Science policy and research in Finland

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Husso, Kai & Pauliina Raento (2002). Science policy and research in Finland. *Fennia* 180: 1–2, pp. 261–274. Helsinki. ISSN 0015-0010.

We investigate the evolution of Finnish science policy and its impact on universities and scientific research. Finnish research is currently enjoying far greater international visibility, impact, and esteem than previously. The role of universities in society has broadened. Apart from their traditional tasks of research and teaching, universities have established closer links with business and responded to regional needs. A number of national reforms carried out in the 1990s launched a heated debate between universities and public authorities. Contested topics include the 'centre of excellence' policy, large-scale research programmes, and graduate schools. These reforms injected new dynamism into Finnish universities, but created new challenges as well. The structure of university research funding changed significantly during the 1990s. In real terms, research expenditure covered from Government budget sources increased by 17 percent, while external, often competitive funding increased by twofold. We believe that this dependency on outside funding may make research more short-sighted and vulnerable over the long run. In order to maintain the quality of Finnish research, science policy ought to be anchored to the needs of universities and scientific research more firmly than during the 1990s and budget funding ought to be increased. These actions would guarantee a more stable development of scientific enterprise and thus strenghten the positive socio-economic impact of research on regions and on society as a whole.

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Introduction

The contributions of universities and scientific research to the welfare of a nation and to its competitiveness have attracted growing attention in all OECD countries since the 1960s (e.g., Government… 1966; General… 1971). This interest reached completely new heights in the 1990s. It is now widely agreed in Western industrialised countries that a highly trained workforce, research, and technological development are the key conditions for innovation and economic success of a country or a region (e.g., Technology… 1998; OECD… 2000). The role of universities and scientific research has thus taken on new political and economic emphases. For example, according to the OECD, there is a "growing demand for economic relevance" of research and "universities are under pressure to contribute more directly to the innovation systems of their national economies" (University… 1998: 8). In the OECD countries, universities have seen this kind of views as a threat to their traditional principal task, i.e., long-term basic research. The Finnish debate regarding the role of scientific research and universities in the country's (regional) economic development has been very lively since the mid-1990s (e.g., Allardt 1997, 1998; Raivio 1998; Häyrinen-Alestalo et al. 2000).

Knowledge and know-how are vital to the production of goods and services. During the past ten years, production has become increasingly based on the efficient use and application of scientific knowledge, on the extensive utilisation of new technologies, and on the command of complex production processes. This trend is evident in the national and international statistics on research and development (R&D), technology, and innovation (see Main… 2001; Science… 2001; Towards… 2001). These statistics show that in most of the OECD countries, R&D expenditures, the production volume of high technology products, the turnover and employment of R&D-intensive companies, and the volume of foreign trade in high technology products have increased significantly. According to these statistics, Finland has done well from the early 1990s onwards. The image of Finland as an R&D-intensive hi-tech country is nevertheless quite recent.

In this article we investigate how Finnish science policy and conditions for scientific research have changed over the past twenty years. The aim is to answer two questions: »What are the current problems and immediate future prospects of universities and scientific research in Finland?» and »How does Finland rank among the world's top research countries?» We will place these questions in the context of public debates on science policy and universities. Our material consists of recent domestic and international statistics on R&D investments and data on the outputs and impacts of scientific research on society. The volume of investment in R&D can be considered an indirect measure of a society's innovation potential and of the status and prestige of research in general. These figures also reflect the R&D- and technology-related economic potential in individual countries and regions.

Science, technology, and economic development

The role of R&D and high technology in national and regional economic development has been studied through the concept of *techno-economic paradigm* (e.g., Freeman 1987, 1992; Freeman & Soete 1987; Dosi et al. 1988). The paradigm refers to the technological changes in industrial and service sectors over time and at different geographical scales. Currently, the focus is especially on hi-tech industries and fields of research that specialise in electronics, information technology and biotechnology, and on production and production process innovations based on these technologies. From the viewpoint of regional development, a novel feature is the mushrooming of new centres of expertise, each with its own area of specialisation. These centres are typically located near universities, public research institutes, and industrial and service businesses that rely on new research and technologies. There exist also various kinds of spin-off companies whose business concepts are based on current technological solutions. The changes in economic activities in regions and the co-operative relations inside and between regions are partly the outcome of the dynamics of technological change.

According to Freeman and Perez (1988: 47–49, 58–59), the concept of techno-economic paradigm refers also to a combination of interrelated technological, organisational, and managerial innovations that embody an increase in productivity for all or most of the economy. This opens up a new range of investment and profit opportunities. Such a change implies a new combination of technological and economic advantages. One needs to bear in mind, however, that a full constellation of the current paradigm's characteristics goes far beyond the technological change itself. The paradigm brings along a restructuring of the productive system and new forms of interplay between the actors of the economy. Thus, at stake are also social and cultural changes, and new types of market behaviour adopted by private and public organisations. In addition, the current paradigm involves (a) new 'best-practice' forms of organisational structure in firms and research establishments; (b) increasing demand of high quality labour force in the knowledge-intensive sectors of economy; (c) new patterns in the location of investment both nationally and internationally; (d) increasing public and private funding devoted to activities which enhance the capacity to create, introduce, and apply new knowledge in the private sector; and (e) new waves of investment designated to facilitate the wide use of the new products and processes in the economy (Freeman & Perez 1988: 59; Freeman 1992).

