Aatto Prihti
Luke Georghiou
Elisabeth Helander
Jyrki Juusela
Frieder Meyer-Krahmer
Bertil Roslin
Tuire Santamäki-Vuori
Mirja Gröhn

Assessment of the additional appropriation for research

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APPENDICES

SUMMARY

The Ministry of Trade and Industry and the Ministry of Education established an international expert group to perform an overall evaluation of the additional appropriation programme of research implemented in 1997-1999. The expert group commissioned extensive studies and interviewed a large number of experts. In this report, the expert group sets out its views on the focusing of the additional appropriation and the effectiveness of research funding as a whole, and raises points that the group believes are relevant for policymakers.

Results of the evaluation

The expert group puts forward the following as a summary of its conclusions:

1. The additional public appropriation for research seems to have had a positive impact on private research investments.

2. Increased research input has led to the growth of company profitability, a rise in the know-how level of personnel and a larger number of product innovations. The research inputs of industry as a whole and of large enterprises each benefit small and medium-sized enterprises through the sub-contracting network and transfer of other expertise.

3. Besides research investments, productivity has been improved by personnel training, renewal of organisation structures, more effective management culture and companies' improved capacity to take in new information.

4. The effects of research input on employment have been clearly positive. However, the effects are of a dual character: demand for highly educated personnel has increased rapidly, but no job opportunities have emerged for employees with lower education levels.

5. Integration of the new and the old economies is an important area for development for maintaining conventional jobs and creating new ones. Encouraging small and medium-sized enterprises to take up new technology calls for new measures.

6. The additional funding has also had positive effects on regional development, but only in the regions where research investments have been focused. In fact, regional policy requires increases in the know-how and entrepreneurship potential of the various regions, so that more projects can meet the criteria of Tekes, the National Technology Agency.

7. Development of both the quantity and the quality of Finnish basic research was very positive and rapid in the latter half of the 1990s. Networks of researchers expanded and cooperation with business enterprises increased both in Finland and abroad.

8. The cluster programmes have made it possible to initiate fruitful cooperation between various sectors and to provide a valuable link between technology and public services. However, it is too early to project any final results. Development needs for these programmes seem evident, especially in giving more focus to the objectives, improving coordination between financiers and reducing multiple reporting requirements.

9. The development of Tekes has been rapid and in many ways successful. As the surrounding conditions are also changing at a fast pace, the expert group proposes that a new strategic assessment of Tekes be carried out (the last evaluation was made in 1995).

10. In developing Tekes, the expert group stresses the following aspects:

- Innovation is a much wider concept than technological innovation alone, so Tekes' efforts to extend its expertise base should be endorsed.
- Ideas and inventions are converted into innovations only after they have been commercialised. Greater resources should be applied to assisting commercialisation as early in the process as the product development phase.
- Tekes reaches dynamic businesses well, but conventional small enterprises poorly. These businesses also have potential but need new approaches.

Future priorities

The additional appropriation programme for research has been a success, but continually changing conditions face future technology policy with new requirements. In this respect, the expert group would like to draw attention to the following priority areas:

1. Policymakers should continue to set ambitious aims for research funding

International competition has become a learning race. Like Finland, many other countries have made heavy investments in the development of research and education. Finland should continue the course of action chosen, and maintain its high level of research funding. Setting up a new additional appropriation programme should be considered, with the aim of complementing existing measures and redressing the deficiencies that are currently evident in the Finnish innovation system.

2. The conditions for basic research should be strengthened

Continuous improvement in the quantity and quality of basic research must be secured. Basic research contributes to producing the basis for applied research and to increasing the number of highly skilled personnel. Financing centres of excellence can be used to accelerate the progress of promising sectors. Networking in Finland and abroad, as well as cooperation with business enterprises, should be strongly encouraged. Despite the generally high levels of industry-science cooperation, there is still scope for improvement, notably in the biosciences.

3. The cluster approach should be improved and extended

Knowledge of cooperation between different sectors, gained from cluster programmes, should be developed and extended to new areas. However, the existing clusters need to be more focused.

4. The new and the old economies should be integrated

To accelerate the integration of the new and the old economies, small and medium-sized enterprises operating in conventional sectors should be actively encouraged to take up new technology. An accelerated schedule calls for a special programme.

5. More focus should be placed on innovation

In future technology programmes, the following aspects should be further underlined:

- improved efficiency of know-how transfer from abroad to Finland;
- development of cultural know-how and managerial skills to complement technological competence;
- development of pre-seed and seed financing;
- a customer- and marketing-oriented approach;
- greater commercial professionalism, especially in small and medium-sized enterprises;
- creation of a special form of support for commercialisation of products since, due to the small size of the domestic market, a small company must start to operate internationally at a very early stage.

6. Future work force competencies should be developed

Future success will rest upon skilled people. Therefore, a permanent aim should be to improve educational opportunities for both the younger and the older population.

- The challenging new task for the polytechnics relates to the integration of the new and the old economies and skills technology.
- The average waiting period of three years, from passing the matriculation examination to obtaining a place in tertiary education, is a waste of resources and calls for restructuring.
- More flexible switching from one subject over to another would improve the opportunities for highly educated personnel to move into areas where demand is growing rapidly.
- The universities' capacity for educating students from abroad should be improved considerably.

Because of the great structural and content-related need for change, consideration should be given to setting up a separate programme to ensure that the necessary funds are available. Furthermore, basic funding for universities must be revised.

The lifelong education of today's work force should be further enhanced by trying out new ideas and preparing new pilot programmes of which we already have good examples. It is important that the Government guarantees sufficient resources for further education and continuing education to ensure the availability of a highly skilled work force and to prevent labour market exclusion.

FOREWORD

In 1996, the Government of Finland decided to allocate over FIM 3 billion in proceeds from State property sales to research and development. The purpose of this additional appropriation, disbursed between 1997 and 1999, was to enhance the operation of the national innovation system to the benefit of the economy, the business environment and job creation alike. In 1999, an appropriation increment of FIM 1.5 billion was introduced on a permanent basis.

With public funding in research and development growing fast, it was deemed essential to ensure close monitoring of the use of funds and thorough evaluation of results. To this end, the Ministry of Trade and Industry and the Ministry of Education set up an independent outside expert group to carry out the evaluation work. The expert group operated between 1998 and 2000 and consisted of the following members:

Aatto Prihti, chairman	President, Finnish National Fund for Research and Development Sitra
Elisabeth Helander	Director, European Commission
Jyrki Juusela	President and CEO, Outokumpu Oyj
Bertil Roslin	Chancellor, Åbo Akademi University
Tuire Santamäki-Vuori	II President, The Trade Union for the Municipal Sector KTV

Foreign experts:

Professor Luke Georghiou	University of Manchester, United Kingdom
Professor Frieder Meyer-Krahmer	Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe, Germany

Due to the reorganisation within the European Commission, Elisabeth Helander has not participated in the work of the evaluation panel since December 1999. A short account of the members of the expert group is given in Appendix 1. The secretary of the group at Sitra was Mirja Gröhn, Lic.Sc. (Tech.).

The expert group arranged a start-up seminar, set up seven research projects and interviewed numerous specialists and experts in different fields at its meetings. And further, the expert group was provided with plenty of material it had requested. Drawing on all these, professor Luke Georghiou and professor Frieder Meyer-

Krahmer drafted the report which the other members then complemented. My warmest thanks to both professor Luke Georghiou and professor Frieder Meyer-Krahmer for their valuable work. I should also like to extend my grateful thanks to all those who made it possible to produce this final report.

Helsinki, November 2000

Aatto Prihti
Chairman of the expert group

1 EVALUATION EFFORT

With public funding in research and development growing fast, it was deemed essential to ensure close monitoring of the use of funds and thorough evaluation of results. Each organisation in charge of the additional funds is responsible for assessing the individual projects and research groups. It was decided that this would be complemented by an overall assessment in order to obtain a general picture of whether the additional funds were appropriately allocated and to receive answers to questions on their impact on the economy and society in general. The parties to the additional appropriation are presented in Figure 1.

Decision-making	Government
Design	Science and Technology Policy Council of Finland
Financiers	Ministry of Education Ministry of Trade and Industry Other ministries
Users	Graduate schools Centres of excellence New business operations Cluster programmes Etc. hundreds of projects in total
Beneficiaries	The economy Enterprises Employment prospects
Evaluation - commitments - overall evaluation	 Financiers International expert group

Figure 1. Parties to the additional appropriation.

The evaluation work involved the assessment of not only the additional funding but also the type of impact the funding has had on innovation activities and productivity. It was not possible, however, to limit the assessment to the impact of additional appropriation alone as it is impossible to distinguish projects that received additional funding from those that were beneficiaries of other forms of R&D financing. Projects set up using the additional appropriation have not been clearly separated from other projects in all cases. Moreover, the effects of projects started up between 1997 and 1999 are not likely to have been fully manifested during the evaluation period, since some of the projects will still be in progress after completion of the evaluation process. In any case, the effects of R&D often take some time to be felt in the economy and society. A re-evaluation could possibly take place around 2005. Furthermore, it is worth bearing in mind that company success is attributable to a number of other factors along with R&D funding.

Figure 2 shows how the evaluation has dealt with this problem. Essentially, we have looked at the effects of past R&D and used these to draw conclusions on the likely effects of the additional appropriation.

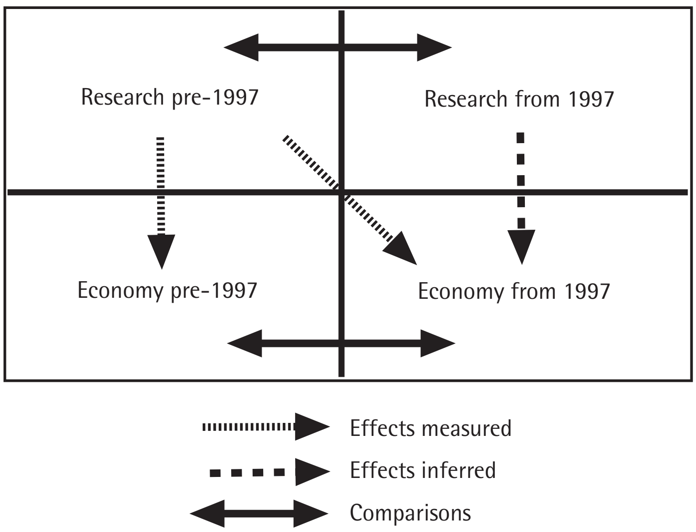

Figure 2. Timing of evaluation.

A seminar was held at the beginning of the evaluation project with a view to making an assessment of existing fields and areas requiring further review. The working group decided to set up seven research projects. In order to ensure the interlinking of the individual research reviews, the research groups convened twice in the course of the work. Since there was very little material on the additional appropriation programme at the time, it was decided that the empirical work would focus on assessing the kind of effect earlier expenditure on public R&D funding has had, whether this effect differs significantly from enterprise to enterprise, from sector to sector or from region to region, and whether the effect derives from the public funding contribution and the increase in volume of public funds.

Three projects addressed these economic relationships with different emphases (ETLA-1, ETLA-2 and ETLA-3). To examine the performance of Finnish science, a project was commissioned to study publication and patenting outputs in Finland (VTT-3). The panel did not have the time or resources to examine individual programmes in detail. Hence, one project sought to summarise the findings of a large number of programme and institutional evaluations which have been carried out in Finland (VTT-1), while another project (LTT) made direct contact with the clients of Tekes in a particular sector from the perspective of applied management research. The remaining project (VTT-2) examined the cluster programme, though with the handicap of having to perform this research during the first few months of activity in the clusters. The names of the projects are listed in full in Table 1.

The research review projects were set up between November 1998 and April 1999 and were completed in April 2000. The final reports on the projects were authorised for publication immediately after their completion in order to allow the committee to benefit from the discussion provoked by the research findings. The groups of researchers are individually responsible for the content of their work. Summaries of the final reports on the projects are presented in Appendix 2. Among numerous other sources used by the working group were material received from the National Technology Agency, Tekes, a report by the Academy of Finland on the state and quality of science and the two latest triennial reports by the Science and Technology Policy Council of Finland.

The working group interviewed experts in a number of different fields, e.g. the management of ministries, financiers, universities and research institutes, leaders of product development projects and experts on cluster programmes. The names of the experts are listed in Appendix 3. The list also includes the members of the informal advisory body. The foreign members of the expert group were particularly active in visiting the main organisations eligible for additional appropriation. Written reports have also been requested on use of the additional funds.

An Internet application was designed in order to collect data on the cluster projects systematically and in a coordinated manner. The aim is to collect data on all projects in the cluster programmes of each sectoral ministry into one database, so that the results of R&D funding between 1997 and 1999 can be evaluated on the basis of outturns. We recommend that the database even be maintained after this evaluation work ends so as to support any future strategic discussions on clusters.

Table 1. Research review projects.

Project/ research centre, contact person	Name
VTT-1 Technical Research Centre Juha Oksanen	*Research evaluation in Finland* (Survey of evaluations made in the 1980s and 1990s and analysis of results. Did the evaluations lead to action being taken? Did any recommended forms of evaluation follow?)
VTT-2 Technical Research Centre Tuomo Pentikäinen	*Economic evaluation of the Finnish cluster programmes* (Focus on research-oriented Forest Cluster research programme and on diffusion-oriented Well-Being Cluster programme; study of developments in networking.)
VTT-3 Technical Research Centre Terttu Luukkonen	*A bibliometric study of Finnish science* (Survey of incidence of international publications by Finnish researchers. Data collected from the Science Citation Index database in collaboration with the University of Umeå.)
ETLA Research Institute of the Finnish Economy Pekka Ylä-Anttila	*Innovation policy and public R&D funding – impact on company success and job creation in Finland* (The aim is to identify the factors with the greatest impact on company success. The project is divided into three smaller projects.)
ETLA-1 Statistics Finland Olavi Lehtoranta	*Impact of public R&D funding on the profitability and growth performance of firms* (A panel data study on Finnish firms)
ETLA-2 Research Institute of the Finnish Economy Rita Asplund	*Public R&D funding, technological competitiveness, productivity, and job creation* (Focus on economic effects of public support handled by the National Technology Agency, Tekes.)
ETLA-3 Labour Institute for Economic Research Eero Lehto	*Regional impacts of R&D and public R&D funding* (Impacts of past R&D capital on current R&D investments and productivity.)
LTT LTT Research Ltd Matti Pulkkinen	*Public research & development funding and international technology commercialisation* (Questionnaire given to clients of the National Technology Agency, Tekes.)

2 ADDITIONAL APPROPRIATION PROGRAMME

Objectives

A specific objective for the additional research funding granted by the Government in autumn 1996 was to intensify the operation of the national innovation system for the benefit of the economy, the business environment and employment alike. One key means to this end was to achieve a sufficiently narrow targeting of funds. An equally important aim was to allocate the research appropriation to end users by means of competitive bidding. [Science and Technology Policy Council 1996, p. 55]

The Science and Technology Policy Council of Finland drew up a plan for the appropriation whereby the bulk of the funds were to be allocated to research and development through the appropriate channels in the science and technology administration, notably by increasing the resources allocated to the National Technology Agency, Tekes and the Academy of Finland by means of competitive tenders. Targeted research funding for the Technical Research Centre (VTT) and to universities was also to be stepped up. Moreover, additional funding was to be granted to R&D projects that aim to foster the development of the country's industrial clusters. These projects were implemented in collaboration between the sectoral ministries, the science and technology administration and individual business enterprises.

It was decided that when projects funded by State privatisation proceeds were implemented, the appropriation sum would be increased in stages over a period of three years. The original plan set the final allocation increment for 1999 at FIM 1.5 billion. The overall target sum for the allocation increment over the course of three years was FIM 3.35 billion. The original target in the additional appropriation programme was to raise the national appropriation contribution to R&D to 2.9 per cent of GDP (as defined in ESA79 terms) by 1999. This goal was reached and surpassed in 1998.

Figure 3 and Table 2 illustrate the funding trend and the breakdown in R&D funding between the private and public sector since 1991. The allocation increment of the additional funding programme signified a rise in public research and development funding of around a quarter compared with the research appropriations included in the 1997 budget proposal [Science and Technology Policy Council 1996, p. 53]. Increased public investment has been a factor in motivating businesses to put more effort into their own research and development activities. Nokia plays an especially important role in this: ETLA has estimated that in 1999 Nokia accounted for about a third of total private expenditure on research and development in Finland (Figure 4). This means over 20 per cent of all Finnish R&D activity [Ali-Yrkkö, p. 12]. However, it should also be noted that there was a substantial increase in R&D spending by other companies. This shows that firms are in this respect the most important players in the Finnish innovation system (as is also the case in many other OECD countries).

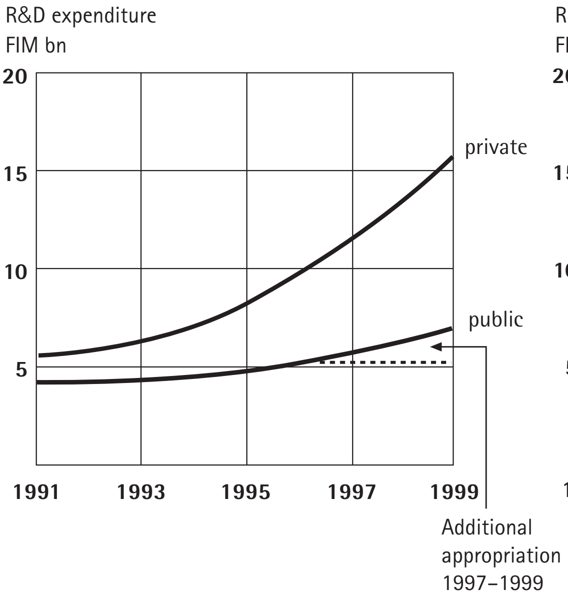

Figure 3. R&D expenditure in the private and public sector[1] 1991–1998, estimate for 1999.

