# The Research and Development System in Austria – Input and Output Indicators

Jürgen Janger

*This paper analyzes the efficiency of research and development activities in Austria in comparison with other countries. Public and private R&D spending, which has been increasing steadily for years, is evaluated against a set of performance indicators, such as the number of scientific publications and patents. The efficiency of Austria's R&D system is currently rated "average." This may change in the future, given that productivity growth in the Austrian economy is declining despite the continually rising research and development ratio. In his conclusions, the author presents suggestions for increasing the efficiency of the system, particularly in the areas of university education and research, in the light of the strong interaction with the corporate sector.*

Studies on research and development (R&D) systems often present input data separately from output data (e.g. comparison of R&D ratios or of the number of patents). This paper thus aims to compare both input and performance indicators of Austria's R&D/innovation system, which makes it possible to draw conclusions about the efficiency of the system. The first chapter describes R&D expenditure in Austria, which is then correlated with various output indicators in the second chapter. The third chapter proposes suggestions for increasing the efficiency of the R&D system.

In general, statistics on the input and output of a research system should be interpreted cautiously since they are subject to significant measurement uncertainties, which are further aggravated in data comparisons at an international or aggregate level, as is the case in this paper. For explanations and the general qualifications of the data, see, for instance, the Eurostat Internet database or the relevant OECD publications (e.g. 2003). At the time of writing, OECD and Eurostat were comparing and reconciling their R&D statistics, which will hopefully lead to improvements, or at least to a more standardized presentation of the data. The situation in Austria is exacerbated by the five-year interval of R&D surveys; shorter intervals would be more effective in terms of innovation system management and control.

## 1 R&D Expenditure (Input Indicators)

### 1.1 Austria's R&D Ratio above EU-15 Average following Catching-up Process

In 2003, for the first time since 1998, an R&D census in reference to 2002 was carried out among Austrian companies, which resulted in a significant upward revision in the estimated R&D ratio (Scholtze, 2004). According to that census, the R&D ratio for the year 2003 was 2.19%, and a ratio of 2.27% was projected for 2004,[1] which means that Austria exceeded the 2002 EU-15 average of 1.99%. Previously, the Austrian R&D ratio had been slightly below the European average. The increase in the Austrian R&D ratio from 1.47% in 1993 to 2.27% in 2004 represents one of the most dynamic growth rates among the EU-15.

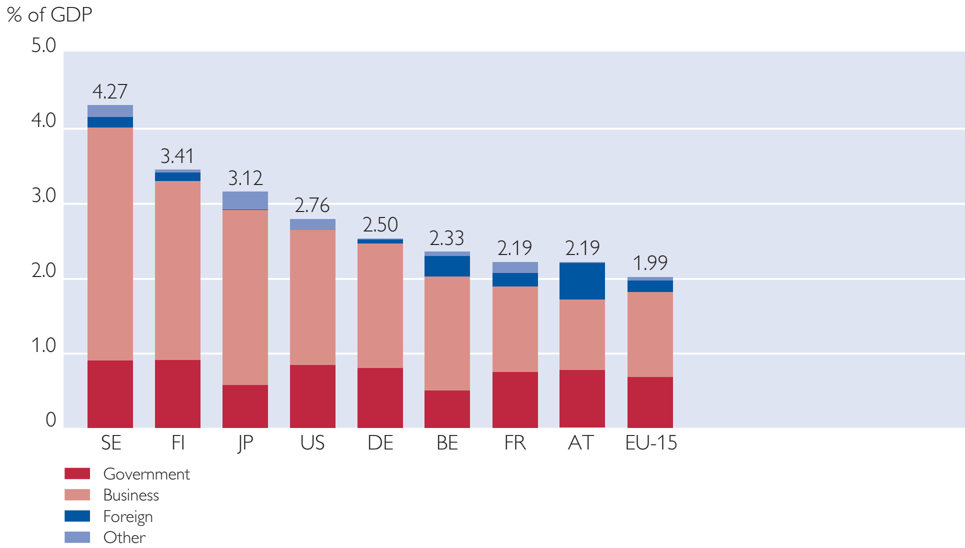
A comparison of present R&D levels shows that Austria has now caught up with France, while Sweden, Finland and Germany are still well ahead of Austria (chart 1). Reaching the Lisbon and Barcelona targets of

[1] *Statistics Austria does not disclose the methods used in the global estimation of R&D expenditure. As a result of censuses, both the 1998 and 2003 figures on estimated R&D expenditure were revised considerably. This gives some cause for doubt concerning the quality of the annual global estimates.*

*Refereed by Gernot Hutschenreiter, OECD.*

Chart 1

**R&D Ratio and Funding by Sector from 2001 to 2003¹)**




*Source: Eurostat.*

*¹) Most current data for each country.*

a 3% R&D/GDP ratio will therefore require considerable effort (for model calculations, see e.g. Schibany and Streicher, 2003, or Hutschenreiter et al., 2001).

### 1.2 R&D Expenditure by Sector

Corporate funding accounts for 64.7% of the total R&D expenditure in Austria, which is slightly above the EU-15 average of 63.7% but still below the Lisbon target of two-thirds of total R&D investment. At around 22%, the share of foreign funding in Austrian R&D expenditure ranks among the highest in the world, as shown in chart 1. Only Canada, the United Kingdom and Greece post similar levels.[2] In other words, Austria has become an international research location, as confirmed by the data presented in chart 2 (ÖFTB 2004, chapter 3).