The described developments have led to a situation where information has become a highly valued commodity and know-how an important production factor. This has highlighted the importance of investment in technological development in business firms and scientific research conducted in universities. Given the key role of research and high technology as engines of industry, governments have naturally wanted to develop their political measures. Indeed, most of the OECD countries (including Finland) made a conscious effort in the 1990s to enhance their science and technology policy measures and integrate them in industrial and regional policies more closely. Governments have increased their own R&D financing, supported development work conducted by business companies, and promoted co-operation between companies, universities, and public research institutes (Technology… 1998; OECD… 1999, 2001). The development of Finnish science system illustrates the benefits and threats that these changes in the economic and political environment have presented to universities. Especially in recent years, both policy-makers and the end-users of R&D findings and new knowledge have begun to underline the importance of applicable research results.

The development of the Finnish science system

The relationship of Finnish universities and scientific research with the surrounding society has faced almost constant pressure of change since the late 1950s (see Paavolainen 1975; Skyttä 1975: 267–280). The current pressures are therefore nothing new. The emphasis of the debate has fluctuated over time, but some of the themes and issues have remained constant, as we will demonstrate later. Table 1 describes the main periods and events in the development of science policy and operational environment of universities in Finland.

The systematic development of the national science system was launched during the late 1960s and early 1970s, following an extensive debate in the 1960s regarding science policy, the social significance of scientific research, and the importance of industrial R&D. It was believed that research and technology could help to alleviate social problems and increase welfare in society. The public sector began to support industrial R&D by investing more in research and promoting industrially-oriented applied research. Budget funding for universities was increased significantly. In 1966–1970, expansion of the university system was initiated, the science administration was reorganised and the Academy of Finland was established (1970)[1]. With increasing funds at its disposal, the Academy began to support university research.

R&D in Finland was still fairly limited in the early 1970s in comparison with most other OECD countries. The development of the national science policy and universities was continued under favourable atmosphere until the mid-1970s, however. The oil crises then sent the economy to a long-term recession causing the Government to cut back its budget funding to universities. During that period, balanced and 'experimental' development of the science system was severely disturbed, as were the conditions for conducting basic research.

The 1980s: a decade of growth

Economic stagnation in the late 1970s and early 1980s caused serious problems for traditional industrial production in most of the OECD countries. At that time, industrial countries started to turn to new high technology and other fields of special expertise. It was believed that economic up-swings and future market growth would be based on knowledge and products of information and communication technologies. In Finland, the decision to favour research-oriented economic and political strategies was supported by the relatively high standard of the country's education system and by the development of the national science system in the 1960s and 1970s.

R&D expenditure increased favourably throughout the 1980s (Fig. 1 & CD-Fig. 1). Overall, this decade was a period of stable development of the science system and its infrastructure. In a drive to increase welfare and affluence in Finland and to strengthen the competitiveness of the national economy, the Government pursued a consistent policy of promoting R&D, investing in the production of hi-tech products and increasing the share of these products in the country's exports. The same priorities formed the basis of the science and technology policy of the 1990s and continue to be highlighted today.

Budget funding for universities and resources allocated to public research institutes increased steadily during the 1980s. The status of research and researcher training were strengthened. These favourable developments were in large part made possible by legislation aimed at the development of the universities. For example, the 1986 Act on the development of universities guaranteed a steady increase in the amount of appropriations to universities until 1996. The resources made available to the Academy of Finland also continued to increase.

Measures introduced to encourage research and development in business companies included tax concessions. Another significant measure was the founding of the National Technology Agency[2] (Tekes) in 1983. The Agency began to

Table 1. Main periods of the development of science policy in Finland (see Paavolainen 1975; Häikiö & Hänninen-Salmelin 1979; Kaukonen 1987; Suomen… 1988; Raatikainen & Tunkkari 1991; Häyrinen-Alestalo et al. 2000; A forward… 1993; Husso & Raento 1999; The graduate… 2000; Husso 2001).

–1959:	Period before systematic (state-steered) science policy. Post-war industrialisation and social changes increase awareness of the need to step up investment in research and higher education. The Academy of Finland is established in 1947. In the late 1950s, there is growing recognition of research as more than just Humboldtian 'higher cultivation of the mind'.
1960–1969	The construction of the basic organisational infrastructure of science policy and research is initiated. The Act regarding the organisation of scientific research goes into effect in 1961. In 1966, a new statute is passed on the reorganisation of the Council for Higher Education and the Ministry of Education, together with legislation on the development of universities in 1967–1981. Expansion of the regional foundation of the university system is initiated: eight regional universities are established during 1966–1979.
1970–1975	Period of science policy planning and 'experimentation'. Systematic development of the science system gets under way. Science administration seeks firmer control over the contents and direction of research (e.g., research foci identified by the Science Policy Council). The Academy of Finland is established in its current form in 1970.
1975–1979	Science policy in decline. The need to reform science policy is debated because universities feel ignored in decision-making on science policy lines and research priorities. In 1977, imbalances in research funding are growing, with cutbacks introduced in budget appropriations to universities (the 1976 level is not reached until 1984).
1980–1990	Revival of science policy. Numerous committees (nominated by the Ministry of Education) make determined efforts to strengthen the position of basic research. R&D expenditure in universities increases by twofold in the 1980s, but universities become increasingly dependent on outside funding. Relative status of universities weakens: they receive 42% of government research funding in 1970, but only 26% by 1986. Industrial-economic and social needs steer scientific research increasingly in the late 1980s. The Ministry of Education's demands lead to the development of a new steering philosophy (management by results) in universities.
1991–1995	Universities are in a state of emergency. Their budget funding reduces dramatically during the recession. The planning of new science policy and new measures begins (Centre of Excellence policy, large-scale research programmes, graduate school system). Government sees investment in knowledge and R&D as a solution to economic problems. The impacts of globalisation and the need to further internationalisation and co-operative networks of the science system are debated. Budgeting of universities based on operational expenditure and performance agreements between universities and the Ministry of Education are adopted in 1994.
1996–	First concrete steps towards a national innovation system. Co-operative activities between R&D performers and funding organisations increase rapidly. The total R&D expenditure in universities grows faster than ever before. Government financing of R&D is increased by FIM 1.5 billion (EUR 250 million) in 1997–1999 (from 1997 budget appropriations). This is exceptional in the OECD. Budget funding for universities in real terms is still lower in 1998 than in 1991 (despite the increase in total R&D expenditure). Simultaneously, calls for measurements of outputs of universities grow louder: research results need to show greater social and economic relevance. The graduate school system's aim to improve the quality of researcher training is fairly successful. Universities disagree over the fairness of the Centre of Excellence policy. The Government increases the Academy of Finland funds in 2001 (overhead payments to universities and a new Centre of Excellence programme). Universities consider this insufficient because of their difficult economic situation.