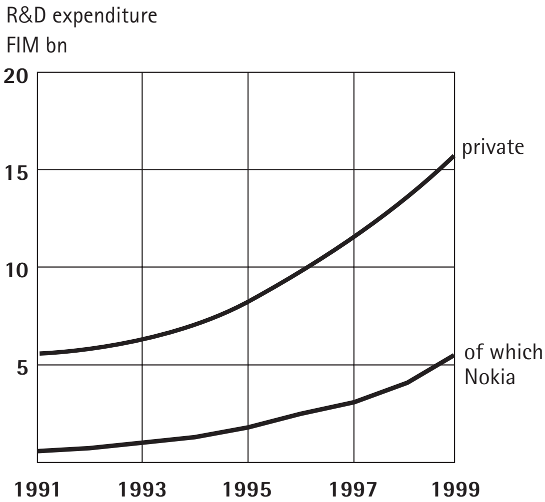

Figure 4. R&D expenditure by private enterprises in Finland, 1990–1999. Estimates by ETLA.

Table 2. Breakdown of Finland's R&D expenditure between the private and public sector and as a percentage of GDP.

Year	FIM million at current prices				%				
	R&D			GDP[2]	Share of R&D		Share of GDP		
	Private	Public[1]	Total		Private	Public	Private	Public	Total
	a	b	c	d	a/c	b/c	a/d	b/d	c/d
1991	5,798	4,374	10,172	499,357	57.0	43.0	1.16	0.88	2.04
1993	6,234	4,443	10,677	492,609	58.4	41.6	1.27	0.90	2.17
1995	8,166	4,750	12,916	564,566	63.2	36.8	1.45	0.84	2.29
1997	11,396	5,876	17,272	635,532	66.0	34.0	1.79	0.92	2.72
1998	13,395	6,550	19,945	686,742	67.2	32.8	1.95	0.95	2.90[3]
1999e	15,472	6,862	22,334		69.3	30.7			3.12

1 Incl. universities and polytechnics.

2 Data in terms of the revised European System of National Accounts (ESA95). GDP data for 1997 and 1998 are provisional, the GDP figures for 1999 are based on a Ministry of Finance growth estimate of 3.8%.

3 Estimate 3.00 based on the earlier GDP definition (ESA79).

Source: Statistics Finland

Use of funds

Appropriation authorisations and commitments are shown in Table 3. Outturns are included as reported by the recipients of the appropriation. In practice, appropriation authorisations imply that funding may be authorised in a given year for allocation to projects in the course of the next few years. This means that actual data on funds used are still pending. (A rough estimate suggests that about one half of all appropriations had been disbursed by the end of year 1999.)

Table 3. Breakdown of the additional appropriation. Realised allocation of the increase in research funding between commitments and appropriations.

FIM million	1997	1998	1999	TOTAL
Appropriations:				
Academy of Finland	166	188	270	624
Tekes	350	545	790	1,685
Total	516	733	1,060	2,309
Commitment				
Ministry of Education administrative sector				
- Universities	175	210	250	635
- Academy of Finland	5	5	5	15
Ministry of Trade and Industry admin. sector				
- Ministry of Trade and Industry		10[1]	11	21
- Tekes	12[2]	20[2]	38[2]	70
- Technical Research Centre of Finland		6	36	42
Ministry of Agriculture and Forestry		15[1]	8	23
Ministry of Transport and Communications	3	5	16	24
Ministry of Social Affairs and Health	10	10	7	27
Ministry of Labour	10	10	6	26
Ministry of the Environment	5	10	8	23
Total	220	301	385	905
Total commitments and appropriations	736	1,034	1,444	3,214

[1] 1997 and 1998 total.

[2] incl. Employment and Economic Development Centres.

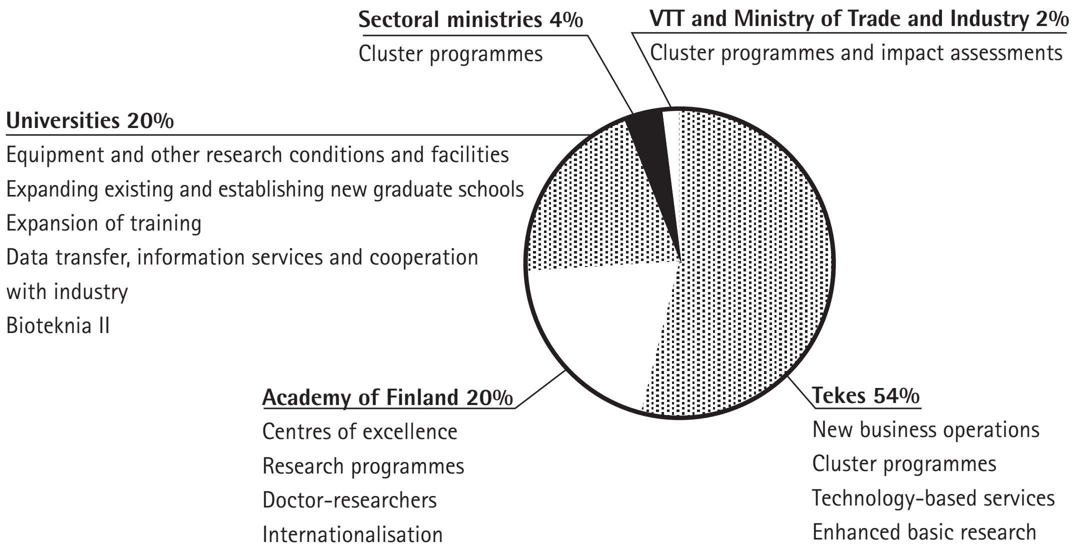

Figure 5. Breakdown of allotment of additional appropriation, 1997–1999 FIM 3.2 billion, by source of funds.

Figure 5 presents the breakdown in the use of funds in the programme over three years. The Ministry of Trade and Industry allocated 56 per cent and the Ministry of Education 40 per cent of all the additional funding. A more detailed table of the targets financed between 1997-1999 can be found in Appendix 4.

Relative significance of the additional appropriation to the recipients

The allocation increment of FIM 1.5 billion for 1999 amounts to around one fifth of all public funding in R&D and is less than seven per cent of all the funding going to R&D in Finland. Figure 6 shows the change in R&D funding to public organisations from 1996 to 1999. This change is not fully accounted for by the additional appropriation programme.[1] [Kolu 2000]

In relation to the situation in 1996, the additional appropriation programme increased the resources of the National Technology Agency, Tekes, and the Academy of Finland the most in relative terms, as finances in these two bodies grew over 1.5-fold from 1996 to 1999. In money terms, these beneficiaries were followed by the universities, where funds grew by about one sixth.

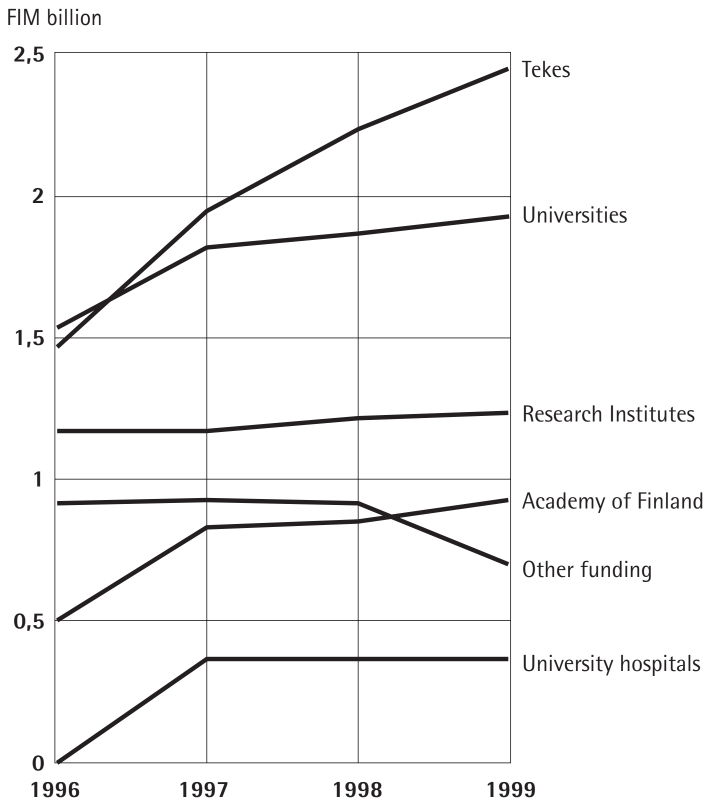

Figure 6. Public R&D funding by organisation – 1996 FIM 5,581.6 million altogether and 1999 FIM 7,584.3 million.

The R&D budgets of the sectoral ministries, which received an allocation increment of FIM 10 million from the additional appropriation programme, and of the Technical Research Centre, which was granted FIM 20 million, grew between 0.5 and 8 per cent. The only exception was the Ministry of Labour, where a very modest R&D input in 1996 meant that the additional appropriation raised the R&D budget by 45 per cent in 1999. Appendix 5 includes a list of total government R&D financing in 1999. It also shows those ministries that were not covered by the additional appropriation programme.

[1] The figures consist of projected estimates based on budget analyses by the Academy of Finland. Actual expenditure data is later compiled into statistical form by Statistics Finland. All public R&D organisations are included in **Figure 6**, not just those involved in the additional appropriation programme. University hospitals have been monitored as a separate item since 1997. [Kolu 1998, p. 2]

Administrative sector of the Ministry of Trade and Industry

Virtually all the cluster programmes launched using funds from the additional appropriation programme received funding (total FIM 9 million) from the Ministry of Trade and Industry. Funds were also allocated to impact assessments of R&D funding (FIM 4 million) and to projects included in the research programme that lend support to impact assessments (FIM 7 million).

The additional appropriation channelled through the National Technology Agency, Tekes, allocated funds not only to the basic operations of the organisation but also to four special fields, namely technology-oriented services, inter-administration cluster programmes, more solid basic research in technology, and new business operations. In the original allocation plan, the appropriations and commitments for Tekes amounted to FIM 1,860 million, but about 6 per cent of the funds were not allocated by the end of 1999. The Tekes project portfolio has repercussions for the Technical Research Centre, as the additional appropriation programme (FIM 40 million planned, FIM 42 million actual) mainly takes the form of greater participation in projects funded by Tekes.

It is estimated that the additional appropriations channelled through Tekes to private enterprises, together with the funds of the companies themselves, could increase almost twofold.

Administrative sector of the Ministry of Education

The additional FIM 635 million disbursed to the universities were used to renew equipment and to improve research conditions and facilities (FIM 283 million), to lend support to existing top graduate schools and to establish new ones (FIM 110 million), to increase the amount of schooling in maths, natural sciences and engineering expertise (FIM 85 million), Bioteknia II (FIM 79 million) and to develop network cooperation and data transfer systems (FIM 78 million). The overall sum originally planned has been used to the full. A description of the targets for these appropriations can be found in Appendix 6.

The additional appropriation granted to the Academy of Finland went mainly to a committee pursuing research in natural sciences and technology, which received 47 per cent of all additional appropriations. The overall sum for appropriations and commitments for three years amounted to FIM 639 million. The appropriation was allocated as follows:

- to bolster centres of excellence in research and training and to create new ones, FIM 198 million

- research programmes in strategic fields, FIM 184 million
- further studies for post-graduates recently completing doctorates, i.e. the creation of a post-doctoral research system, and project funding to foster careers in research for young doctoral researchers, FIM 164 million (the plan was FIM 170 million)
- to broaden international research cooperation, FIM 79 million.

The Academy of Finland channelled about half of the additional appropriation to universities in the Helsinki region, the biggest shares going to the University of Helsinki (28%) and the Helsinki University of Technology (17%). In scientific fields, those gaining more than a 10% share are physics, biology and environmental science and biomedicine. More detailed information on appropriation allocation by the Academy of Finland is available in Appendix 7 and Appendix 8.

Sectoral ministries

The three-year additional appropriation allocated to the Ministry of Agriculture and Forestry totalled FIM 23 million, and was distributed to the Food Cluster Research Programme and the Finnish Forest Cluster Research Programme (Wood Wisdom) aimed at improving the competitiveness of these sectors.

The additional appropriation of the Ministry of Transport and Communications, altogether FIM 24 million, was placed in the Transport Cluster (KETJU, developing logistic systems and TETRA, developing inter-operable IT systems) and the Telecommunication Cluster (NetMate promoting the utilisation of information networks in SMEs).

The FIM 27 million funding granted to the Ministry of Social Affairs and Health was placed in the Well-Being Cluster Programme promoting research and production in the social and health-care service sector.

The additional appropriation (FIM 26 million) received by the Ministry of Labour was used to support research in the National Workplace Development Programme. The aim was to improve productivity and the quality of working life.

The additional funds of FIM 23 million received by the Ministry of the Environment were allocated in projects in the Environmental Cluster Research Programme examining ways of creating solutions that protect the environment and turning these into products focusing on ecological efficiency.

Distinctive features of projects set up using the additional appropriations

The additional appropriation allocated to the National Technology Agency, Tekes, and to the Technical Research Centre are typically not earmarked, so it is seldom possible to identify whether projects were set up through the additional appropriation programme or by other means. A new feature in projects launched by Tekes is that the additional appropriation has given rise to new types of collaboration, notably in the form of cluster programmes, and has enhanced the position of the service sector.

The additional appropriation to the universities was mainly targeted at bolstering resources to expand existing activities and at establishing new forms of activity. Projects financed by additional funds from the Academy of Finland focus on fields such as the economy, the business environment and on activities that foster job creation. The additional appropriation programme has altered the funding criteria of the Academy of Finland to some extent. For example, competitive funding, project evaluations by outside experts and research cooperation between disciplines and organisations have become more common.

The recipients of additional funding from the Ministry of Trade and Industry and the sectoral ministries form a separate new group. The aims of the cluster programmes vary considerably:

- securing employment
- creating good conditions for product development
- enhancing ecological efficiency
- boosting competitiveness
- operational changes and commercial products
- improving public services, e.g. in health care.

However, a common feature in all these is that they are knowledge-based clusters as opposed to the Porterian concept of clusters based only on industrial competitiveness. Several of them also involve sectors where public services play a major role.

Assessment of intention of appropriation against actual allocation

The introduction of new types of programme has required more time than initially anticipated. This is manifest, for instance, in the case of Tekes, in that the additional appropriation has been channelled to the intended specific areas of use but in different ratios from what was originally planned. Since the cluster programmes started off more slowly than anticipated, it became possible to allocate more funds to new business operations, for example. In part for the same reasons, the outturn in funding at the Ministry of Trade and Industry was considerably smaller than originally planned. The 1998 appropriation sum for Tekes was reduced by FIM 40 million and, in 1999, the difference between the intended appropriation and the actual outturn totalled FIM 80 million. The net increase to the Technical Research Centre fell short of the intended by FIM 14 million in 1998, but was offset by FIM 16 million in 1999.

A survey carried out by the Ministry of Education indicates that, since the supplementary budget for 1997 was adopted at such a late date, the universities were unable to use the appropriations until 1998. The Bioteknia II project headed by the University of Kuopio was introduced as a new item. This reduced the resources available for other activities. The Academy of Finland observed that since the student application process in the graduate schools required time, it was not possible to allocate the appropriation for 1997 properly. New graduate schools started their four-year operation at the beginning of 1998.

3 EVIDENCE OF IMPACTS

In this section we summarise the evidence we have collected on the effects of the additional appropriation. These findings are organised in the following sequence:

- the effects on basic research;
- the degree of networking, both in general and in the cluster programmes;
- effects on productivity and employment;
- implications for modernisation and regional development and finally;
- a comment on Tekes.

Basic research

The purpose of university research is to produce new knowledge regardless of whether that knowledge can be exploited in the short term. However, the importance of the contribution of basic research to a knowledge-driven economy is indisputable. It is now understood that the traditional linear model of technology transfer, in which each stage towards innovation is the unique consumer of the output of the previous stage, is at best a special case. Today's research policies stress the stimulation of interaction at all stages and the continuing relevance of basic research even as commercialisation is under way. Knowledge flows proceed not only through scientific publication but also collaborative networks in research, expert advice, the development of equipment and other resources and, above all, through the flow of trained personnel from university to industry. A range of new intermediary devices has emerged to accelerate the process, including science parks, incubators, spin-off companies and services to connect small firms to research. It is therefore a matter of great importance to assess the effect of the additional funding on the state and quality of basic research in Finland.

Funding effects

Universities have been major beneficiaries from the additional funding, receiving direct funding from the Ministry of Education, research funding from the Academy of Finland and a share of Tekes funding for collaborative projects. There are no distinctive measures which result solely from the additional funding. Rather, the effect of the funding has been to reinforce existing policies. The most important effects on the nature of inputs appear to be:

- a shift in the proportion of university research funding from external (project funding) rather than core sources;
- a relative shift towards programme funding by the Academy of Finland;
- increasing cooperation and gearing of funding between public agencies, notably between the Academy of Finland and Tekes;
- development of new graduate schools and expansion of existing ones; and
- a higher success rate for applicants for funding to the Academy of Finland (rising from an acceptance rate of 14% of applications in 1995 to 23% in 1999).

A critical question from the point of view of evaluation of the additional funding is whether the quality of research funded has been maintained while the proportion of applicants funded has risen. We are assured by the Academy of Finland that this is the case – in their evidence they argue that 80% of applications are of sufficient quality to fund. The selection of even 23% represents highly competitive funding. The general shift to project funding has increased competition within the system.

System changes

As well as reinforcing trends in funding inputs, the additional funding has also increased the pace of structural changes in the research system. Most notable is the large increase (trebling during the 1990s [Academy of Finland]) in the numbers of research staff in universities. Both research and training benefits arise from the expansion in the numbers of post-doctoral positions and there is a need to maintain a flow through the system to industry as well as to maintain the capability for university teaching. However, this expansion also emphasises the volatility of this effect which has been reinforced by the additional funding – without continuing support at this enhanced level there could be negative effects on research employment in Finland.

