

European Academies



Science Advisory Council

# **Towards 3%: attainment of the Barcelona target**



# Towards 3%: attainment of the Barcelona target

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# Introduction

The European Union is committed to being an economically competitive player at the global level. It is also committed to the view that, in order to achieve this goal, it must be globally competitive in science and technology. These ambitions are enshrined in the declarations of the European Council at the March 2000 Summit in Lisbon and the March 2002 Summit in Barcelona, and are endorsed by the European Parliament. They signify direct recognition at the highest political level of the central role of science and technology in economic prosperity.

More specifically, the Lisbon Summit set 'a new strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion'. The Barcelona Summit spelt out what this meant for R&D:

*In order to close the gap between the EU and its major competitors, there must be a significant boost of the overall R&D and innovative effort in the Union, with a particular emphasis on frontier technologies. The European Council therefore agrees that overall spending on R&D and innovation in the Union should be increased with the aim of approaching 3% of GDP by 2010. Two-thirds of this new investment should come from the private sector.*

And the Summit also stressed the urgent need to strengthen arrangements for intellectual property.

It is obvious that these are challenging targets. They have to be if they are to be worth achieving. The 3% target challenges national governments and the European Union itself as the channels of public funds to S&T; even more, it challenges industry and commerce as the channels of private funds to S&T.<sup>1</sup> And it challenges the research community to make good use of the funding it receives, and industry to work much more closely with academe. This does not mean that academic research has to be focused on narrow goals of immediate applicability, but it does mean a relentless pursuit of excellence and an awareness of factors that promote interaction between those who create new knowledge and (where different) those who put it to use.

These issues demand attention from us all. As a contribution to this, the Industry, External Trade, Research and Energy Committee of the European Parliament commissioned EASAC to undertake short case studies of R&D expenditure trends in Sweden and Finland, the two countries with the highest and most rapidly growing R&D spends in the EU. The case studies were carried out by small teams of experts selected by EASAC over a two-month period and were then presented to Parliamentarians at a workshop held in Brussels on 2 December 2003. In

addition to the case studies, the workshop included individual presentations on three related topics identified by the Industry Committee.

The two case studies and the other workshop contributions are presented here to make them available to a wider audience and to stimulate debate about the 3% target and the associated issues. We should welcome comment both on the evidence in these pages and on the policy issues addressed.

Finally, we should like to thank most warmly those who contributed to the workshop as speakers and as participants. Considerable work was done in a short period of time, and we are most appreciative of the willingness of colleagues to share their expertise. Dialogue between Parliamentarians and scientific experts is vital to achieving the policy goals of the 21st century. The workshop reported here was a valuable step in the direction of building science into policy, and we look forward to continuing interactions as we work towards the goal of a globally competitive Europe.

*Professor Uno Lindberg  
Chairman, EASAC*

*Dr Rolf Linkohr, MEP  
Member, Industry, External Trade,  
Research and Energy Committee*

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<sup>1</sup> To reach 3% GDP by 2010 from current levels implies an overall annual growth of 8% in real terms, with public R&D expenditure growing at 6%pa and private expenditure at 9%pa.



# 1 Summary

**Peter Collins, Executive Secretary EASAC**

This report stems from a workshop organised by EASAC at the request of the European Parliament Committee on Industry, External Trade, Research and Energy. It is built around case studies of how Finland (with R&D spend at 3.4% of GDP) and Sweden (4.3%) grew their total spend on R&D to above the Barcelona target of 3% of GDP, and considers whether there are lessons from these case studies for how other EU member states, and the EU as a whole, might move towards this target. In publishing these papers, EASAC seeks to make its findings available to a wider audience and support the developing debate about the 3% target with evidence from recent experience.

The case studies were undertaken under EASAC auspices by small teams from the Finnish and Swedish Academies of Science. In addition, the workshop benefited from individual papers on experiences in Hungary and in the USA, and on the pervasive issue of intellectual property.

The workshop was not intended to deliver comprehensive policy recommendations from the European Academies, but simply to stimulate thought by presenting relevant evidence. Nevertheless, some conclusions can be drawn.

- The 3% target is typically interpreted as implying public R&D expenditure of 1% of GDP and private (ie primarily industrial) R&D expenditure of 2%. The 3% target cannot be achieved by concentrating primarily on driving up public expenditure on R&D. Finland and Sweden are in the bottom three of EU member states in terms of the proportion of R&D spend that comes from public sources. An overriding consideration is therefore how to create the facilitating conditions under which it is in industry's interest to invest strongly in R&D.
- In Finland, this has been achieved by: a long-standing culture supportive of technological advance; an explicit, consistent commitment to prioritising public expenditure on R&D that was maintained – indeed, enhanced – throughout a major economic crisis; and a high-powered national R&D policy structure that included major industrial concerns. In Sweden, the same factors are evident, together with a macro-economic policy (the decision to let the Swedish Krona float) that reduced costs for companies based in Sweden.
- Close connections between the public and private R&D sectors are vital if R&D investment is to generate practical outcomes.
- There is more to Finland's industrially funded R&D investment than Nokia, though Nokia has obviously played a major role. However, even in larger countries with a more diversified industrial base than Finland, the industrial situation can change quickly since research-active companies (and especially multinational companies) increasingly scour the world for the best partners with whom to collaborate and the best locations for their own R&D efforts. With R&D now a globally competitive activity, governments need constantly to ensure that they are doing all in their power to provide the most attractive conditions for industrial investment in R&D.
- From the Hungarian study comes a reminder of the importance of a social and political consensus about the role of R&D in driving economic and social development.
- Like Finland and Sweden, the USA has seen a major surge in industrial R&D spend, which grew at 7% pa in real terms between 1994 and 2000. This is attributed to a favourable IPR regime, the fiscal stimulus to private investment provided by tax policy, the availability of capital for technology-based startup enterprises, the openness of the United States to foreign contributions via direct investment and temporary and permanent immigration, and growing cross-sector cooperation between industry and government and between industry and universities. Defence accounts for a far higher proportion of R&D spend in the USA than in any EU member state, and R&D activity in the USA can be strongly affected by changes in the international security situation.
- Finland and Sweden lead the EU in patent applications per capita, and it is evident that an effective system of intellectual property is central to promoting industrial investment in R&D. However, the IPR regime in Europe is regarded as inferior not only to those in the USA and Japan but also, increasingly, those in China and India as well.
- Increased expenditure on R&D implies corresponding increases in the numbers of skilled scientists and engineers employed in research and development activities. While some may be imported from other countries (the extreme example here is the USA), most will have to be home-grown. An effective educational system that is good at the basics and attracts and retains enough students into S&T disciplines is therefore pivotal. Finland in particular scores highly on this.



## 2 How Finland managed to increase its R&D spending to 3% of GDP

Erkko Autio, Helsinki University of Technology and Helsinki Institute of Physics

### 2.1 Summary

This discussion paper looks at how Finland succeeded in raising its R&D expenditure to above 3% of GDP. The most important findings, from the policy-making perspective, are the following.

- a) Even though Finland's success in becoming the 'most competitive country in the World' (World Competitiveness Yearbook ranking 2003) and the third most R&D-intensive country may appear recent, the foundations for this progression were laid in the early 1970s.
- b) The transformation of Finland from a 'low-tech' country in the early 1960s to a 'high-tech' country in the 1990s appears to have been the result of (1) a long-standing, consistent policy; and (2) appropriate facilitating conditions.
- c) Relevant facilitating conditions include:
  - an historically high level of investment in educational systems: already in the late 19th Century, the literacy rate in Finland was among the highest in the world (alongside Germany and Japan);
  - a national culture that appreciates technological advances and the mastery of harsh climatic conditions: new technological innovations have always been diffused early and rapidly in Finland (eg railway, gas light, electricity, telephony, mobile telephones);
  - educational emphasis on science and technology: in 1998, for example, Finland ranked 3rd globally in terms of the amount of funding allocated to education as percentage of GDP; and in 2001, Finland ranked 2nd in terms of the share of science and technology PhDs per 1000 population aged 25 to 34 years;
  - good public governance: in 2003, for example, Finland was ranked as the least corrupt country in the world;
  - an exceptionally deep economic recession in the early 1990s that helped foster a national sense of urgency and helped the government push through the use of proceeds from privatization of government-owned companies to achieve a 25% increase in public R&D spending;
- d) Even though Finland's transformation has been achieved through active policy, the share of the public sector of the total R&D spending remains notably low: After Ireland and Sweden, the share of public sector in R&D spending is the third lowest in EU.
- e) While the role of the Nokia corporation has been very important, Nokia alone does not explain Finland's transformation. Also, Nokia can be seen both as an outcome and as a cause of Finland's transformation. Notably, the national 'Finnsoft' technology program helped Nokia gain a crucial early lead in the emerging GSM mobile telephony standard.

Increasing public R&D spending alone may not be sufficient to achieve the policy goal of 3% R&D spending. Perhaps even more important is a consistent, long-term focus on national facilitating conditions.

### 2.2 Development of the general institutional framework in Finland

To understand Finland's emergence as an R&D-intensive country, it is necessary to look back into the 1960s (Lemola, 2002). At that time, Finland was undergoing a transformation from an agricultural society to an industrialized economy. The industrial structure was heavily dependent on forest industries. The technological level of Finland was low, as compared to its main counterparts. 'Modernization', or catching up with these counterparts, became the main objective of Finland's industrial policy from the 1960s. By mid-1970s, science and technology policy had become a central part of Finland's industrial policy.

Even though Finland's technological level was not particularly high in the 1960s, it should be noted that Finland's educational system has always been of a very high standard. The village school system created in the 19th century ensured that, already in the 1870s, Finland's literacy rate was among the highest in the World. The well-functioning educational system (ranked as the best in the world in 2002) had ensured a relatively high general educational level of the population, and this system was versatile enough to adapt to, and carry through, the 'modernization policy' initiated in mid-1970s.

In the early days of Finnish science and technology policy, OECD exercised heavy influence. Lemola (2002) notes that the first science and technology policy programs written in early 1970s were almost direct translations of OECD documents. During that era there emerged the view that scientific and technical progress and social and economic development were closely interrelated, and science and technology policy became to be seen as an integral part of an overall social and economic policy.

Institutionally, an important element of the Finnish science and technology policy design was the Science and Technology Policy Council, the predecessor of which was created already in 1963. This council was modelled after the Swedish example (Lemola 2002). Today, this council is chaired by the Prime Minister of Finland, and its members include top-ranking industrial, political and academic leaders. This influential council has traditionally drawn the general lines of the Finnish science and technology policy. One of its recommendations was the establishment of the National Technology Agency Tekes, in 1983, as the central government agency responsible for the planning and implementation of technology policy measures in Finland. Again, models for this agency could be found in Sweden and, for example, in Japan. The first initiatives of this agency were national technology programs, the first of which focused on information technology. The success of these programs helped bolster a broad-based support for science and technology policy in the 1980s.

These policy efforts bore fruit. By early 1990s, Finland's R&D expenditure had been raised to a good international level of 2%. There existed a broad-based network of universities, and the output of university engineers as a percentage of the total number of university graduates was, alongside Japan, the highest in the world. Finland's industrial base was also rapidly expanding, and new industry sectors were developed to complement forest-based industries.

### **2.3 Impact of the 1990s economic recession**

In the early 1990s, an economic crisis struck Finland. Until then, Finland had traditionally depended on the Soviet Union for up to a third of its exports. When the Soviet Union collapsed in 1991, as much as 25% of Finland's export trade contracts became irrelevant virtually overnight. What followed was the deepest economic recession experienced by any European market economy since the second World War, as Finland's unemployment rate rose from around 3-4% to nearly 20% within the space of a few months. At the same time, Finland's foreign debt was virtually exploding.

The depth of the economic crisis in the early 1990s helped create a general national sense of urgency, which helped further bolster the role of science and technology policy in Finnish economic policy. By the early 1990s, the importance of technological development for societal

and economic development had become widely accepted. There was a strong consensus regarding this issue. Thus, in spite of deep cuts being made elsewhere, the funding for science and technology remained the same and even grew. Because of the widespread sense of urgency, there was little resistance to this policy, even though it largely had to be funded by reallocating funds from other purposes and, notably, from privatisation of government-owned companies, as the soaring rate of government debt did not permit funding through loans.

### **2.4 The role of Nokia**

That Finland's R&D expenditure continued to increase in the 1990s was largely due to the extraordinary development of the Nokia Corporation. The Nokia Corporation itself provides an interesting example of the success of the Finnish science and technology policy. Until the 1970s, this corporation was largely known for basic industrial products, such as industrial cable, industrial rubber (including rubber boots and car tyres), soft tissue (or toilet) paper and so on. During the 1970s and 1980s, the corporation underwent perhaps the most sweeping technological transformation experienced by any large industrial conglomerate, as it re-invented itself as an electronics and communications company. In the 1980s, the company started a process of rapid international expansion, initially targeting the consumer electronics industry. This strategy failed miserably, and by the early 1990s the company was almost bankrupt.

However, Nokia had developed also some potential growth areas, notably in telecommunications and in mobile telephony. These turned out the salvation of the company. Nokia's position in mobile telephony was boosted by the creation of the Nordic Mobile Telephony standard, which became the first international standard in mobile telephony. But perhaps the crucial turning point for Nokia was the achievement of an early leadership in the emerging digital standard for mobile telecommunications, the GSM standard. One important reason why Nokia managed to gain an early lead in GSM technology was the Tekes-funded 'Finnsoft' technology program, under which many of the core components of the GSM standard were developed. Nokia was later able to recruit many of the research teams that had been funded by the Finnsoft technology program.

### **2.5 Balance of public and private sector R&D spending**

Nokia's phenomenal success largely explains why Finland's R&D expenditure continued to increase rapidly in the 1990s, as a percentage of GDP. Nokia's contribution to Finnish private sector R&D spending is shown in Figure 2.5. As can be seen, Nokia's growth has been so strong that, even though public funding for R&D continued to increase almost throughout the 1990s, the

dominance of the private sector as the main source of R&D spending has continued to increase (see Figure 2.4). In 2001, of the total of €4.6 Billion invested in R&D in Finland, the public sector was responsible for €1.3 Billion (28%), and the private sector was responsible for €3.3 Billion (72%). With this distribution, Finland ranks clearly below EU average in terms of public sector participation of R&D. Thus, as shown in Figures 2.2, 2.3 and 2.4, the share of private sector of the total has continuously increased in Finland since year 1985.

## 2.6 Role of defence R&D

In Finland, the role of defence R&D has been historically very low, and in 2000, defence-related R&D spending only amounted to 1.3% of GDP. This is lower than the EU average, at 15%, and considerably lower than the US (50%).

## 2.7 Economic instruments used to influence R&D spending

Given the rapid increase in Finland's R&D funding, one might expect that the role of the public sector would be crucial in pushing this increase. The statistics quoted above suggest the opposite, however. In fact, in Finland, direct public support to the R&D activities of industrial firms amounts to only 5% of the total, since the public R&D funding is primarily channelled to universities. This is less than the OECD average (10%) and significantly less than the OECD recommendation (10%-15%).

The low share of public research applies even when one eliminates Nokia and the defence spending from the Finnish R&D statistics. Herein lies an interesting paradox: even though Finland has a proactive and prominent science and technology policy, and even though the increase in Finland's R&D spending reflects a hands-on policy approach, the role of the public sector in Finland's R&D spending remains surprisingly small compared to other countries. The same applies to Sweden.

One of the oddities of the Finnish situation is that fiscal measures to encourage R&D spending have been used quite conservatively. There was only a brief period during the 1980s when the government experimented with fiscal incentives. For a period of three years, industrial firms were permitted to deduct up to 25% of their R&D spending from their taxable income. This experiment was not successful, however, mainly because of the difficulty in controlling R&D spending deductions. In the early 1990s, virtually all fiscal subsidies had been eliminated, in an effort to streamline and simplify the fiscal regime. Today, it only remains possible for industrial companies to activate their R&D spending into their balancesheet, but this is both in keeping with the nature of R&D investment and with the universal practice.

The only notable, and major, increase in public R&D spending occurred in 1993-1995, when the government increased the allocation of public funds to R&D by 25%. This increase was made possible by the government's privatisation program, under which several previously publicly held companies were privatised. The government managed to resist the temptation to spend these one-off funds for social security and public services, and channelled the funds to Tekes and universities instead. This was made possible by the strong consensus regarding the importance of R&D as a driver of economic and societal development, as well as the sense of national crisis and urgency instilled by the deep economic recession.

The total funding flows to R&D in Finland, and its evolution since 1983, are shown in Figure 2.4.

In terms of channelling public funding to R&D, the government's main instrument has been the National Technology Agency, Tekes. Since its foundation in 1983, Tekes has actively developed its funding instruments for R&D. Typically, Tekes funding is provided as R&D loans for firms, and as R&D grants for universities. The national technology programs are typically organized around research and industry projects, such that universities are charged with the responsibility of carrying out generic research projects, and industry projects are organized around these. In such programs, the industry participation typically takes the form of observation and the allocation of in-kind contributions (eg working time). For Tekes, the national technology programs provide a strategic instrument with which to support, guide, and steer Finnish industrial R&D activity. The evolution of the national technology program funding over time is shown in Figure 2.7.