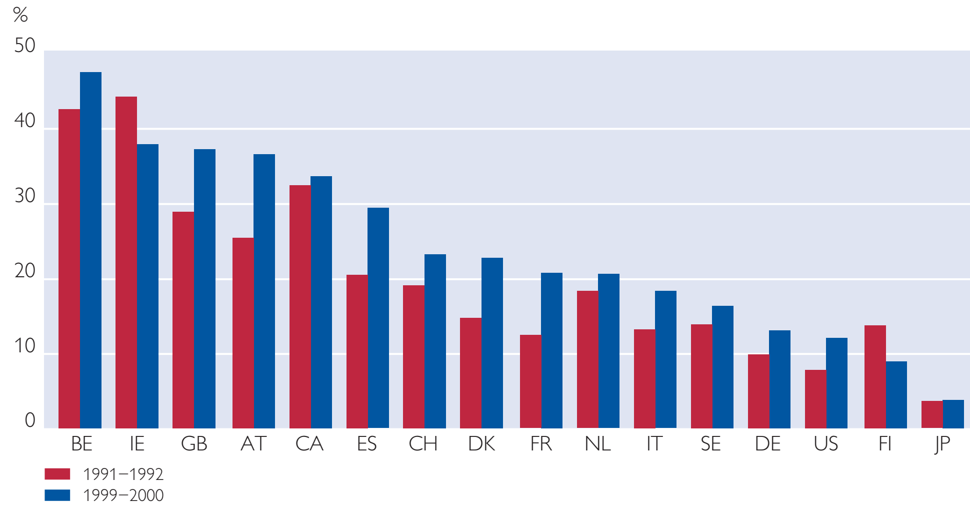
This development, however, also implies a certain degree of vulnerability in Austria's R&D activity, especially since most of the foreign-funded R&D activities are concentrated in a small circle of major subsidiaries of multinational corporations (e.g. Siemens, Infineon, Magna Steyr). The withdrawal of only a few of the R&D departments of such corporations would severely reduce R&D expenditure. As a result of an increase in the level of the Austrian R&D tax credit, the general conditions for research activities have certainly not deteriorated.[3] According to Schibany et al. (2004), there is no significant trend toward a migration of R&D activities; nevertheless the general conditions for research activities must be enhanced further, especially by maintaining and improving the quality of the national science system as a key determinant

[2] *The domestic and foreign funding sources for Austrian R&D expenditure are indicated in separate statistics. For the most part, foreign funding is devoted to R&D projects in the business sector.*

[3] *According to Knoll (2004), many companies are still unaware of the new tax incentives.*

Chart 2

**Foreign Ownership of Domestic Inventions[1])**




*Source: OECD patent database.*

*[1]) Share of patent applications to the EPO owned by foreign residents in total patents invented domestically.*

of Austria's attractiveness as a research site (Schibany et al., 2004).

The fact that Austria's corporate R&D expenditure is clearly below the EU average is attributable to structural factors rather than a lack of competitiveness or of understanding of the importance of innovation and research. Austria shows a comparatively higher degree of specialization in less R&D-intensive sectors (Peneder, 2003).

## 2 R&D Productivity – Output Indicators in Relation to R&D Expenditure

The output of R&D activities is more difficult to measure than their input. A number of R&D activities do not result in publications or patents, but rather in tacit knowledge, which may be as important for the national economy. Furthermore, even output evidenced in writing, e.g. publications or patents, may differ widely as to its scientific and economic impact. Aggregated presentations should therefore always be interpreted with caution.

### 2.1 Productivity of the Public Research System Close to EU-15 Average, Below the U.S.A.

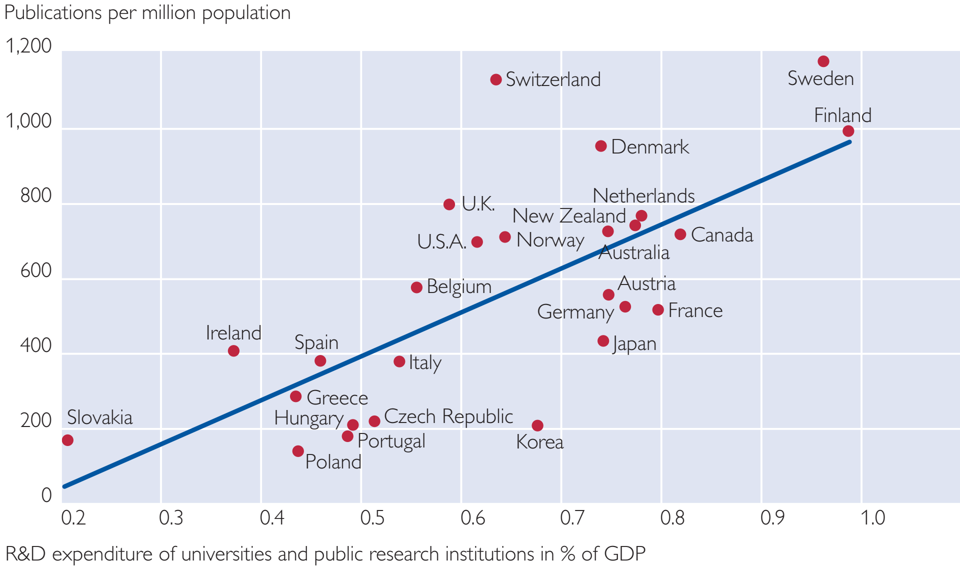
Direct output from universities and other public institutions can best be measured by publications. Judged by the number of publications per million population in relation to R&D expenditure, the productivity of public research institutions and the university sector in Austria is slightly below average. The trend line shown in chart 3 is a simple linear regression line across the country data. Countries with an above-average number of publications relative to R&D expenditure are situated above the regression line.[4]

To factor in the quality or impact of publications, the Relative Citation Index (RCI) can be used as a measure

[4] *The information value of this indicator is reduced by the varying intensity of publication activity in different scientific disciplines and by divergent national scientific specializations. In addition, R&D expenditure especially in the U.S.A. is underestimated (OECD, 2003).*

Chart 3

**Correlation between R&D Expenditure of Universities as well as Public Research Institutions and the Number of Scientific Publications in 2001**




*Source: Eurostat, NSF 2004, World Bank 2004.*
*In analogy to ÖFTB 2004, p. 51.*

of R&D productivity. The RCI is the citation rate for national publications (the average frequency of citation of Austrian publications by other, non-Austrian publications) relative to the share of national publications in total publications. An index greater than 1.00 would imply, for example, that Austrian publications were cited more frequently than indicated by their share in total publications. Austria scores in the average range for industrialized nations. It must be noted, however, that the Science Citation Index (SCI) mostly covers English-language publications and is therefore biased toward English-speaking as well as smaller countries that do not share a common language with other countries (e.g. the Scandinavian countries). According to Leeuwen et al. (2001), the scientific output of Germany and France, as measured by the SCI, is underrated by as much as 10%.[5] In relation to R&D expenditure, the performance of the public scientific research system in Austria is slightly above average.[6] The leader in Europe is Switzerland, whose citation index even outranks that of the U.S.A. by a substantial margin (chart 4).