A significant proportion of additional funding is being used actively to support improved networking between universities and industry. Here again, the general trend nationally and internationally is for an increase. Taking just one measure, direct funding of research in universities by industry is reported to have increased by a nominal 17% in the period 1995-1998 (68% from 1993 to 1998). However, this increase is somewhat less than the corresponding rise in overall industrial R&D spending, where the increase for 1995-1998 was 66% (113% in 1993-1998). This suggests that there is still scope for improvement here. In fact, the private sector spent only 1.4% of its R&D funding in universities in 1998. (Appendix 9.) [Statistics Finland]

One reason why the level of cooperation with industry is less than it could be is suggested by the VTT study of Finnish US patents [Persson, p. 32]. This showed a certain imbalance between strength in science and strength in innovation. In patenting, Finland shows strength in telecommunications, wood and paper, and related science and engineering fields. However, in other fields such as biotechnology and pharmaceuticals, the number of patents is increasing relatively slowly considering the strong national research base. This in turn may partly be explained by the strong national orientation of the technology base and the international orientation of the science base. In other words, researchers in pharmaceuticals may be collaborating with foreign firms. The biotechnology sector is not yet mature enough to affect the industrial structure, but it is important to guide its development so that, in the future, the right balance between science and industry emerges. More generally, better national cooperation will require action on both sides.

Concentration of funding in certain universities is strong but has hardly changed during the period of additional funding. Hence, the two major universities – the University of Helsinki and Helsinki University of Technology – account for about 40% of research funding of all Finland's twenty universities. Together with the University of Oulu (in the far north), the share rises to 50%. Adding a further five universities covers two thirds of R&D expenditure. A different type of concentration, the policy on centres of excellence, seems to us an important development. A small country needs to achieve critical mass if it is to be internationally competitive in research. This also places Finland in a potentially good position to take advantage of the development of the European Research Area.

The classification of research fields was revised in 1997, which makes it difficult to compare the development between individual disciplines, especially those of natural sciences and engineering. If these two fields are considered as one group, it can be said that selectivity of funding between research fields at the top level has been only slightly affected (Table 4).

Table 4. R&D in universities in 1993, 1995 and 1998. Spending on research by discipline. (Statistics Finland)

Discipline	1993		1995		1998	
	FIM 1,000	%	FIM 1,000	%	FIM 1,000	%
Natural sciences	465,800	24.2	554,230	22.7	1,117,045	32.1
Engineering	547,800	28.5	604,911	24.7	702,236	20.2
Medicine	374,100	19.5	456,245	18.7	522,185	15.0
Agriculture and forestry	90,500	4.7	100,041	4.1	80,175	2.3
Social sciences	403,800	21.0	452,709	18.5	699,932	20.1
Humanities	218,200	11.4	277,788	11.4	360,251	10.3
Total	2,100,300	100.0	2,445,924	100.0	3,481,822	100.0

Table 5 presents a list of the top ten individual disciplines, measured by R&D expenditure in 1998. Biology and environmental sciences held the top position. Support for the ICT sector can be recognised by computer science and mathematics appearing in the top ten list. Business economics is also gaining more of a foothold.

Table 5. The ten individual disciplines receiving the most university R&D funding in 1998. (Statistics Finland)

	% of all university R&D spending	Cumul. %
Biology and environmental sciences	10.1	10.1
Clinical medicine	6.4	16.5
Electrical engineering	5.7	22.2
Physics	5.5	27.7
Chemistry	5.3	33.0
Education	5.1	38.1
Business economics, economic geography	4.9	43.0
Computer science	4.8	47.8
Linguistics	4.5	52.3
Mathematics	4.1	56.5
Total FIM 3,481.8 million for 45 disciplines		

One further issue in structural terms concerns the balance of funding. The trend towards external funding has resulted in a shortfall in the availability of infrastructure for research paid for out of core funds which have not seen a corresponding rise. Areas of particular concern are research equipment and library support. An even more important concern is the potential diversion of resources from basic education and the long run effects which this could have.

Quality and impact of research

The relevance of basic research is inseparable from its quality – companies are rarely interested in basic research which is not excellent. Hence, the key evaluation issue concerns the quality of this research. As with all aspects of the additional funding, it is not possible to separate the incremental activity, so it is necessary to look at the overall performance of the Finnish system. The only indicator of research quality is independent peer review. Our examination of past evaluations by international peers indicates a generally satisfactory situation. However, such reports are difficult to aggregate or compare. In view of this, our main effort at assessing the state of research impact for Finland was through the commissioned study of scientific publication and citations from VTT and partners. This provided several important findings, all of which point to an excellent performance and hence national potential for the future:

– Finnish scientific production shows a positive growth in terms of papers and their citation impact. Finland's share of world output has increased from 0.70% in 1990 to 0.92% in 1998. This is the largest increase among the Nordic countries. Since 1991, the relative citation impact of Finnish papers (citations per paper for Finland/citations per paper for the world) has been above the world average, and in the late 1990s well above the world average (Figure 7). When a scientist cites an article in a refereed journal, it is normally considered that the article is making a significant contribution. Hence, citation impact is considered a good measure of impact and quality.

– In straightforward numerical terms there were 6,623 papers with Finnish authors in SCI/SSCI journals in 1998, an increase of 66% since 1990. Universities account for almost 80% of the total.

– The improved relative citation impact is explained by an increased tendency to publish the results of Finnish research in international journals with a high ranking (journal impact factor). A further explanatory factor is the increasing tendency for Finnish papers to be internationally co-authored (see section

Cooperation networks and cluster programmes). Such papers are usually more highly cited, particularly if the co-author is from the USA. This arises from the general effect of home country bias in citation and the generally higher citation rates attained by US journals. While it may be more difficult to be published in such journals, it does not necessarily mean that the papers are of higher quality. Furthermore, some topics, notably in the social sciences, are of national interest but do not have a natural outlet in American publications.

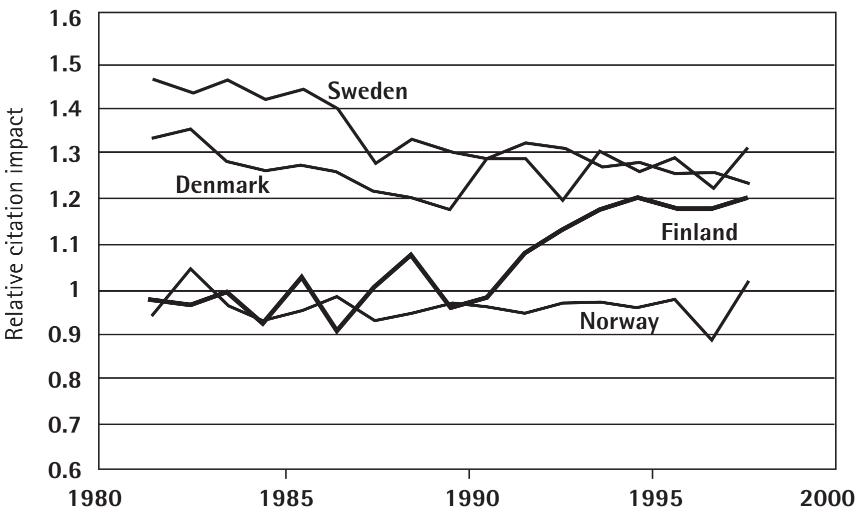

Figure 7. Citation impact of the Scandinavian countries relative to the world average (=1). [Persson]

An important argument for funding basic research is its role in attracting industry to locate its technological activities in a particular region. Universities can also be an engine of economic growth for existing and new firms. That being the case, it is relevant to examine the distribution of knowledge output. Two observations can be made. Firstly the Uusimaa (Helsinki) region produces about half of the total output of Finnish science in terms of publication. Indeed, in 1998 the University of Helsinki alone accounted for 35% of Finnish output. Nonetheless, the trend over the period 1986-1998 is for a slight decentralisation, with this region losing about 3 percentage points, mostly to the Southwest Finland region. In terms of citation, analysis of journal impact factors shows a positive correlation between size of output and impact.

Cooperation networks and cluster programmes

Cooperation networks

The Science and Technology Policy Council has stated that the development of the Finnish innovation system rests heavily on close cooperation between the public and private sector, with networking a key element. Networking, defined here as cooperation between universities and industry, research institutes and industry, and between large firms and SMEs, is generally seen as a key strength for Finland. International indices show Finland at or close to the top of any list seeking to measure networking. Thus the Second European Community Innovation Survey shows Finland with 53% of innovative firms having cooperation agreements with universities in the period 1994 to 1996, compared with an EU average of 7.5% — admitting that the EU average consists of heterogeneous countries when it comes to their cooperation culture – and a similar picture for cooperation agreements with research institutes. OECD data shows Finland second only to Sweden in the share of firms with cooperation agreements with university or government research institutions. [OECD]

This positive situation has at least in part arisen through policy actions. The report commissioned for this exercise from VTT on "Research Evaluation in Finland" shows that insufficient cooperation had been diagnosed as a weakness in the 1980s and early 1990s. Nonetheless the report concludes:

"Measures taken over the years to further cooperation between the main players of the national R&D system have been successful, i.e. collaboration between universities, research institutes and industry has, in general terms, strengthened. R&D programmes have enhanced target-orientation among researchers, and generated closer cooperation between researchers and users of research results." [Oksanen]

The extent to which networking is actively promoted can be seen in current Tekes activities, where FIM 909 million is spent on research funding for universities and research institutes (38% of total R&D funding in 1999). Networking also takes place through company projects funded by Tekes as illustrated in Figures 8 and 9. The planning phase of technology programmes appears to be one forum for networking between companies and the research sector (including private as well as public research institutes). The latter figure shows a rapid increase in financing of research institutes and universities by companies in 1997, driven at least in part by the overall increase in funding. The smaller rise for networking with SMEs reflects the greater difficulties involved in achieving this goal and insufficient resources in Tekes, at that time, to improve this performance. We are informed that the problem is now being addressed.

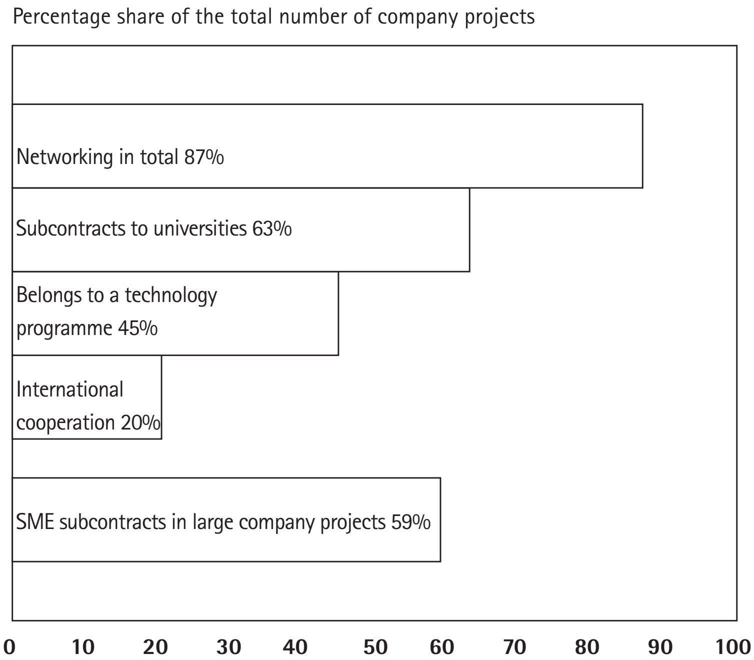

Figure 8. Networking in company projects funded by Tekes.

It is also the case, as noted in the section on cluster programmes, that networking can take place even where there is no financial relationship, for example where companies participate in project steering groups. Evidence of this comes from the recent study of the impact of Tekes grants for applied technical research, where survey findings showed that companies felt that working in the steering group gave them access to important information on the latest breakthroughs and developments in their area of interest. Furthermore, two thirds were envisaging further cooperation. [Bergenwall]

With this generally positive picture, two items of evidence give cause for concern:

- The Tekes project monitoring system indicates that the increase in networking is slowing down and will continue to do so without new incentives.
- SME cooperation is modest, both with universities and with large companies.

Furthermore, the evidence of increased inputs to networking is not at present reflected in academic publication. The bibliometric study shows that collaboration between academia and industry is more or less constant and decreasing relative to the overall Finnish paper output (Figure 10). On the other hand, cooperation

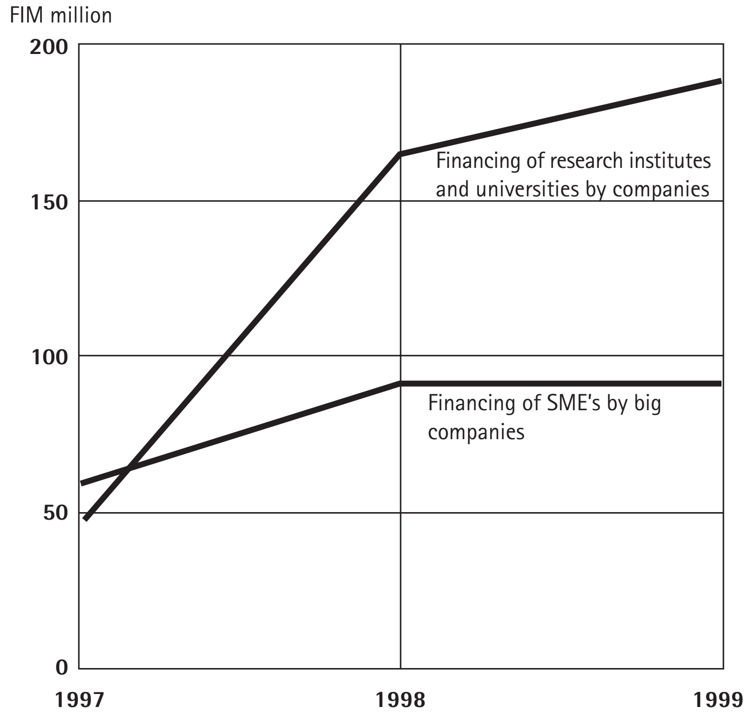

Figure 9. Networking in projects funded by Tekes.

between academia and the institute sector is growing. However, when industry publishes papers, most are in collaboration with academia and the proportion is growing – from 46% in 1986 to 56% in 1998. Most industry papers are from pharmaceutical companies. This may give a clue to the apparent poor performance on this indicator. Vigorous growth in coauthorship in the USA is heavily driven by the biotechnology sector, which is much smaller in Finland both relatively and absolutely.

The final aspect of networking to consider is that of international cooperation. The review of past evaluations states that most of them point out the benefits that a small country like Finland can gain from contacts with the international research community. They have also shown that Finland has generally played an active role in defining international programmes, particularly those of the European Union. They also warn that such cooperation is not always cost-effective because of the high overheads involved. This has not proved a significant barrier up to the present time. The bibliometric study has shown a dramatic increase in international coauthorship of papers (159% growth from 1986 to 1998). Not surprisingly, the greatest growth has been in cooperation with EU countries, which is now twice as frequent as with the USA. Nonetheless, the importance of working with the USA is emphasised by the fact that it remains the single largest partner country. Cooperation with the USA should be strengthened.

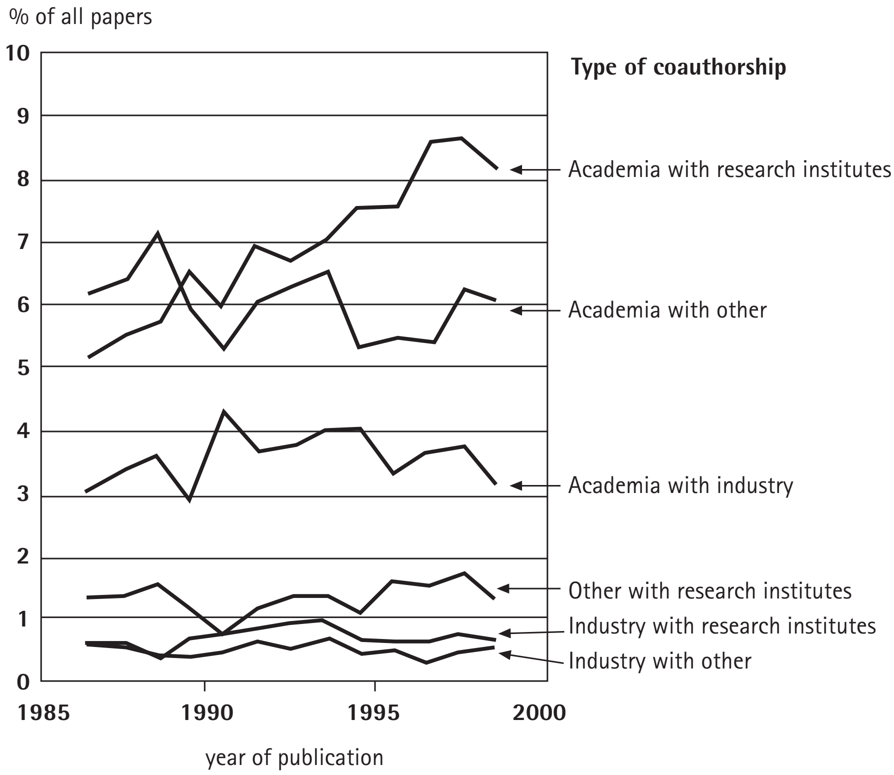

Figure 10. Percentage of all Finnish papers coauthored across sectors. (Note: The classes are not exclusive.) [Persson]

Cluster programmes [1]

The exploitation of the potential of clusters of economic activity has been a growing theme of innovation and competitiveness policy in several EU Member States throughout the 1990s. In this context, a cluster is understood as a network of enterprises and other organisations with similar interests in which participants seek benefits from collaboration. Participants are enterprises, the public and private service sectors, government and the research and education system. In line with this, a cluster programme was one of the main new elements in the additional appropriation of research funding from 1997. Eight cluster programmes were launched under five sectoral ministries (described in the section on sectoral ministries). While the overall aim was to support R&D which strengthens industrial clusters, the areas chosen appear to be those where the maximum potential for public-private leverage exists rather than the areas of maximum industrial activity (though the two may overlap). They are extremely diverse in their nature, ranging from fundamental research through applied research to product development and promotion of technology diffusion. A similar variety exists in their size and structure. In total, this activity involves 441 participating organisations, of which 282 are firms working in 303 projects, of which 110 are industry-driven. Total finance is FIM 607 million, of which 23% is earmarked cluster funding from the sectoral ministries[2]. A similar amount is contributed by private industry. As intended from the outset, the clusters also draw upon other sources of public funding, notably Tekes and the Academy of Finland.