## 2.8 Structural transformation of the Finnish industrial landscape, education of workforce

The above suggests that the key drivers behind Finland's emergence as a knowledge-intensive society should be sought elsewhere than in government spending. A key driver, in fact, can be found in the transformation of the Finnish industrial landscape. As shown in Figure 2.6, from 1991 to 2000, Finland's exports of high-technology products increased by over a tenfold, and its imports of high-tech products tripled. While an important part (maybe over 30-40%) of this transformation can be attributed to Nokia, the effect cannot be explained by Nokia alone, however. As noted above, the Tekes national technology programs have probably done much to help re-orient industrial R&D activity toward emerging and high-technology sectors.

An equally important factor has been the very high average level of education in Finland:

- in 1998, for example, Finland ranked 3rd globally in terms of the amount of funding allocated to education as percentage of GDP (see Figure 2.8);
- in 2001, Finland had the highest number of researchers per 1000 of workforce (10.62; Japan was 2nd at 9.26; EU average 5.26);
- the average annual growth in the number of researchers in Finland was the second highest, at 12.7% (Ireland leading at 16.5%; EU average 2.9%);
- in 2001, Finland ranked 2nd in terms of the share of science and technology PhDs per 1000 population aged 25 to 34 years, at 0.97 (Sweden 1st at 1.17; EU average 0.55).

It can, thus, be concluded that Finland enjoyed a number of facilitating conditions, notably a high-quality education system and a highly versatile, well educated workforce, that operated as an important facilitating factor behind Finland's structural transformation. An active government policy toward R&D was important, but it is doubtful whether that push alone would have produced the desired effects. An important contributing factor can also be found in the highly transparent interface between the educational system and industry. As one example, Finland leads Europe in terms of the percentage of innovating firms cooperating with other firms, universities, or public research institutes. As many as 70% of the Finnish innovating firms indicated such collaboration in a recent EU comparison. The EU average was only 25%.

## 2.9 Role of SMEs

As is clear from the above, SMEs have never played an instrumental role in the Finnish R&D scene, in spite of efforts to enhance their role in recent years. Structurally, Finland's economic landscape remains dominated by large firms – this is partly explained by the fact that in the forest industry sectors, for example, the scale requirements can be considerable. The large 'locomotive' companies, such as Nokia and a number of metal and engineering industry companies, have, however, provided an important pull for a number of subcontracting companies. And there is an active government policy designed to increase the participation of SMEs in R&D-intensive sectors. As one sign of this emphasis, Finland ranked 2nd in a recent EU comparison, where the annual growth in publicly funded R&D executed in the SME sector was concerned: at 14%, this figure was well above the EU average.

## 2.10 Conclusion

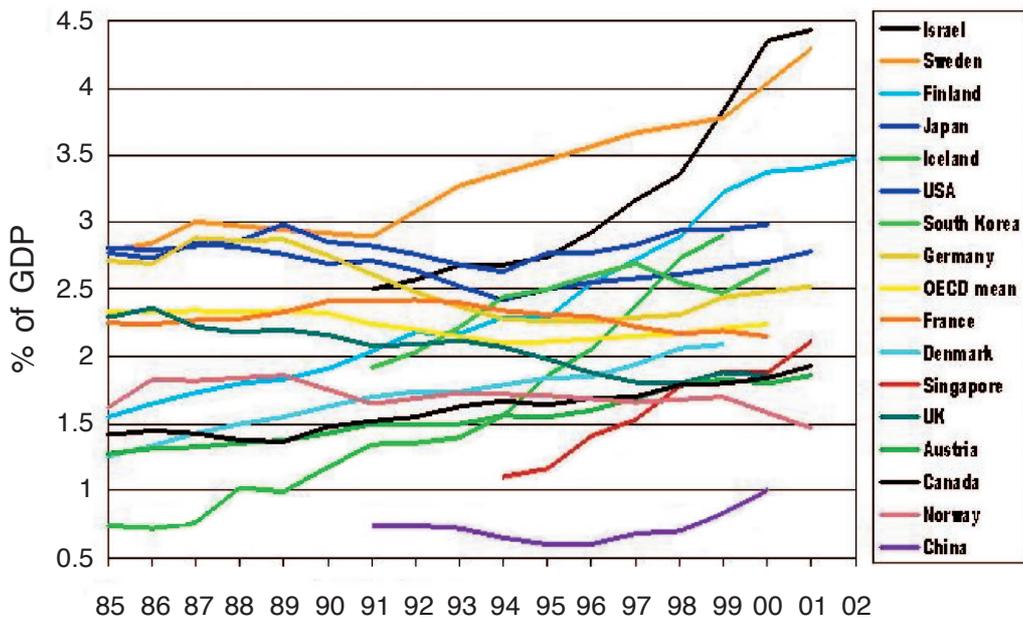
As should be clear from the above analysis, it is doubtful whether the goal of 3% R&D spending of GDP can be achieved simply by increasing government funding allocations to public R&D. A number of facilitating conditions must come together before this goal can be realistically contemplated:

- 1 well educated (and therefore, versatile) workforce;
- 2 well functioning and efficient education system;
- 3 national consensus on the importance of R&D;
- 4 well structured, sufficiently empowered, and competent institutional structure for the design and implementation of S&T policies;
- 5 close, open collaboration between policy-makers and private sector firms;
- 6 good luck.

Government policy can only be effective if the facilitating conditions exist. For European policy, therefore, it is important to avoid a myopic focus on R&D investment only, and to focus also on enhancing the general facilitating conditions.

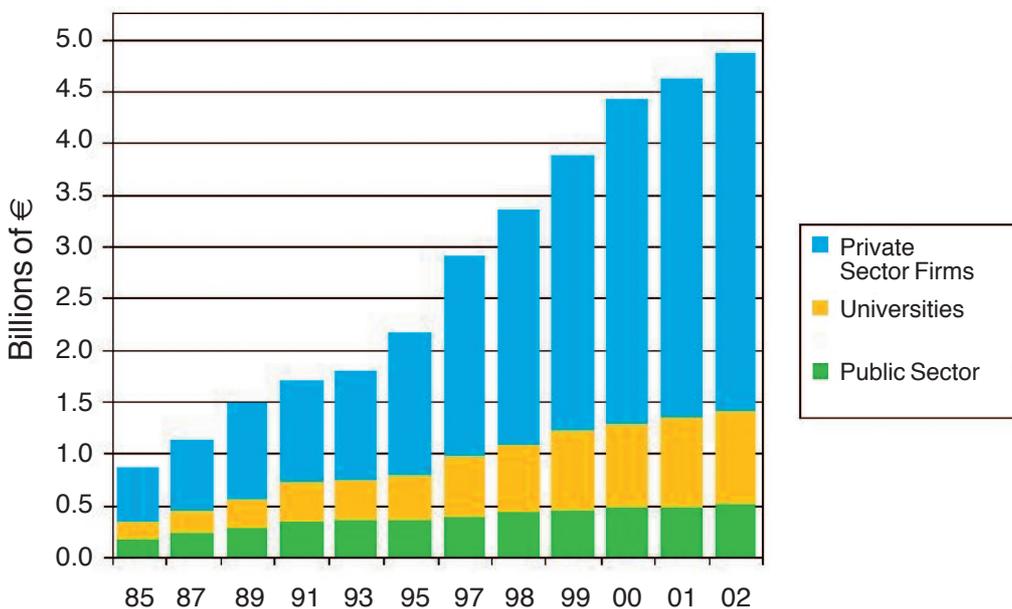
## 2.11 Figures

**Figure 2.1 R&D investment in selected OECD countries, % of GDP**



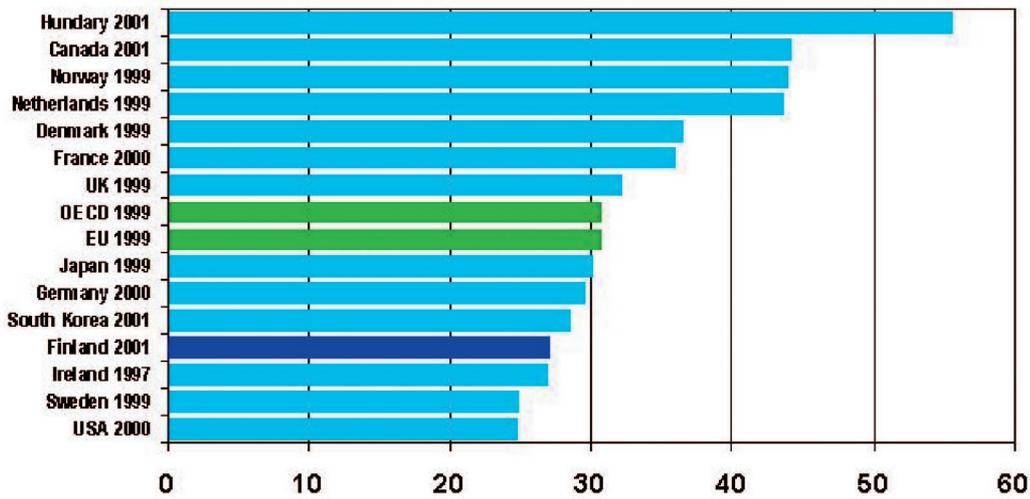
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.2 R&D investment in Finland, €Bn**



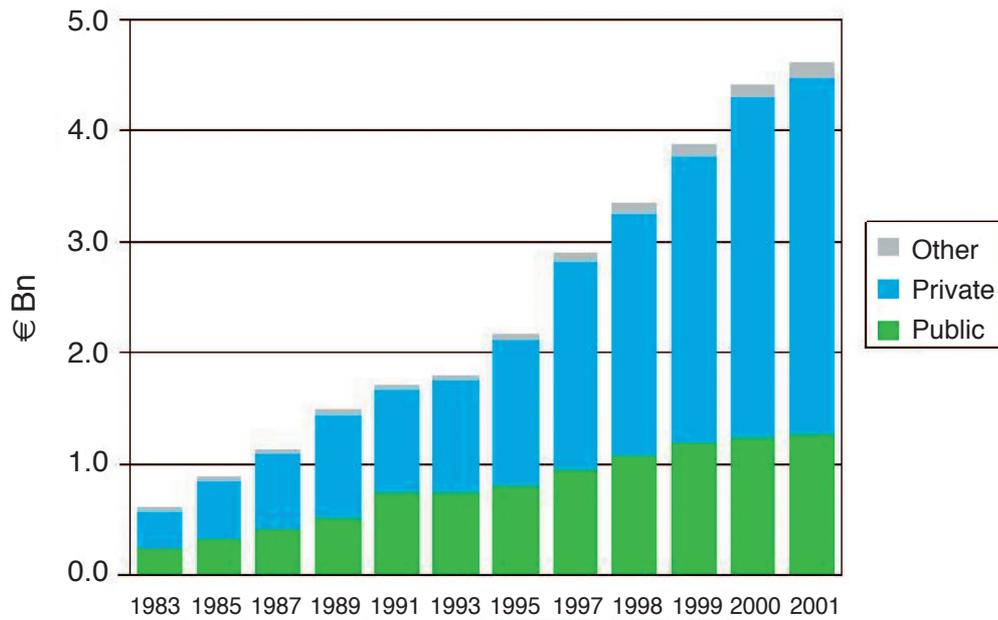
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.3 Public investment in R&D as % of total R&D spend in selected countries**



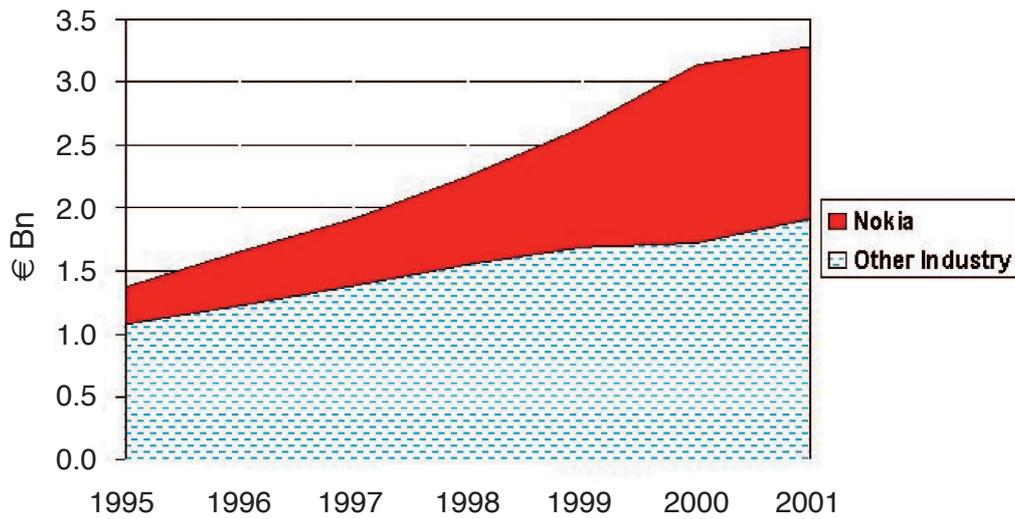
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.4 Sources of funding for R&D in Finland, € Bn**



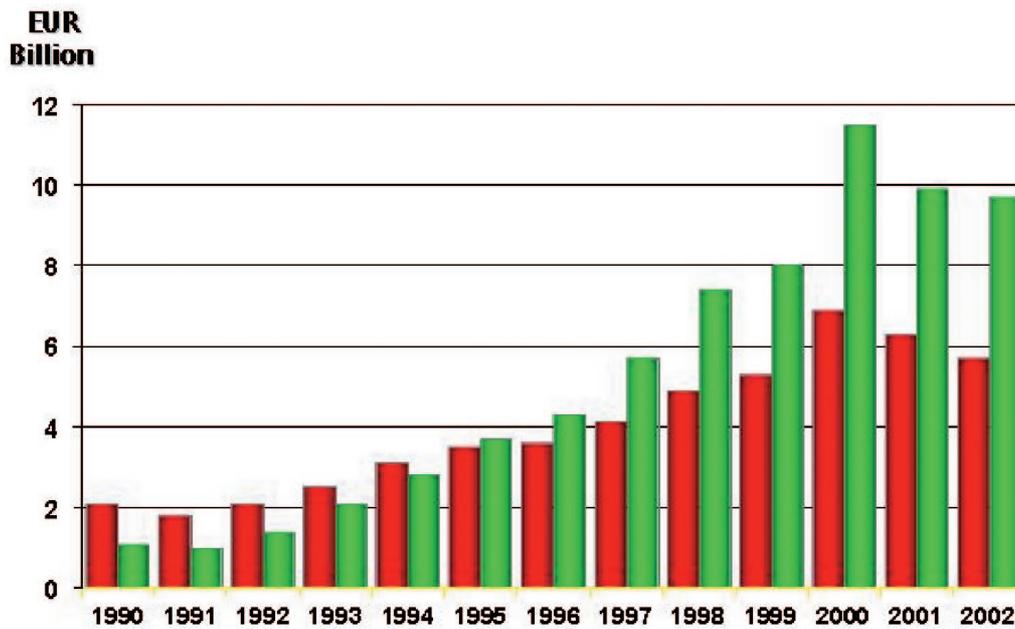
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.5 Industrial R&D spending and the estimated share of Nokia, € Bn**



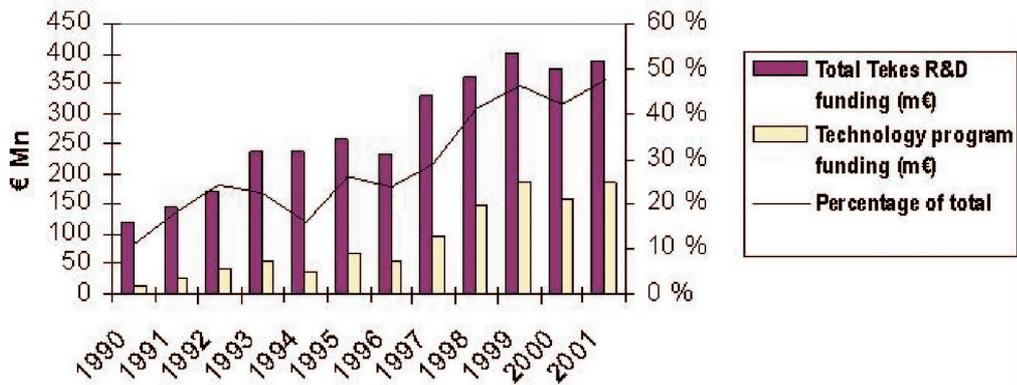
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.6 Finnish trade on high-tech products, 1990 – 2002**