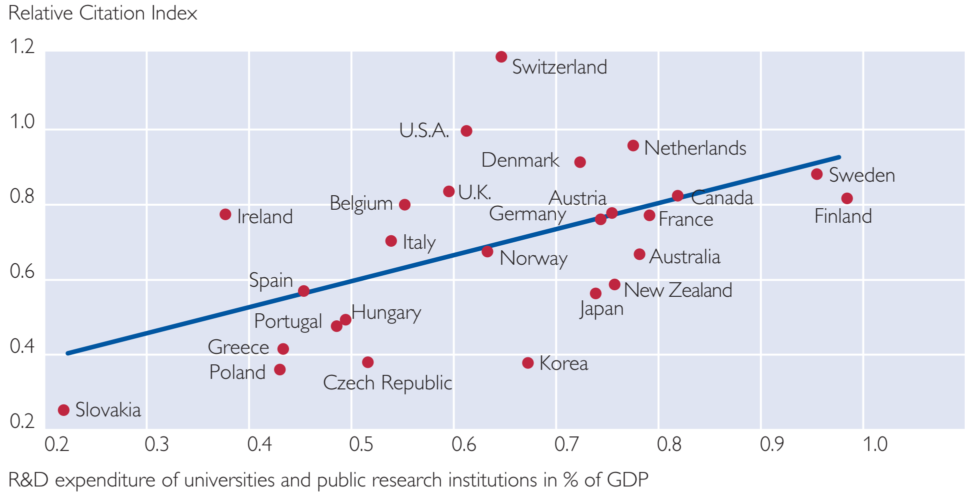
Comparing changes, rather than levels, is, however, more significant. Austria managed to catch up in the 1990s; the improvement in the country's citation index exceeded the average impact of increased R&D expenditure (chart 5). Since the mid-1990s, however, the citation index has risen only slightly or, in the wake of a rapid catching-up process, has remained flat (Dachs et al., 2003).

[5] *Not only because the SCI might not take into account non-English language publications, but also because such publications are cited less frequently – a fact that does not depend on scientific quality but simply on the research community's language proficiency.*

[6] *In this case, the RCI is presented unweighted, i.e. the fact that citation rates vary by scientific disciplines and that scientific specializations vary across countries is not taken into account.*

Chart 4

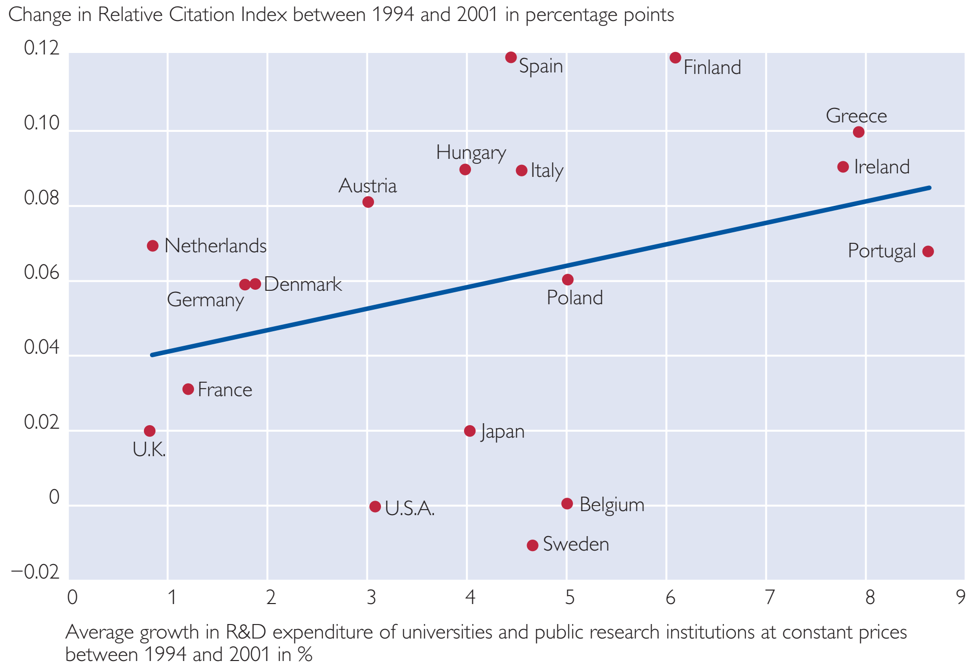
## Correlation between the Impact of Scientific Articles and Public R&D Expenditure in 2001




*Source: Eurostat, NSF 2004.*
*In analogy to ÖFTB 2004, p. 52.*

Chart 5

## Public R&D Expenditure and Change in the Impact of Scientific Publications from 1994 to 2001




*Source: OECD 2004, Eurostat, NSF 2004.*
*In analogy to ÖFTB 2004, p. 53. R&D expenditure for Austria between 1993 and 1998.*