Diversity
The first point of our findings, supported by all our sources of evidence, is that the term cluster covers such a wide variety of activity that it is difficult to make generalisations. The NetMate Development Programme and the National Workplace Development Programme stand out in particular from the rest of the group, the first because it is an awareness programme without a research mission, and the second because it spans a wide range of sectors. This does not imply that these programmes are less worthwhile, only that there is no single concept that can be evaluated. Hence, we cannot say whether all clusters fit the cluster concept as the concept is not clearly defined.

Networking
For the other clusters apart from the two mentioned above, especially the largest, Wood Wisdom, the original networking dimension comes through very clearly, with the whole value chain in the sector being covered and new linkages being established. This is also true for others, such as the Well-Being and Environmental clusters. The networking is of different kinds. As the VTT report points out, one of the clear successes of this mechanism has been to bring together the sectoral ministries and the bodies responsible for the support of science and technology. This will be of lasting benefit if it convinces the sectoral actors of the value of science and technology in pursuing their public service missions. It is this combination of sponsors that has enabled an integrated approach to the value-chain.

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1 In forming an opinion about the clusters we have had access to the following sources of information: presentations on the cluster concept and progress from the Science and Technology Policy Council of Finland; a commissioned study from VTT addressing the Wood Wisdom and Well-Being clusters; comments from coordinators of the clusters on the detail and general relevance of the VTT study conclusions; testimony from the coordinator of the Wood Wisdom cluster (which is the largest accounting for 34% of total financing; separate evaluations of the NetMate Programme and Well-Being Cluster; testimony from industrial participants in Wood Wisdom and Well-Being.

2 If a broader interpretation is applied in the Well-Being cluster, the overall magnitude of funds in the cluster programmes rises to FIM 1.3 billion [Academy of Finland, p. 42].

A second level of networking arises from the interaction between sponsors and participants. A good example is the Satakunta Macro-Pilot, a major element in the Well-Being cluster which aims to develop integrated client-centred services and to pilot an electronic smart card for personal identification in collaborative projects between municipalities, service providers and enterprises. This cluster has positioned itself at what is widely recognised as the leading edge of innovation, that is to say the fusion of products and services. This is being achieved by bringing together social and health service providers with industry and private services. In addition, those responsible for creating the framework for service provision in the ministries are also involved. This is not to say that this has been an unqualified success, but at this early stage it is clear that the effort is in the right direction.

Finally, the clusters involve direct collaboration between research participants. Such collaboration is less distinctive, as it is promoted in many other schemes, particularly by the Tekes Technology Programmes, but it remains of value as a concept.

Industrial participation

As a result of the emphasis on industrial clusters in the original funding decision, concerns have been raised about the level of industrial participation and commitment. These have been confirmed by a majority of cluster coordinators, most of whom feel that the number of firms involved in projects could have been higher. Evidence to the panel from industry has tended to contradict this view, with particularly strong statements of commitment coming from industrial participants in Wood Wisdom. Several qualifying explanations have been offered concerning the level of industrial participation:

- Industry and coordinators have stated that the rapid start to the programme did not give firms time to commit research resources.
- Industrial participation should be counted not only in the projects but also through presence in steering committees. This is particularly the case when results on basic research are being considered.
- A further “hidden” mode of industrial participation of particular importance in sectors dominated by traditional firms and SMEs is the engagement of research and trade associations. These bodies consider it their mission to disseminate the results to their client groups.
- In one cluster we were told that some Tekes-supported industrial work was in the cluster from the point of view of networking but did not have formal status because there was no incentive for the firms to report to the two sponsors.

All of the above points have some validity, but probably the most important explanation lies in the strategic positioning of the clusters. Their strongest features, notably their engagement in public sector missions, have tended to position them upstream in the innovation cycle from where industry is most likely to participate. Some coordinators believe that the first cycle of cluster programmes can be seen as a preliminary stage creating a platform which industry will join in the future. The VTT report also called for clusters to be started in more clearly industrial sectors such as telecommunications. We are not convinced by this argument – the more the sector is industry-driven, the less the need for engagement of the public sector in this very active manner, except in circumstances such as development of standards and promotion of new firms. We note the findings of the Advantage Finland study on Finnish clusters, which identified essentially sectoral clusters, but concur with more recent analyses which see the core of clusters being knowledge-driven and often drawing upon new combinations of sectors [Hernesniemi].

In general, the administration of the clusters appears to have been satisfactory for participants if allowance is made for the need to start up very quickly. One issue which has been prominently discussed is the question of coordination of funding from multiple sources. In general, the pattern has been that joint discussion of applications by sponsors has been followed by participants being referred to the normal procedures of whichever body is sponsoring them. This can create problems of synchronisation, and possibly divergent objectives, when there are multiple sponsors for a single project. Some have called for funding to be issued from a single source. While this has some appeal, it might be hard to implement in practice and could risk losing the commitment of the sponsors. Instead, the sponsors should strive for better coordination and elimination of duplication (in at least one case there was already a Tekes programme in place providing similar support). Some inefficiencies and lack of focus, which can be easily excused given the novelty of the concept and the need to mobilise quickly, should nonetheless be eliminated in future rounds.

Productivity and employment

Most OECD countries are in a process of transition from resource-based to knowledge-based economies. For more than ten years, the OECD has been active in analysing these developments and the characteristics of the transition. The new economic theories, the new growth theory and the new trade theory suggest that research and innovation have become the driving force for economic growth, social development and job creation and the primary source of international competitiveness. Nevertheless, empirical evidence shows that, not only for Finland, the relationships between research, productivity and employment are not so simple and clear as the popular understanding suggests. The ETLA study on "Privately and Publicly Financed R&D as Determinants of Productivity: Evidence from Finnish Enterprises" studied these relationships with firm-level data from 1986 to 1996 [Asplund, chapter 3]. The analysis covers the whole manufacturing sector as well as many service industries. The study shows that industry-level R&D intensity has substantial impact on a firm's productivity growth. The effect seems to be particularly strong for small firms. High skill levels, especially in the fields of engineering and science, appear to play an important role in the productivity growth process. Product innovations also contribute significantly to productivity growth. In contrast, the estimated impact of R&D intensity at the level of the individual firm is mostly statistically insignificant. This shows, as in studies on other OECD countries, that there is a large variation in behaviour and characteristics among firms within industries. Nevertheless, the results obtained for industry-level R&D intensity indicate that the R&D environment of industry is a crucial factor behind the productivity growth of Finnish enterprises.

A second important result of the ETLA study is the relevance of spill-over effects. The spill-over effects of R&D influence the relationship of productivity development between firms, sectors and nations. The ETLA study supports and confirms the importance of spill-over effects, especially for small and medium-sized firms. For Finland, this means that while large enterprises account for a dominant share of the total R&D effort undertaken in the industries, large enterprises can also be argued to be important for the performance of small and medium-sized enterprises. Other studies in OECD countries also show the increasing importance of the international spill-over effects of R&D.

Finally, the results of the ETLA study indicate that skills are crucial, not only in improving the quality of labour input from a productivity perspective, but also on account of their critical role in the process of developing technologies in the longer term. The study gives strong support for the widely held view that research and development, as well as education, are key factors for competitiveness and economic development in Finland.

Nevertheless, the aggregate productivity patterns may give a misleading picture at firm level. Not only R&D, but also other factors, such as worker training, organisational structure and managerial ability are crucial. Organisational change is also influential in securing productivity gains. The absorptive capacity of firms determines the extent and efficiency of the absorption of spill-over effects. R&D alone can only bring limited productivity gains. A policy focus solely on R&D, therefore, is too limited.

R&D influences not only productivity but also employment. The ETLA study on "Job Creation by Supporting Technology Advances? Evidence from Finnish Plants" [Asplund, chapter 4 and App. II] provides a fair amount of evidence for Finnish manufacturing and services in support of the contention that high-tech firms are of considerable importance for job creation as well as for job sustainability (Figure 11). Firm-level as well as industry-level R&D intensity seems to contribute positively to net job creation in Finland. On the other hand, there is a relatively large amount of simultaneous job creation and destruction and also of simultaneous hiring and firing among Finnish high-tech plants. Worker outflow to unemployment is relatively low while worker inflow from unemployment is relatively high (Table 6). It seems that both high productivity in the individual firm and high industry-level R&D intensity are significant for net job creation especially in small and medium-sized enterprises. Firm-level R&D intensity, in turn, appears to be more strongly associated with job creation among large firms. The study demonstrates that the R&D intensity of firms contributes positively to net job creation in the Finnish economy. Moreover, industry-specific R&D intensity – the R&D environment of the firm – seems to have additional impact on net job creation. As a consequence, the Finnish economy, after going through a painful adjustment process during the recovery period, has gained a large number of productive jobs, safeguarded by superior competitiveness.

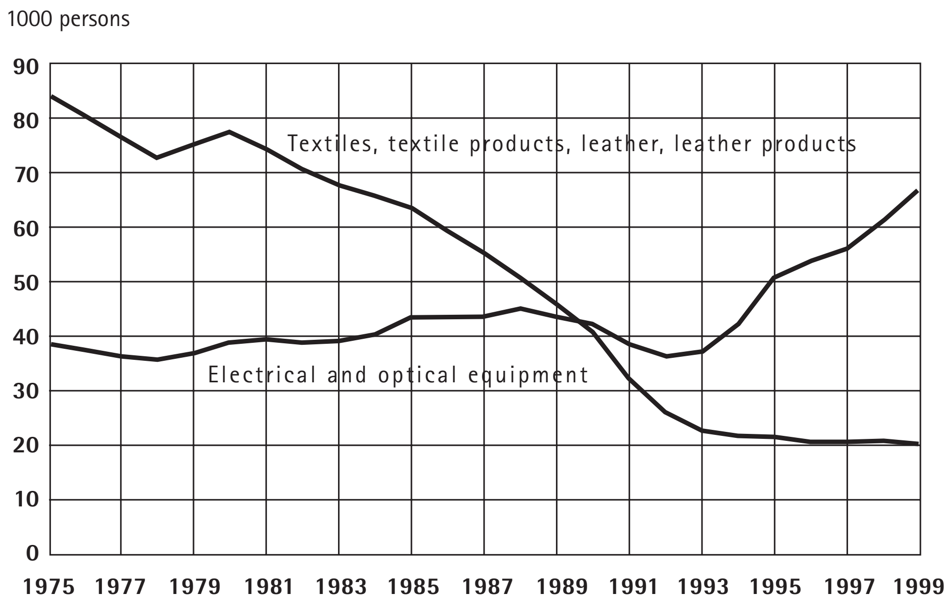

Figure 11. Employment in two Finnish manufacturing industries. (Source: ETLA database)

The study of the statistical R&D unit, Statistics Finland, on "Impacts of Public R&D Funding on the Profitability and Growth Performance of Firms: A Panel Data Study on Finnish Firms" [Lehtoranta] supports the empirical evidence: the number of employees was positively influenced, not only by sales but also by product innovativeness and R&D intensity. Direct subsidies and subsidised loans had a minor but statistically highly significant positive effect on firms' staff numbers. Insofar as firms conducted R&D, the R&D intensity and the share of staff with higher education influenced the gross operating profit ratio in a statistically highly significant manner. The average growth of sales (over the period 1993 to 1997)

Table 6. Changes in employment in Finnish manufacturing.

	Technology level by industry		
	high	middle	low
Number of employees 1995	124,000	84,000	205,900
Change in employment, %			
1987–1989	-0.9	23.2	-0.4
1989–1991	-28.1	-22.8	-18.9
1991–1993	1.4	-29.8	-8.4
1993–1995	24.1	39.6	-0.6
1995–1997	9.3	4.9	-4.1
1997–1999	10.3	5.2	1.0
1987–1995	-10.3	-6.8	-29.1
1995–1999	20.6	10.4	-3.1

Note: The categorisation of industry branches into technology levels follows the OECD definition. Source: Parjanne (1999) for the years 1987–1995 and calculations performed by Statistics Finland for the years 1995–1999 with the underlying technology categorisation finalised by Parjanne.

was positively influenced by the share of employees with higher education, export share and product innovativeness, and also by receipt of R&D funding. The share of direct subsidies in relation to a firm's own R&D expenditure in 1993 also seemed to have a significant positive effect on sales growth from 1993 to 1997.

Although it is methodologically impossible to quantify the effects of the 1997-1999 additional R&D expenditures on productivity and employment, a broad spectrum of empirical evidence supports the idea that this policy will significantly contribute to the growth of new jobs in Finland as well as to the adjustment process of firms and industrial sectors.

Nevertheless, as other OECD studies show, the positive correlation between R&D and employment at the level of the firm leads to significant overall employment effects only if the macroeconomic conditions are favourable (especially those which foster growth, such as monetary and fiscal policy). Therefore, favourable conditions at the macroeconomic and microeconomic level are necessary if R&D-based employment growth is the aim of economic, science and technology policy.

Finally, the ETLA study shows that forced and strong technological and structural change in the Finnish economy led to a deep change of skills and demand for higher qualifications (Table 7). This strong mismatch between low and high skills, which is a general phenomenon in the OECD, can only be solved by a very advanced and flexible system of education, primary education and occupational training, and an economic policy supporting occupational, sectoral and regional mobility of the workforce. Nevertheless, low-skilled workers are the losers in globalisation and technical change not only in Finland but also in nearly all OECD countries. It cannot be expected that support for R&D, education and training will solve this problem in general. Very specific labour market programmes for this part of the workforce are necessary in a society in which social integration is of high value.

Table 7. Percentage shares of blue- and white-collar workers in the Finnish economy.

	1987	1989	1991	1993	1995	1997	1999
Manufacturing:							
Blue-collar, %	72.0	68.5	64.4	63.7	63.5	61.8	62.4
White-collar, %	28.0	31.5	35.6	36.3	36.5	38.2	37.6
All sectors:							
Blue-collar, %	44.9	44.2	41.4	39.1	39.5	38.2	38.0
White-collar, %	55.1	55.8	58.6	60.9	60.5	61.8	62.0

Source: Parjanne (1999) for the years 1987–1995 and calculations performed by Statistics Finland for 1997 and 1999.

Modernisation and regional development

Integration of the new and the old economies

The competitive advantage of the Finnish economy and the firms in it has changed significantly as the Finnish industrial structure has shifted from slow-growth industry towards knowledge-driven industries and clusters. This move has made the country less dependent on world markets for wood-based products. From the perspective of a small open economy, overcoming the relative disadvantage of size means specialising in niche markets and exploiting company networks; this is particularly true in the case of small and medium-sized enterprises.

In the early 1990s, the Finnish economy was in the middle of its deepest recession of the century. The economy was in a severe slump, accompanied by major structural crises. Now the economy is booming; the industries with the largest growth rates include manufacturing of electrical and optical equipment, insurance, services for the financial and insurance industries, real estate business services and other services. As in other countries, it seems likely that in Finland high-tech industries and knowledge-intensive services – the so-called new economy – offer the highest growth potential. Because of this experience, a certain tendency exists in Finland to focus research policy mainly on new, high-tech areas and to pay less attention to the "old economy".

The economic theories of trade argue that countries have to specialise economically and technologically. Many studies show that there is a positive correlation between technological specialisation and trade specialisation in individual countries. That means that individual countries are economically competitive in those fields in which they are technologically strong. Empirically, national innovation systems differ in their patterns of technological specialisation. The world's major economies follow very different paths in utilising their respective strengths. Internationally, the main features are that there are no overall signs of convergence of different specialisation profiles, and for most countries there is a significant positive correlation between past and present patterns, which means that specialisation is highly path-dependent. This leads our expert group to the conclusion that – besides the support of new high-tech areas – the modernisation of traditional areas of the Finnish economy is a crucial complement to the support of new high-tech areas.

The popular understanding of substitution of the old economy by the new economy should be modified and transformed to a vision of the integration of the two, as shown in Figure 12.

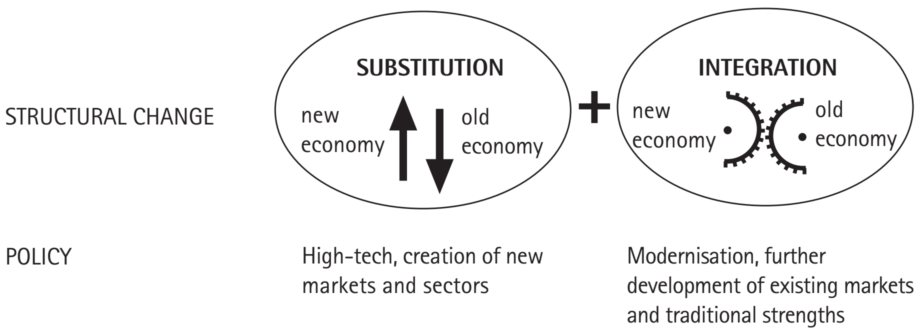

Figure 12. Complement substitution with integration of the new and the old economies.

Based on OECD reports, the main traditional strengths of Finnish industry are forestry, wood products and furniture, paper, paper products and printing, basic metals, and textiles and leather (up to the eighties). "Modernisation" means in these cases that the new cutting-edge technologies such as communication, information technology, biotechnology, new materials, etc., offer a wide range of new opportunities in these traditional areas. Modernisation also means improvement of the sectoral and inter-sectoral innovation systems (this is the idea of the cluster policy), which, besides public policy, includes especially company strategies, production factors, demand conditions and supplier-customer relations.

Public R&D funding has been aimed at this kind of modernisation, for example in Reima-Tutta Oy, which represents the Finnish clothing and textile industry. Their Smart Clothing project aimed at developing an outdoor suit that increased the wearer's chances of survival in the event of an accident in arctic conditions. Reima-Tutta Oy developed the suit in cooperation with the University of Lapland, Tampere University of Technology, Suunto Oyj (electronic compass), Polar Electro Oy (heart-rate monitor) and Du Pont Advanced Fibre Systems (fibres). Development work for the prototype suit was partly financed by Tekes.