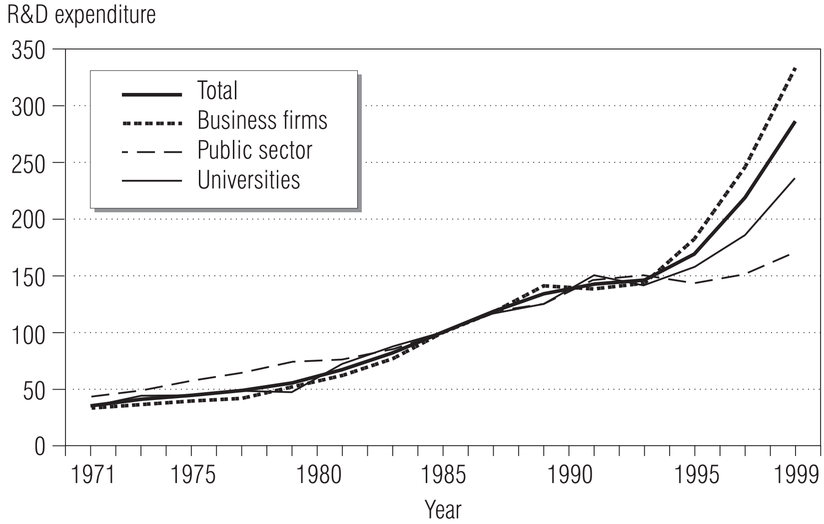

Fig. 1. Finland's R&D expenditure in real terms, in 1971–1999 (index 100 = 1985, prices in 1985) (Source: Statistics Finland R&D database).

fund R&D primarily in business firms but also in universities. The decade's other main administrative and organisational reform was the founding of the Science and Technology Policy Council in 1987. This was a novel experiment in the Western world, and it was thus unknown how this kind of governmental body would impact science and technology policies and their institutional status. One of the factors behind the creation of the Council was the OECD country study on science and technology policy in Finland (Reviews… 1987). The study stated that science policy and technology policy planning and co-ordination should be enhanced to guarantee the efficient use of the existing research know-how and technological potential in the country. The report underscored some of the problems associated with traditional sectoral policy: co-operation between science and technology policies were seen as insufficient (Reviews… 1987: 8, 22–23; see Raatikainen & Tunkkari 1991: 26–28).

Towards the end of the decade, the emphasis of science and technology policy started to shift slowly towards stressing the importance of co-operation between universities, public research institutes, and business companies. The aim was to encourage closer interaction and exchange between basic and applied research and development. At the same time, attitudes regarding research were changing. The new primary objectives in both public and private sector were to strengthen technological development in industry and to develop research-intensive products, i.e., to maintain the industry's strategic competitiveness. Research was required to show greater efficiency, productivity, and impact. This new way of thinking was captured in such slogans as »Research and know-how: the foundation of competitiveness» and »Product development and technological know-how: key conditions for industrial success.»

The 1990s: conflicting trends

The economic recession in the beginning of the 1990s halted the real growth of R&D expenditure. In the private sector R&D expenditure began to decline in 1991. In universities this happened two years later, in the public sector, four years later. The overall impacts of the recession (1991–1996) on the total volume of R&D were not very dramatic or very long-lived, however. Since the mid-1990s, the Government guaranteed continuity by considering investment in R&D and technological innovation the key to competitiveness in the future (see Finland... 1996). It was believed that this investment would eventually help to heal the national economy. The recession did leave its mark, however: the funding structure of R&D changed and caused significant diversification within the national science system in terms of the conditions for conducting research (Fig. 1 & CD-Fig. 1).

In recent years, R&D expenditure has grown due to private sector investment in the development of high technology. During the recession, government investment in research was cut back, which reduced the amount of core funding available to public research institutes and universities. The balanced development of the entire R&D system was seriously disturbed. On the one hand, universities found themselves struggling with a lack of resources that threatened the continuity of their long-term basic research. On the other hand, since 1993, private business invested more money than ever before in applied research and development that was aimed at creating new products and upgrading production processes. Business firms were not interested in conducting basic research, however. Throughout the 1990s, only five percent of all R&D expenditure in the private sector was spent on basic research type activities, i.e., on work that was not directly aimed at new products or processes (Tutkimus- ja… 1997, 2000).

