90 <sup>1)</sup>	38.7 <sup>1)</sup>	49.8 <sup>1)</sup>	97 098.0 <sup>1)</sup>	52.1 <sup>1)</sup>	30.5 <sup>1)</sup>	16.3 <sup>1)</sup>	1.1 <sup>1)</sup>
U.K.	1.83	31.1	47.3	270 000.0 <sup>3)</sup>	65.8	19.5	13.4	1.3
<b>EU total<sup>12)</sup></b>	<b>1.81<sup>11)</sup></b>	<b>36.0<sup>11)</sup></b>	<b>54.8<sup>11)</sup></b>	<b>1 607 369.0<sup>11) 14) 15)</sup></b>	<b>63.6<sup>11)</sup></b>	<b>20.6<sup>11)</sup></b>	<b>14.8<sup>11)</sup></b>	<b>1.0</b>
Iceland	2.04 <sup>1)</sup>	55.9 <sup>1)</sup>	37.7 <sup>1)</sup>	2 273.0 <sup>1)</sup>	36.6 <sup>1)</sup>	24.9 <sup>1)</sup>	37.3 <sup>1)</sup>	1.2 <sup>1)</sup>
Norway <sup>15)</sup>	1.66	42.9	49.4	24 877.0	56.9	26.6	16.4 <sup>4)</sup>	. <sup>5)</sup>
Switzerland <sup>9)</sup>	2.73	26.9	67.5	50 265.0	70.7	24.3	2.5 <sup>7)</sup>	2.5
Poland	0.73	59.0	37.8	84 510.0	41.5	27.6	30.8	0.1
Czech Republic	1.26	36.8 <sup>14)</sup>	60.2	22 740.0	64.6	9.5	25.7	0.2
Turkey <sup>15)</sup>	0.49	53.7	41.8	23 432.0	32.3	57.2	10.5	.
Hungary	0.68	56.2 <sup>13)</sup>	36.1 <sup>13)</sup>	20 315.0	38.4 <sup>13)</sup>	25.2 <sup>13)</sup>	31.2 <sup>13)</sup>	.
Australia	1.49	47.8	45.0	90 717.0	45.1	29.4	23.4	2.1
Japan <sup>12)</sup>	3.01	19.7	73.4	877 162.0	71.9	14.0	9.3	4.8
Canada	1.62 <sup>11)</sup>	31.9 <sup>11) 12)</sup>	48.7 <sup>11)</sup>	137 198.0 <sup>2)</sup>	62.0 <sup>11)</sup>	23.6 <sup>11)</sup>	13.1 <sup>11)</sup>	1.2 <sup>11)</sup>
Mexico	0.34 <sup>15)</sup>	71.1 <sup>15)</sup>	16.9 <sup>15)</sup>	33 297.0 <sup>2)</sup>	19.7 <sup>15)</sup>	39.9 <sup>15)</sup>	38.7 <sup>15)</sup>	1.6 <sup>15)</sup>
Korea	2.55	22.9 <sup>15)</sup>	72.5 <sup>15)</sup>	128 669.0	70.3	11.2	17.6	0.9
New Zealand <sup>15)</sup>	1.13	52.3	30.5	12 908.0	28.2	36.4	35.3	.

Scandinavian countries <sup>15)</sup>	2.63	31.8	61.5	167 862.0	68.0	22.1	9.5	0.4 <sup>12)</sup>
USA <sup>11)</sup>	2.61 <sup>6)</sup>	30.7 <sup>6)</sup>	65.3 <sup>6)</sup>	.	74.6 <sup>6)</sup>	14.4 <sup>6)</sup>	7.9 <sup>7)</sup>	3.1 <sup>6)</sup>
North America <sup>11) 12)</sup>	2.22 <sup>8)</sup>	31.2 <sup>8)</sup>	63.9 <sup>8)</sup>	.	73.3 <sup>8)</sup>	15.1 <sup>8)</sup>	8.6 <sup>7)</sup>	2.9 <sup>8)</sup>
<b>OECD total <sup>11) 12)</sup></b>	<b>2.18 <sup>8)</sup></b>	<b>30.7 <sup>8)</sup></b>	<b>62.5 <sup>8)</sup></b>	.	<b>69.2 <sup>8)</sup></b>	<b>17.1 <sup>8)</sup></b>	<b>11.1 <sup>7)</sup></b>	<b>2.6 <sup>8)</sup></b>

---

Source: OECD; Statistik Austria. -- 1) national estimate. -- 2) 1995. -- 3) 1993.— 4) Also contains other categories. — 5) Contained elsewhere. — 6) Without investment expenditures. —

7) Only federal funds or funds of the central government. -- 8) Without the investment expenditures of the USA.—9) 1996 – 10) National survey results (values adapted by the OEOD). -- 11) Interim values. --

12) Estimate by OECD (based on national sources). -- 13) The sum of the elements listed does not provide a total sum. -- 14) Break in time —15) 1997