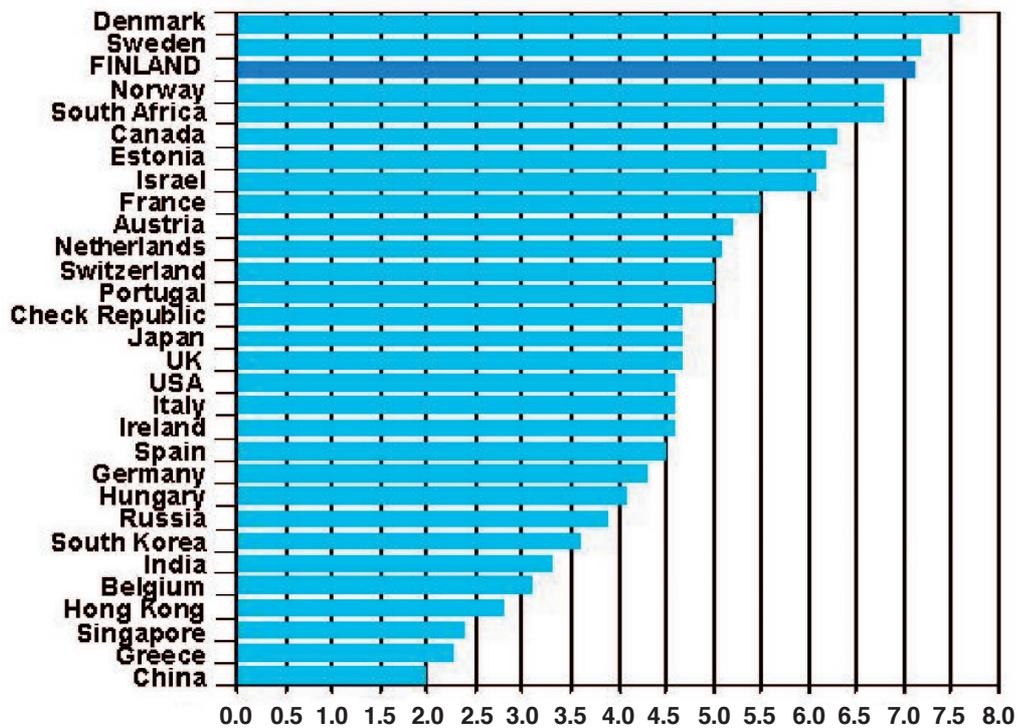
Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden  
Exports of Finnish high tech products totalled €9.7 Billion and imports €5.7 Billion in 2002

**Figure 2.7 Total annual R&D funding channelled through Tekes, € Mn**



Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

**Figure 2.8 Education spending as % of GDP in 1998**



Source: Tekes, OECD, Main Science and Technology Indicators, Statistics Finland, Statistics Sweden

# 3 Research and development in Sweden 1993-2001

Birgitta Bergström Balkeståhl, Statistics Sweden

## 3.1 Background

Since 1993, Sweden has been amongst the top OECD countries with respect to R&D expenditures relative to GDP. Many factors have contributed to this: high level of education, favourable industrial structure, existence of many multinational companies, well developed infrastructure, health care, physical and working conditions, and a military defence system.

A relatively favourable salary and taxation policy have made it possible for people to afford new products and services, resulting in the rapid dissemination of these products throughout the country. This has constituted a strong incentive to carry out research and development. Therefore, even though Sweden is a small country, it has been considered an interesting test market for many new products.

The Swedish parliament and government have a policy to guard the freedom of research in all sectors. In some cases, the governing organizations have taken initiatives directly to influence development in certain directions. From the latter part of the 1960s to the mid 1980s, there were some tax exemptions for R&D expenditures of companies. This may have stimulated the companies to start R&D activities and thereby contribute to an 'R&D culture' in Sweden. The possibility for enterprises in local areas of Sweden, that risk decreased employment, to obtain support for development of products with loans, which would have to be paid back only if the enterprise was successful, has stimulated developments. However, this is regional policies rather than national R&D policies.

Another example of government or parliament initiatives, where the direction is clearly indicated, is the introduction of two types of grants: one for energy research and a second for environment research. In later years, fewer grants of this type have been awarded. In government research policy propositions, certain areas may be prioritised. Last year, technology, biotechnology and information technology were prioritised. How these selected areas have manifested themselves in production cannot yet be evaluated.

In the 2003 budget proposition, it was announced that the government wanted to support industrial research within the ICT / Telecom sector with 100m SEK. The implementation of the plans for sustainable development, agreed upon at the UN summit in Johannesburg 2002, most likely will also lead to initiatives in various areas. The reorganization of the research councils and sector specific research councils will certainly be important for academic research. The mobilization of capital for research from the special research foundations created during the 1990s has

been, and will continue to be, important for R&D. From these research foundations, about 2.5 bn SEK will be allocated for research in the Academic sector.

In one area, the government and the parliament have passed a law forbidding R&D related to nuclear power (Law 1984:3; about nuclear technology, with the addition of paragraph 6 Law 1987:3). Certain theoretical or basic research may be allowed under certain conditions.

## 3.2 Statistics

(i) *Level of education.* R&D activity depends very much on the level of education of people in general. According to the OECD, 32% of the adult population (25-64 years) in Sweden in 2001 had college education or higher. Only Canada, USA, Ireland and Japan had a higher percentage. Furthermore, more than 50% of the well-educated in Sweden had a university education of 3 years or longer or had a research education. About 3% of an age group today attend graduate school.

The education is mostly financed by public means. In 1999, the cost of publicly financed education amounted to 6.5% of GDP, whereas the privately financed education corresponded to less than 2%. The availability of a well-educated workforce has motivated the multinational companies to place/retain their R&D activity in Sweden.

(ii) *R&D resources 2001.* In year 2001, the expenditure for R&D in Sweden was calculated to amount to 96.7 bn SEK, which corresponded to 4.3% of GDP. The number of R&D person-years amounted to about 72 000. The major part (72%) of the R&D expenditures was financed by the Business sector, whereas the Public sector (governmental authorities) accounted for 21%, the Private Non-Profit Sector (PNP) for 2,5%, and EU and other foreign sources accounted for 3.4%. In addition, the Business sector financed R&D in foreign countries and in international organizations with 24 bn SEK (3.4%). The influx of currency from abroad has increased since 1989. It should be noted that about two thirds of the expenditures of the Private sector were linked to activities in the 20 largest companies in Sweden.

In 2000, the R&D performed in companies with fewer than 50 employees was also investigated. It was found that these companies produced about 11 000 R&D person-years and that the expenditure amounted to 7 bn SEK. Most of the expenditures were spent on IT-consultants, computer services and the like.

- (iii) *R&D-activities linked to certain product groups.* R&D within the producing industry is linked to six groups of products, namely pharmaceuticals, machinery, office equipment and computers, telecom products, precision instruments (incl. medical and optical instruments), and means of transportation. Together, these six groups of products accounted for more than 80% of the total R&D costs during the period 1993-2001. In 2001, the percentage was 94.3%. Means of transportation, telecom products and pharmaceuticals all exceeded 20% in 2001. The reason for this concentration is by and large the effects of demand, ie the market anticipates new developments and is prepared to pay for it. The R&D activity in the pharmaceutical industry has changed most rapidly since 1993 (27% per year). This development, to some extent, has been the result of the responsibility taken by the Public sector for health care with subsidies on pharmaceuticals. In this way the pharmaceutical industry has had a secure market.
- (iv) *Personnel structure and costs.* Personnel structure and costs are important factors influencing the R&D figures. During the period 1993-2001, there was a significant change with respect to personnel involved in R&D work. Today, a higher percentage of the personnel involved in R&D work have gone through long time education, ie university studies for 3 years or longer, some with research education (academics). The number of R&D person-years performed by academics increased from 30 400 in 1993 to 46 800 in 2001, whereas the R&D person-years produced by non-academics decreased from 25 700 in 1993 to 24 600 in 2001. The costs for personnel per R&D person-year increased during the period by about 4%. The change in the personnel structure is caused not only by the fact that the number of people with long academic education has increased, but also by the fact that increased use of computers has made personnel with shorter education redundant.
- (v) *Basic and applied research and development.* The Private sector is mainly concerned with development, but from 1993 to 2001, it has spent between 14 and 17% of its R&D person-years on basic and applied research. In 2001 the percentage decreased to 12.9%. The Academic sector is thought to be involved in basic and applied research only, and the Public sector (governmental authorities) has a very high percentage of its R&D person-years in basic and applied research (60-72% during 1993-2001). Together the costs for personnel engaged in basic and applied research in 2001 amounted to 13.4 bn SEK.
- (vi) *Research linked to the Swedish defence research.* Sweden is one of the few small countries having a defence of its own and linked to it a certain R&D activity. Therefore, research in this sector is added as a part of total R&D of the country. Defence research is carried out by the defence authority as well as within the Private sector. The expenditures connected to defence R&D can be identified in the Authority sector, and estimated for the Private sector with the military authorities as a financial source. In 2001, this research cost amounted to a little less than 5 bn SEK. The percentage of the total R&D expenditures amounted to 5%. The highest percentage was reached in 1995, when it was 7.5%.
- (vii) *Science and technology indicators.* In 1993, 1121 patent applications were sent from Sweden to the European Patent Organization (EPO). The number of applications has increased over the years. In 1998 they reached 2017, which is an increase of 79%. The patent organization in the USA (USPTO) granted 1033 Swedish patent applications in 1993, and in 1998, the figure was 1715, representing a 66% increase. In the ICT, as well as in the biotech area, the rate of increase in the number of patent applications was impressive.
- (viii) *Quality of the statistics presented here.* The statistics presented here are based on the results from enquiries given to the Private sector (excepting enterprises with fewer than 50 employees), to the Academic sector, the Public sector (in particular governmental authorities) and to the sector of private non-profit (PNP) organizations and foundations serving the household sector. The R&D within County Councils and Municipalities was not part of the investigation. These investigations are performed on a regular basis every other year. Statistics Sweden uses the manual for research statistics agreed between the OECD countries (Proposed Standard Practice for Surveys of Research and Experimental Developments, Frascati Manual, OECD). Its definitions of concepts and delimitations are clear from the delivered enquiry material. It is unavoidable that those who provide the data have certain difficulties to differentiate R&D work from other activities. Obviously, this is so the more advanced the activity is. However, the enterprises have a long tradition in responding to the R&D enquiries. This means continuity in delivering the replies. Sometimes, it is difficult to compare results from one year to another, since units may merge or divide into several smaller units, and disappear altogether.
- About 93% of the enquiries are recovered from the Private sector and from the Academic sector, and almost 100% from the Authorities. The PNP sector does not play a prominent role in Swedish R&D activities, but is mostly a financier. The difficulty concerning the PNP sector is to obtain an adequate population. Possibilities to compare with other OECD countries are considered satisfactory with regard to the three sectors: private sector, academic sector and public sector, if one considers the lack of information from County Councils and Municipalities. However, it is uncertain if the same types of costs are included in the academic sector and public sector. There could be differences in costs for premises and social insurances

between these sectors in different countries.

The R&D due to enterprises with fewer than 50 employees and to R&D linked to County Councils and

Municipalities are estimated to 10 bn SEK. This means that the 4.3% R&D relative to GDP was underestimated in 2001.

### 3.3 Figures and tables

**Figure 3.1 Level of education**

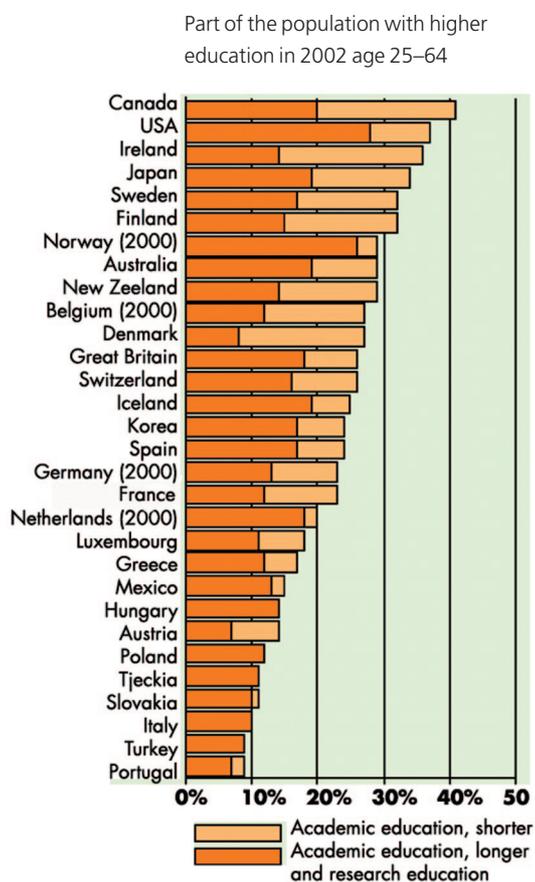


Figure 3.1 is part of the publication 'Swedish education in international statistics', Statistics Sweden, 2002. As shown, Sweden is in fifth place, when comparing the fractions of people in the age group 16-65 having academic education, and in the sixth place when comparing people with longer education and research education.

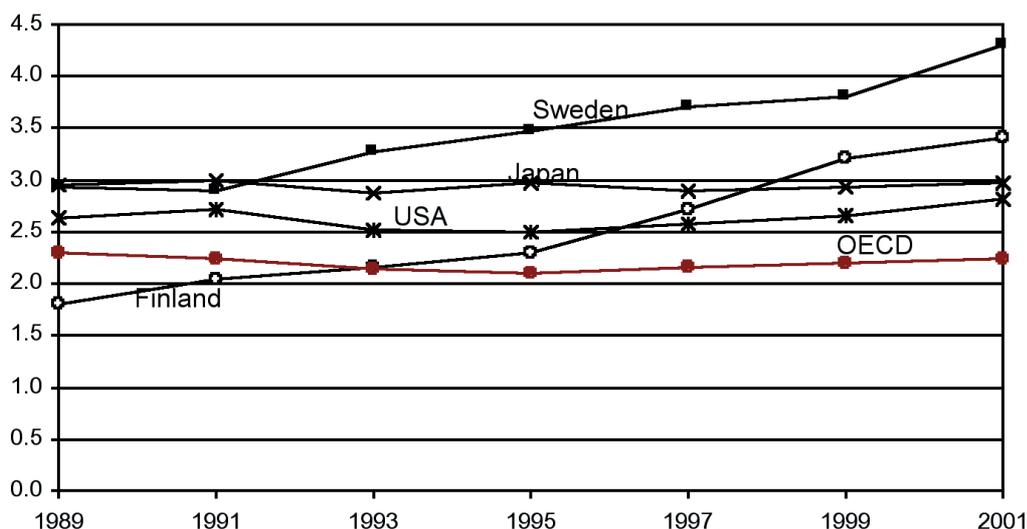
Source: OECD Education at a glance 2002

**Table 3.1 R&D expenditures as % of GDP for Sweden, Finland, Japan, USA and the OECD countries in general**

	1989	1991	1993	1995	1997	1999	2001
<b>Sweden</b>	2.94	2.89	3.27	3.46	3.70	3.80	4.30
<b>Finland</b>	1.80	2.04	2.17	2.29	2.72	3.22	3.40
<b>Japan</b>	2.95	3.00	2.88	2.98	2.90	2.94	2.98
<b>United States</b>	2.64	2.71	2.52	2.50	2.58	2.65	2.82
<b>Total OECD</b>	2.29	2.24	2.15	2.11	2.16	2.20	2.24

Source: MSTI, OECD 2002:2

**Figure 3.2 Development of R&D expenditures in relation to GDP**



Source: Research and Development in Sweden 2001, a review, SCB UF 16 SM 0301  
 Research and experimental development in Sweden 2001

Sweden has, like Finland, experienced a steady increase of R&D in relation to GDP since 1993. Sweden, USA and Japan have been above the OECD average for a long

time. However, for USA and Japan the level has been unchanged for this time period.