Another example of public support for those outside high-technology, though not within the additional appropriation programme, is the Skills Technology programme. The programme is trying to reverse the downward trend in the number of employees in areas manual skills, culture, services and agriculture. Some ten per cent of the labour force is involved in these areas nowadays. The bottleneck lies mainly in the marketing phase. Hence, the programme aims at promoting networking and internationalisation of small and medium-sized enterprises. At the same time, we can expect better payback from public investment in SME product development. The following pilot projects have been launched: bag and leather industry, building of musical instruments and interior design of public premises.

Regional impacts of R&D and public funding

Competition over technology and growth is shifting increasingly away from competition between nations towards competition between regions. In particular, European economic and monetary union will accelerate this process. Even though geographic boundaries no longer affect the availability of the information and know-how needed for innovation as a result of increasing globalisation and continuous improvements in telecommunication and transportation, this information and know-how is still being generated and used at a local level. As a rule, production is initially sited in the regions where the research is being conducted — and vice versa. Competence and expertise come together in a "network of players" comprising science and industrial research, production and services, "core-products" manufacturers and component-makers, small and large firms, old and new businesses, sources of supply and sources of demand. In their early stages, such networks tend to have strong regional ties, facilitating the emergence of internationally important innovation locations through pooling expertise and know-how.

Regional concentrations of innovative industrial expertise are primarily characterised by the fact that industry in the respective region has a strong demand for college graduates and employs a large number of scientists and engineers whom it also deploys in research and experimental development (high-quality services). Differences between regions also emerge through the presence of research-intensive industries. Thus, the Labour Institute for Economic Research was asked to perform a study on "Regional Impacts of R&D and Public Funding" [Lehto] to test the main hypothesis of whether regional and industrial proximity matter in Finland. Generally, the study comes to the conclusion that they do.

Policy intervention which increases R&D in one location in a specific industry raises the productivity of other firms in the same area or in the same industry. As a consequence, R&D activity of other firms in the same sub-region also tends to grow. Total employment in the same area may also increase, at least in high-skill professions. The study also shows that small and medium-sized firms are more dependent on geographical distance than large firms. It shows that the research intensity within the region has positive effects on the R&D and productivity of the individual firms. The increase in the proportion of the staff who have had tertiary level education had a remarkably positive impact on productivity. A plant's own R&D and external R&D in the same sub-region strengthen local R&D activity but do not necessarily improve the competitiveness of low-skill activities in the area. On the contrary, in many sub-regions with scarce R&D, the low cost of living, local infrastructure and supply of labour make the circumstances favourable for running assembly plants and other activities with less strict requirements for professional labour skills.

Figure 13 presents the spread of companies' overall R&D investments geographically. Salo, Helsinki and Oulu are the most R&D-intensive regions in terms of the number of inhabitants (index over 200). They are followed by Northeast-Pirkanmaa, Porvoo, Vaasa and Tampere (150-199). The last group above the average level for the country consists of Äänekoski, Imatra, Raahe and Southwest-Pirkanmaa (100-149). The R&D capital is an estimate and it is defined as the R&D capital committed to companies which has been accumulated from the companies' own R&D investments as a result of earlier activities. It does not include public sector R&D investments. [Lehto]

These results show that there is room for regional policy in R&D. They prove increased awareness of the research policy on the regional distribution of industrial R&D and public R&D infrastructure, the establishment of networks and linkages and the improvement of linkages between public research and industrial R&D. Nevertheless – as can be observed in other OECD countries and especially at the European Union level – a conflict exists between the aim of balanced regional development (such as cohesion at the EU level) and national and international excellence in R&D aimed at enhancing national competitiveness. In many countries it is possible to observe that the mix of these two aims leads to counter-productive

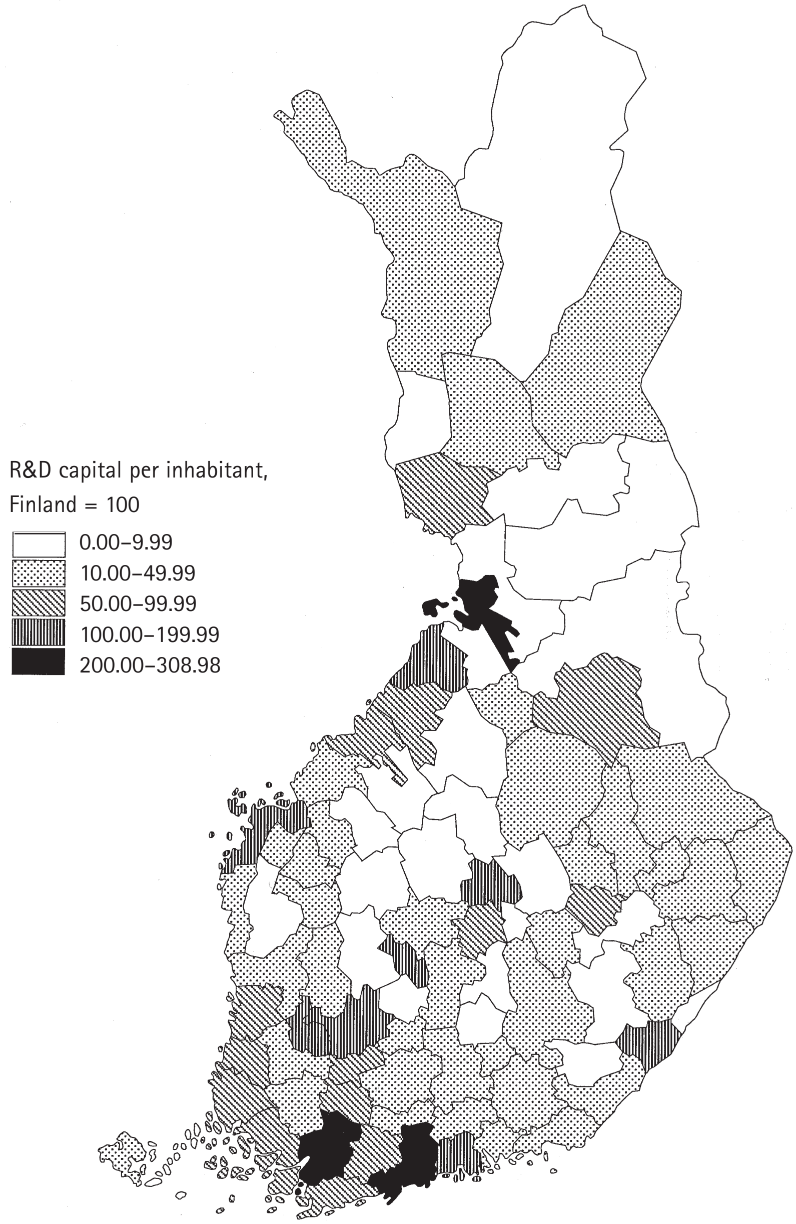

Figure 13. R&D capital per inhabitant by regions in 1997.

and inefficient policies if only one research policy instrument is used for these two distinctly different aims; this leads to the problem of over-determination. Although global excellence and regional development are inter-dependent, they should be managed as separate missions. Different instruments should be used to achieve the aim of regional balance and the aim of national and international R&D excellence.

Tekes

The impact of the National Technology Agency, Tekes, activities has already been discussed in the sections on networking and clusters. However, there are some further points we would like to make about this organisation. Our general view is that Tekes is at the leading edge of innovation agencies in Europe, both because it has been well-financed and because its project selection and management procedures are very rigorous. A vast majority of our industrial interviewees expressed an appreciation of what Tekes was doing. However, past success does not mean that no changes are needed to meet a rapidly changing global situation. In fact, we believe that by 2002 it will be time for a new strategic evaluation of Tekes (the last was in 1995). This could also extend to other parts of the innovation system that interact with industry. Our comments here are based upon much more limited information.

One point where we feel some change is needed is a stronger effort to create an organisational culture which fully appreciates that innovation occurs not only in technology. We recognise that the new strategies and structures are moving in this direction, but the movement could be still faster. The interdisciplinary demands made by many new sectors of the economy require a more explicit combination of social science, management and even the humanities with science and technology. The example we cited in this report of a company which combines excellence in clothing design with advanced technology shows the type of area Tekes should build on.

A second point is that success in innovation does not result only from developing excellent new products or processes but also requires these to be combined with a variety of business, marketing and commercial skills. We believe more could be done in helping small firms to acquire these competences. Again this is an area where an encouraging start has been made but greater resources appear to be needed.

The third point arises directly from our supporting study (LTT) [Huolman]. This shows that Tekes reaches dynamic firms. This is good, but there is also a need to encourage the large group of companies which lack any kind of technology base except through purchase of equipment. Bringing technology to traditional and conservative sectors may in the past have been inhibited by the use of the same instruments for all sectors. Targeted programmes which meet the needs of specific sectors may be a better option.

Our final point on Tekes is to express concern that there have been external pressures for it to take regional considerations into account in the allocation of resources. Several decades of experience of technology policy have shown that combining regional assistance with support for excellence in a single measure is doomed to failure. There should be a clear separation of these two missions.

4 POLICY OPTIONS FOR THE FUTURE

In 1996, the Science and Technology Policy Council of Finland identified knowledge and know-how as being of crucial importance for the development of economic growth, employment and social welfare. From this concept of the knowledge-based society came the decision to increase public research funding, which we have been asked to evaluate. In the intervening years, the assumptions which underpinned that decision have proved to be correct and have even been exceeded. The rapid development of science and technology, the pace of globalisation of both industry and science, the transition from manufacturing to knowledge-based companies and the growing importance of human capital for competitiveness are trends which govern national competitiveness. Major global changes are described in more detail in Appendix 10.

Against this background, our task has been to assess the impact of the additional research funding (or as we have interpreted it, the more general impact of research funding in Finland). Our inquiries have covered all major players in the Finnish innovation system and encompass a variety of methodological approaches. All of this evidence points consistently to the conclusion that the policy has been highly successful.

- Basic research in Finland as measured by international peer review and by the evidence of scientific publication has been shown to be of very high quality. There has been outstanding growth in terms of Finland's share of international papers and the impact those papers have had in terms of citations. This improvement achieved by long-term investment in research is both absolute and relative to other countries.

- Networking between science and industry is internationally recognised as one of Finland's strong points and has shown a marked improvement over the past two decades. Internationalisation of Finnish science has also shown strong growth.

- For industry, there has been a large increase in R&D spending during the period of increased public funding. This can be taken with the finding that there is a clear impact on productivity growth arising from the intensity of firms' R&D activity. Furthermore, the well-documented success of larger firms in Finland has also been shown to benefit SMEs through spill-overs.

- R&D influences not only productivity but also employment. The R&D intensity of firms makes a positive contribution to job creation in the Finnish economy, though only in combination with other policies such as raising skill levels or securing favourable macroeconomic conditions.

- The importance of having an R&D presence in a region has been clearly demonstrated. Also clear is the importance of a highly educated workforce to the productivity of a region.

- Finally, we have looked at some of the cluster programmes where key actors are brought together in fields important to social welfare and to rejuvenating traditional sectors, both of which promise to extend the benefits of R&D to the population as a whole.

Despite these successes, we believe that there is scope for further improvement of present policies and for new policies to meet the changing environment. The first decade of the 21st century requires new answers. In our view the basic orientations for the next policy steps should be:

- improvement in building up the competencies of individuals, sectors and systems;
- co-evolution of public and private R&D;
- widening the focus from R&D to innovation and problem-solving;
- balancing high-tech, integration of the new and the old economies, and diffusion;
- strengthening Finland's attractiveness internationally and improving her influence in Europe;
- acting against marginalisation (regions, workforce, individuals).

In the following paragraphs we will make selective proposals which elaborate on our analysis but only represent the start of the debate on these basic orientations.

Main messages
1. Continue setting ambitious aims for research funding
2. Strengthen the conditions for basic research
3. Improve the cluster approach
4. Integrate the new and the old economies
5. Focus more on innovation
6. Develop the future competencies of the workforce

Continue setting ambitious aims for research funding

The additional appropriation programme was associated with fairly demanding objectives. The surveys which have now been completed suggest that these objectives were on the whole met both in quality and quantity. Although the final results of the programme will not be seen until much later, we can already now identify many positive multiplier impacts on the Finnish economy. Deviations from the objectives were mostly to do with the time of launching certain projects and the ensuing delays in their finalisation.

The results attained clearly show that ambitious objectives and follow-up of the outcome will lead to good results. However, as the volume of funding grows, the need to ensure balance in the control of funding grows with it. For instance, the National Technology Agency, Tekes, the largest agency that channels additional appropriations, does not specify the user groups of the appropriations in the Agency's cost accounting. We would also have appreciated more detailed information on the Well-Being Cluster. Statistics on science and technology need to be kept up to date and comparable to serve decision-making also in the future.

The question that now needs to be addressed is whether continuing control should be adopted in the form of content reports for projects eligible for appropriations even during the duration of the projects. This means that a true and fair assessment could be made of each project to evaluate whether there is reason to terminate the allocation of funds to a project, thereby making room for projects that might prove to be more fruitful. On the other hand, it should be remembered that where assessments become more frequent, measures to ease the burden of reporting by the organisations being assessed should be improved. The aim should be that projects receiving joint funding are not required to report separately to all their sponsors.

It is our recommendation that both the monitoring of cluster projects and the evaluation of the use of non-restricted research funds allocated to ministries be continued. Non-restricted research funds totalled almost FIM 700 million in 1999 (excluding the share allocated to university hospitals) and that indeed should be brought within the scope of systematic monitoring.

Since the original decision on additional funding, the increase in research spending in the USA has continued unabated while other European countries, such as the United Kingdom and most recently Sweden, have also increased research funding and set new ambitious goals. The most similar cases can be found in Austria and in Ireland. The changing global economy is characterised by a competitive process of continuous learning, and there is no longer time to take a break. We should therefore like to insist on the following recommendations.

- The high level of research funding now reached should most definitely be maintained in order to safeguard Finland's economic success and prosperity.

- In order to secure and improve Finland's competitiveness, consideration should be given to launching a new, precisely targeted additional funding programme.

Strengthen the conditions for basic research

The research community provides a vital pillar in the overall structure of the knowledge-based economy. As well as being a source of trained people and ideas, it provides a window on the much larger world of global research, where, even in its areas of specialisation, Finland cannot hope to achieve more than a small percentage of the world's total effort. A research base of world standing is also necessary if world-class companies are to locate or remain in Finland.

As well as the general case for maintaining increased support, there are five specific issues worthy of further investigation.

- The rapid increase of project funding relative to core funding has placed significant strains on the university system. In particular, the scientific infrastructure of equipment facilities and libraries has not kept pace with the demands being made upon it. This is at a time when the international trend is for research to become more capital-intensive even in fields which were not traditional users of equipment. The need for a specific investment programme should be investigated.

- In evidence, we have heard that the situation regarding intellectual property arising from university research is in need of review. Intellectual property rights are becoming more and more important in international business and rapid action is therefore needed.

- Making a contribution to economic and social problems requires holistic approaches. One consequence is that universities and institutes should be prepared to provide training and structures for interdisciplinary research and to foster close linkages of basic, applied and industrial research. Even basic research can be performed effectively in the context of a problem or goal.

- In Finland, in fields such as pharmaceuticals and biology, basic science is very strong. The industry side is comparatively weak. New modes of university–industry linkage have to be developed. This means fostering new international relationships or increased effort to start up and cultivate new Finnish companies.

- Centres of excellence will continue to be an effective way of promoting rapid development of promising research areas.

Improve the cluster approach

Overall, the cluster mechanism is an innovative experiment in innovation policy which recognises that improving linkages in the economy is one of the most powerful catalysts for progress. For a relatively small investment large-scale resources have been mobilised. However, the novelty of this approach has led to inevitable start-up problems. All of the specific evaluations of the clusters have commented that it is too soon to make a conclusive judgement. In general we welcome the decision to extend the life of the clusters. While the role of public funds is catalytic, none of the clusters has reached a level of maturity where private industry could be expected to carry the full burden of funding. However, the clusters should take the opportunity to learn from experience and give a sharper and more planned focus to their activities.

There is scope for the introduction of new clusters, but before this is done, some clarification is needed about the true goals of this instrument. The greatest potential arises in areas where completely new linkages are created. This includes those areas where there is a coincidence of interest between improvement of public services and provision of innovative industrial products and processes to achieve those improvements.

Integrate the new and the old economies

Owing to successful R&D investments, the so-called new economy (high-tech industries and knowledge-intensive services) offers the highest growth potential. Because of this experience, a certain tendency exists in Finland to focus research policy mainly on new, high-tech areas and to place less emphasis on the old economy.

The popular understanding of substitution of the old economy by the new economy should be modified and lead to a vision of the integration of the new economy and the old economy.

We propose programmes or actions of the following type:

- a new business concept for traditional industries based on areas such as e-commerce, integration of new components, integration of products and services, and design;

- new types of management concept, innovative organisation and production;
- studies to analyse the potential, needs and requirements of these firms and sectors;
- a new reflection on regional innovation policies by the Ministry of Trade and Industry which could consider what role should be played by the Employment and Economic Development Centres.

Focus more on innovation

After conducting a successful technology push type of innovation policy, it is now time to focus on a more customer-driven innovation policy. In some cases this involves shifting the focus from invention (creating new products, processes and services) to true innovation, their successful introduction to the market or application as a public good. We recognise that the strategic shift of Tekes in 1998 now gives this goal a central position but still consider that its implementation needs to be driven harder and faster.

In product development and marketing of the new products, we have to understand the customer needs in different cultures and religions. Cultural know-how is also needed when developing new products and services for the rapidly growing markets in contents and meanings. This is particularly true for a small country like Finland which must export to customers in a wide range of countries with different needs and values.

A successful innovation policy requires creative solutions for finding new innovations both in Finland and abroad. As a part of the Finnish innovation system, technology transfer policy should focus more on knowledge transfer policy. The diffusion of new technology, especially among small and medium-sized companies, calls for new ideas and policy decisions.

The Finnish venture capital market has developed rapidly, but new efforts are still needed to develop the pre-seed and seed financing markets. The quality and effectiveness of business incubators should be supported and new types of international and virtual incubators should be developed, especially to meet the needs of small start-ups at the regional level.

A special form of support for commercialisation of products should be considered to help small companies. Due to the narrowness of the domestic market, Finnish companies must start to operate internationally at a very early stage.