Universities felt immediately the effects of economic recession, the cutbacks in government research appropriations and the neo-liberal policy in the early 1990s (see Alestalo 1991, 1993). The situation was quite desperate, especially if mirrored against the 1986 Act on the development of universities. As Saarinen (1997: 16) observes, the third section of the Act guaranteed to universities an increase in their appropriations equivalent at least to the rise in cost levels in 1987–1996. Paradoxically, the Government decided in 1993 that this section should no longer be applied – in precisely the kind of situation for which it had been originally designed. Government officials began to emphasise efficiency, performance, productivity, and impacts of R&D. The way of thinking evident in these catchwords was entirely alien to the universities, and the simultaneous cutbacks in their budget funding further complicated the pursuit of positive development. It was unfortunate that the management by results and efficiency indicators were introduced on a broader scale in universities at the very same time in the early 1990s as political measures were introduced to reduce budget funding.

Finnish universities have resorted increasingly often to outside sources in order to meet the shortfall of funding caused by budget cutbacks. Research funding by the Academy of Finland almost doubled from 1995 to 2000. Simultaneously, the Academy introduced new measures in order to support the science system. The most important measures were the foundation of the graduate school system, introduction of the programme on 'centres of excellence' in research, and the development of large-scale research programmes (see Husso et al. 2000: 20–32, 94–98, 106–107). The general aims of these measures have been (a) to help Finnish research to reach the international forefront and (b) to increase co-operation between research groups, between disciplines, between universities, and between business firms and universities. These favourable developments have not, however, eliminated the problems that resulted from decreasing total budget funding for universities.

Indeed, universities' total R&D expenditure may have shown fairly strong growth, but their total budget funding (i.e., the general grant received from the Ministry of Education in support of all university activities) in 1998 was still at a lower level than at the beginning of the decade (Tutkimusedellytystyöryhmä… 1998: 26). Also the budget funding for scientific research showed poor development. From 1991 to 1999, in real terms, research expenditure covered from government budget sources increased by 17 percent, while external funding increased by twofold (for a detailed analysis, see Husso 2001). In some academic fields or departments the scarcity of budget funding meant an absolute decrease in research funding even when outside sources of support were available. According to Nenola (2000: 4), those who argued that external funding compensates for the lack of core resources did not appreciate this. In many university departments, the small tenured teaching and research staff had to redirect most of their time and capacity away from research and towards securing that as large a number of students as possible would get their undergraduate or graduate degree.

Another legacy of the 1990s is that scientists are now expected to work increasingly on practical questions. According to this line of thinking, the emphasis of research should be on fulfilling industrial and societal needs and on technological development aimed at new products and production processes. Already in the 1990s, this endangered the sufficiency of resources allocated to the real engine of applied research and development, i.e., basic research. As a response, universities began to call for a science policy that would safeguard the diversity of domestic research and its capacity for regeneration. From the perspective of the social sciences and humanities, the stressing of economic benefits was seen as problematic – more resources were poured into research in such fields as biotechnology and information technology or, more generally, into research that was expected to produce results with immediate application and innovative potential.

In the latter part of the 1990s, a key booster of R&D funding in Finland was the decision by the Cabinet Committee on Economic Policy in 1996 to raise the level of Government financing by a further 1.5 billion marks (EUR 250 million) by 1999 (compared to 1997 budget appropriations). The total additional R&D funding increased by some FIM 3.2 billion (EUR 540 million) from 1997 to 1999 (Prihti et al. 2000). The aim was to strengthen the entire R&D system, to enhance co-operational networks and clusters, and to support the national economy, business, and employment. Most of the funds (55%) were allocated through the National Technology Agency. Thus, the emphasis of use of additional appropriation was on applied research and development. The total share of universities and the Academy of Finland on the additional appropriation was some 40 percent. With the help of this new investment, the graduate school system was extended, and universities' equipment and other research facilities were updated, among other improvements. These measures did not help universities in their difficult economic situation.

An international comparison

R&D intensity, i.e., research expenditure's share of the GDP, is commonly used in international comparisons of R&D investment. It is not an entirely accurate and reliable measure, however, because the exact measurement of GDP and R&D expenditure is extremely difficult. Nonetheless, R&D intensity provides a relatively useful general-level measure of how much a country invests in R&D and technological development in relation to the value of its total production.

Table 2. R&D intensity, the government's share of total R&D financing, and the share of universities of total R&D expenditure in selected OECD countries, in 1999, 1994, and 1989 (or the closest year available) (Main… 1995: 16, 20, 22, 1998: 16, 20, 22; OECD… 1999: 126, 128, 2001: 147, 149, 151).