**Table 3.2 Financing of R&D 1989-2001; sector distribution in percent**

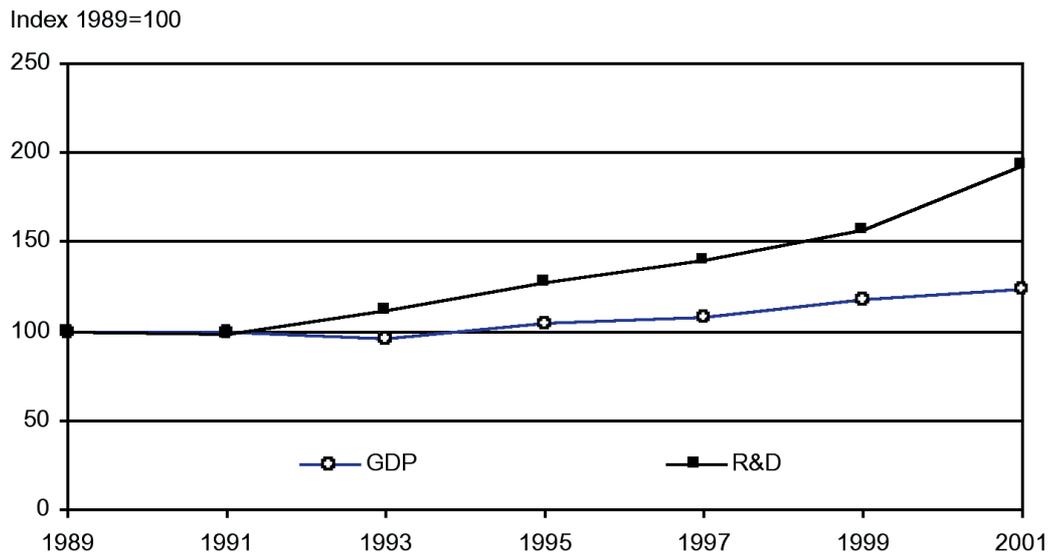
Year	Business sector	Public sector	Private non-profit sector	Foreign countries	Sum total
1989	58.6	38.1	1.7	1.6	100
1991	61.8	34.0	2.7	1.5	100
1993	61.0	33.6	2.5	2.8	100
1995*	65.5	29.6	1.5	3.4	100
1997	69.2	25.6	1.8	3.5	100
1999	67.7	26.0	2.8	3.5	100
2001	71.9	22.2	2.5	3.4	100

\* 1995 the research foundations were included in the private non-profit sector. They amounted then to 56M SEK. From 1997 they were included in the public sector total.

The proportion of R&D financed by the public sector has decreased since 1989. In absolute numbers, public sector spend has increased, for example by 1.7 bn SEK between

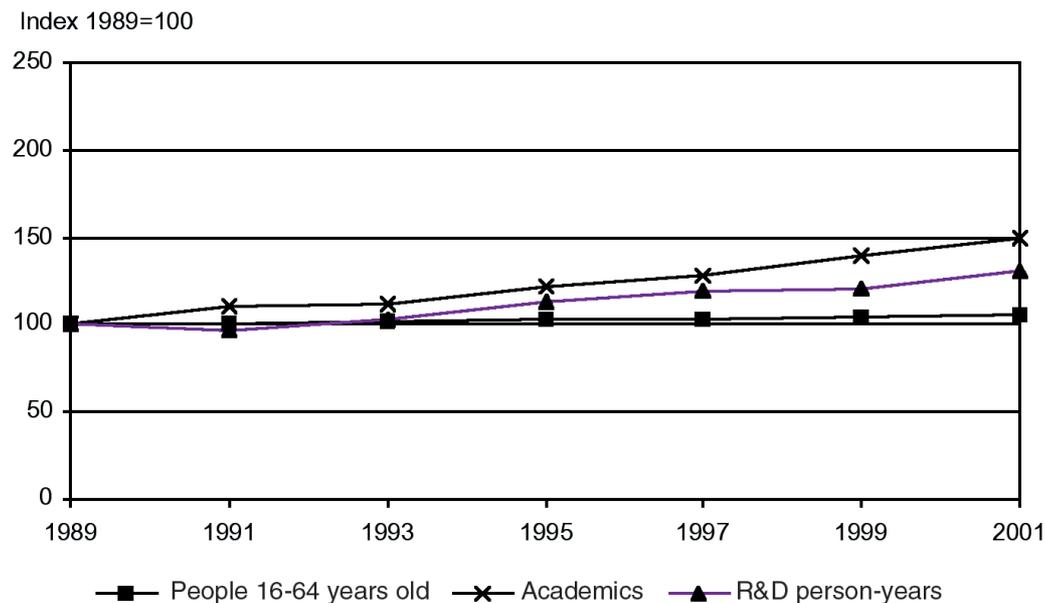
1999 and 2001, but spend by the business sector and by foreign countries has increased even more rapidly during this period.

**Figure 3.3 Development of GDP and R&D expenditures in Sweden 1989-2001**



Since 1989, R&D expenditures have increased more rapidly than GDP.

**Figure 3.4 Development of population, number of Academics and R&D**



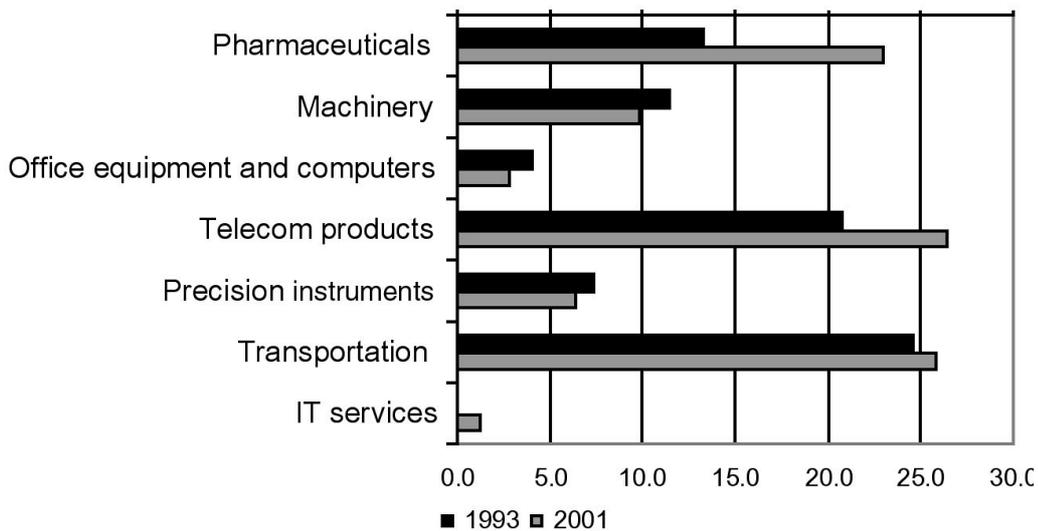
Relatively speaking the number of Academics in the age group 16-64 years old increased somewhat more rapidly than the number of R&D person-years.

The business sector dominates the input into R&D in Sweden. In 1999, its contribution amounted to 75% of the total R&D in the country. In 2001, the percentage had increased to 78%. The business sector has increased its expenditures with 26% since 1999, as estimated in the

price level of 1995. The number of R&D person-years is calculated to 49 500 in 2001.

It should be pointed out that the definition of 'Academics' was changed in 2000. For consistency, the curve in figure 3.4 for Academics between 1999 and 2001 is based on the assumption that the development for this category has been the same as during the period 1989-1999.

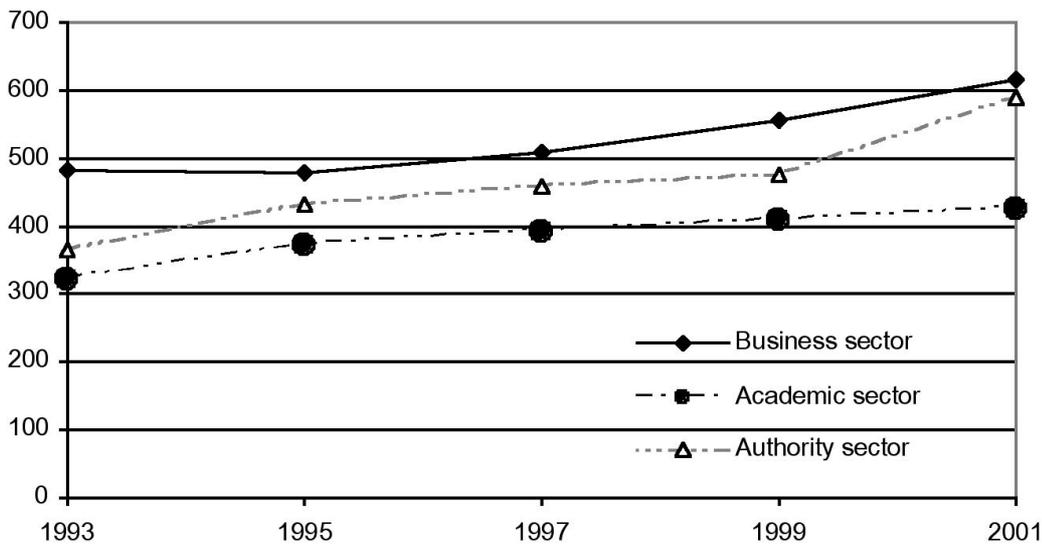
**Figure 3.5 Percentage of R&D expenditures in the Business sector spent on specific products**



During the period 1993 - 2001 over 80% of the R&D expenditures of the manufacturing industry was spent on: pharmaceuticals, machinery, office equipment and

computers, precision instruments etc, transportation and IT services. In 2001 the number was 94.2%.

**Figure 3.6 Personnel costs per R&D person-year in 2002 prices, SEK t**



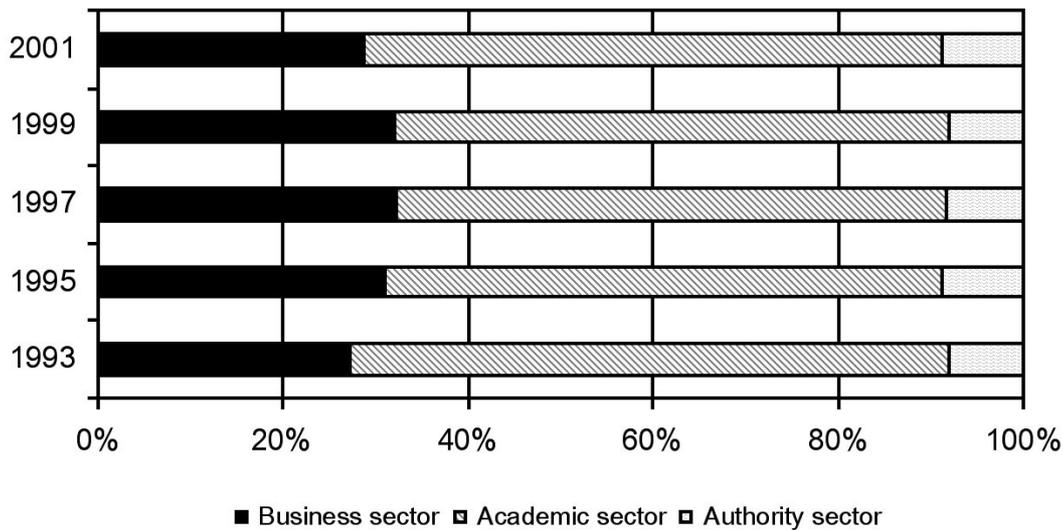
A restructuring of the R&D personnel has taken place. Today more Academics are used for R&D efforts. This has influenced the distribution of costs.

fraction of the R&D work in the academic sector is carried out by graduate students.

The cost for personnel has increased, especially within the public sector (authorities) and the academic institutions. On average, the yearly change for the business sector was 3.5%, the academic sector 4.1%, and for authorities 7.8%. There is a difference between the costs per person-year in the academic and business sectors. The largest difference was noted in 1993, but a further increase has occurred after 1995. This could be ascribed to the fact that a large

Figure 3.6 shows the average personnel costs (including social security costs) per R&D person-year in the Business sector, Academic sector, and the Authority sector (Public sector excepting County Councils and Municipalities). The social costs are ca 35%, and if counted on an average tax exemption of 28% of the salary, the average net salary in 2001 is about 24 000 SEK in the business sector, 17 000 in the academic sector, and about 23 000 in the authority sector.

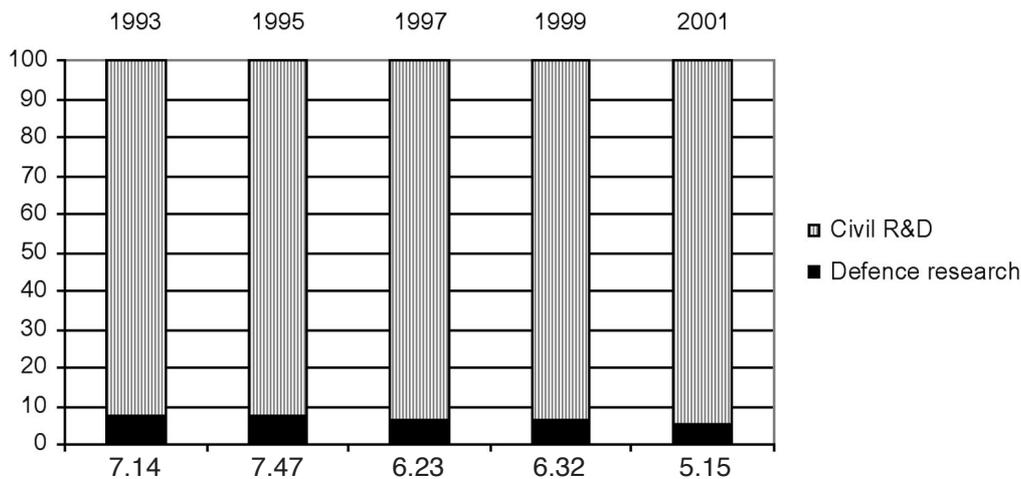
**Figure 3.7 Distribution of personnel costs for basic and applied research between different sectors**



During the period 1993 to 2001, 62-64% of the personnel costs for basic and applied research was accounted for by the academic sector. The corresponding

number for the business sector was 27-32%, and for the public sector (authorities) ca 8%.

**Figure 3.8 Defence and civil R&D as % of total R&D**



In 2001, defence research amounted to ca 5 bn SEK. The increase from 1999 was less than 0.7% in the prices of 2002. Since 1995, the fraction of total expenditures has decreased steadily. Costs for defence research have been calculated from the information obtained from the business sector as costs financed by the defence

authorities plus the R&D reported by the defence authorities themselves.

Non-military R&D in relation to GDP in 1993 was 2.94% and in 2001 4.06%.



## 4 The 3% R&D target: Are there lessons to be learned from Sweden?

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### 4.1 Summary

As of 2001, Sweden and Finland are the only countries within the EU achieving the 3% target. This paper describes some facts about the performance of Sweden that are useful to have in mind in the further discussion regarding the EU 3% target. In brief, the paper presents the distribution of R&D on public and private sector expenditures. One result is that with respect to public expenditures, Sweden does not differ much from other EU member states. Another result is that the private R&D expenditures are above the average level of all other countries. The main reason for this is the high proportion of large multinational corporations located in Sweden and especially the fortune of having such corporations in the main technology areas, whose markets grew during the 1990s.

Is there any policy action connected with the development of the R&D intensities, which the EU could learn from? The answer is both yes and no. Beginning with the answer 'no', this is concerned with the fact that investment decisions in large multinational enterprises (MNEs) are mainly conditional on market considerations. The facts show that Sweden-based MNEs are competitive partly because of their large investments in R&D.

The 'yes' answer has three aspects. First, Sweden made the deliberate decision to maintain the absolute amount of public R&D expenditures, while several other countries decreased theirs because of the economic recessions in the beginning of 1990s. Second, the Swedish currency crisis in the beginning of 1990s forced the government to give up the fixed exchange regime of the Swedish Crown (SEK) in favour of a floating regime. The immediate implication of this was a depreciated SEK (more than 20%). The Swedish MNEs gained in competitiveness because of this, and their exports were spurred. The boosting of incomes and the lowering the number of R&D employees' salaries relative to other countries implied further investments in R&D in Sweden. Thus, macroeconomic monetary policies have influenced R&D investments in the 1990s. Third, Sweden has had a technology policy like other countries. However, it is uncertain whether this technology policy had a more positive impact on research intensities in Sweden than in other countries. For example, the national board of science and technology pursued programs in mobile telecommunications in the 1980s, which might have spurred the R&D of MNEs like Ericsson.

In Sweden, there is a so called 'paradox' debate about why the strength, in relative terms, of aggregated investments in knowledge as R&D intensities does not

seem to lead to a similar strength in performance with respect to commercialization of inventions, growth of new technology-based firms and aggregate growth. This discussion puts efficiency considerations into focus rather than expenditures, which is also something the EU ought to consider.

Finally, the paper reminds us about structural adjustment in the economies. According to OECD, the R&D intensities of the USA and the EU were almost the same in the early 1980s. The difference that has emerged since then can be explained by the development in the sectors of telecommunications and business services. These sectors do not represent the same proportion of GDP in the EU as they do in the USA. Thus, the challenge for the EU is to remove barriers between countries and sectors - barriers that impede the generation of structural change and development.

### 4.2 Distribution of R&D financing in Sweden

According to the OECD database, Swedish R&D intensity, measured as total expenditure on R&D in relation to gross domestic product (GDP), was 4.27 in 2001 (OECD 2003). This is well above the USA figure of 2.65, and more than twice the EU average of 1.93 (Table 4.1).<sup>1</sup> Sweden has increased its R&D intensity by more than two percentage units since 1981. In fact, Sweden, Finland and Denmark are the only members of the EU that in the last twenty years have increased their R&D intensity by more than one percentage unit (OECD source). To clarify the Swedish case, we divide the R&D intensity on public and private sectors R&D financing.

<sup>1</sup> OECD, MSTI database 2003, <http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/>. The 2001 figure for Sweden decreased in 2002 owing to Ericsson and ABB downsizing.