Business thinking in technology policy requires new efforts in management training and internationalisation, especially for small traditional companies. A more general question is why there is so little inward investment in Finland. A new theme for innovation policy should be to attract international companies which can work with the national science base and highly educated workforce.

Develop the future competencies of the workforce

The success of Finnish technology policy in the future requires a good infrastructure in research and education. The lack of competent people in the area of technology and natural sciences has been clear for many years (particularly the shortage of skilled IT workers). A lack of commercial resources is already in sight. In the near future, the lack of cultural know-how will also become critical. A success path for innovation policy is shown in Figure 14.

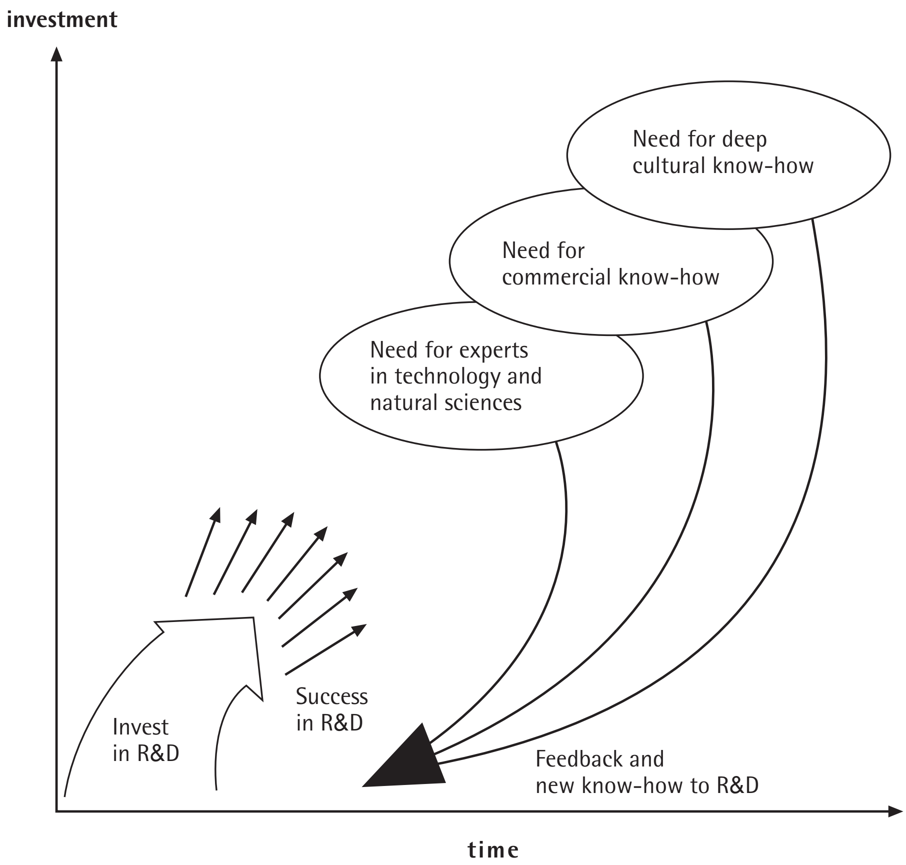

Figure 14. Success path for innovation policy.

The distinctions between basic and applied research are becoming blurred as a new research paradigm emerges for the service industries. This emphasises the need for industry to pay attention to long-term strategic applied research, and for a widening of the range of institutes involved in basic research beyond the present situation where it is performed only by the universities.

Only a high quality of basic research will secure good applied research and a supply of competent teachers in the future. These are factors essential to the future success of Finnish innovation policy.

The competence-based society is very sensitive. We can lose our competitiveness overnight. This means that competition is tough and has taken on the form of learning competition. Only those able to learn faster, easier and better than others can aspire to be a success in the future. This puts special demands on the Finnish school system. Especially girls should be encouraged to study mathematics and natural sciences.

Besides providing IT education and training for their citizens, governments can themselves become sophisticated users of information technology. By developing advanced applications of IT, government can change the attitudes of workers, firms and consumers and lower their costs of adopting IT. This is particularly useful if it will be increasingly the use of information technology rather than its production that matters for economic growth in the future.

At university level two major problems are evident:

- It takes about three years for high-school graduates to enter university. This is a waste of young people's time and energy.

- It is very difficult and time-consuming to move from one discipline to another. In a rapidly changing world, flexibility is an essential element in the education system.

Because of the lack of basic funding for basic education in universities and training functions we are losing future opportunities. Today's students will be tomorrow's scientists. If tomorrow's scientists are trained without sufficient contact with their teachers, they will not be internationally competitive.

One more future challenge for the universities is to be able to greatly increase the number of international students they train, especially those from Eastern Europe. Finland also has a lot to offer to students coming from the most developed countries.

On account of large structural and content-related needs for change, consideration should be given to setting up a separate programme that would allow for the securing of sufficient funding to implement the changes.

As a final point on education, the importance of lifelong learning for the existing workforce should not be neglected. Unless we address this issue, we risk creating a socially excluded group of middle-aged workers. Adult vocational training is more and more important, and more programmes similar to the National Workplace Development Programme will be needed.

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Appendix 1

Presentation of the members of the expert group

Professor Luke Georghiou is Executive Director of PREST (Policy Research in Engineering, Science and Technology) and professor of Science & Technology Policy and Management at the University of Manchester. His research interests include evaluation of R&D and innovation policy, foresight, national and international science policy and management of science and technology. Recent projects include several studies of industry-science relations, policy for international scientific cooperation, evaluation of foresight and changes in public sector research institutions. He has chaired or been a member of committee of many evaluation projects in different countries. Prof. Georghiou has published widely in these areas.

Dr. Elisabeth Helander is Director in the European Commission. She works in the area of Regional Policy and Cohesion, being since April 2000 responsible for the Community initiatives INTERREG and URBAN as well as for regional programmes of innovation. Before joining the Commission she served as Counsellor at the Finnish Ministry of Education and as Director of Research of the Academy of Finland. Dr. Helander has served as chair or member of committees or advisory boards in many international and national science and technology committees, councils and evaluation panels. She has published articles on evaluation, science and technology policy, educational policy and radiochemistry.

Dr. Jyrki Juusela is Chief Executive Officer and Member of the Board of Directors and Chairman of the Group Executive Committee of Outokumpu Oyj. He is Doctor of Technology, having graduated from the Helsinki University of Technology. Dr. Juusela has held different R&D and management positions within Outokumpu Group. He is also Chairman of the Confederation of Finnish Industry and Employers and holds many chairman positions and board memberships in different Finnish companies and associations. In addition, he has been member of the board of the Academy of Finland.

Professor Frieder Meyer-Krahmer is Director of the Fraunhofer-Institute for Systems and Innovation Research in Karlsruhe, Germany and professor of Innovation Economics at the University Louis Pasteur in Strasbourg, France. His research subjects comprise technology and innovation policy, evaluation of governmental R&D programmes, barriers to innovation, innovation in small and medium-sized firms, innovation and regional development, structural change and industrial policy, and innovation and environment, for instance. He is member of the Scientific Board of the Maastricht Economic Research Institute on Innovation and Technology, and is also member of many other scientific committees. Prof. Meyer Krahmer has published many scientific books and articles.

Dr. Aatto Prihti is the President of The Finnish National Fund for Research and Development Sitra and Chancellor of Helsinki School of Economics and Business Administration. Prior to Sitra he was President of Orion Corporation, professor at the University of Helsinki and Managing Director of the Helsinki Research Institute for Business Economics. His scientific publications are in the area of business economics and corporate finance. Dr. Prihti is chairman and board member of many Finnish companies, foundations and other organisations.

Professor Bertil Roslin is Chancellor of Åbo Academi University. Earlier he was Director and Member of Board of Alko Group Ltd and prior to that Vice President of the Finnish National Fund for Research and Development Sitra. His academic specialisation is in public finances and taxation, industrial economics and technical research and development. Prof. Roslin is well published in these areas. He has also been and still is chairman and member in many scientific associations and other organisations.

Professor and Docent Tuire Santamäki-Vuori is II President of the Trade Union for the Municipal Sector (KTV). Prior to that she was Research Director of Labour Institute for Economic Research and Acting Associate Professor at the Helsinki School of Economics and Business Administration. Her scientific publications are mainly in the field of labour economics, for example in the area of labour markets, unemployment problems, human capital, social policy, etc. Prof. Santamäki-Vuori has held and still holds positions in many international and national committees and scientific and economic policy organisations.

Appendix 2

VTT-1
Juha Oksanen
Research evaluation in Finland
Practices and experiences, past and present

Executive summary

This report provides an up-to-date review on the evaluation of public research and development activities in Finland during the last two decades. The purpose of the work is to shed light on the development and use of evaluation in the field of Finnish science and technology policy. More thoroughly analysed issues cover the extent of evaluation activities, main conclusions and recommendations, and the significance of evaluation information in decision-making processes. The report draws on a broad selection of published evaluation reports and number of interviews conducted among decision-makers with a vantage point over the Finnish R&D system. The main findings of the report are as follows:

1. The evolution and diffusion of the evaluation culture has taken place gradually. After 17 years of development, evaluation is visibly anchored in the Finnish research and development system. In the 1980's and at the beginning of the 90's, evaluations focused more on the quality of research, on the position of basic research, and on the conditions of research. Since then, more attention has been paid to the relevance and impact of R&D activities, and to organisational and strategic questions.

2. The R&D evaluations are characterised by a fairly established toolkit of peer review and impact analyses procedures. Evaluations are carried out by people who have a good track record either in the research community, in the administration of research institutions, or in industry. Finnish commissioners tend to look for evaluators from countries that are close "culturally".

3. On numerous occasions the decision to launch the evaluation had a "pulling-the-trigger" effect, i.e. the evaluation process was the start-up for major organisational restructuring.

4. The need for strategic rethinking among Finnish R&D organisations was widely identified in the evaluations. Organisations were recommended to target activities at a limited number of selected subject areas or core tasks, and to increase co-operation with other relevant actors nationally and internationally.

5. The length of post-graduate studies leading to a doctorate has been one of the most visible structural weaknesses in the Finnish research system. The situation improved noticeably after the new graduate school system was created in 1995.

6. The development of co-operation in its various forms is one of the enduring concerns in evaluation. Finnish institutions are encouraged to exploit opportunities to participate in the definition and development of new international R&D programmes. Also, with rapidly increasing involvement in international co-operation it has become even more important than before that participation in international activities is based on strategic considerations and balanced against strategic priorities and available resources.

7. Evaluation is seen as an important external "second opinion", in relation to which decision-makers can reflect their own ideas. In addition, evaluation is also valuable for justifying and convincing other actors about the necessity of proposed decisions. Decision-makers find that evaluations are worth carrying out because they highlight and emphasise issues and aspects which are easily forgotten or lost in everyday business.

8. Some weaknesses in current evaluation practices may diminish the usability or trustworthiness of the conclusions and recommendations. Weaknesses most often mentioned by the interviewees relate to following questions: (1) lack of time for evaluations which may lead to inaccuracies; (2) evaluators' competence, and in particular, their insufficient knowledge of local circumstances.

9. The continuation of research evaluation activities was seen as integral part of managing the national R&D system at its different levels. However, excessive evaluation should be avoided, because of the large amount of human resources and time that the whole process tends to take.

VTT-2
Tuomo Pentikäinen
Economic evaluation of the Finnish cluster programmes

Executive summary

1. There are eight Finnish cluster programmes under six ministries. The programmes were planned to take place during the period 1997-99. In practice, most programmes started during 1998 and they will last until 2000 or 2001.

2. The total financial volume of the programmes is more than FIM 600 million. One fourth (FIM 170 million) of funding is 'ear marked' cluster-specific funding, which was allocated to ministries. TEKES and the Academy of Finland are other major public financiers. Ninety seven per cent of funding is domestic, 60 per cent is competitively allocated and public, and one fourth is private.

3. This report is mainly based on a deeper analysis of two cluster programmes: The Finnish Forest Cluster Research Programme (Wood Wisdom) and the Well-Being cluster programme. The study is based on a survey-analysis that was targeted to sub-projects of these programmes, on project managers' reports of funding and co-operation structures, and on interviews.

4. Wood Wisdom has been successful in generating and fostering co-operation between public financiers; particularly TEKES, the Academy of Finland and the Ministry for Agriculture and Forestry. The Well-Being cluster has managed to facilitate new co-operation between authorities and other public organisations within social and health care sectors.

5. The participation of companies is rather low in both programmes, and the participations are dominated by 'not-for-profit' companies. Companies carry only little R&D risk and they do not find the programmes attractive.

6. The governance of the both studied programmes has been organised by temporary ad hoc co-ordination. Programme co-ordination, especially in the case of the Well-Being cluster, is rather heavy and costly. However, the interviewees and the survey respondents found this kind of organisation effective and even necessary. Respondents agreed that co-ordination should

eventually be shifted so that it is the responsibility of the underlying organisations, but that it is still too early to do that.

7. Cluster-specific financial instruments are not yet mature. Typically, participating financiers use their existing instruments without far-reaching synchronisation. As a corollary, no or only very little co-financing or syndication occurs. However, in both studied programmes there are interesting attempts to improve the financial instruments.

8. In Wood Wisdom, the programme co-ordination together with financiers organised 'co-ordination meetings' where applications were directed to appropriate financiers. Together with cluster co-ordination these meetings refocused projects and grouped separate projects into larger consortia.

9. The Well-Being cluster has a financing model, where a temporary ad hoc organisation receives and reallocates funding. It guarantees great flexibility but it may be questioned due to its non-transparency and the fact that outside financiers did not see the model as attractive.

10. The programmes are currently not attractive to private profit-oriented financiers. Possibilities for a broader financier-base as well as development of financial instruments should be taken under serious consideration.

11. Currently, there are major fields in the Finnish economy that are not addressed appropriately in the cluster programmes. In particular, the telecommunications, base metal, chemical and pharmaceutical industries as well as construction should be better covered in the forthcoming cluster policies.

12. It may be questioned whether ministries are the right 'home-base' of cluster programmes, or whether some other organisation might be more suitable for truly inter-sectoral and innovative networking that would be attractive even for the private sector.

13. In the future, the cluster policy's goals, instruments and evaluation criteria need to be made more clear and transparent.

14. Collection of evaluation and monitoring data, co-ordination and minimisation of overlapping bureaucracy and development of appropriate evaluation tools and indicators are topical future tasks.

15. There is still a need for top-down cluster initiatives, but the real structuring of the programmes and projects could be organised more on a bottom-up basis.

VTT-3
Olle Persson, Terttu Luukkonen and Sasu Hälikkä
A bibliometric study of Finnish science

Abstract

This study is the most comprehensive bibliometric report of Finnish science carried out, and it is based on a long time series. It uses many types of bibliometric indicators to describe the scentific and technological activities of the Finnish research base. It draws attention to

- publication activities and the international visibility and impact of Finnish scientific research
- domestic and international collaboration patterns, and
- indicators of technological innovation activities.

The major findings of the report include the following. The report gives a very positive picture of Finnish science. The policy to strengthen the internationalisation of Finnish science seems to have been effective. Finland has increased its international publishing and has improved the international visibility and impact of its research publications. Overall, Finnish scientific publications are well above the world average in impact. The positive trend in the international impact of Finnish science is associated with a dramatic increase in international collaboration. Today, 40 % of the Finnish publications are co-authored with researchers from other countries, while the corresponding figure was only half that in 1986. Researchers from EU countries have become major collaboration partners for Finnish researchers. Twenty percent of Finnish papers are co-authored with researchers from the EU-countries, and the share has grown significantly faster than the share of papers co-authored with researchers from North America. EU research collaboration and the EU Framework Programme for research and development have probably played an important role in the increase of scientific collaboration with other EU countries.

The report further shows that, in the Finnish national research system, the Helsinki region dominates. To some extent, there has been a decentralisation process, which has reduced this dominance a little. The decentralisation of research into small units, however, is not advantageous for research impact - and quality, which impact is expected to reflect. Regions that produce small numbers of papers do less well in impact than other regions.

The study of Finnish US patents shows that Finland is active in producing technological innovations and has impact in telecommunications, industrial process

equipment, and wood and paper. To some extent, Finland appears to be strong technologically and economically in the same fields (especially in telecommunications and wood and paper). However, in other fields, such as biotechnology and pharmaceuticals, the number of patents is increasing but is relatively small considering the strong national research base. The technological innovation base is much more nationally oriented than the Finnish science base, but there is a steady trend toward internationalisation in this area too.

When using bibliometric indicators, and particularly Science Citation Index (SCI) based data, we focus on basic research in natural sciences and medicine. The SCI uses scientific journals as source material, and publishing in journals plays a major role in basic science, while it is not true for applied areas of research or in fields such as the social sciences or humanities. In Finland, as in the other Nordic countries, medical fields dominate the country's publications in SCI based journals. This reflects particularly the fact that medical scientists have adopted the publication habits that fit the underlying assumptions of the SCI to a larger extent than other scientists have. Their frequent publications in the SCI based journals also reflect a greater degree of internationalisation of their fields of research compared with other fields.

The report also uses patent data, which is more relevant for industrial research. The report utilises the US patent system, which is used most in international comparisons and is expected to provide a filter for measuring the importance of the patents. As a drawback, Finnish firms take fewer patents in this system than in the European or national system.

ETLA-1
Olavi Lehtoranta
Impact of public R&D funding on the profitability and growth performance of firms: A panel data study on Finnish firms

Abstract

This study set out to address the following main questions:

* Have R&D and public R&D funding had an impact on the profitability and growth performance of Finnish companies over the past 8-10 years?
* What kinds of company characteristics contribute most significantly to companies' profitability, sales and number of employees?
* What are the main differences between companies that have received public R&D funding and those that have not?

The main concern in this study was with the effect of public R&D support channelled via Tekes, the National Technology Agency of Finland. It was found that the likelihood of an application for support being accepted was influenced by certain industries and by the firm's export share. However, it needs to be borne in mind that there is selection bias within the group of firms applying for subsidies: innovating export companies with highly educated personnel apply for R&D support more often than other firms.