Country	1999			1994			1989		
	R&D intensity* (%)	Government share of total R&D financing (%)	University share of total R&D expenditure (%)	R&D intensity* (%)	Government share of total R&D financing (%)	University share of total R&D expenditure (%)	R&D intensity* (%)	Government share of total R&D financing (%)	University share of total R&D expenditure (%)
Sweden	3.80	24.5	21.4	3.46	28.8	21.9	2.94	38.1	30.6
Finland	**3.19**	**29.2**	**17.2**	**2.29**	**35.1**	**18.9**	**1.83**	**35.3**	**19.3**
Japan	3.04	19.5	14.8	2.63	21.5	20.2	2.98	18.6	18.0
Switzerland	2.73	26.9	–	2.66	28.4	25.0	2.86	23.2	19.9
United States	2.64	29.2	14.1	2.42	37.1	15.7	2.76	45.6	15.4
Germany	2.44	33.0	16.6	2.26	37.1	18.7	2.87	34.1	14.4
France	2.17	37.3	17.6	2.34	41.6	16.2	2.33	48.1	14.9
Denmark	2.00	36.1	20.9	1.80	37.7	22.8	1.55	45.5	24.8
Belgium	1.98	24.9	24.2	1.74	26.9	27.9	1.70	32.0	25.7
Netherlands	1.95	37.9	27.1	1.95	43.8	28.8	2.12	41.8	21.4
United Kingdom	1.87	27.9	20.0	2.07	33.2	18.7	2.20	35.7	15.0
Austria	1.80	39.3	–	1.54	49.8	35.0	1.37	43.4	32.4
Norway	1.70	42.5	28.6	1.73	49.1	27.3	1.86	50.8	24.0
Canada	1.66	31.2	26.7	1.77	39.8	23.6	1.37	44.1	25.0
Australia	1.49	47.8	29.4	1.57	47.5	24.6	1.26	54.2	25.1
Ireland	1.39	22.2	19.2	1.31	22.1	19.7	0.84	34.0	22.6
Italy	1.04	51.1	25.1	1.05	50.2	25.8	1.24	49.5	19.8
European Union	1.85	36.0	20.4	1.83	39.3	20.8	1.98	40.4	17.3
OECD	2.21	29.8	17.0	2.10	35.0	17.9	2.34	38.8	16.1

* R&D intensity = gross domestic expenditure on R&D as a percentage of gross domestic product (GDP).

The highest figures for R&D intensity in 1999 were recorded in Sweden, Finland, and Japan (Table 2). Finland's R&D intensity grew very rapidly in the 1990s. In 1989–1999, Finland ranked among the top five OECD countries in terms of R&D intensity growth (together with Iceland, Ireland, South Korea, and Sweden). Finland's R&D intensity was still below the OECD and EU averages in the late 1980s, but by 1994 it was 0.19 percentage points above the OECD average and 0.46 percentage points above the EU average. In 1999, Finland showed an R&D intensity of 3.2 percent, while the average for all OECD countries was 2.2 percent and for EU countries, less than 1.9 percent (Main… 1995, 1998, 2000; OECD… 1999). In general, the level of research intensity in almost all EU countries has always been much lower than in the Union's toughest rivals, Japan and the United States. In the late 1990s, some individual countries (Belgium, Denmark) have managed to narrow down the gap, but only slightly (Main… 2001: 18).

From the viewpoint of the ratio between research intensity and per capita GDP, the top OECD countries in 1997 were Sweden, Finland, and Japan (see Husso 2001: 32). On this measure, investment in research is also higher than average in France, Switzerland, and Germany. The results indicate that countries with a high per capita GDP generally invest more in research than others.

One of the distinctive features of research in the EU countries in comparison with Japan and the United States is to be found in private sector research: measured in terms of research expenditure, private business in the EU (with the exception of Sweden) accounts for a smaller proportion of R&D than is the case in Japan and the United States. In 1991, the private sector accounted for (on average) 64 percent of total research expenditure in the EU countries, while this figure was 71 percent in Japan and 73 percent in the United States. The situation remained largely unchanged throughout the 1990s (Main… 1995: 22, 2001: 22).

In Finland, business investment in R&D accounted for roughly 57 percent of total R&D expenditure in 1991. The sectoral breakdown of research expenditure changed considerably in the late 1990s, however. For instance: The business sector accounted for 60 percent of the total Finnish R&D expenditure from 1985 to 1995, while the shares of public sector and universities were some 20 percent each. The share of the business sector increased rapidly from 1995 onwards, while that of universities and the public sector (mainly research institutes) declined. In 1999, the business sector already accounted for some 69 percent of total R&D expenditure. With the exception of the late 1990s, both the nominal and real trends for public sector research expenditure were declining. The balance of the entire R&D system was thus threatened. The same applied to most other OECD countries. The Government's share of total R&D financing and the universities' share of total R&D expenditure both declined through the 1990s (Table 2). According to the estimates by Statistics Finland (Science… 2001), the share of business probably continues to rise over the next few years unless the Government invests additional funds into R&D as it has done in recent years.

The OECD has given a very positive assessment of the sharp increase in R&D investment by the business sector and of its growing share of the total R&D expenditure in Finland. These have been interpreted as positive developments that will help to improve the competitiveness of the national economy in the global markets (Technology… 1998; OECD… 2000, 2001). At the same time, however, Finnish universities have repeatedly been anxious about the risk of unbalanced development of the R&D system. We fear that in the future, the emphasis in R&D may shift too heavily towards business companies. This may distort the balance of the entire R&D system, seriously undermine the position of universities and scientific research in that system, and reduce the secured resources available for long-term research.

In terms of the role of universities in R&D co-operation and the output of scientific research, Finnish universities showed internationally healthy development in the 1990s. Innovation studies from EU countries indicate that in the mid-1990s Finland and Sweden were the two countries with the highest frequency of contract-based co-operation between business firms and universities and public research institutes. According to the survey results (OECD… 1999), some 45 percent of Swedish and 38 percent of Finnish innovative business firms had contractual co-operation with universities or government research institutes in the mid-1990s. In other countries, the proportion of firms working closely with public research institutes varied from 9 to 19 percent. According to an innovation survey (for the period 1994–

1996) by Statistics Finland (Leppälahti 1998), almost 30 percent of Finnish industrial companies regarded universities as important sources of information for innovation. Over 19 percent thought the same of public research institutes. These results lead us to conclude that in Finland public research organisations are important partners to a large number of firms and that there has been close and extensive collaboration at least since the early 1990s.