**Table 4.1 Gross domestic expenditure on R&D (GERD) as a percentage of GDP**

	1981	1985	1991	1995	1997	1999	2001
<b>Sweden</b>	2.17	2.71	2.70	3.35	3.54	3.65	4.27
<b>EU</b>	1.69	1.86	1.90	1.80	1.80	1.86	1.93
<b>USA</b>	2.34	2.76	2.72	2.51	2.58	2.6	2.65

Source: [http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/Annex\\_Tables\\_excel/At2.1\\_e.xls](http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/Annex_Tables_excel/At2.1_e.xls)

**Table 4.2 R&D expenditures by source of funds (%)**

	1991	1995	1997	1999	2000	2001
<b>Sweden</b>						
Public	34.0	28.8	25.8	24.5	..	21.0
Private	61.9	65.5	67.9	67.8	..	71.9
<b>EU</b>						
Public	41.2	38.8	37.1	35.0	34.5	
Private	51.9	52.6	53.8	55.5	56.2	
<b>USA</b>						
Public	38.9	35.4	31.5	28.5	26.0	26.9
Private	57.2	60.2	64.0	66.9	69.3	68.3

Source: OECD, MSTI database 2003 <http://www1.oecd.org/publications/e-book/92-2003-04-1-7294>

Note: Cells do not add up to 100 as other sources are not included in the Table.

Table 4.2 shows that in Sweden the private sector in the 1990s financed an increasing share of total R&D expenditure. As compared with the USA and EU averages, the Swedish share exhibits both a larger share in 1991 and a larger increase in the 1990s. Table 4.2 also shows a concomitant decrease in the public share. Table 4.3 shows that the decreasing share of public financed R&D does not necessarily imply that the absolute amount decreases.

In Sweden, there was a deliberate policy to maintain R&D levels in the higher education system, while coping with the large public budget deficit in the beginning of 1990s. In contrast to both the USA, which decreased the public financing, and the EU, which more or less maintained the level, Sweden succeeded not only in maintaining the

levels, but also to increase them by almost 2% on a yearly basis.<sup>2</sup> On the other hand, the financing of the private sector increased almost 8% annually. These figures demand some reflection about the realism in the R&D expenditure target of the EU, which in order to be met 2010 implies a target of 6% increase annually for the public and 9% annually for the private financing.<sup>3</sup>

In 1991, the public financing of R&D expenditure amounted to 0.92 percentage units of GDP, while that of the total EU was 0.79. In 2000, the Swedish figure was 0.89, whereas the EU value had decreased to 0.67.<sup>4</sup> In this context, it is important to note that the public financing of R&D in Sweden includes R&D related to defence procurements.

<sup>2</sup> Even if the levels were increased, the number of research graduates also increased, causing a debate in Sweden about whether the net effects actually were a decrease per capita financed.

<sup>3</sup> Linkohr A5-0389/2003 and European Parliament resolution of 18/11/2003 on Investment in Research

<sup>4</sup> 0.92=34% (Table 2 1991) of 2.70 (Table 1 1991)

**Table 4.3 Total financing amounts out of total expenditures, millions of \$US 1995 prices (PPP corrected)**

	1991	1995	1997	1999	2000	2001	Annual growth %
<b>Sweden</b>							
Public	1 602	1 754	1 729	1 828		1 938	1.70
Private	2 918	3 990	4 541	5 060		6 637	7.70
<b>EU</b>							
Public	53 487	50 811	50 533	51 510	53 690		0.04
Private	67 494	68 974	73 315	81 746	87 479		2.60
<b>USA</b>							
Public	68 774	65 134	64 438	65 192	63 238	67 883	-0.10
Private	101 048	110 800	130 875	152 857	129 170	132 708	2.50

Source: OECD MSTI database <http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/> and own calculations. Note: Funding from abroad and from other national sources (non-private) is not included.

It is important to evaluate the efficacy of public financing, since that is the component on which policy might have a more direct influence. The number of academic publications, patents in US and Europe, and foremost the relative citation impacts of Swedish outputs are top ranked. For the period 1994-1998, relative citation impact of Swedish research was 1.25, in contrast to 1.02

for the EU and 1.19 for the USA (Table 4.4)<sup>5</sup>. Table 4.4 indicates that Sweden, despite its achievements, seems to have had a negative trend in citation impact, pointing at the necessity of analysing the efficacy of public financing with respect to quality, and its adjustment to new research areas.

**Table 4.4 Relative Citation Impact (RCI), all science areas**

	1983–87	1986–90	1990–94	1994–99
<b>Sweden</b>	1.35	1.27	1.24	1.25
<b>EU</b>	1.00	0.99	1.00	1.02
<b>USA</b>	1.19	1.18	1.19	1.19

Secondary source: Persson (2002) original source: National Science Indicators, ISI<sup>6</sup>

### 4.3 Private sector R&D

Sweden is dominated by multinational enterprises (MNEs; Figure 4.1). Approximately 40% of the employment and value-added in manufacturing is due to the MNEs. If foreign MNEs, active in Sweden, are included, these proportions increase to 70%. There is a strong correlation between a high privately financed R&D

intensity and the occurrence of large MNEs. Sweden is a corroboration of that observation. In 1995, seven large manufacturing groups – Ericsson, Volvo, Saab, Astra, Scania, Sandvik and Incentive – accounted for as much as 75% of total R&D expenditures in the Swedish manufacturing sector.<sup>7</sup> Enterprises with more than one thousand employees were responsible for more than 70% of performed R&D.<sup>8</sup>

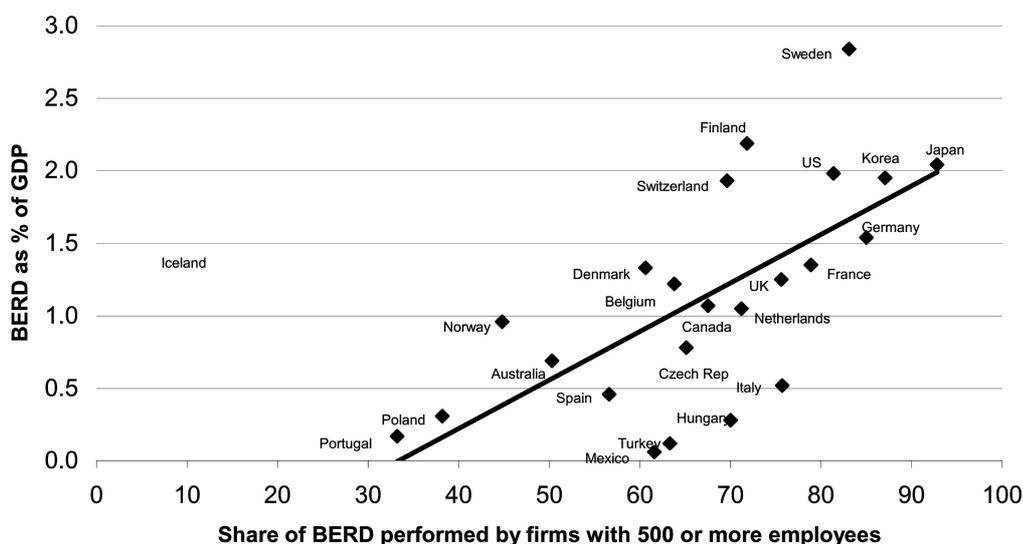
<sup>5</sup> See for example: EU (2001) Towards A European Research area: Key figures 2001 European Commission, Bruxelles

<sup>6</sup> Note: RCI is calculated as a moving averages on overlapping 5 year periods. The number denotes the country average citations per paper in relation to world average.

<sup>7</sup> NUTEK (1998) p 58. Note that Sweden Defence Policy implies military procurements of almost the same relative scale as USA. These procurements imply high R&D intensities in enterprises supplying the procurements (Celsius and SAAB).

<sup>8</sup> Statistics Sweden UF14 SM 0301, see also OECD DSTI/STP/TIP(2002)16/REV1

**Figure 4.1 Sweden as an outlier with respect to MNEs**



Source: Sheehan & Wycoff (2002)

The decision of allocation of investments in R&D differs from the decisions regarding production and marketing. Sweden has been a good location for investment in R&D, because of skilful labour at relatively low cost (see below), and the fact that MNEs have to adjust to the relative inertia in labour mobility. Production demands other skills and prices, where Sweden has not been a competitive location for these large corporations. For this reason several Swedish MNEs increased the outward investments in the second half 1980s, driven partly by increasing labour costs for non-R&D personnel, partly by the general force of increased globalisation. A typical feature in the skill-biased technical change was also observed elsewhere.<sup>9</sup>

Most likely, the monetary policy in Sweden has had an influence on the localization of R&D investments. In short, Sweden has had different kinds of exchange rate regimes since the 1970s. Owing to the cost crisis emanating from the Swedish tax- and wage-setting system, Sweden used devaluation of the SEK several times in the late 1970s and in the beginning of the 1980s. For a short time, these actions seemed to solve the main concern of keeping unemployment at a low level. From the aspect of R&D investment, there was a concomitant increase in R&D person-years immediately after the devaluation in the 1980s. However, the cost-driving causes were not taken

care of, so in the late 1980s Sweden again was hampered by an inflation-driven economy. This culminated in the general recession in the beginning of the 1990s. As a remedy, the Social Democratic Government tied the SEK to the ECU in the spring of 1991, which effectively curbed the inflation. However, the changed rules of the game pronounced a crisis in the banking and financial sector. In November 1992, the Central bank had to abandon the fixed exchange regime to the ECU, and the value of the Swedish Crown (SEK) was declared floating, obeying the laws of supply and demand. In Figure 4.2, the variation in the value of SEK is illustrated. While a larger value in the TCW-index implies a depreciated SEK, Figure 4.2 shows that setting the SEK on float implied a depreciation of more than 25% between 1992 and 1995. Table 4.1 and Table 4.2 show that at this time there is a larger step in the business related R&D. This is also evidenced by the big increase in R&D person-years in the business sector (18% between 1993 and 1995). Thus, there is a strong indication that the monetary policy, both in the 1980s and in the 1990s, influenced the large-R&D MNEs to invest more in Sweden-located R&D. This in turn has probably enforced the division of labour or skills within these large MNEs, locating production facilities of high value added products to the far east, while retaining R&D facilities in Sweden to a higher degree.

<sup>9</sup> Eg OECD (1996)

**Figure 4.2 The Swedish Crown related to a basket of currencies. Higher index implies less valued SEK**

**Valutakurs index, SEK/TCW January 1992–March 2004**



Source: The Swedish Central Bank, [www.riksbanken.se](http://www.riksbanken.se)

A closer look, especially at the manufacturing sector, Sweden as compared to USA and EU, 1995, gives the impression of higher R&D intensities mainly in telecommunications, pharmaceuticals, motor vehicles and machinery. Compared to OECD averages, Swedish R&D in pulp and paper and instruments is also higher. The question is whether this is profitable. In investigating the development of Swedish competitiveness, Lundberg (1999) and Gustavsson & Kokko (2003) have compared speciality index in several industries for a number of OECD countries. The regression analyses all show that higher Swedish R&D intensities have a positive correlation with increased competitiveness (interpreted as higher speciality index).<sup>10</sup> Other references confirm that the high R&D investments in the 1980s in the Swedish MNEs have been instrumental for their expansion globally (Andersson et al [1996], Fors & Kokko [2000]). According to Paphristodoulou (1991), the merger of ASEA and Brown Boveri in 1988 implied that the suboptimal R&D intensity of the former increased to the levels of competitors. In the late 1980s, Ericsson made a similar strategic decision to increase suboptimal R&D intensities to the level of rivals like Alcatel and Siemens.

The observation that R&D intensity is a reflection of a country's industrial structure has been noted recently by OECD 2002.<sup>11</sup> Sweden gained in R&D intensities, like Finland with Nokia, because of the presence of Ericsson and its growth, which emanated mainly from the large increase in the market of mobile-telephone systems. In Sweden, R&D in the communications equipment industry as a share of GDP grew by 40%, boosted by a 34% increase in the same sector's value added as a share of GDP. However, the R&D increase in this sector as a proportion of value added was only 4%.<sup>12</sup> A similar situation is true for the large pharmaceutical enterprises, and the advance transportations producers located in Sweden.

In Tables 4.1, 4.2 and 4.3 above, one can discern a third larger increase in the Swedish R&D intensity between 1999 and 2001. This increase cannot be explained by policy actions. The fierce competition in the telecommunication market probably provides the best explanation - driving costs in R&D to gain competitive edge. There are indications that at least Ericsson in Sweden experienced increased R&D expenditure due to expensive hired consultants.

<sup>10</sup> Speciality index = ratio of an industry's exports minus imports to its production. If this increases over time this is an indicator of increased competitiveness.

<sup>11</sup> OECD DSTI/STP/TIP(2002)16/REV1

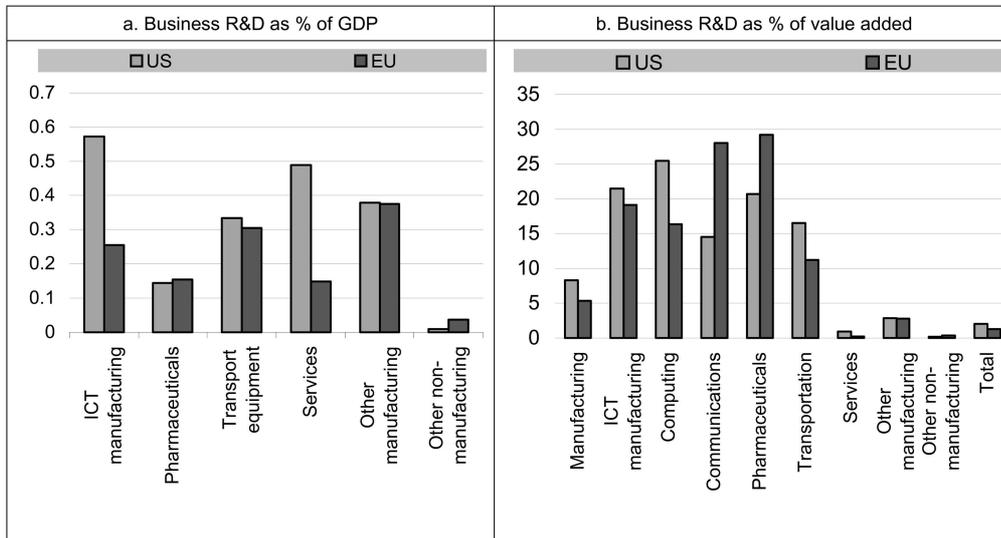
<sup>12</sup> Ericsson R&D was equivalent to almost 60% of Swedish business expenditure on R&D in 1999 although a significant fraction of this was performed outside Sweden (OECD DSTI/STP/TIP(2002)16/REV1)

## 4.4 Concluding discussion

Sweden has been fortunate to have a large proportion of successful MNEs. A small language and a small home market, like the Swedish, require success in foreign

markets to achieve economies of scale. So Swedish MNEs have used high R&D investments as an instrument for increasing their global competitiveness.

**Figure 4.3 Comparison of business R&D intensity in the USA and EU by industry sector**



Source: Sheehan & Wycoff (2002)

Structural differences in business R&D intensity explain the gap between the USA and the EU. Figure 4.3, panel (a) shows that the gap is mainly due to the differences in R&D intensity in the ICT manufacturing and business services sectors. Almost 70% of the difference of almost 1 per cent unit in R&D intensity between the US and the EU is accounted for by the above difference. In Figure 4.3, panel (b), the equal size of R&D as share of sector value-added confirms the conclusion that especially the ICT sector in the US comprises a larger share of overall GDP. The US ICT sector is more oriented towards computing equipment, while the EU ICT sector is more communication oriented. Figure 4.3 also shows that having a large R&D intensity relative to sector value-added does not necessarily imply a correspondingly high sector R&D intensity relative to GDP (see for example EU pharmaceutical sector in panel (b) versus panel (a)).

The analysis of Sheehan & Wycoff leads to two comments. The first is the importance of competition-policy, ie enforced competition as a medium to increase productivity. The intense growth in Sweden in the late 1990s can also be explained by the early deregulation in the telecom market abolishing state monopolies.

If enterprises are not competitive enough, they should not rely on the national state for survival. Sweden, together with the UK, has the lowest state aid to national enterprises according to State Aid Scoreboard. Sweden actually does not have any R&D tax allowances today. However Sweden still has a large public service sector secluded from competition because of political considerations.

The second comment brings up the Swedish 'paradox' debate, which seems to be very relevant for the EU. Besides expenditure targets, there must be an increased focus on performance and efficiency.

Finally, Sweden had technology programs in the 1980s (and still has), connected to emerging markets like telecom, but today there are no studies indicating how large the influence of these programs might have been (Ericsson has probably gained from them). Sweden does not differ from other countries with respect to the existence of technology programs. Thus, there is no evidence today that Swedish Science and Technology policy has brought about the increases in R&D intensities. In this respect the case of Finland might be more telling.