## 2.2 Productivity of Corporate Innovation Efforts Close to EU-15 Average

Based on the findings of the Community Innovation Survey (CIS II and III), the direct research output in relation to R&D funding of Austrian companies can be analyzed and compared across EU countries (Falk and Leo, 2004). It should be noted, however, that this survey used the more broadly defined term "innovation," which also includes, for example, minor improvements in existing products. According to the CIS, Austria's innovation ratio ranks fifth within the EU: 43% of the Austrian companies included in the survey stated that they had launched innovations in the past three years. At 54%, Germany takes the lead, followed by Belgium, Luxembourg and Portugal. In terms of innovation output, i.e. the proportion of innovations relative to total sales, Austria came in third at 21%, behind Germany (37%) and Finland (27%). As Austria's corporate innovation expenditure is in the average range, a positive picture of the "innovation productivity" in Austrian companies emerges. The R&D and innovation activities of foreign subsidiaries in Austria are more productive, however, due to various advantages of companies that have the resources to operate internationally (Bellak and Pfaffermayr, 2002).

## 2.3 Patent Activity of Public Institutions and Private Firms Close to EU-15 Average

In an EU-15 comparison, the number of inventions patented by Austrian institutions per million population is average in terms of filings with the United States Patent and Trademark Office (USPTO) and slightly above average for filings with the European Patent Office (EPO), as shown in table 1. The growth rate of the number of applications filed with both patent offices is below average.[7] Geographical proximity has a relatively strong effect on the number of filings with national and regional patent offices: U.S. inventors submit more patent applications to the USPTO than to the EPO, while EU inventors similarly tend to favor the EPO. Triadic patents, i.e. patents registered at all three major patent offices (EPO, USPTO and the Japanese Patent Office), suggest a particularly strong market potential warranting the higher expenditures on application fees. In this category, Austria is slightly below average but shows somewhat higher growth rates. Given Austria's above-average GDP, the number of patents relative to GDP would be below average in all three categories.

In this context, it is also important to take into account the varying degrees of "patent intensity" in different economic sectors. In some industries, filing large numbers of patents is more important than in others (e.g. the pharmaceutical industry versus the electronics industry). Empirical evidence also indicates that a company's size correlates positively with its propensity to file patents (Scholz and Schmalholz, 1984). Another contributory factor is that new products are easier to patent than new processes. In all three aspects, Austria's economic structure has a limiting effect on patent intensity: a low percentage of technology-intensive sectors, a lim-

[7] *For an analysis of the information value of patent statistics, see e.g. Dachs and Schibany, 2003, and OECD, 2001.*

Table 1

## European, U.S. and Triadic Patents (TP)

per million population, growth rate (GR) in %

| | EPO 2000 | GR 1991–2000 | | USPTO 2001 | GR 1992–2001 | | TP 2000 | GR 1991–2000 |
|---|---|---|---|---|---|---|---|---|
| Switzerland | 365 | 5.2 | **U.S.A.** | 307 | 5.9 | Switzerland | 105 | –0.1 |
| Germany | 262 | 7.1 | Japan | 262 | 4.7 | Finland | 95 | 12.8 |
| Finland | 261 | 13.6 | Switzerland | 198 | 1.8 | Japan | 93 | 2.9 |
| Sweden | 251 | 9.9 | Sweden | 196 | 11.9 | Sweden | 91 | 8.1 |
| Netherlands | 210 | 9.2 | Finland | 143 | 8.4 | Germany | 70 | 4.8 |
| Denmark | 166 | 9.9 | Germany | 137 | 4.9 | Netherlands | 54 | 4.0 |
| Japan | 161 | 6.0 | Canada | 116 | 6.9 | **U.S.A.** | 53 | 3.1 |
| **Austria** | 144 | 6.1 | Denmark | 91 | 10.8 | Denmark | 48 | 9.9 |
| **EU-15** | 131 | 6.7 | Netherlands | 83 | 4.9 | **EU-15** | 36 | 4.3 |
| Belgium | 121 | 8.2 | **Austria** | 72 | 5.2 | Belgium | 35 | 4.4 |
| France | 118 | 3.8 | **EU-15** | 72 | 5.4 | France | 35 | 1.6 |
| **U.S.A.** | 104 | 4.6 | Belgium | 72 | 9.5 | **Austria** | 34 | 4.9 |
| U.K. | 97 | 5.4 | France | 69 | 3.3 | U.K. | 31 | 3.9 |
| Italy | 68 | 5.9 | U.K. | 66 | 5.7 | Canada | 17 | 6.2 |
| Ireland | 52 | 12.3 | Ireland | 37 | 11.8 | Italy | 13 | 1.5 |
| Canada | 50 | 10.8 | Italy | 30 | 3.5 | Ireland | 12 | 5.1 |

*Source: OECD patent database, Eurostat.*

*Patent statistics: breakdown by inventor's country of residence; European Patent Office (EPO): by date of application; U.S. Patent and Trademark Office (USPTO): by date of grant; triadic patents (TP): by date of application.*

ited number of large companies and a focus on process innovation lead to a structurally lower number of patents.[8]

In relation to R&D expenditure, the innovation productivity of Austrian companies is below the EU-15 average (table 2). The relatively small proportion of U.S.-owned triadic patents and U.S. patents registered with the EPO is particularly significant. The American domestic market obviously offers sufficient marketing opportunities to make research efforts profitable. The EU's improvement is