Scientific research produces results whose impacts on society and economy are most typically of an indirect nature and therefore difficult to measure. The main outputs of research appear in the form of publications. According to the ISI database (see Husso & Miettinen 2000), a total of some 7,000 articles authored by Finns were published in international scientific series in 1999. The number of publications increased on average by more than six percent per year during 1991–1999. The figure was the ninth highest in the OECD. Of all publications, Finland accounted for roughly one percent in 1999. Since the early 1990s, this figure has increased considerably. In addition, relative to population and GDP, Finland is currently one of the world's biggest publishers. On these indicators Finland ranks among the top four countries in the world. Also the results of citation analysis are favourable for Finland. Finnish publications were cited more often than ever before in 1995–1999: they received 15 percent more citations than world publications on average. This was the ninth highest ranking in the OECD group. If analysed by bibliometric indicators, Finland ranks among the top ten countries in the OECD area. The leading research countries in the OECD are Switzerland, Sweden, the Netherlands, and the United States (for more, see Husso et al. 2000: 72–93).

Regional analysis of research

Spatially uneven development is arguably an unavoidable feature of the process of technological change and capital accumulation (Dicken 1992). Research- and innovation-related activities play an important role in these processes. It has been shown that research, innovations inspired by R&D, and their various spin-off effects have a major beneficial effect on the regional economy (e.g., Florida & Smith 1993; Feldman & Florida 1994; Regional competitiveness… 1997). Of course, technological and economic development in the regions depends not only on R&D, but on a number of closely interrelated factors, such as the local industry's capacity for regeneration, level of education and social capital, and intellectual capacity to generate new business and to adapt to technological, economic, and social change (e.g., Temple 2000; Sotarauta & Mustikkamäki 2001). The interplay between the involved factors is highly complex and difficult to demonstrate. The theoretical approaches and models adopted in the fields of economics and geography regarding the regional economics, R&D, innovation, agglomeration tendency, and local milieus has been discussed recently in an article by Husso (2001).

The following analysis of the breakdown of R&D by regions provides an overall view of the current potential of R&D- and high-technology-dependent regional economic development in Finland. Finland had an R&D intensity of 3.19 percent in 1999. The regions above this figure were Uusimaa, Pirkanmaa, North Ostrobothnia, and Varsinais-Suomi. The figure exceeded one percent in Central Finland, Ostrobothnia, South Karelia, North Savo, North Karelia, Kanta-Häme, and Satakunta. The figures for R&D expenditure per capita show similar results (CD-Fig. 2). In sum, a regional analysis of the value of GDP and R&D expenditure shows that the two sets of figures correlate with one another.

The highest figures for R&D expenditure in 1999 were recorded for Uusimaa, which accounted for 47 percent of all R&D (Table 3). The share of Uusimaa thus declined (51% in 1995). The other regional centres of R&D, Pirkanmaa (14%), North Ostrobothnia (11%), and Varsinais-Suomi (10%), together accounted for 82 percent of the country's total R&D expenditure. The figure for 1995 was 79 percent, which suggests that regional concentration continued in the late 1990s.

The location of such public institutions as state-owned companies, research institutes, and universities has shaped regional development and regional division of R&D. The tendency of regional concentration is strongest for research in the public sector. Two-thirds (65%) of the work is done in Uusimaa. In the private sector, the corresponding figure for Uusimaa is 42 percent, for the universities, 44 percent. The Metropolitan Helsinki district alone accounts for two-fifths of R&D by private business in Finland (Tutkimus- ja… 2000).

Only in Häme the public sector accounted for most of the R&D expenses (56%) in 1999. Private

Table 3. R&D expenditure by region and by sector of performance, in 1995 and in 1999 (Tutkimus- ja… 1997: 18, 2000: 31). FIM 5.94573 = EUR 1.

Region	1999 (FIM million) R&D expenditure, total	Business firms	Public Sector	Universities*	1995 (FIM million) R&D expenditure, total	Business firms	Public sector	Universities
Uusimaa	10,729 (46.5%)	6,662	1,812	1,741	6,547 (50.7%)	4,050	1,461	1,036
Pirkanmaa	3,255 (14.1%)	2,478	210	503	1,141 (8.8%)	681	151	309
North Ostrobothnia	2,599 (11.3%)	1,966	160	396	1,127 (8.7%)	764	107	257
Varsinais-Suomi	2,231 (9.7%)	1,544	78	538	1,390 (10.8%)	986	59	345
Central Finland	928 (4.0%)	552	136	234	451 (3.5%)	211	61	180
North Savo	500 (2.2%)	179	74	179	297 (2.3%)	111	47	139
Ostrobothnia	496 (2.1%)	447	4	43	349 (2.7%)	305	6	39
Satakunta	350 (1.5%)	324	10	1	251 (1.9%)	234	5	12
North Karelia	320 (1.4%)	117	44	132	188 (1.5%)	50	32	106
South Karelia	301 (1.3%)	192	12	89	216 (1.7%)	148	8	60
Kanta-Häme	267 (1.2%)	103	150	4	270 (2.1%)	84	183	3
Kymenlaakso	227 (1.0%)	221	2	–	168 (1.3%)	165	3	–
Lapland	222 (1.0%)	97	58	51	181 (1.4%)	82	71	28
Päijät-Häme	221 (1.0%)	207	1	5	131 (1.0%)	130	1	0.4
South Ostrobothnia	145 (0.6%)	128	3	10	56 (0.4%)	54	0.3	2
South Savo	128 (0.6%)	81	20	16	66 (0.5%)	46	17	3
Kainuu	87 (0.4%)	53	10	22	61 (0.5%)	50	5	5
Central Ostrobothnia	54 (0.2%)	42	11	–	22 (0.2%)	14	8	–
Åland	3 (0.0%)	3	0	–	4 (0.0%)	1	3	–
Total	**23,062** (100%)	**15,720**	**2,795**	**3,966** (4,547)*	**12,916** (100%)	**8,166**	**2,226**	**2,524**