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# 5 Reflections on R&D in Finland and Sweden

Uno Lindberg, Chairman EASAC

## 5.1 Summary

This chapter compares the situation in Finland and Sweden and to make some additional comments that may be of value for future discussion about the 3% target. A comprehensive analysis of the Swedish situation including a comparison between Sweden and Finland was recently published by the Department of Finance, Sweden, as part of the so called Long-term evaluation (LU, 2003 part 6) by Patrik Gustavsson, Trade Union Institute for Economic Research (FIEF) and Ari Kokko, Stockholm School of Economics; <http://www.finans.regeringen.se/LU2003/bilagor.htm>).

The Finnish Science and Technology Policy Council (STPC) has greatly influenced Finnish research and technology politics during the 1990s. STPC has been successful in facilitating cooperation between different actors in the innovation system by bringing together representatives from different ministries, public and private research institutes, companies, consumer organisations and higher education.

With a system perspective, Finland has effectively incorporated the strategy of forming industrial clusters and cluster policy into plans for industrial development.

Analyses concerning the role of technoparks and clusters in the Swedish innovation system are in agreement with what we have learnt from the Finnish case. Also here, the importance of cooperation between companies, society and research organizations in forming clusters and regional innovation systems is emphasized.

Clusters develop an internal competence - a silent, experienced-based knowledge – that is most valuable and difficult to achieve otherwise. Nursing the clusters strengthens the competitiveness of the innovative environment, and the presence of big companies forces the development of SMEs.

The importance of close contacts with universities and institutes for higher education and research is emphasized.

Eradication of science illiteracy requires a major effort in the years to come.

## 5.2 The importance of STPC and TEKES in Finland

In terms of the size of the economy, structure of industry, educational level and other variables, Finland and Sweden are quite similar, although there are significant differences

in tax load and in many indicators measuring the size of the economy. There are also differences in soft indicators. On the positive side for Finland is that the business sector appears to trust the economic policy and knowledge infrastructure. The reason for this trust in Finland may be related to the functioning of the Science and Technology Policy Council (STPC; [http://www.minedu.fi/tiede\\_ja\\_teknologianeuvosto/eng/](http://www.minedu.fi/tiede_ja_teknologianeuvosto/eng/)), the structure and function of which is discussed by Erkkö Autio in his report above. The purpose of this paper is to highlight some aspects described in the different reports, trying to identify possible instruments that might be valuable in the process of strengthening R&D in Europe.

It is obvious that the Finnish Science and Technology Policy Council played a major role in shaping the economic policy of Finland, and that Nokia has been of particular importance. The success of Nokia, with its positive effects on literally thousands of other companies, has influenced the entire economic policy in a favourable way. The telecom and IT businesses owe their success to the economic policy, which has built on ideas of cluster formation and innovation systems. These concepts have been popularised in the Academic debate during the last decade, and the Finnish business policy, with its emphasis on system perspective, has become a role model internationally. The International Monetary Fund (<http://www.imf.org/external/>) has provided excellent proof of the strong competitiveness of Finland. As a complement to the STPC, the technological development centre (TEKES) was established in 1983 to finance applied and industrial R&D.

It has been pointed out that, even if Ericsson of Sweden has been successful, Nokia appears to have had a comparatively greater influence on the economy of Finland (Swedish long-term analysis (LU, 2003 part 6)). Nokia became the nucleus of an IT cluster that was almost equal in importance to other basic business activities in Finland, and it has had a big influence on the economic-political debate in Finland. The Finnish system-thinking gradually led to an attempt to strengthen the business environment by introducing different reforms. TEKES and STPC became more and more important. Since 1983 when TEKES was formed, it has administered between 75 and 89% of public R&D spending targeted towards the manufacturing industry. In a typical project TEKES finances 30-40% of the R&D of the project, but the share is often higher if the receiving part is a university or a research institute. The projects still require cooperation between the private sector and the university, and are aimed at facilitating the spread of technology and internationalisation by the involvement of many actors also outside Finland. In year 2000, 2400 companies and a large number of research institutes participated in the

different technology programs of TEKES: a large part of R&D and production takes place in networks of companies and research institutes. It is obvious that TEKES' demand for cooperation and spreading of the research results has had the desired effects.

It is noteworthy that Finland during 1990-1993 did not abandon its then 2% target in R&D, despite the financial crisis and the collapse of the Soviet Union, which threatened the structural changes in Finland. If anything, the Finns were strengthened by the crises. The structural reorganization was continued to retain the income level, especially since it was obvious that entry into the EU and EMU would eliminate the possibilities to create competitiveness through adaptations of the Finnish mark to developments in the surrounding world. The emphasis on technical development and upgrading was retained, and R&D was one of the few areas protected against financial cuts during the crisis.

So it is clearly valuable to incorporate the strategy of forming industrial clusters and cluster policy into plans for industrial development. Cooperation between different actors in the innovation system should be facilitated. The lesson learnt from the Finnish case is that it is favourable if different ministries, public and private research institutes, companies and consumer organisations can cooperate, and keep a close contact also with higher education in universities and research institutes. This is the functioning of STPC, which is a reviewing organisation with an advising function. It has greatly influenced Finnish research and technology politics. Its success as a rather independent think-tank depends on having representation from almost all important actors and a very strong backing from the government. It is led by the prime minister, and among the members you find the ministers of business and industry, finance, education, communication, defence and culture, and representatives of the private sector, industrial organisations, TEKES, Academy of Finland and environment organisations. Horizontal communications between business, research and authorities have the capacity to identify the weakest links in the system rapidly, to initiate a broad debate, and to take immediate actions. With the rather wide fluctuations that can occur in the competitive business world today, it is important to be able to react swiftly.

A cluster strategy in research policy appears to be very important for the efficient use of available national financial resources for R&D. Knowledge, created through R&D activities, can be spread to many companies for the benefit of an entire industry, if the conditions are favourable. However, the spread of knowledge depends on close contacts between an innovative company and other actors, and on the capacity of companies that are not carrying out R&D to receive the knowledge. To strengthen capacity to receive knowledge in small and medium-sized enterprises, it may be wise to direct public R&D-financing to companies and industries carrying out publicly financed R&D projects (often dominated by multinational enterprises, MNEs - like Nokia), supporting the cluster rather than a specific enterprise.

### 5.3 The Swedish 4.3% of GDP

Since the days of industrialization, Sweden has gone through many phases in its development. To create a good educational system in parallel with industrial development has been a part of the will of the political establishment. The period from 1950 to 1960 was characterized by a consensus policy referred to as the 'spirit of Saltsjöbaden' ('The Swedish model'), allowing piecemeal social engineering. This resembles the relation between political forces and industrialists developed in Finland during recent years. In Sweden, this consensus policy was abandoned in the early 1970s, after which the situation on the market became rather chaotic with strikes and lock-outs. An interesting analysis of the economic development in Sweden since industrialization was recently published by Deiaco, Giertz and Reitenberger (VINNOVA, 2002). These authors have analysed the role of technoparks and clusters in the Swedish innovation system. Their conclusions are in agreement with what we have learnt from the Finnish case. The authors emphasize the importance of cooperation between companies, society and research organizations, forming clusters and regional innovation systems. The clusters develop an internal competence - a silent, experienced-based knowledge, which develops over time and is difficult to reproduce. Nursing the clusters strengthens the competitiveness of the innovative environment, and the presence of big companies forces the development of SMEs. Close contacts with universities and institutes for higher education and research is considered important.

Since the beginning of the 1990s, Sweden has been investing more in R&D relative to GDP than any other country in Europe. In 2001, the total R&D expenditures amounted to 11 billion. About 1% of the workforce was involved in R&D activities. During the latter half of the 1990s, investments were made in education on different levels, especially in natural science and technology. However, as seen in the illustration reproduced from the work of Deiaco, Giertz and Reitenberger (VINNOVA, 2002), there has been no real increase in expenditures on basic research in Academe. Most people have access to mobile phones and computers and use the internet, not just at work. However, although the R&D investments are the highest, production, income and competitiveness in Sweden are closer to average in the western part of Europe. This has been referred to as the 'Swedish paradox'.<sup>1</sup>

Considering the fact that a number of the largest Swedish and foreign multinational companies have chosen to place their R&D in Sweden but to place a large part of their production in low-cost countries, there would seem to be a 'Swedish problem' rather than a paradox. However, there are factors that are slowing down economic development in Sweden, and a number of independent researchers and governmental institutes are

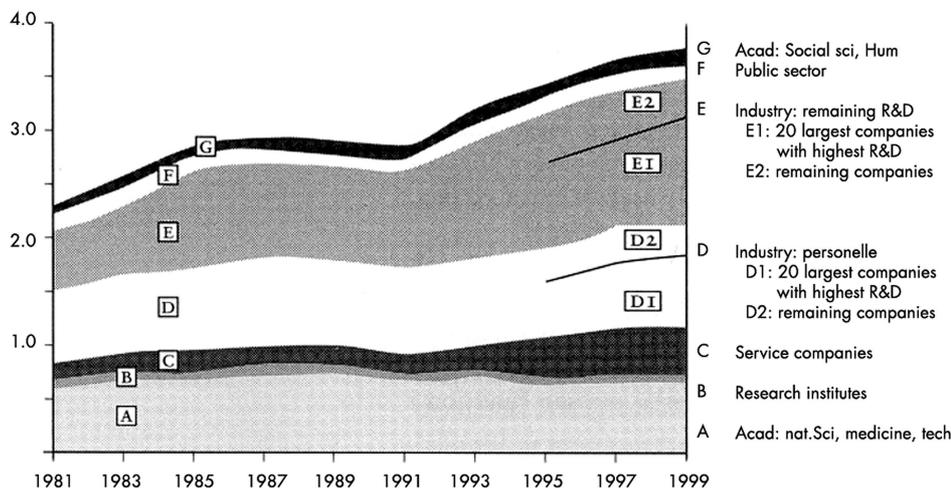
<sup>1</sup> See OECD STI-outlook 2002, country response to policy questionnaire. [http://www.oecd.org/document/55/0,2340,en\\_2649\\_34269\\_1962487\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/55/0,2340,en_2649_34269_1962487_1_1_1_1,00.html) and European Trend Chart on Innovation; Country report, Sweden <http://trendchart.cordis.lu/CountryPages/index.cfm?fuseaction=CountryTrend&CountryNumber=17>

involved in analyzing whether the problems concern the education system, taxes, the function of the market and its institutions, driving forces for entrepreneurship, availability of venture capital etc.

It is important to know what the Swedish 4.3% R&D

actually stands for. Many analysts believe that today the figure is significantly lower (perhaps below 4%), despite the fact that there are known R&D activities that cannot be included in the statistics because of lack of information.

**Figure 5.1 R&D spend as % of GDP**



Source: Deiacio, Giertz and Reitberger, 'Teknikparkens roll i det svenska innovationssystemet' (VINNOVA, 2002)

As seen in figure 5.1, by far the largest share of R&D spend is accounted for by activities in the 20 largest companies (see also Bager-Sjögren and Bergström Balkeståhl above). The R&D consists of basic research, target-oriented research carried out by the company, and development of processes and products. However, a significant part of the R&D spend reported may represent costs for consulting carried out for the large companies, and it is not clear to what extent this has influenced the R&D figures and the actual research and development. As seen from figure 5.1, the estimated spend on basic research is not that impressive. It is particularly alarming that the expenditures on basic research have not increased during the period 1981-1999.

The message is that efforts in the coming years in the different EU countries to reach the 3% target must be evaluated carefully to see what expenditures directly benefit the development towards a knowledge-based society in Europe. It is also important to realize that today many important developments come from discoveries made during basic research and that in fact several of the thematic areas supported by the 6th Framework Programme are based on such discoveries. Therefore, for the long-term development of Europe into the most competitive and dynamic knowledge-based economy in the world, there is a need for the development of highly competitive basic research.

In addition to the Long-Term Evaluations made directly for the Swedish Department of Finance, there are also a number of institutes, linked in various ways to the government, evaluating the performance of different sectors, assessing education and research, growth, and innovation strength in Sweden. There is no question that these evaluations provide important information about the development of Sweden in their respective areas, and, collectively, their results constitute a valuable basis for forming a policy for the future development of the country.

## 5.4 Education

Finally, it seems appropriate in this context to make a statement concerning education. As a consequence of research and development in a number of areas from the 1970s onwards, all of us have to learn to live in, and handle, an increasingly more difficult world. It is in this world of innovations and high density of information that the young have to find their place and make their living. All of us will need an improved all round knowledge, including natural science and technology, and for those who are to engage in R&D in the future the educational system has to be excellent. As I understand it the educational system has to be revolutionized. The situation for teachers at work has to be improved and the teaching of science to those who are choosing to become teachers

and teaching of the young have to be modernized to allow everybody to use their cognitive ability to its limits.

Efforts are being made in Sweden and in France to introduce systematic inquiry-based science and technology teaching in schools. Experimentation is at the centre of the teaching. In Sweden there is a program run by the Royal Swedish Academy of Sciences (RSAS) called Natural Science and Technology for All (NTA; <http://www.nta.nu/>). It is based on a programme created by the National Science Resource Center (NSRC) supported by the National Academy of Sciences and the Smithsonian Institution USA, and implemented in Sweden in 1996/97. It should be emphasized that we are dealing with an elaborate concept comprising a number of products and services, including, in addition to experimental set-ups, materials and manuals for teachers and pupils, involvement of politicians in the municipalities, teaching of teachers, and continuous evaluations etc. The concept had to go through a far-reaching adaptation to Swedish education culture. Today there are more than 2000 teachers and 40 000 children in more than 40 municipalities involved in NTA. In 2003 the municipalities formed a special organization called NTA Production and Service for supplying the municipalities with the products and service. A second organization called NTA-U will take care of the continued evaluation of the results of the program and of science education research in connection with NTA. The hope is that the NTA-program will reach all 287 municipalities in a period of 5-10 years. The introduction of the program has been financed by the Department of Education and a large number of private funds.

Recently, the Nobel laureate George Charpak of the Académie des Sciences took the initiative to form an alliance with the RSAS and academies in Estonia, Hungary and Portugal to produce an application to the EU for a project to the EU FP6 call March 2003 – Science and Society, European Science Education Initiative. The project is aimed at introducing inquiry-based science education. We have just recently been informed that this project has received a positive evaluation and the hopes are that it will be funded.

Eradication of science illiteracy requires a major effort in the years to come. It will have to be a central effort for European Union in the making of a knowledge-based society, where the citizens understand the material world and participate in the democratic decision process. Building science into policy is important. 'The way we teach today, tomorrow will be.' (Peter Medawar).

## 5.5 Contacts

The web addresses to the home pages of some of the institutes involved in the evaluation of the Swedish situation are listed here.

*ITPS* (*Swedish Institute for Growth Policy Studies*; [http://www.itps.nulin\\_english/index.htm](http://www.itps.nulin_english/index.htm)) is a Government agency responsible for policy intelligence, evaluation and various areas of official statistics. It provides a knowledge base for a forward-looking growth policy. Growth policy is defined as any policy designed to increase wealth in the country by creating better opportunities for providing supporting material to help policy-makers formulate policies for economic growth.

*VINNOVA* (*Swedish Agency for Innovation Systems*; [http://www.vinnova.se/index\\_en.htm](http://www.vinnova.se/index_en.htm)) integrates research and development in technology, transport and working life. VINNOVA's mission is to promote sustainable growth by financing RTD and developing effective innovation systems. Through a number of new books this agency has explored Swedish R&D. Several of their publications are in English. One of the most interesting publications (unfortunately no translation) deals with 'The role of the technology park in Sweden'.

*SISTER* (*Swedish Institute for Studies of Education and Research*; <http://www.sister.nu/>) started work on 1 January 2000. The Institute is an initiative for independent analysis and investigation of the Swedish educational and R&D system. The Institute has been set up jointly by four royal Swedish academies and four research-funding foundations (links to these organisations).

*NUTEK* (*Swedish Business Development Agency*; <http://www.nutek.se/sb/d/112/a/180>) is organised in four divisions: Entrepreneurship, Business Information, Business Financing, and Analysis.

*SNS* (*Swedish Centre for Business and Policy Studies*; <http://www.sns.se/english/default.htm>) is an independent network of leading decision-makers from the private and public sectors who share a commitment to social and economic development in Sweden. Its aim is to improve the basis for rational decisions on major social and economic issues, by promoting social science research and stimulating public debate.

## 6 The role of R&D in Hungary

Gyula Horváth, Centre for Regional Studies, Hungarian Academy of Sciences

### 6.1 R&D – loser of the transition period

Research and development declined significantly in Hungary during the transition period. R&D expenditures as a percentage of GDP were 2.70 % in 1987, 0.75 % in 1995 and 0.94 % in 2001. The number of personnel employed in R&D also shows a steep decline and the Hungarian figures are rather low in international comparison. While in 1987 every 13th person with higher education was employed in the R&D sector, in 2001 this figure was 26, that is the ratio decreased by half.

It seems that none of the three successive governments since 1990 has taken seriously the important role of science for the future progress of the country. Although, on the level of declarations, all of them acknowledged its importance, in practice the situation has deteriorated.