Table 2

## Number of Patents Relative to Corporate R&D Expenditure from 1992 to 2000

| | EPO | | | USPTO | | | Triadic Patents | |
|---|---|---|---|---|---|---|---|---|
| | 1992–1996 | 1997–2000 | | 1992–1996 | 1997–2000 | | 1992–1996 | 1997–2000 |
| Netherlands | 0.57 | 0.75 | Japan | 0.56 | 0.62 | Netherlands | 0.23 | 0.23 |
| Germany | 0.55 | 0.73 | **U.S.A.** | 0.62 | 0.61 | Finland | 0.26 | 0.22 |
| Finland | 0.59 | 0.60 | Finland | 0.54 | 0.45 | Germany | 0.19 | 0.22 |
| Italy | 0.41 | 0.60 | Germany | 0.38 | 0.44 | Japan | 0.18 | 0.20 |
| **EU-15** | 0.41 | 0.54 | Netherlands | 0.38 | 0.38 | Sweden | 0.17 | 0.17 |
| **Austria** | 0.54 | 0.54 | Denmark | 0.36 | 0.34 | **EU-15** | 0.15 | 0.16 |
| Denmark | 0.45 | 0.49 | **EU-15** | 0.30 | 0.34 | Denmark | 0.16 | 0.16 |
| France | 0.34 | 0.44 | Sweden | 0.33 | 0.33 | France | 0.12 | 0.14 |
| Sweden | 0.36 | 0.41 | Italy | 0.24 | 0.31 | **Austria** | 0.15 | 0.14 |
| Belgium | 0.34 | 0.41 | **Austria** | 0.33 | 0.30 | Belgium | 0.14 | 0.13 |
| U.K. | 0.28 | 0.38 | U.K. | 0.25 | 0.29 | U.K. | 0.11 | 0.13 |
| Japan | 0.24 | 0.29 | France | 0.24 | 0.27 | Italy | 0.10 | 0.13 |
| Ireland | 0.19 | 0.26 | Belgium | 0.27 | 0.25 | **U.S.A.** | 0.10 | 0.10 |
| Spain | 0.17 | 0.24 | Ireland | 0.19 | 0.22 | Ireland | 0.06 | 0.07 |
| **U.S.A.** | 0.17 | 0.18 | Spain | 0.10 | 0.11 | Spain | 0.04 | 0.04 |

*Source: OECD patent database, Eurostat.*

*R&D expenditure by economic sector; constant prices based on 1995 data by purchasing power standard.*

[8] *Moreover, the propensity to file patents is positively correlated with GDP growth (Dachs and Schibany, 2003). The sluggish economy between 2001 and 2004 could therefore result in the U.S.A. outperforming the EU.*

attributable to subdued R&D expenditure growth coupled with average growth in the number of patents; the decline in Austria – especially in the period between 1997 and 2000 – was caused by a sharp increase in R&D expenditure in the business sector.

### 2.4 Indirect Output – A New Paradox?

Indirect output can be described as the contribution of R&D activities to economic and productivity growth. It should therefore be considered the most important indicator of a research system's productivity.

At the aggregate level, R&D and innovation activities, along with the accumulation of human capital, are generally recognized to be the most important engines of economic growth (Temple, 1999). Empirical growth literature reports that R&D activities result in a total economic return of more than 50% (Jones and Williams, 1998). In the medium term, the 0.3 percentage point increase in the R&D ratio from an average of 1.85% between 1995 and 1999 to an average of 2.14% between 2000 and 2004 would thus entail an increase of 0.15 percentage point in the long-term growth rate.

As demonstrated by Coe and Helpman (1995), international R&D spillovers are especially important for small, open economies. According to their estimates, Austria's total factor productivity (TFP) is highly responsive to the development of Germany's R&D capital stock. In the same period as indicated above for Austria, the German R&D ratio rose from 2.31% to 2.51%. In this context, it must be taken into account that a country's R&D activities not only increase productivity through innovations, but are also an essential prerequisite for absorbing international research findings in the first place (Griffith et al., 2004a). In addition, corporate R&D expenditure influences productivity growth more directly than university R&D expenditure, since companies tend to concentrate on applied research while universities primarily engage in basic research. According to these studies, the increase in national and international R&D expenditure can be expected to boost productivity growth in Austria.

At the national level, however, there are no findings on whether Austria's R&D activities lead to comparatively more or less productivity growth than those of other countries.[9] The combination of low R&D ratios and high productivity growth rates in Austria was dubbed a "structure-performance paradox" (Peneder, 2001) in the past. At least, this did not indicate a low-efficiency research system. A new paradox – not so much in comparison with other countries, but rather in comparison with the empirical findings mentioned above – would be presented by the opposite situation, i.e. a sustained decline in productivity growth combined with a steadily rising R&D ratio (chart 6). In Austria, total factor productivity – a measure of efficiency that is significantly influenced by R&D activities – is dropping rather sharply.[10]

Given that TFP is very difficult to calculate and that short-term movements in TFP growth are not particularly significant, it would be advisable

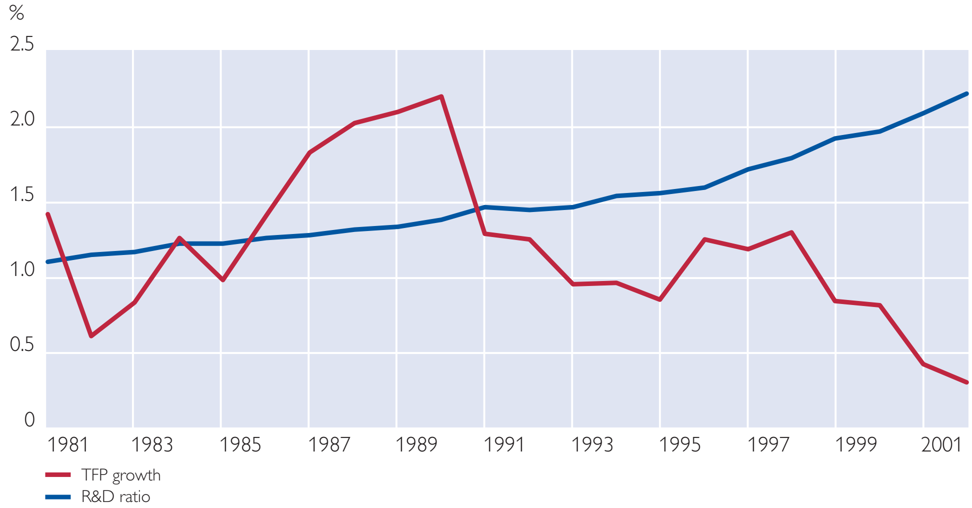
[9] *A study by Pottelsberghe (1998), although not related to Austria, concludes that the total economic return from R&D expenditure in Japan is much higher than in the U.S.A.*