* Statistics Finland included hospitals in its calculations for the first time in 1997, and polytechnics in 1999. In order to make figures for 1999 and 1995 comparable, R&D expenditure by university central hospitals and by polytechnics for 1999 are excluded. In 1999, the sum of R&D expenditure by the entire university sector was FIM 4,547 million.

R&D-intensive firms and universities were apparently few in this region. The universities held the largest share of total R&D expenditure in North Karelia (41%; University of Joensuu) and North Savo (36%; University of Kuopio). The private sector accounted for the majority of R&D in all other regions. Most of the research by private business was concentrated in large firms with a personnel of over 500. They were responsible for over 70 percent of private sector research, while the figure for small business with a staff of less than 50 people was only about ten percent.

All in all, the most notable changes during the 1990s at the regional level were the decrease in the share of Uusimaa and the increase in that of Pirkanmaa and North Ostrobothnia. In absolute terms, R&D investments increased most significantly in Uusimaa. The R&D expenditure in absolute terms increased favourably also in Pirkanmaa, North Ostrobothnia and Varsinais-Suomi, and in Central Finland, North Savo, Ostrobothnia, and North Karelia (especially due to growth in business firms) (cf. Table 3).

R&D is heavily concentrated within the regions, most notably in their principal urban centres. For instance, the Metropolitan Helsinki district accounted for 99 percent of Uusimaa's R&D expenditure in 1999. Oulu and its surroundings (in North Ostrobothnia) were responsible for 96 percent and Tampere district (in Pirkanmaa) for 94 percent of the region's R&D expenditure. In Central Finland, Jyväskylä district recorded 80 percent of the region's R&D expenditure, and in Varsinais-Suomi, the districts of Turku and Salo, 62 and 32 percent, respectively (Tutkimus- ja… 2000: 31–33). The success of the relatively small Salo district (of 51,000 inhabitants) draws from the Nokia Corporation's notable presence in the area. The combined R&D expenditure of the above-mentioned six districts (out of 85 districts in all in Finland) was FIM 18.7 billion (EUR 3.14 billion), or 81 percent of the country's total R&D expenditure. From the viewpoint of regional development, it is noteworthy that the same six districts were the only ones to receive clear migration gain during the latter part of the 1990s (Regional development… 2001: 2).

The regional concentration of R&D has shown no signs of decreasing. The Government has thus introduced new measures in order to avoid the situation where know-how, research, and innovation are heavily concentrated in very few growth centres. For example, the second phase of the National Centre of Expertise programme (1999–2006) aims to create a dense nationwide network of R&D-intensive regional knowledge centres (CD-Fig. 2). In addition to the fourteen centres of expertise included in the map, there are two regionally dispersed national centres – or networks – of expertise that focus on wood products and on food technologies. The two entities bring together numerous universities, research institutes, and business companies from various parts of the country.

The first phase of the Centre of Expertise programme (1994–1998) provided rather encouraging results: 8,000 new jobs were created, 300 new high-technology firms were established, and 130 firms moved to the knowledge centres (see Hämäläinen et al. 2000). The current programme seeks, i.e., to

(1) identify regional strengths and create economic growth
(2) increase the number of competitive products, services, enterprises, and jobs based on the highest standard of expertise
(3) reinforce and regenerate regional expertise
(4) create conditions for innovation and commercialisation
(5) make the latest knowledge and expertise readily available
(6) promote regional, national and international networking and collaboration between and within Centres of Expertise and fields of expertise
(7) improve co-ordination between local, regional, and national development measures (Centre… 1999).

In sum, the nodes are generally expected to offer know-how services, funding, and social and human capital throughout their own area of influence.

The links between regional policy and the location of high-tech industries and universities are strong. New initiatives and programmes do not therefore change the impression that the Government's policies favour the regions that are already advanced and have (economically) the best chances to be successful in the global market.

The current link between regional and industrial policies seems to be strong as well. According to the Office of the Prime Minister's expert group, "promoting competition and raising real competitiveness have meant replacing traditional business subsidies with support for research and development. [T]his has shifted the main focus [of the policies] to the big university cities" (Regional development… 2001: 5). Due to this change, it is possible that the above-mentioned programmes fail to decrease the regional imbalance in the future. We do not contest the Government's support of the potential 'winner cities' – quite the contrary. We do suggest, however, that more attention should perhaps be directed to those regions that are located near the knowledge centres and to those areas that lag behind socio-economically. In order to safeguard the favourable development of regional economies and promote general welfare, policy-makers should make every effort to remove those barriers that hinder spatially widespread diffusion and utilization of new knowledge and research findings. The authorities need to address such problems as the shortage of co-operative links and the lack of resources and (communication) channels that facilitate regionally extensive transfers of codified and tacit knowledge between business firms, universities, and the government sector.

Discussion

The general conditions for R&D in Finland developed very favourably during the latter half of the 1990s and the national strategic significance of research continued to increase. In order to break loose from economic recession (1991–1996) and to inspire growth, the Government decided to start investing more in education, know-how, research, and technology (see Finland… 1996). This decision deviated clearly from the OECD mainstream policy-lines.