Science and technology policy is repeatedly defined in the 2002 government programme as an increasingly important government tool to promote the development of the society and economy. The further continuous growth of the R&D expenditures will be provided by direct budget allocations and indirect economy and science policy incentives.

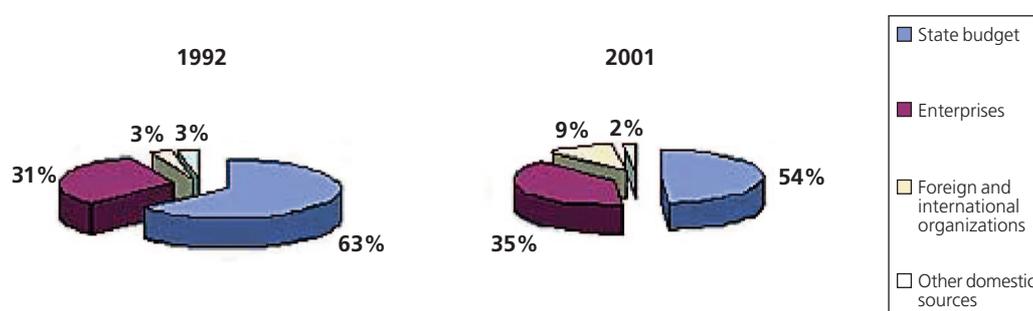
**Table 6.1 Principal data of research and development**

Year	Number of R&D units	R&D staff	R&D staff as % of active earners	R&D expenditure, total (billion HUF)*	R&D expenditure as % of GDP
1991	1 257	29 397	0.63	27.1	1.09
1992	1 287	24 192	0.57	31.6	1.08
1993	1 380	22 609	0.58	35.3	1.00
1994	1 106	22 008	0.59	40.3	0.93
1995	1 442	19 585	0.54	42.3	0.75
1996	1 461	19 776	0.55	46.0	0.67
1997	1 679	20 758	0.57	63.6	0.74
1998	1 725	20 315	0.56	71.2	0.70
1999	1 887	21 329	0.56	78.2	0.68
2000	2 020	23 534	0.61	105.4	0.82
2001	2 333	22 930	0.59	140.6	0.94

Source: Kutatás és fejlesztés (Research and development) 2001, Budapest, KSH, 2002

\* 250 HUF= 1 Euro

**Figure 6.1 Expenditure by financial sources, 2001**



Source: Research and development. Various years

Policy targeted to production related innovation has a priority in the Government programme. Investments are based on advanced technology, highly skilled workforce and cooperation with local development initiatives. The government defines four priority areas:

- a legal framework conducive to innovation
- making Hungary attractive as an R&D site
- enhancing the protection of intellectual property
- increasing the role of SMEs as sources for innovation

The regional coordination of innovation has to be strengthened to provide all regions with significantly more domestic and international sources for science and technology.

The Government programme declares that both the state and the business community have to fulfil their role in ensuring that research, development and industry are brought closer to each other and placed in the service of the country's economic advancement. To achieve this, the country needs coordinated education, research, development and innovation policies, as well as measures to stimulate the research and development activities of the private sector. The national programmes formulated in this spirit include the main directions of development, taking into account the economic, social and political changes in the world as well as Hungary's national characteristics.

The National Development Plan places knowledge society and knowledge economy in the middle. Hungary joins the European Union on 1 May 2004, and then will be entitled to receive subsidies from the Structural Funds of the EU. The main strategic objectives of the NDP are in harmony with the future scenario describing the successful establishment of a knowledge-based society in Hungary, although sometimes only indirectly, because of the different time frames. Along the development pathway described in the 'Creative Hungary' scenario, mainly by efficiently utilising the EU resources, the country will soon

successfully step into the development's innovations controlled period from the investment controlled period. This allows Hungary to maintain the high growth rate characteristic of the reconstructing transition period, so that by 2015 it will catch up with the developed member states of the European Union in several fields. The continuous improvement of the quality of life is ensured by an ecologically and economically sustainable, regionally balanced development that is based on the competitiveness and profitability of the knowledge-based economy.

In the frames of the National Development Plan, R&D and innovation are treated in the Economic Competitiveness Operational Programme, along with further important topics like information society, investment incentives, SME promotion and tourism. All existing and planned R&D and innovation actions are organised in three large measures:

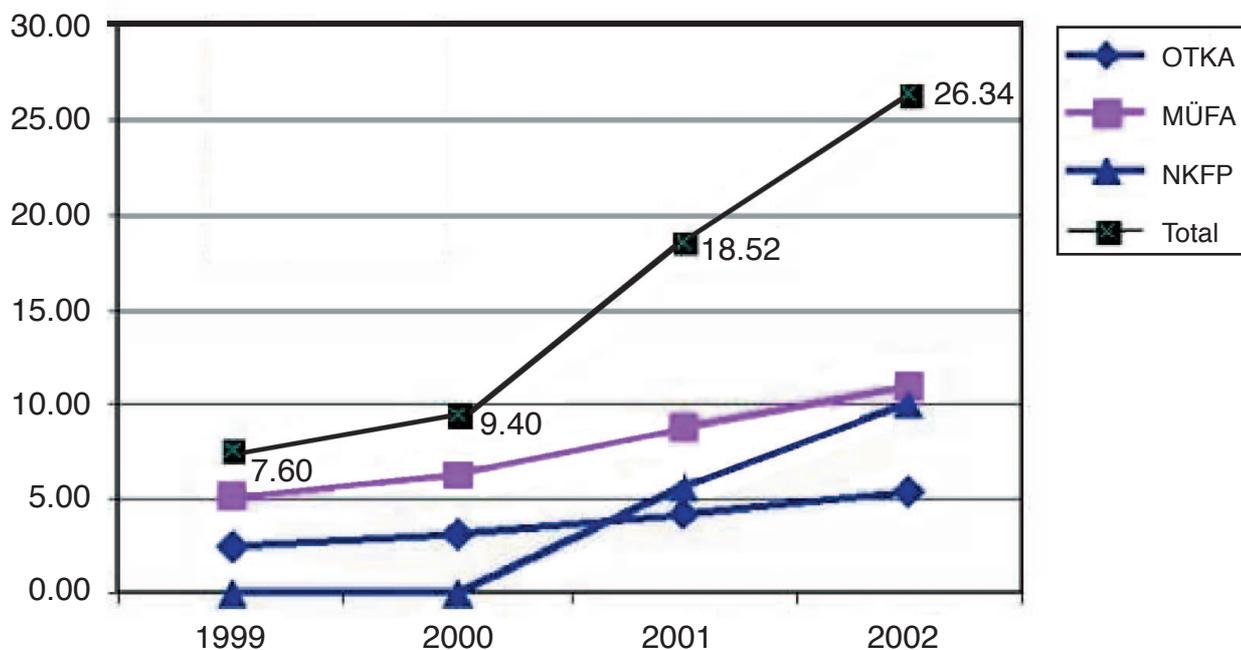
- Strategic and cooperation research and technology development projects
- R&D resource and infrastructure development for the research institutions, development of human resources for innovation
- Innovation skills, innovative networks and resources

## 6.2 Promoting innovation: government policy

The Gross Expenditure on R&D (GERD) as a percentage of GDP is still fairly low in the European context as well as compared to most of the OECD countries. As a result of the substantial economic and financial challenge that accompanied Hungary's transition to a market economy, state subsidies as well as the business spending for R&D and innovation dropped significantly in the 1990s.

Figure 6.2 shows the growth of the sources of the three major R&D programme allocated by the budget law of the Parliament.

**Figure 6.2 Financing of the three large R&D funding systems (in billion HUF)**



Source: Ministry of Education

In Hungary, there exist mainly two types of governmental support for R&D and innovation in the private sector: tax incentives and direct non-refundable state support through calls for proposals.

From January 2001 companies can account for their R&D expenditure at 200%. This option is now also available for extramural (subcontracted) R&D activity not carried out in the companies themselves.

Also from January 2001 the amortisation (depreciation) of all R&D investments is flexible, and its rate depends on the company. From January 2003 further incentives were introduced, such as the option for tax-free investment reserves up to 500 M HUF, accelerated amortisation of ICT investments, 70 % tax release for R&D donations and faster tax reimbursement etc, making innovative activities and the overall entrepreneurial conditions more favourable.

### 6.3 Programmes for research and technological activities

(i) *National Scientific Research Fund (NSRF)* was established in 1986, supervised by the Hungarian Academy of Sciences. Since 1991, it has been operating as an independent organisation. The mission of the NSRF is to support basic research, the development of R&D infrastructure and the scientific work of young researchers. The Laws XXII of 1993 and CXXXVI of 1997 provide the legal base for its operation.

(ii) *National R&D Programmes*. The Government decided in 2000 to launch the NRDPs included in the document 'Science and Technology Policy 2000'. The programmes covered the following five fields:

- improving the quality of life;
- information and communication technologies;
- environmental and materials science;
- agribusiness and biotechnology;
- the national heritage and contemporary social challenges.

The purpose of the NRDPs is to support the implementation of comprehensive research, development and innovation projects. The programmes are intended to concentrate on financial and intellectual resources, to synchronise basic and applied research with technological development, to strengthen and ensure the efficient utilisation of national research and development capacities and to improve international scientific competitiveness. The programme promotes the R&D projects of consortia leading by HE or R&D institutes and containing the companies taking part in the usage of R&D results.

(iii) *Calls for proposals in applied research.* The National Technology Development Fund (NTDF) supports applied research through a competitive call for proposals. Its goals are defined by the Government Regulations of 1996 and of 2001 as promoting technological innovation, development of R&D infrastructure, and the dissemination and economic application of development results. The main ongoing calls for proposals supporting business R&D are as follows.

- Promotion of applied research, calls for proposals in applied research. The aim is to promote applied research and technical development based on national and international cooperation creating new, up-to-date, valuable, marketable products, procedures and services as a result. Preference is given to enterprises that intend to cooperate with a university, college, public research institute or non-profit R&D organisation in order to implement the development; as well as projects generating a clearly detectable economic result in a short time.
- Application of information and communication technologies. The aim here is the development and testing of new marketable information and communication procedures, tools and services; establishment of large, information infrastructure with a large bandwidth, based on experimental and modern technology, in the computer network of higher education and research institutions; in addition, promotion of the establishment and dissemination of new digital information systems and services based on image technology, as well as other technologies and skills related to those.
- Biotechnology, with the aim of improving the competitiveness of Hungarian biotechnology enterprises, and creating modern, valuable marketable biotechnological products, procedures and services, where advantages can be achieved without constituting a risk to human health or environment, taking into account the ethical requirements. The priorities within the programme include the safety of foodstuffs, biomass utilisation, bio-remediation, bioconversion, phyto-technology, biomedicine and biopharmacology. Preference is given to projects related to international programmes and projects that promote the process of EU accession, as well as enterprises that engage in the development in co-operation with a university and/or research facility.
- Environmental research activities, with the aim of developing technologies and products related to the prevention of environmental pollution, and representing a smaller load on the environment. A further aim to improve the competitiveness of the environmental protection industry. Preference is given to projects aimed at the development of

'cleaner' products and technologies, recycling of waste, development of combustion equipment with low emission, equipment using renewable energy sources and purification of communal waste water in small settlements.

- Cooperative research centres (CRCs), in which close relations could be developed between Hungarian higher education institutions, other non-profit research facilities and members of the corporate and business innovation sector, and in which education, research development and knowledge and technology transfer can be integrated for strategic purposes. CRCs can only be established together with business partners. The leading institutions of the consortia may only be an institution offering PhD training and accredited by the Hungarian Accreditation Committee.
- Applied research development activities in high technology, where the aim is to establish a research facility, either as an individual economic organisation, or as a separate organisation unit in an existing business organisation, with which the development and introduction of modern technologies can be achieved. At least HUF 500 million investment is required for the establishment or an extension of a research base, in which, within six months from the completion of the investment and start of operation, the employer will employ at least 30 people in new full-time jobs. The employees must be researchers, with qualifications from a higher education institution. The established research facility and the new (extra) research development employees must be used and employed in accordance with the original purposes for at least five years.

(iv) *The Research and Technological Innovation Fund.* Law XC on the Research and Technological Innovation Fund was accepted by the Hungarian Parliament in November 2003. The RTIF is intended to enable the R&D expenditure of the national economy to increase perceptibly after the recent drastic decreases.

With the establishment of the Fund a totally new situation will occur in the national support of research & development and innovation. The central source for subsidising research and development will grow by 20-40 % in the coming years, and R&D activities with a market focus will be multiplied. The source of the demand-led research and innovation supporting policy will be established with this. At the same time it will be possible that critical sized research-development projects, necessary for the technological and market changes, would participate in bigger centre support than before.

The two main income sources of the Fund are innovation duty – paid by the companies – and budget support. The base of the duty-payment is the

net income of the business year. The annual amount of the duty is 0.2% of net income in 2004, 0.25% of net income in 2005 and 0.3% from 2006.

The Fund may be used for the following aims:

- as security for R&D costs and the realization of R&D results, and spreading the application of R&D results, including the financing of the national R&D programmes and projects;
- to develop the infrastructural conditions of R&D and technological innovation, including participation in international R&D networks and infrastructure, in harmony with the international commitments of the Hungarian Republic;
- to support the network-building activities of the services underpinning R&D and technological innovation, including the costs of conferences, exhibitions, publications;
- to inspire technological innovation in the regions and municipalities and to increase their innovation capacity;
- to support international scientific and technological cooperation;
- to create R&D posts, to develop human resources, to supply the researchers, to support training; to support national and international mobility, exchange of experiences of researchers, to support the professional integration of researchers returning to Hungary;
- to obtain national and international scientific and technological knowledge.

## 6.4 Territorial structure of research and development

The bulk of research and technological development is carried out in publicly-financed research institutes, which are highly concentrated in Budapest. Around 60 % of all employees in R&D institutions work in the capital and its surroundings (13 128 scientists and engineers). Only 18 of Hungary's 63 R&D institutes are located in non-metropolitan areas. Of the 183 corporate research and development units, 108 operate in Budapest. Many large regional centres such as Pécs, Szeged, Győr, Debrecen and Miskolc have higher education institutions with research activities or other research institutions. These five cities account for another approximately 20-25 % of all employees in R&D. Public R&D expenditure is almost insignificant in small and medium-sized towns. Only three counties are over the average of 0.94 %, with Budapest and Csongrad producing particularly outstanding figures. The rest of the country carries out very little R&D.

Counties from the Northeast, South Transdanubia and the Northern Great Plain lag at the very end. Not even the winning western counties produce significant figures. Komárom and Vas counties are among the five last.

Assessing innovation performance through the measurement of R&D expenditure and personnel might be thought to imply that expenditure automatically leads to a new commercial product, which is clearly not always the case. During the communist regime, Hungary typically had high expenditures and high numbers of employees in R&D but produced few marketable products. Alternative indicators such as business expenditure on R&D (BERD) are more appropriate. Measuring BERD slightly alters the picture of Hungarian regions in terms of R&D activities. The preponderance of the central region is even more striking in business-related research. Budapest and its surrounding county absorb around 80 percent of expenditure and employ three-quarters of business R&D personnel in Hungary. The South Great Plain (the country's second-ranking scientific centre) primarily operates research institutes in the public sector, while West Transdanubia, which has considerable business research capacity, lacks university research centres. Research capacity in both sectors is rather weak in South Transdanubia and the Northeast.

To complete the analysis on recent research efforts, statistics on patents are often referred to. Hungarian performances in this respect are particularly modest. In 1998, the Hungarian Patent Office received 44 913 patent applications, the great bulk of which (98.6 percent) were submitted by foreign companies, against an almost insignificant number submitted by Hungarian companies (only 727). Their spatial distribution is, therefore, irrelevant. This suggests serious problems with the innovation culture, dissemination of research and technology and social capital.

## 6.5 Comments to the Finnish and Swedish case studies

The success stories of Finland and Sweden cannot simply be transposed to other countries, since the starting conditions are very different. But some lessons can be applied to eastern European countries, notably that government policy should concentrate on the facilitating conditions.

Consensus among those concerned with economic and public policies is central to increasing R&D spending in both public and business spheres. Hungary has to learn how to build consensus on the importance of R&D as a driver of economic and social development.

One of the secrets of increasing spending efficiently is strong cooperation between the elements of the innovation chain. Public-private partnership as a starting point of the synergy-effects should be supported.

State subsidies should include the target of diminishing regional disparities in R&D spending. In this respect a strong coordination is needed between regional and industrial policies.

In the process of reforming structural fund, the new requirements of cohesion and competitiveness policies have to be taken into account.