The study produced an estimation result according to which firm profitability measured in terms of gross operating profit as a proportion of turnover was influenced only by industry and capital intensity. In technology firms, however, the proportion of highly educated personnel also had a bearing on profit margins.

Apart from personnel number and the proportion of highly educated personnel, other company characteristics with an impact on sales levels included the share of exports, innovativeness, capital and R&D intensity and, to some extent, foreign ownership. Looking at average sales growth during the 1993–1997 period, the estimation results indicate that receipt of R&D funding (a dummy variable) has a significant positive effect on the growth of sales, whereas the amount of subsidies does not. This result applies even if the analysis is confined to technology firms with internal R&D activities. It is evident that the dummy variable describing receipt of R&D support picks out those firms that show the fastest growth.

Key words: public R&D funding, profitability, sales growth, firm-level panel data analysis

ETLA-2
Rita Asplund (Ed.)
Public R&D funding, technological competitiveness, productivity and job creation

Press release

- Technology both creates and destroys jobs.
- Technology companies have improved the employment situation significantly in the post-recession era. They have also hired large numbers of unemployed.
- Companies that have received public R&D funding have normally grown in subsequent years.
- The technological knowledge available within an industry is important for corporate productivity. In particular, it improves productivity in small and medium-sized companies (SMEs).
- Personnel with a high level of education and training maintain high productivity and develop products and production methods, i.e. boost future productivity.

Technology, productivity, well-being

Well-being and competitiveness in the economy rest on productivity and the level of technology. Finland is therefore targeting a growing proportion of its resources at technological development. The proportion of GDP accounted for by R&D expenses in Finland is among the highest in the OECD, i.e. more than 3 %.

The study considers whether publicly and privately funded R&D enhance productivity and employment. It is based on extensive firm and plant level data sources from the manufacturing and the services sector.

The relations between companies' R&D inputs, technological level and productivity are complex and therefore challenging as a subject of research.

Companies funded by the National Technology Agency (Tekes) have normally done well in subsequent years

When public R&D funding decisions are made, the development potential and prospects of the company in question are taken into account. The following features are typical of companies that have received public R&D funding:

- the personnel have a high level of training and education
- R&D expenses are high relative to turnover
- a lot of new patents are produced
- labour productivity is high
- capital intensity is high

It is common for a company to receive public R&D funding over a number of years: more than 600 companies were granted funding by Tekes on at least four occasions in 1991-1998.

Economics also justifies public R&D funding

R&D carried out in companies enhances the overall productivity in the economy. Indirect effects are important: each company contributes to the pool of knowledge in its own sector, and it is from this pool that companies engaged in the sector derive part of their productivity. Public R&D funding can thus be justified also from the point-of-view of economic theory.

Knowledge spillovers particularly important for SMEs

Public R&D funding goes not only to SMEs but also to successful large companies. It is essential for the overall success of the economy that R&D efforts make an efficient contribution to the pool of technological knowledge in a given sector, as spillover effects then help other companies to improve their productivity.

Extensive spillovers throughout the corporate field of the sector are particularly important for SMEs.

Education: a dual impact on productivity

Personnel with a high level of training and education are capable of making efficient use of current production potential and maintaining high productivity. On the other hand, companies need skilled labour also to develop products and production methods, i.e. to boost future productivity.

The conclusions that can be drawn concerning the importance of education are summarised in table 1. The findings indicate that 'technical' expertise is particularly important for the personnel of manufacturing companies wishing to improve their productivity in the future. On the other hand, the immediate impact of 'technical' competencies on a company's productivity figures may even be negative if that staff is not mainly involved in production proper but in developing technology. 'Non-technical' expertise, in turn, is particularly valuable for the current productivity of service enterprises, and also plays a role in their later productivity.

R&D both creates and destroys jobs

Product innovations and more efficient production methods make for profitable business. Their adoption creates new jobs, while technological advances gnaw at the profitability of business relying on older technology elsewhere, and destroy jobs.

Especially in the post-recession years of 1994–1996 technology-driven companies have created more new jobs in industry than others, and fewer jobs have disappeared in them than in companies with low R&D intensity. Technology companies have also hired more unemployed people than companies with low R&D intensity.

It is, however, important to note that at that time Nokia had not yet reached its current heights and accounted for only a few per cent of industrial employment (slightly more if its subcontractor network is included).

On the other hand, plenty of old jobs have disappeared also from companies with high R&D intensity, while new jobs have been created in companies with low R&D intensity as well. Thus, high R&D intensity is neither a necessary nor a sufficient precondition for job creation. R&D-intensive companies are also characterised by high labour turnover.

In conclusion, we might say that jobs and employees shifted from companies with low R&D intensity to companies with high R&D intensity during the recession years and the years of recovery that followed. This shift appears to have taken place partly via unemployment.

Sector-specific R&D intensity also enhances job creation

Apart from the company's own R&D efforts, the R&D intensity of the entire sector enhances job creation. Large companies find it particularly important to have a high R&D intensity of their own, while small companies essentially require high sectoral intensity for job creation. These conclusions are usually the same for both the service sector and manufacturing.

Privately funded R&D seem to enhance employment in companies. The immediate benefits from publicly funded R&D remain to some extent ambiguous. On the other hand, if public R&D funding is extended to reinforce the pool of technological expertise in the sector in question, this results in better preconditions for companies to create high-quality jobs.

Figure 1. Number of people employed in subsequent years by companies that received R&D funding from Tekes, median by cohort.

Table 1. Educational level of the personnel and corporate productivity.

		EDUCATIONAL LEVEL*	
CORPORATE PRODUCTIVITY		Technical and natural sciences	Commercial, social sciences, etc.
Current productivity	Manufacturing	-	+ or 0
	Services	- or 0	+
Future productivity	Manufacturing	+	0
	Services	+ or 0	+ or 0

*The educational level of the personnel was expressed by the proportion of employees with at least post-secondary qualifications.
- = negative link, + = positive link; 0 = link ambiguous

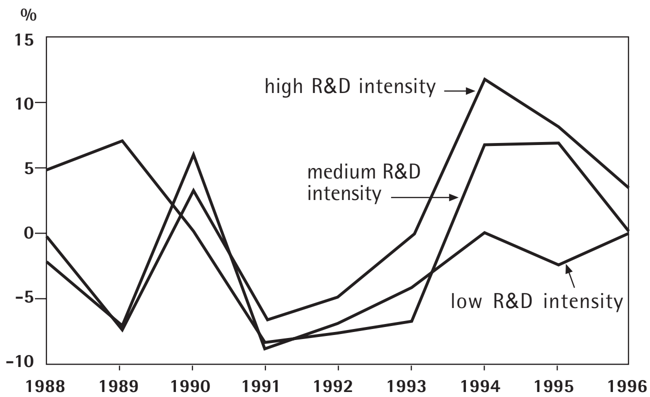

Figure 2. Net change in the number of jobs according to the R&D intensity in the company owning the workplace, manufacturing.

ETLA-3
Eero Lehto
Regional impacts of R&D and public R&D funding – The analysis of the impacts of past R&D capital on current R&D investments and productivity

Abstract

This study shows that a firm's past R&D stock and its current turnover have a statistically significant, positive impact on a firm's current investments. The main interest of this study is, however, in the impacts from other firms' past R&D stocks. It happened that other firms' past R&D stocks which are located in the same industry – either in the same area or in other areas or in the same area but in other industries – positively contribute to current R&D investments. Only that part of external R&D which is located in other areas and in other industries has no positive, rather negative, impact on current R&D. If the variation between the industries and sub-regions is eliminated, the positive impact related to the industrial proximity, however, vanishes. All in all, we conclude that, at least, geographical proximity of external R&D encourages the plant's R&D investments. According to the results the possible positive spillover effect, from other firms' R&D in other areas and in the same industry weakens, however, if the number of R&D active plants in this R&D stock pool increases. This dilution effect, discussed by Adams and Jaffe (1996), describes those difficulties which firms face when they try to receive information from many remote sources. Our results show that the dilution effect also concerns spillovers from the firm's other plants which are located in other sub-regions. The regressions which include the public authorities' R&D funding – loan or direct support – show that the publicly funded R&D does not crowd out privately funded R&D investments. According to this, one unit increase in the public funding of R&D leads to one unit increase in total R&D investments. Results also hint that the firms fight for limited public funding that brings about adverse external effects.

The estimated productivity elasticity for a plant's own R&D turned out to be roughly 0.03. The exclusion of external R&D, however, raised this estimate to the level of 0.06. According to the results, the estimated elasticity for other firms' past R&D which is located in the same sub-region and in the same industry is around 0.024. The estimated elasticity for other firms' R&D in the other areas and in the same industry is about the same size. Also, external R&D in the same sub-region but in other industries positively contributes to productivity. Only other firms'

R&D which is located in the other sub-regions and in the other industries has no positive productivity impact. The external R&D from the firm's other plants in other sub-regions has a positive productivity impact as well, whereas, the productivity elasticity for a firm's own R&D in other municipalities in the same sub-region is zero. If the number of those units from which knowledge spillovers are received increases, given the amount of external R&D, the spillover effect on productivity weakens. This dilution effect is very strong as far the other firms' R&D in the same industry and in the other sub-regions and also the firm's own R&D in other sub-regions are concerned. These results concerning the determination of productivity hold also in the fixed industry and sub-region effects models.

According to the results, other firms' past R&D stock has also a positive impact on the manufacturing plants' total employment. The respective impact of external R&D in the other industries is negative. It is possible that the employment effects concerned do not reflect the effects of knowledge spillovers only. Investing on R&D, other firms also affect labour supply. Therefore the increasing R&D activity in one industry can hurt employment in another industry. In the determination of employment the regional dimension has not as important role as in the determination of R&D investments. This may be an indication of geographical specialisation. Low-skill activities are partly located in other regions than high-skill activities. Despite this, the relevance of regional distance, as concerns the total employment impacts of external R&D, can not wholly be rejected.

LTT
Mika Huolman, Heli Penttinen, Matti Pulkkinen and Jussi Tiilikka
Public research & development funding and international technology commercialisation

Summary

The purpose of this study has been to find out what is the role and impact of Tekes R&D funding at small and medium sized companies. In addition we have studied what are the challenges in commercialising the technology and how can public R&D funding be developed to strengthen the prerequisites of the Finnish SMEs for conducting international business. To be able to answer these questions we studied 70 firms, which had received R&D funding from Tekes. Our research focus has been both on R&D ventures and on the firms accomplishing these ventures.

According our study Tekes undoubtedly has a role and impact on R&D activity at the company level. The volume of cumulative venture sales is clearly increasing yet lags far behind original goals. The direction of business is on the average right but the speed is in many cases very slow in absolute numbers. The studied firms still set their targets very high although they have decreased them considerably compared to the figures once written in Tekes-funding applications.

Whether the growth continues and even accelerates is hard to answer. We can nonetheless state that on the average the growth will continue but clearly at a slower pace than that anticipated by the CEOs. Yet, there are clearly observable differences between companies. Whereas some firms are growing very rapidly some are in a clear danger of missing totally the commercialisation i.e. sales phase.

The lack of business and especially international business and management skills and other resources is evident in most studied firms. The core competence of the CEO's is often in engineering and they recognise and admit the shortage of management skills.

Financing seems to be a secondary challenge compared to business knowledge and skills. Quite many of the firms have already or are targeting venture capital funding. The increase of venture capital funding seems to have decreased the financial challenge of building international business. There is more important shortage in business skills and knowledge. The technological features of the product/service developed and sold, instead, were widely viewed as the major strength in crossing the current abyss between R&D and (international) commercialisation.

We believe that the co-operation between the Finnish key innovation institutions should be intensified and there may be need for structural re-arrangements too. Tekes should increase the amount of business knowledge and networks and should coach and monitor their clients more closely in future. Incentives and incentive structures may be used to strengthen the business supporting mode of Tekes too.

Appendix 3
List of persons interviewed

Martti af Heurlin, National Technology Agency, Tekes
Matti Alahuhta, Nokia Mobile Phones
Erkko Autio, Helsinki University of Technology
Kari Ebeling, UPM-Kymmene Group
Jari Forsström, Atuline Oy
Jarl Forstén, Technical Research Centre of Finland
Christine Hagström-Näsi, National Technology Agency, Tekes
Kimmo Halme, Science and Technology Policy Council of Finland
Sten-Olof Hansen, Turku School of Economics and Business Administration
Jorma Hattula, Academy of Finland
Pentti Hurmerinta, Reima-Tutta Oy
Kai Husso, Academy of Finland
Timo Hämäläinen, Finnish National Fund for Research and Development Sitra
Timo Janhunen, Fimet Oy
Ilkka Kartovaara, StoraEnso Oyj
Tapani Kivini, Prosthetic Foundation / Pikosystems
Markus Koskenlinna, National Technology Agency, Tekes
Seija Kulkki, Center for Knowledge and Innovation Research
Alpo Kuparinen, Ministry of Trade and Industry
Kalevi Kurkijärvi, Bio Fund Management Oy
Juhani Kuusi, Nokia Research Center
Osmo Kuusi, Government Institute for Economic Research
Esa Kärkäs, PhysioTools Oy
Jarmo Laine, Academy of Finland
Seppo Laine, Finpro
Arvo Laitinen, Audio Riders Oy
Saara Lampelo, Medipolis Ltd.
Markku Lehtonen, Finnish Wood Research Ltd.
Tarmo Lemola, Technical Research Centre of Finland
Jan-Erik Levlin, KCL (The Finnish Pulp and Paper Research Institute)
Kari Lindström, Finnish Institute of Occupational Health
Markku Linna, Ministry of Education
Raimo Lovio, Helsinki School of Economics and Business Administration
Markku Mannerkoski, Technical Research Centre of Finland
Björn Mattsson, Danisco Finland Oy
Martti Mäenpää, National Technology Agency, Tekes
Ilkka Niiniluoto, University of Helsinki
Anu Nokso-Koivisto, Finnish National Fund for Research and Development Sitra
Heikki Ojanperä, Finnish National Fund for Research and Development Sitra

Erkki Ormala, Science and Technology Policy Council of Finland
Antti Paasio, Turku School of Economics and Business Administration
Leena Paavilainen, Finnish Forest Cluster Research Programme WOOD WISDOM
Anneli Pauli, Academy of Finland
Hannele Pohjola, Confederation of Finnish Industry and Employers
Marja Pulkkinen, Ministry of Education
Kari Raivio, University of Helsinki
Jorma Rantanen, Finnish Institute of Occupational Health
Akseli Reho, Reima-Tutta Oy
Arto Remes, Mega Electronics Ltd.
Jari Romanainen, National Technology Agency, Tekes
Keijo Räsänen, Helsinki School of Economics and Business Administration
Liisa Saarenmaa, Ministry of Agriculture and Forestry
Veli-Pekka Saarnivaara, National Technology Agency, Tekes
Ilpo Santala, Innopoli Oy
Gerd Schienstock, University of Tampere
Esko-Olavi Seppälä, Science and Technology Policy Council of Finland
Pekka Silvennoinen, Technical Research Centre of Finland
Paavo Uronen, Helsinki University of Technology
Tytti Varmavuo, Nokia Group
Reijo Vihko, Academy of Finland
Reino Viita, Academy of Finland
Markku Virtaharju, Statistics Finland
Pentti Vuorinen, Ministry of Trade and Industry
Björn Wahlroos, Mandatum Bank
Pekka Ylä-Anttila, The Research Institute of the Finnish Economy
Mikael Åkerblom, Statistics Finland

Appendix 4

Use of the additional appropriation between 1997 and 1999

FIM million	1997 plan	1997 actual	1998 plan	1998 actual	1999 plan	1999 actual	1997-1999 plan	1997-1999 actual	1997-1999 actual %
Ministry of Education administrative domain									
- Universities									
Expanding existing and establishing new graduate schools		26		24		60		110	17%
Data transfer, information services and co-operation with industry				23		55		78	12%
Equipment and other research conditions and facilities		83		100		100		283	45%
Expansion of training		20		30		35		85	13%
University of Kuopio, Bioteknia II		33		33				66	10%
Pohjois-Savo Polytechnic		13						13	2%
Universities in total	175	175	210	210	250	250	635	635	100%
- Academy of Finland									
Research programmes		49		70		65		184	29%
Centres of excellence		33		18		147		198	31%
Doctor-researchers		36		73		55		164	26%
Internationalisation		49		27		3		79	12%
Appropriations in total	170	166	190	188	270	270	630	624	98%
Commitments	5	5	5	5	5	5	15	15	2%
Academy of Finland in total	175	171	195	193	275	275	645	639	100%
Ministry of Education in total	**350**	**346**	**405**	**403**	**525**	**525**	**1,280**	**1,274**	
Ministry of Trade and Industry admin. domain *									
- Ministry of Trade and Industry									
Technology research programme				4.254		2.990		7	
Cluster programmes:									
Forest Cluster Research Programme				1.561				2	
Food Cluster Research Programme				0.320					
Well-being Cluster				0.241		2.401		3	
Transport Cluster KETJU				0.350		0.565		1	
Transport Cluster TETRA				1.650		1.885		4	
Environmental Cluster Research Programme						0.650		1	
Impact assessments				2.047		2.251		4	
Ministry of Trade and Industry in total *	10	incl. 1998	10	10	10	11	30	21	
- Tekes									
Enhanced basic research		14		45		95		154	9%
New business operations		231		279		431		941	54%
Technology-based services		57		91		138		287	16%
Cluster programmes		48		130		126		303	17%
Appropriations in total	350	350	585	545	870	790	1,805	1,685	96%
Basic operations of the organisation	10	12	20	20	25	38	55	70	4%
Tekes in total	360	362	605	565	895	828	1,860	1,755	100%
- Technical Research Centre of Finland			20	6	20	36	40	42	
Ministry of Trade and Industry in total	**370**	**362**	**635**	**581**	**925**	**874**	**1,930**	**1,818**	
Sectoral ministries									
- Ministry of Agriculture and Forestry									
Food Cluster Research Programme				5.2		4.6		10	
Forest Cluster Research Programme		incl. 1998		9.5		3.8		13	
Ministry of Agriculture and Forestry in total	5		10	15	10	8	25	23	19%
- Ministry of Transport and Communications									
Telecommunication Cluster (NetMate)				2.5		4.7		7	
Transport Cluster									
- KETJU		1.7		0.8		4		7	
- TETRA		1.5		1.6		6.8		10	
Ministry of Transport and Communications in total	10	3	10	5	10	16	30	24	19%
- Ministry of Social Affairs and Health *	10		10		10		30		
Well-being Cluster (Macro-Pilot)		10		10		7		27	22%
- Ministry of Labour *	10		10		10		30		
National Workplace Development Programme		10		10		6		26	21%
- Ministry of the Environment *	5		10		10		25		
Environmental Cluster Research Programme		5		10		8		23	19%
Sectoral ministries in total	**40**	**28**	**50**	**50**	**50**	**45**	**140**	**123**	100%
Commitments and appropriations in total	**760**	**736**	**1,090**	**1,034**	**1,500**	**1,444**	**3,350**	**3,214**	

* Appropriations will be used after 1999.