The Government's additional funding programme (1997–1999) wanted to raise the level of research intensity in Finland to 2.9 percent by 1999. This goal was reached ahead of schedule. The findings of evaluation reports published in 2000 (Husso et al. 2000; Prihti et al. 2000) indicate that the increase in R&D expenditure had a beneficial impact on employment and the economy. The diversity and comparatively high quality of the educational infrastructure and universities in Finland, on the one hand, and the strong growth of the national economy since the mid-

1990s, on the other hand, supported the positive assessment.

The relationship between science and technology, and between universities and business, grew closer and more interactive than ever before in the 1990s. The development and production of goods and services currently relies heavily on the use and application of scientific research and on new knowledge. Consequently, the importance of developing new tools for science and technology policies has been recognised widely. In the future, one of the most critical tasks is to maintain a balance in the relationships between universities and business firms. Increased co-operation is in the interests of both parties, provided that there is a proper division of labour and that academics are given the opportunity to focus on long-term basic research. Enough space for the independent development of the science system should be guaranteed. Universities' own internal objectives that are not at least primarily constructed through co-operation with industry or activities aimed at innovations should be respected more.

Everything should look generally good: during the latter part of the 1990s, the total funding of R&D was increased, new science policy measures that aimed at upgrading the conditions for conducting research were introduced, and co-operation within the science system and between universities and business firms increased favourably. Finnish research reached the international forefront in many fields of science. Unfortunately, however, this is not the entire picture – at least not from the viewpoint of universities and scientific research. The insufficient level of budget funding for research is clearly one of the current defects in the science system. The problem is not only the level of funding, but also the allocation of these funds. According to Husso et al. (2000: 110),

> Funding for scientific research is increasingly allocated on a competitive basis; to an extent one could argue that there is too much competition for funding. Core funding to universities as well as financing between the faculties are frequently allocated on the basis of quantitative measures and repeated peer reviews and evaluations. [This development ties] in closely with the adoption […] of management by results, the aim of which is to raise the quality standards of research and to give closer attention to performance and productivity in the allocation of resources. [U]niversities still remain quite divided in their views on how well the new management philosophy really has worked and on how fair it is. A common criticism against management by results is that in a strict application, it gives too much weight to short-term activities and to quantitative results and efficiency requirements at the expense of quality and long-term development.

Government officials have recently drafted plans to maintain the positive trend in total R&D funding. Some indications suggest that the increase in R&D expenditure will continue in the near future (see Review… 2000). This, however, will require careful planning and co-ordination – without forgetting the risks of excessive science policy planning and outside manipulation of scientific research.

> A key question […] is the extent to which research needs to be […] planned and organised; how far can research be steered […] before it becomes excessive? The key factors in this regard are the ability and willingness of funding bodies and research scientists to take risks and to pioneer new fields of research. In addition, it is important that research funds are always available that are not tied in advance to any specific purpose and that free research is given the space and resources it needs. To make sure that universities can […] work in a positive and encouraging atmosphere, it is essential that the Government […] continues to underline the importance of scientific research and its relevance to well-being in society. (Husso et al. 2000: 115)

If universities are to make justified calls for additional funding in the near future, they have to provide proof of the benefits and impact of their work. In order to convince the funding bodies and decision-makers, universities have to show continuous improvement in international success and visibility of scientific research, to make their organisational structure and administration more practical and flexible, and to reform their financial procedures and rules for co-operative agreements with extramural organisations.

In regional policy terms, public funding for R&D is highly selective. Most of the funds go to growth centres, further increasing regional imbalances. Investment thus tends to flow especially to the areas of greatest opportunity and return to investment. It is difficult, however, to allocate funds to areas where there is no research or where the standards of research are not high. In recent years, the Government's policy regarding universities and R&D funding has nonetheless been to emphasise regional considerations (e.g., Korkeakoulujen… 2001). Also, the aim of the Centre of Expertise programme has been to enhance regional strengths in various parts of the country. On the other hand, the National Technology Agency has wanted to stress the quality of applications received, the viability of proposed projects, and their potential technical and economic impacts. About one half of the Agency's research appropriations go to Uusimaa.

Since R&D is risky business, we expect to see more risks taken in funding decisions as well – especially now that more and more money is being invested in research. This would be particularly valuable to small and promising research teams and to those organisations that work outside today's major research centres. Networking among these parties and co-operation with researches from the principal urban R&D centres will help to create new opportunities in less developed regions.

NOTES

[1] The Academy of Finland is the national organisation for science administration operating under the Ministry of Education. The Academy's responsibilities include the advancement of scientific research and the encouragement of its exploitation, and the enhancement of international scientific co-operation. The main function of the Academy is to finance high-quality scientific research conducted in universities. In 2001, the Academy's annual funding volume was FIM 1.1 billion (EUR 184 million). This represented about 14 percent of the total government R&D financing (see Research… 2000: 6; Academy... 2002).

[2] The National Technology Agency (Tekes), which operates under the Ministry of Trade and Industry, is the principal source of public funding for applied technological research and industrial R&D. In addition, Tekes is the main implementing body of Finland's national technology policy. In 2001, Tekes' funding totalled some FIM 2.3 billion (EUR 387 million), of which two-thirds were devoted to industrial R&D and the rest to research by universities and research institutes. This represented almost 30 percent of the total government R&D financing (see Research… 2000: 7; Tekes... 2002).

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