[10] *For an overview of the empirically confirmed determinants of total factor productivity, see Gnan, Janger and Scharler (2004).*

to wait and see how the trend evolves over the next few years before making a final assessment. In addition, structural TFP determinants such as R&D expenditure have a delayed effect, even though the R&D ratio has been uptrending rather clearly for more than ten years. If this trend continues and is confirmed by new figures, the question arises of whether the additional research funding is being used inefficiently or whether the deterioration in productivity growth is the result of contrary developments affecting other TFP determinants.[11]

Chart 6

**Growth in Total Factor Productivity (TFP) in Austria versus R&D Ration from 1981 to 2002**




*Source: AMECO database (European Commission), Eurostat, OeNB (moving averages).*

## 3 Means to Improve the Productivity of the R&D System

In terms of patent activity, the productivity of Austria's R&D system is equivalent to that of the U.S.A. and lags behind that of the EU-15. In the field of scientific publications, the U.S.A. and Switzerland set the standards for the quality of the scientific research system as measured by the citation count; Austria scores in the average range within the EU-15.[12] As regards innovations, there is no survey in the U.S.A. comparable with the Community Innovation Survey; benchmarked against the rest of Europe, Austria ranks above average. Assessing the relative impact of R&D activities on productivity growth, i.e. indirect output, will require a longer observation period and in-depth studies. All in all, the productivity of the Austrian research system – or rather innovation system – may be characterized as "average."

So what are the possible starting points to enhance the efficiency of the system, i.e. where can we find potential for quality improvements?

[11] *See Pottelsberghe (1998, p. 234): ". . . although R&D activities seem to be a necessary (but not sufficient) condition for productivity growth, they might be a sufficient condition against a productivity deterioration."*

[12] *It should be noted that these figures do not, or only to a very limited extent, reflect the impact of the 2002 university reform and the Dienstrechtsgesetz (Employment Act) of 2001. As has already been pointed out, the disadvantage of German as a publication language should not be underestimated.*

In the following sections, we will address government-funded research, corporate R&D, and university research and education.

In the past, criticism was leveled against the Austrian system of research promotion because of the excessive number of underfunded programs and the resulting high administrative costs, which were out of proportion to the net value of the funds distributed (Aiginger and Kramer, 2003). This situation, which is partially caused by the division of technology policy responsibilities among several different ministries, has improved significantly following the creation of the Austrian Research Promotion Agency (FFG), which is dedicated to business R&D promotion. It now remains to be seen whether or not the new structures will prove effective.

In Austria (Austrian Science Fund, FFF), as in the U.S.A. (National Science Foundation), the system of promoting research for scientific or university projects is based on the peer review principle, i.e. the assessment of research quality by scientists of equivalent standing. At the EU level, the distribution of funds by the R&D Framework Programmes is not yet subject to such strict evaluation criteria. A corresponding reorganization of structures and procedures (the report by Sapir et al., 2003, calls for a European Agency for Science and Research) might also provide a positive impetus for Austria.

To determine the optimal mix of higher education and government research and research institutes, the Council for Research and Technological Development currently pursues a strategy of promoting the government sector. According to the estimation of Guellec and Pottelsberghe (2004), however, research performed by the higher education sector has a higher impact on productivity – a phenomenon which may be attributable to a number of causes, for instance, the different funding systems employed (global funding versus project funding). More in-depth studies are necessary to validate this interpretation.

The research productivity of companies domiciled in Austria can be described as average because of the relatively sharp hike in R&D expenditure and the above-mentioned structural disadvantages of the Austrian economy. As has already been discussed elsewhere in this paper, the R&D performance of foreign subsidiaries is higher, owing to the advantages inherent in major companies. Technology and economic policy is limited, therefore, to a small set of direct measures; instead, an effort can be made to optimize the conditions necessary to strengthen corporate technology absorption capacities.[13]

Considering that reforms in the research promotion system have already been implemented and that corporate research productivity is difficult to influence directly, reorganization efforts should focus on the potential for change in tertiary education and university research, which strongly interact with corporate research productivity in a number of ways.

First, analyses of the Community Innovation Surveys (Falk and Leo, 2004) show that companies with a higher percentage of university-educated employees initiate product or

[13] *To quote Griffith et al. (2004b, p. 56): "The best policy towards spreading technology is more likely to be improving the environment for firms through better skills and greater competition rather than in an R&D policy per se."*

process innovations more frequently, not least because such employees remain in contact with their former schools or can easily get back in touch, which in turn facilitates the transfer of knowledge between science and industry. A company's own research activities become more productive because they entail lower search costs.

The capacity of Austrian companies for technological absorption and innovation could soon peak out because of the relatively small number of tertiary-level graduates with science and technology degrees. According to Eurostat, in 2003, there were only 8.3 graduates with science and technology degrees per 1,000 population between 20 and 29 years of age in Austria, versus an EU-15 average (in 2001) of 11.9 (U.S.A.: 10.9).[14] By contrast, graduates with science and technology degrees account for a large share of total graduates, which means that the low figure of 8.3 results from the small number of total graduates (OECD, 2004b). Accordingly, the cause of the problem seems not to be a lack of enthusiasm for science and technology, but rather the structurally small number of university graduates overall. In Austria, the number of women graduating from such fields is particularly low (3.5 versus an EU-15 average of 7.3).