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# 7 Benchmarking R&D investment: a perspective from the USA

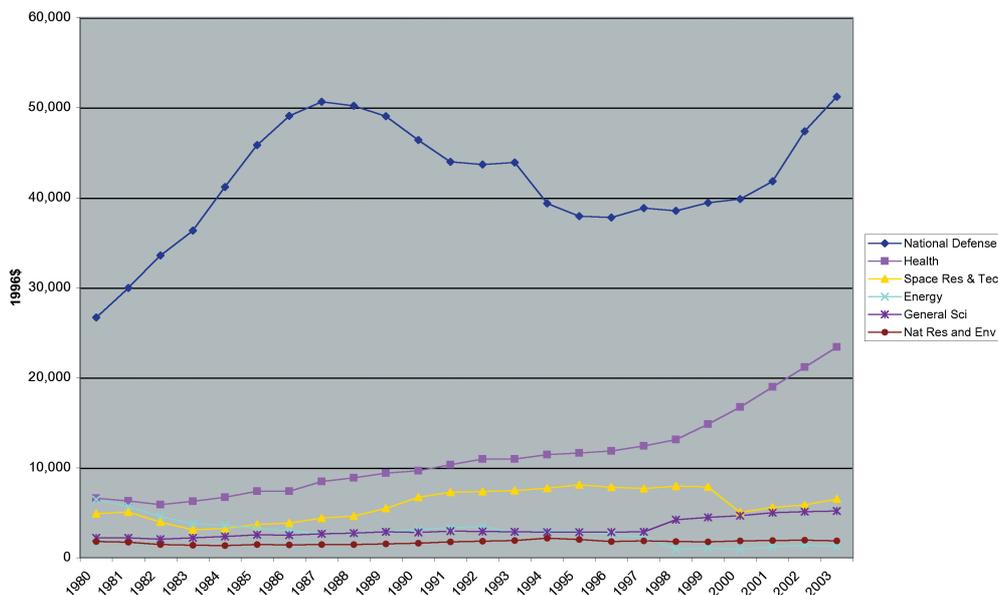
Steve Merill, Executive Director Science, Technology and Economic Policy, The National Academies, Washington DC

As in the European Union, the United States is resuming a national innovation policy discussion spurred by a decline in manufacturing employment and migration of many manufacturing and service jobs overseas. This will be an occasion to assess significant changes over the past two or three decades in the composition of US research and development and the policy environment for financing

and utilizing the results of R&D.

A preliminary survey<sup>1</sup> suggests that US strengths include the sheer size and diversity of the national R&D portfolio, a decline in the defence share of that portfolio since the mid-1980s (despite a sharp increase in defence spending after 2001; figure 7.1), and an increase in the private sector share.

**Figure 7.1 Federal R&D by budget function**



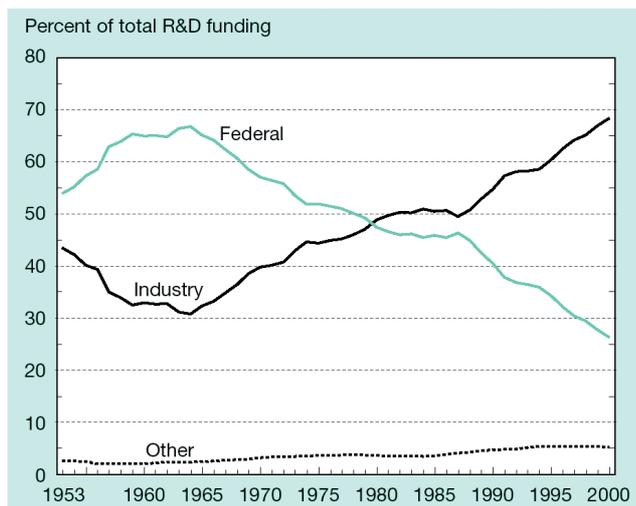
Source: NSF

Federal government spending exceeded industrial investment until 1980; by 2000 industry and federal shares of total R&D spending were approximately 70 % and 25 %, respectively (figure 7.2). In terms of R&D

performance, industry accelerated after 1980 and between 1994 and 2000 grew at a remarkable rate of 7.0 % in real terms (figure 7.3).

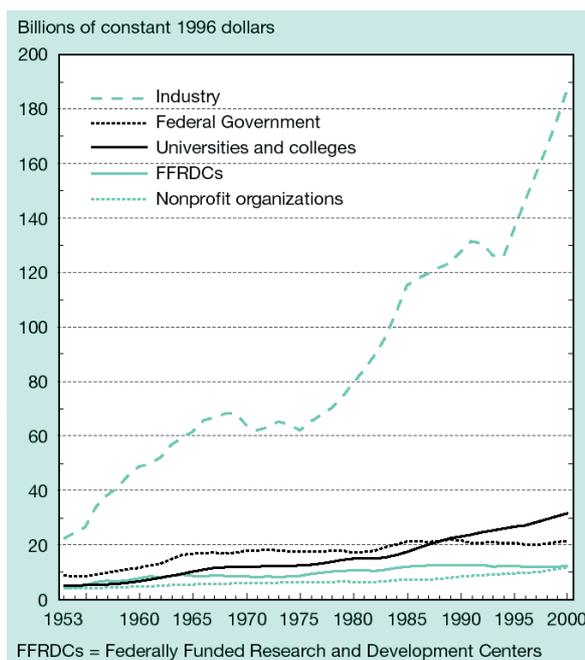
<sup>1</sup> Data are from National Science Foundation, Science and Engineering Indicators 2002, Arlington, VA.

**Figure 7.2 Public and private shares of R&D**



Source: NSF

**Figure 7.3 R&D performance by type of performer**



Source: NSF

Favourable environmental conditions include the extension and strengthening of intellectual property rights enhancing the appropriability of R&D results, the fiscal stimulus to private investment provided by tax policy, the availability of capital for technology-based startup enterprises, the openness of the United States to foreign contributions via direct investment and temporary and permanent immigration, and growing cross-sector cooperation, between industry and government and between industry and universities.<sup>2</sup>

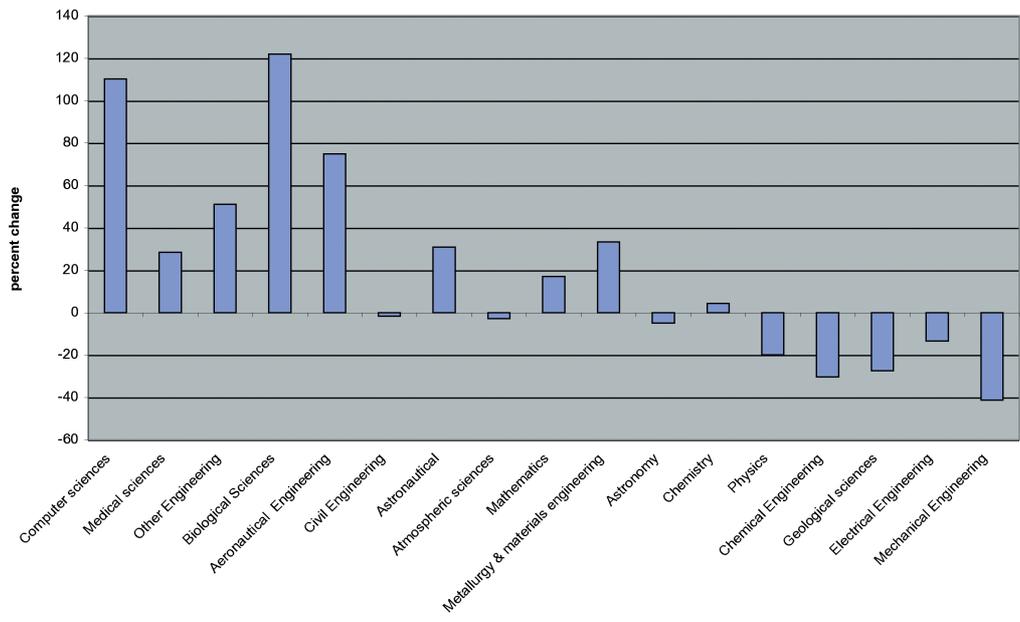
The United States nevertheless has significant vulnerabilities. For almost a decade, the post-Cold War

decline in defence and space R&D spending yielded declines in public support of basic and applied research in most physical science and engineering fields apart from computer science, not just in relation to the prospering health sciences but in real terms. And these reductions, between >10 % and >40 % from 1993 to 2001 in the cases of physics, chemical engineering, geology, and electrical and mechanical engineering (figure 7.4), correlate with a drop in graduate student enrolments, of both US and foreign nationals, and even a drop in US-authored publications in those fields.<sup>3</sup>

<sup>2</sup> W. Cohen and S. Merrill, eds., *Patents in the Knowledge-Based Economy*, Washington, DC: National Academy Press, 2003; C. Wessner, ed., *Government-Industry Partnerships for the Development of New Technologies*, Washington, DC: National Academy Press, 2003.

<sup>3</sup> S. Merrill, ed., *Trends in Federal Support of Research and Graduate Education*, Washington: National Academy Press, 2002.

**Figure 7.4 Shifts in federal research support, 1993–2001**

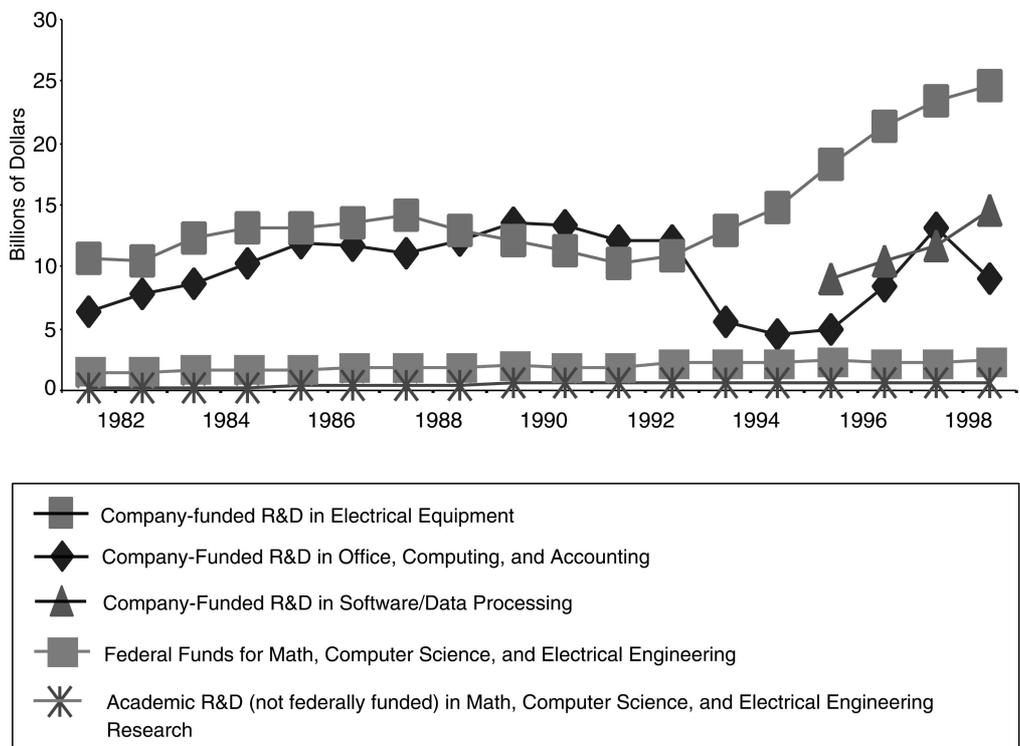


Source: NSF Federal Funds Survey

It is also the case that company-funded R&D has not been increasing uniformly across the IT sector (figure 7.5), whereas pharmaceutical and biotechnology industry

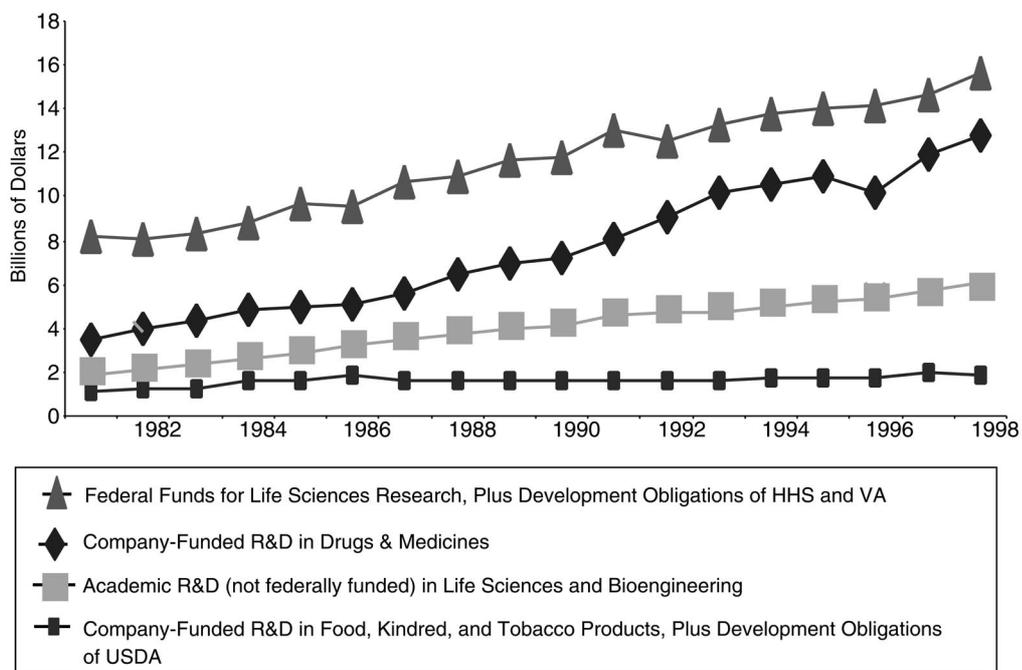
spending has accelerated in tandem with the National Institutes of Health budget (figure 7.6).

**Figure 7.5 National investment in IT R&D, 1981–1998**



Source: Various NSF surveys

**Figure 7.6 National investment in R&D related to life sciences, 1981–1998**



Source: Various NSF surveys

Other vulnerabilities include a comparatively very weak central science and technology policy apparatus that until very recently failed to document, evaluate, and seek to compensate for these trends. A renewed priority on national security has to some extent reversed the decade of neglect of the physical sciences and engineering but poses some threat to the openness of the US science and engineering enterprise. Meanwhile, the productivity and

efficiency of the pre-university education system remain poor.

The size of the US economy and population has helped compensate for and mask such weaknesses, which is why (among other reasons) China and India loom as formidable competitors in a growing number of high technology industries in the years ahead.

## 8 Intellectual property and investment in research

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### Abstract of talk

Intellectual property rights have become one of the most important pillars in the global knowledge-based market economy. Ever-increasing numbers of patent applications, of royalties paid for patent licenses and of the market value of manufacturing industry on the stock market reveal that. Academic research institutions, especially in the United States, have become major players of innovation. Their importance is best demonstrated by the fact that, based on licenses granted, for instance by US universities, hundreds of thousands of new jobs have been created. The US legislator, by adopting an adequate legal framework and adequate financing of academic research endeavour, has widely contributed to these developments. Especially the Bayh-Dole Act and the Stevenson-Wydler Act of 1980 enabled publicly funded institutions in the US to start successful commercialising of their research results, not least by successfully protecting them through intellectual property rights. A number of most important drugs have their origins in US universities.

The United States, also by the 21st Century Strategic Plan, and Japan by its newly established Strategic Council on Intellectual Property, directly attached to the Office of the Prime Minister, have fully realized the importance of intellectual property for investment in research, as well as for defending and improving their competitive positions in the global economy. By contrast, European countries and, more specifically, the European Parliament still struggle in accepting the overall beneficial effects of intellectual property rights for the European economy especially in areas of new technologies, such as biotechnology and communication and information technologies.

One example of this hesitation and scepticism in Europe is the slow implementation of the European Directive on the Legal Protection of Biotechnological Inventions (98/44/EC), which had to be implemented in national laws by 30 July 2000, but has so far been implemented only by seven Member States.

A second example is the 118 amendments put forward by the European Parliament to the proposed Directive on Patentability of Computer-Implemented Inventions. This move watered down the proposal of the Commission and would, if accepted by the Council and Commission, actually make patents worthless in an important area of the European industry and science.

The third example is the never-ending process of adopting a Community Patent System. These three demonstrate the gap between Europe on the one hand and the United States and Japan, and more and more also China

and possibly India, on the other, in prevailing perceptions towards intellectual property rights as an important tool not only for innovation but also for competitiveness in the globalised economy.

Apart from a more general discussion of the issues at hand, the presentation offers empirical data underlying the topics addressed. It shows that those European countries which have the highest investment in research and development, namely Finland and Sweden (and outside the Union Switzerland) are also leading in patent applications per capita. Moreover, specific desiderata are expressed also as far as the needs of the non-industrial research area is at stake:

- to pay adequate attention to the needs of academic research;
- to harmonise and determine the research exemption in patent laws Europe-wide;
- to introduce an adequate grace period in order to provide a safety net for unintended publication of important research results eligible for patent protection; and
- to provide for an adequate legal framework and funding of non-industrial research, along the lines of the past and successful US developments.