Appendix 5

Government R&D appropriations by ministry in 1999 and share of the additional appropriation

	FIM million		%
	R&D financing total	Additional appropriation	Share of additional appr.
Administrative domain of the Ministry of Education	2,939	525	18
Universities	1,922	250	13
Academy of Finland	925	275	30
Research institutes	34		
Other	59		
Ministry of Trade and Industry	2,917	874	30
National Technology Agency	2,445	828	34
Research institutes	390	36	9
Other	81	11	13
Ministry of Agriculture and Forestry	448	8	2
Ministry of Social Affairs and Health	680	7	1
Ministry of Transport and Communications	180	16	9
Ministry of the Environment	153	8	6
Ministry of Defence	108		
Ministry for Foreign Affairs	45		
Ministry of Finance	39		
Ministry of Labour	36	6	17
Ministry of the Interior	32		
Ministry of Justice	6		
Prime Minister's Office	2		
TOTAL	**7,584**	**1,444**	**19**

Source: Kolu 2000, p. 13

Appendix 6

Targeting of the additional appropriation in the Ministry of Education

The first graduate schools started their 4-year-operation in 1995. With help of the additional appropriation, the Ministry of Education allocated FIM 110 million to expanding some of the existing graduate schools and establishing new ones as follows:

	No. of schools	Addition of students
Expanded graduate schools	31	171
New graduate schools	12	96
	43	267

After these additions there are altogether 95 graduate schools for 1,287 students in Finland in 2000. Fifteen out of twenty universities have at least one graduate school. By the end of the first half of 1999, the graduate schools reported that 889 students from the positions provided by the Ministry of Education or the Academy of Finland had received their doctoral degree. Within the graduate school system, the average age of obtaining doctoral degree had come down to 32 years. According to a survey made by the Ministry of Education, graduate schools are functioning well.

An appropriation of FIM 78 million was placed in developing data transfer, information services and co-operation with the industry. Funds totalling FIM 13 million have been targeted to university projects which promote the dissemination of the results and technologies to business needs as well as the development of mechanisms serving this purpose. E.g. one of the projects dealt with immaterial rights, and thanks to it, steps towards better use of universities' research results have been taken. To mention some of the other targets: to develop the national electronic library serving the entire university sector and other research systems (FIM 27 million) and to cover the increased financing needs of the national research network (FUNET) and the additional costs incurred for the increase in high-performance computing capacity (FIM 38 million). A special project organisation has been established for the library project.

Equipment and other research conditions and facilities were granted an appropriation of FIM 283 million. This includes computers, laboratory equipment etc. The appropriation has been allocated to the universities on the basis of calculations. The intensity of the university research operations has been a particularly weighted criterion, especially in fields with an emphasis on equipment. The largest increases were allocated to the universities of Helsinki, Turku and Oulu, as well as to the Helsinki University of Technology. (Targets of spending cannot be identified as there is no register on equipment.)

Expansion of training of basic skills in mathematics and sciences as well as in technology was financed by FIM 85 million. Compared with the initial situation, the increase in the number of students was 650 in 1997, 1,000 in 1998 and 1,165 in 1999. Ten universities are involved with this increase.

The appropriation (FIM 78.7 million) reserved for the University of Kuopio Bioteknia II project was used to buy the shares which gave the title to the facilities of over 3,000 square metres of useful area, to be used in the University of Kuopio research operations, as well as to grant state funding to the joint municipal authority providing the academic professional training in the region of Pohjois-Savo, for the facilities and equipment to be acquired in the Bioteknia II building. A.I.Virtanen Institute had earlier 3,197 m^2 at Bioteknia I building. The expansion of 1,533 m^2 at Bioteknia II building was ready for use at the end of 1999.

The Bioteknia II project was included as a new, earmarked item in the plan for the use of the additional appropriation by the University. As a result, the following deductions were made in the initial plan for the use of funds: enhancing the equipment and other research conditions and facilities, FIM - 2 million; launching of new graduate schools and expansion of existing schools, FIM - 9.72 million; and development of data transfer, information services and co-operation with industry, FIM - 66.98 million.

Appendix 7

Academy of Finland: Appropriations allocation by discipline

Discipline	1997	1998	1999	Total	Share
Natural sciences	**56%**	**40%**	**45%**	**47%**	
Mathematics	1,134	6,799	5,922	13,855	2%
Computer science	7,526	13,101	11,405	32,032	5%
Physics	37,865	14,976	42,960	95,801	15%
Space sciences and astronomy	7,200	1,116	500	8,816	1%
Chemistry	15,412	10,502	14,122	40,036	6%
Biology, environmental sciences	23,508	19,242	47,309	90,059	14%
Geography	259	2,381		2,640	0%
Geosciences, meteorology	800	7,500	21	8,321	1%
Engineering	**7%**	**21%**	**19%**	**16%**	
Architecture		3,510	500	4,010	1%
Construction engineering and community development studies	410	358		768	0%
Electrical engineering	6,951	24,480	26,100	57,531	9%
Power technology		16	470	486	0%
Metallurgy and quarrying technology	1,500	1,110	6,965	9,575	2%
Machinery and production technology		1,748	1,823	3,571	1%
Process and materials engineering		1,000	3,755	4,755	1%
Chemical engineering chemical process technology	1,070	1,592	3,968	6,630	1%
Wood processing technology		3,086	1,922	5,008	1%
Bioengineering, food engineering	2,240	1,799	4,944	8,983	1%
Other engineering		776	599	1,375	0%
Medicine	**18%**	**12%**	**21%**	**17%**	
Biomedical science	23,708	11,700	33,617	69,025	11%
Clinical medicine	4,171	7,490	13,068	24,729	4%
Public health science		2,019	6,962	8,981	1%
Dentistry	68		500	568	0%
Pharmacy	1,234	1,108	750	3,092	0%
Nursing science		33	500	533	0%
Veterinary science	68	23	335	426	0%
Agriculture and forestry	**2%**	**7%**	**3%**	**4%**	
Agricultural and food sciences		100		100	0%
Forestry	3,108	13,678	7,379	24,165	4%
Social sciences	**13%**	**13%**	**7%**	**10%**	
Economics	2,268	1,862	650	4,780	1%
Business economics, economic geography	2,751	5,433	1,750	9,934	2%
Law	819	940	400	2,159	0%
Social welfare sciences	3,340	6,543	1,250	11,133	2%
Psychology	7,877	2,486	7,060	17,423	3%
Education	2,497	4,970	6,000	13,467	2%
Political science, administrative science	889	1,418		2,307	0%
Media and information sciences	800	495	970	2,265	0%
Humanities	**4%**	**7%**	**6%**	**6%**	
Philosophy	445	1,337	250	2,032	0%
Linguistics	2,538	100	8,160	10,798	2%
Art research, literature	345	1,240	530	2,115	0%
Theology	2,574	2,381	5,220	10,175	2%
History and archaeology		6,296		6,296	1%
Comparative culture studies	727	1,211	954	2,892	0%
Total	**166,102**	**187,955**	**269,590**	**623,647**	**100%**

* Statistics Finland classification for 1998

Appendix 8

Academy of Finland: Planned distribution of additional appropriation by university

University or other organisation	1997	1998	1999	2000	2001	2002	Total	%
University of Helsinki	785	31,178	41,724	50,359	30,393	22,068	176,507	28.3
Helsinki University of Technology	140	14,438	24,765	32,725	19,822	11,652	103,542	16.6
University of Jyväskylä	110	9,118	11,858	13,080	8,698	9,297	52,161	8.4
University of Oulu	300	7,960	11,013	14,058	8,312	5,476	47,119	7.6
University of Turku	80	10,445	14,409	11,933	3,919	1,792	42,578	6.8
Tampere University of Technology	35	5,170	7,172	11,297	8,427	5,677	37,778	6.1
Åbo Akademi University	90	5,413	8,627	9,944	4,610	2,659	31,343	5.0
University of Joensuu	70	4,862	6,656	6,556	3,420	2,140	23,704	3.8
Department of Meteorology	800	3,440	5,087	4,927	1,116		15,370	2.5
University of Tampere	105	3,947	5,183	4,428	1,108		14,771	2.4
University of Kuopio	115	2,906	5,139	4,574	1,559	253	14,546	2.3
Technical Research Centre of Finland		1,639	3,004	4,684	3,058	1,930	14,315	2.3
National Public Health Institute		1,421	1,334	3,828	2,899	2,167	11,649	1.9
Foreign organisations		1,023	4,756	2,532	650	40	9,001	1.4
The Finnish Forest Research Institute METLA	10	1,645	2,349	2,558	778		7,340	1.2
Helsinki School of Economics and Business Administration		1,058	1,427	1,259	389		4,133	0.7
Lappeenranta University of Technology		104	534	1,350	1,110	557	3,655	0.6
Companies		750	1,034	570	47		2,401	0.4
Turku School of Economics and Business Administration		313	954	687	146		2,100	0.3
Svenska handelshögskolan	105	787	546	250	146		1,834	0.3
University of Lapland		92	530	538	380		1,540	0.2
Programme coordination by the Academy		235	368	205	340	292	1,440	0.2
Associations		322	427	245	200	200	1,394	0.2
National Research Centre for Welfare and Health		268	247	257			772	0.1
Finnish Environment Institute	35	262	252	145			694	0.1
University of Art and Design Helsinki		104	310	206			620	0.1
Helsinki University hospital		103	248	145			496	0.1
University of Vaasa	10	212	122				344	0.1
The National Veterinary and Food Research Institute			165	170			335	0.1
Sibelius Akatemia			80	80			160	0.0
Total	**2,790**	**109,216**	**160,322**	**183,589**	**101,524**	**66,200**	**623,641**	**100.0**
Cumulative percentage	0	18	44	73	89	100		

Appendix 9

R&D expenditure by sources and targets of funding in 1998

Sector	Expenditure	Source of funding: Finnish enterprises	Public funding in total	Public sector/State: Total	Prime Minister's Office	Ministry of Justice	Ministry of Foreign Affairs	Ministry of the Interior	Ministry of Defence	Ministry of Finance	Academy of Finland	Other Ministry of Education*	Ministry of Agric. and Forestry
Total	**19,945**	**12,395**	**6,381**	**5,976**	**3**	**8**	**23**	**6**	**157**	**43**	**502**	**2,065**	**451**
Private sector	**13,395**	**11,835**	**936**	**822**	-	-	-	-	-	-	-	-	-
Industry	11,013	10,221	580	525	-	-	-	-	-	-	-	-	-
Other	2,382	1,614	356	296	-	-	-	-	-	-	-	-	-
Public sector	**2,639**	**384**	**1,957**	**1,806**	**3**	**8**	**8**	**3**	**151**	**41**	**32**	**65**	**429**
State	2,374	370	1,784	1,751	3	8	8	3	151	41	30	52	410
Other public organisations	137	2	133	24	-	-	-	0	-	-	0	3	16
Private non-profit associations	128	12	40	31	0	-	0	-	-	0	2	10	3
University sector	**3,911**	**177**	**3,487**	**3,348**	-	**0**	**15**	**3**	**6**	**1**	**470**	**1,999**	**22**
Universities	3,482	168	3,083	2,948	-	0	15	3	6	1	467	1,978	22
University hospitals	430	9	404	400	-	-	-	-	0	-	3	22	-

* Including graduate schools financed by the Ministry of Education

** Companies are not expected to classify their source of funding by administrative domain

Source: Statistics Finland

Appendix 9

Sector	Source of funding												
								Other public sources of funding	Funds	Foreign			
	Ministry of Transp. and Communicat.	TEKES	Other Ministry of Trade and Ind.	Ministry of Social Affairs and Health	Ministry of Labour	Ministry of the Environment	Other**			Total	Foreign enterprises	EU	Other foreign funding
Total	**68**	**1,345**	**440**	**643**	**96**	**91**	**36**	**405**	**155**	**1,014**	**579**	**325**	**110**
Private sector	**-**	**772**	**14**	**-**	**-**	**-**	**36**	**115**	**21**	**602**	**510**	**69**	**23**
Industry	-	502	6	-	-	-	18	55	2	209	158	37	15
Other	-	269	9	-	-	-	18	60	20	393	353	31	9
Public sector	**62**	**195**	**403**	**264**	**55**	**86**	**-**	**152**	**90**	**208**	**30**	**132**	**46**
State	62	189	396	261	53	85	-	33	32	188	26	117	45
Other public organisations	0	0	2	1	0	0	-	109	0	2	-	2	-
Private non-profit associations	1	6	5	2	1	0	-	9	58	19	4	14	1
University sector	**6**	**378**	**23**	**379**	**41**	**5**	**-**	**139**	**43**	**204**	**39**	**124**	**41**
Universities	6	371	23	11	41	5	-	135	40	192	30	121	41
University hospitals	-	7	-	368	-	-	-	4	4	12	9	3	1

Appendix 10

Major global changes

A society based on competence differs significantly from an industrial one built on capital. First of all, competence is a very sensitive production factor, where those best in the markets at one given time may well lose their position overnight. In the days when capital still prevailed, being the second or third best on the markets could still allow you to be successful, but in the age of competence only the best prosper. This means that competition is tougher than ever, taking on the form of competitive learning. This applies as much to the individual, to companies and to other organisations as it does to whole nations and to all of Europe. Only those able to learn faster, easier and better than others can aspire to become a success in the future. Foreign funds virtually flood into companies and projects that give prospect of extreme competence. Correspondingly, companies believed to provide insufficient competence are drained empty through large dividend distributions or other means and the drained company is eventually sold off to the best bidder, usually a multinational operating in the same field and interested in acquiring a greater market share. We have noted in Finland that it is often production plants located here that are the ones to be closed down sooner or later.

The competence society reflects a new way of life, where information technology is almost all-pervasive. Children and youngsters, and probably parents soon too, seek companionship via the Internet; we communicate by electronic mail and mobile phone; "smart clothes" transform our clothing into advanced technology products designed to care for the young and old – and the same trend is spreading into other traditional fields too. Today, the value of a company is determined on the basis of expectations, so that material value and yield based on cash flow plays an ever smaller role in value assessment. This means greater investment risk and ever more complex risk analysis. On the other hand, options are infinite.

Different branches of industry are subject to radical changes. Not only have the familiar bank and insurance sectors transformed but also the rapidly expanding field of telemedicine, which is so complex that it is difficult to determine whether it falls under the category of medicine or information technology. In the clothing industry, new technology is applied to traditional clothing to such an extent that when determining the price of an article, the part played by the actual item of clothing has become minimal. Packing material is also taking on "smart" forms. Hard competition hand in hand with business collaboration is becoming standard practice.

Around-the-clock operation poses problems for small enterprises. Customers on the global markets exist in all time zones and answers are often demanded immediately. The disappearance of distance is an interesting phenomenon; Finland is no longer on the periphery. This means for instance that electronic commerce is accessible just as easily to customers of companies located in Lapland as in New York. All we need to do is understand this and exploit it. Networks of organisations use information technology to "knit" businesses into rapid collaboration, thus creating a sharp competitive edge.

Economies of scale have traditionally provided a competitive advantage. A mere increase in production volumes evolved into the provision of various services so that the basic product became just one part of the whole service package. This process is still ongoing. Two new horizons have now opened up in competition – speed and intelligence. Unless you are fast enough in entering the markets or in responding to a customer's request, you automatically drop out of the game. Likewise, success can no longer be achieved by means of hard work alone but through hard and intelligent work.

These changes take on many forms in our daily lives. Knowledge as measured in terms of input resources is spread out very unevenly in Finland, as elsewhere too. Helsinki accounts for over 44 per cent of knowledge-based investments, Tampere for 12 per cent, Oulu for about 11 per cent and Turku (including Salo) for approximately 10 per cent of all input in Finland. After excluding other university cities and large urban areas such as Jyväskylä, Vaasa, Porvoo and Kuopio from the remaining 20 per cent, very little is left. Migration flows where the resources lie.

Another major phenomenon of interest is marginalisation of a new kind. The conventional concept of "work" used in national economics has largely transformed into one of competence, although not entirely. The lack of competence generates unemployment and marginalisation. This means that together with the fostering of entrepreneurship based on knowledge, it has become essential to strongly promote branches of industry that rely on competence. Heavy migration leads to a loss of the economically active population in some regions and those that remain become marginalised through lack of services and due to loneliness. Creating and implementing new ways to curb marginalisation has become all the more important, especially since the population structure is changing fast.

Decision-makers in Finland recognised already in the 1980s the profound change that had set in motion, and as a result, concerted efforts were made to promote advanced technology. Indeed, Finland's contribution to high technology has been substantial even by international standards, and results have been forthcoming. There are now more business starts in technology than ever before. Funding businesses that have just started up is so risky that few private capital investors are willing to take the risk. New Internet businesses and similar IT companies, where fast appreciation in the valuation of the companies can be anticipated, make the exception. On the whole, therefore, enterprise funding in the early stages of start-up still remains in the hands of public operators.

The most topical question currently is in which ways to allocate potential new resources. Consequently, the task of the international evaluation group has been to examine the effectiveness of the additional funding programme. Rapid technological advances as well as the overall globalisation of knowledge and capital are changing existing structures so fast that constant monitoring and development is necessary in order to keep the entire innovation system up to date. Bottlenecks in any one part of the system are detrimental to the efficiency of the whole innovation network.