Second, the quality of the scientific research system is a basic factor influencing a company's choice of location for its R&D activities (see also chapter 1). Knowledge transfer between research institutes, universities and companies is favored by geographical proximity (local R&D spillovers, see Keller, 2002).[15] Research by Schibany et al. (2004) shows that according to multinational corporations specific advantages in certain scientific disciplines in Austria are not the reason for choosing Austria as a location for sizable subsidiaries with a high degree of R&D activities. As the integration of foreign R&D activities into the Austrian innovation system works relatively well (Schibany et al., 2004), improvements in the quality of the scientific research system can be expected to stimulate the entire national economy.[16] The promotion of new generations of scientists and the accumulation of knowledge attracts more companies, which in turn boosts productivity growth and employment. Structural change toward more technology-intensive sectors is accelerated by the formation of new technology-oriented companies, and the potential for starting up such companies is likewise increased by improvements in the system of tertiary education and research.[17]

So what are the possible starting points to improve university education and research?

[14] *The EU average would be reached if the graduates of secondary technical and vocational colleges (HTLs) were taken into account.*

[15] *Jaffe (1989, p. 968) summarizes the results of his estimates as follows: ". . . it appears that university research causes industry R&D and not vice versa. Thus, a state that improves its university research system will increase local innovation both by attracting industrial R&D and augmenting its productivity." Acs et al. (1992) confirm his findings.*

[16] *To facilitate the transfer of knowledge between industry and universities, the Uni:Invent program was established last year. Experts referred to as "innovation scouts" assist universities in optimally utilizing patenting and licensing potentials.*

[17] *See, for example, the study by Zucker et al. (1998), which describes the relationship between scientists, the proximity to universities and startups (limited, however, to the biotechnology sector, which is known to be closely related to science).*

Scheibelhofer (2003) investigates the motivation of Austrian scientists now working in the U.S.A. In the course of her qualitative interviews with the respondents it became apparent that the working conditions at U.S. universities constituted a major reason for the scientists' decision to emigrate, with an emphasis on employment law and the broad research latitude (as confirmed by Allmendinger and Eickmeier, 2003). Another decisive factor was the lack of basic research in Austria, while salary levels or the reputation of American universities played only a secondary role. One reason that these scientists do not return to Austria is that the qualifications they have acquired in the U.S.A. are often insufficiently recognized in Austria.

Universities in the U.S.A. offer researchers a long-term career plan through the tenure track system: after a probationary period of several years, there is the possibility of obtaining a fixed contract if the candidate meets the eligibility criteria. Research and teaching continue to be evaluated even after tenure is granted. There are no such prospects of a research career at Austrian universities. The position of an assistant professor in the U.S.A. differs considerably from that of a *Universitätsassistent* in Austria; in the U.S.A., there is significantly more leeway to develop one's own research program. The department head acts only in the capacity of a coordinator or facilitator, which means that (research) hierarchies are flatter. The Austrian Universitätsgesetz (University Act) of 2002 and the Dienstrechtsgesetz (Employment Act) of 2001 contain no such tenure provisions. The collective agreements currently under negotiation may offer an opportunity for improvement for academic personnel (Pechar, 2004).

Other studies (Allmendinger and Eickmeier, 2003; Mayr, 2003) focusing on Germany stress the importance of structured (postgraduate) education for scientific research. In Austria, it is left to the individual school to decide what kind of support doctoral students should get or whether they should be employed in other activities. Establishing graduate schools or structured, more directive doctoral programs could be an important step toward improving the quality of future generations of scientists.

Based on the figures mentioned above, one way to increase the number of graduates from scientific and technological programs could be to expand the total number of university graduates (i.e. by making systemic changes that would encourage taking advantage of the tertiary education system), while at the same time increasing the number of female students in scientific and technological disciplines. Both approaches require more in-depth studies and evaluations of existing promotional projects.[18] Schneeberger (2004) addresses the need for expanding and diversifying the choice of accelerated degree programs, which would reduce university drop-out rates and at the same time effectively prepare students for the job market. Another alternative would be to expand the range of institutionalized options for working students at universities, as offered in other

[18] *See, for example, Leuthold (2000) for an investigation of the possible strategies for motivating women to take up scientific and technological subjects and an overview of the existing measures for promoting female development. The Austrian Report on Research and Technology (ÖFTB) for 2005 will also address the issue of women in science and technology.*

countries. It might also prove effective to think about ways to improve the percentage of students qualifying for university entrance, which is relatively low in Austria (36%) as compared to other countries (e.g. Sweden: 71%).

Finally, in the light of its international success, it seems advisable to examine the functional structures of the Swiss university research system in greater detail. Austria's research institutions are probably more closely aligned with the Swiss structures and procedures than with the U.S. system.

## References

**Acs, Z. J., D. B. Audretsch and M. P. Feldman. 1992.** Real Effects of Academic Research: Comment. In: The American Economic Review 82(1). March. 363–367.

**Aiginger, K. and H. Kramer (project managers). 2003.** Wirtschaftspolitik zur Steigerung des Wirtschaftswachstums (final version). Vienna: WIFO.

**Allmendinger, J. and A. Eickmeier. 2003.** Brain Drain. Ursachen für die Auswanderung akademischer Leistungseliten in die USA. In: Beiträge zur Hochschulforschung. Volume 2. 26–34.

**Bellak, C. and M. Pfaffermayr. 2002.** Why Foreign-Owned Firms are Different: A Conceptual Framework and Empirical Evidence for Austria. In: Jungnickel, R. (ed.): Foreign-Owned Firms – Are they Different? Palgrave: Houndsmill, Basingstoke. 13–57.

**Coe, D. T. and E. Helpman. 1995.** International R&D Spillovers. In: European Economic Review 39(5). May. 859–887.

**Dachs, B. and A. Schibany. 2003.** Patente. Ein Indikator für technologische Leistungsfähigkeit und Internationalisierung. Vienna: Tip – Technologie Information Politikberatung.

**Dachs, B., S. Diwisch, K. Kubeczko, K.-H. Leitner, D. Schartinger, M. Weber, H. Gassler, W. Polt, A. Schibany and G. Streicher. 2003.** Zukunftspotentiale der österreichischen Forschung. Abschlussbericht. Study on behalf of the Austrian Council for Research and Technology Development. Joanneum Research and ARC systems research.

**Falk, M. and H. Leo. 2004.** Die Innovationsaktivitäten der österreichischen Unternehmen. Empirische Analysen auf Basis der Europäischen Innovationserhebung 1996 und 2000. Vienna: WIFO.

**Gnan, E., J. Janger and J. Scharler. 2004.** Determinants of Long-Term Growth in Austria – A Call for a National Growth Strategy. In: Monetary Policy and the Economy 1/04. 25–49.

**Griffith, R., S. Redding and J. Van Reenen. 2004a.** Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Countries. In: Review of Economics and Statistics (forthcoming).

**Griffith, R., S. Redding and J. Van Reenen. 2004b.** R&D and Productivity. In: OENB Workshops 2. 48–57.

**Guellec, D. and B. van Pottelsberghe de la Potterie. 2004.** From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter? In: Oxford Bulletin of Economics and Statistics 66(3). 353–378.

**Hutschenreiter, G., H. Gassler and W. Polt. 2001.** Möglichkeiten zur Erhöhung der österreichischen Forschungsquote – Abschätzung der Effekte öffentlicher auf private F&E-Ausgaben. Final report to the working group on Research Ratio.

**Jaffe, A. B. 1989.** Real Effects of Academic Research. In: The American Economic Review 79(5). December. 957–970.

**Jones, C. I. and J. C. Williams. 1998.** Measuring the Social Return to R&D. In: Quarterly Journal of Economics.

**Keller, W. 2002.** Geographic Localization of International Technology Diffusion. In: The American Economic Review 92(1). 120–142.

**Knoll, N. 2004.** International orientierte Unternehmen in Österreich. Rahmenbedingungen für Steuerungsfunktionen und Forschungskompetenz. WIFO-Monographien 4.

**Leeuwen T. N. V., H. F. Moed, R. J. W. Tijssen, M. S. Visser, A. and F. J. van Raan. 2001.** Language Biases in the Coverage of the Science Citation Index and its Consequences for International Comparisons of National Research Performance. In: Scientometrics 51(1). 335–346.

**Leuthold, M. 2000.** Mädchen und Technik-Studiengänge. Oder: Wie können Mädchen für ein technisches oder naturwissenschaftliches Studium motiviert werden? IHS Reihe Soziologie 43.

**Mayr, E. W. 2003.** Erfahrungen eines deutschen Universitätsprofessors in den USA. In: Beiträge zur Hochschulforschung. Volume 2. 48–55.

**NSF (National Science Foundation). 2004**. Science and Engineering Indicators.

**OECD. 2001.** Using Patent Counts for Cross-Country Comparisons of Technology Output. STI Review 27.

**OECD. 2003.** Science, Technology and Industry Scoreboard.

**OECD. 2004a**. Research and Development Statistics (forthcoming).

**OECD. 2004b.** Education at a Glance.

**ÖFTB. 2004.** Österreichischer Forschungs- und Technologiebericht. 2004. Vienna: Federal Ministry for Science, Education and Culture.

**Pechar, H. 2004.** Österreichs Universitäten brauchen einen Tenure Track. Contribution to Hochschulpolitisches Forum of March 25.

**Peneder, M. 2001.** Eine Neubetrachtung des „Österreich-Paradoxon". In: WIFO-Monatsberichte 12. 737–748.

**Peneder, M. 2003.** Industrial Structure and Aggregate Growth. In: Structural Change and Economic Dynamics 14(4). 427–448.

**Sapir, A., P. Aghion, G. Bertola, M. Hellwig, J. Pisani-Ferry, D. Rosati, J. Viñals and H. Wallace.** 2003. An Agenda for a Growing Europe: Making the EU System Deliver. Brussels.

**Scheibelhofer, E. 2003.** Brain Gain, Brain Drain oder Brain Waste? Zum Problem der Abwanderung österreichischer Wissenschafter. In: Wirtschaftspolitische Blätter 3.

**Schibany, A. and G. Streicher. 2003.** Die Barcelona-Ziele zwischen Ambition und Realismus. In: TeReg Working Paper 6.

**Schibany, A., B. Nones, G. Streicher and H. Gassler. 2004.** Attraktivität Österreichs als Forschungsstandort für internationale Unternehmen. In: TeReg Research Report 28-2004.

**Schneeberger, A. 2004.** Hochschule und Arbeitsmarkt. Trendanalyse und internationaler Vergleich. Ibw-Bildung & Wirtschaft 30.

**Scholtze, E. 2004.** Finanzierung der Ausgaben für Forschung und experimentelle Entwicklung in Österreich. In: Statistische Nachrichten 6. 500–510.

**Scholz, L. and H. Schmalholz. 1984.** Patentschutz und Innovation. In: Oppenländer, K. H. (Hrsg.). Patentwesen, technischer Fortschritt und Wettbewerb. Berlin and Munich: Duncker & Humblot. 189–211.

**Temple, J. 1999.** The New Growth Evidence. In: Journal of Economic Literature 37(1). March. 112–156.

**Winnacker, E.-L. 2003.** Talentflucht in die USA. In: Beiträge zur Hochschulforschung. Volume 2. 36–46.

**Van Pottelsberghe de la Potterie, B. 1998.** The Efficiency of Science and Technology Policy in the Triad. Dissertation at Université Libre de Bruxelles.

**Zucker, L. G, M. R. Darby and M. B. Brewer. 1998.** Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises. In: The American Economic Review 88(1). March. 290–306.

## Databases

Eurostat Internet database:
Eurostat New Cronos Internet database.
European Innovation Scoreboard 2004 database.
AMECO database of the European Commission.
OECD: Patent Database.
OECD: Research and Development Statistics.