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ABSTRACT

Finland is challenged to make the most of globalization by reinforcing its positive aspects. The 1990s taught that success in creating innovations is a key factor for success of business and societies. A precondition, high-level technological and business know-how, requires systematic input into producing social innovations that prevent societal and social development from diverging from economic and technological development. This set of actions constitute the national strategy's core. Internationalization must proceed at the level of the innovation system, and Finland must be able to internationalize its operations and its national science and technology institutions through quality and cooperation. Success in implementing the national strategy entails determined development measures. Finland's foremost strengths in knowledge--the national competencies--must be developed further. Measures must be taken to promote the use of technological and social innovations in business enterprises to accelerate renewal of traditional industries. Research organizations must be developed as active and dynamic cooperation partners for business and industry. Investment in basic information society skills must continue. Research and innovation financing must be increased to accelerate internationalization of the innovation system and improve overall conditions for innovation. Regions face the same internationalization challenges and need to enhance their own factors for development. (Appendixes include report excerpts and policy reports.) (YLB)

Knowledge, innovation and internationalisation

Science and Technology Policy Council of Finland
Helsinki 2003

Abstract

Recent economic and societal development in Finland has essentially been based on the development of high technology, its effective utilisation and determined increases in exports. This has resulted in a significant improvement of Finland's position in international competition. According to international comparisons, Finland, recuperating from the recession of the 1990s, has succeeded in combining extensive production and economic utilisation of knowledge and know-how with other aims, such as the promotion of welfare and sustainable development.

The main challenge for economic and societal development, in conditions of growing global competition, is to be able to keep Finland sufficiently attractive to business and jobs and as a living environment in general. Apart from the international challenges, there are a number of domestic issues to be addressed. Faced with an ageing population and the ensuing pressures for taxation, Finland will have to secure welfare services, to curtail unemployment, which is still high in the aftermath of the recession, and to solve other problems relating to human and social development. Employment rates must be raised and regional development balanced.

Towards a national strategy

The sixth triennial review of the Science and Technology Policy Council *Knowledge, innovation and internationalisation* looks at challenges facing Finland and Finnish science, technology and innovation in the coming years, especially in terms of growing internationalisation. One challenge for Finland is to be able to make the most of globalisation by reinforcing the positive aspects of the trend.

One of the main lessons to be learned from the 1990s was that *success in creating innovations* is a key factor for the success of both business enterprises and societies. One precondition for this is high-level technological and business know-how. Apart from technological innovations, this requires systematic input into producing social innovations geared to prevent societal and social development from diverging from economic and technological development. The set of actions thus determined will constitute the core of the *national strategy* in the coming years.

Finland as part of the global community

Behind the internationalisation of science, scholarship, research and innovation lie similar factors as behind globalisation and relevant network-building more generally. A systematic aspiration to create innovations cannot be limited to the national setting and traditional international cooperation. Internationalisation must proceed at the level of the innovation system as a whole, and Finland must be able to internationalise its own operations and its national science and technology institutions.

The challenges work both ways. What Finland needs above all in order *to be able to compete* for competent researchers and research resources, projects and business enterprise research and development with other countries is quality. On the other hand, Finnish players must be *equipped to take part in and make use* of cooperation openings.

National development challenges

Success in implementing the national strategy entails determined development measures. Finland's foremost strengths in knowledge – the *national competencies* – must be developed further. In addition, it is especially important to invest in promising research fields and to achieve a sufficient volume and good quality in them.

Measures must be taken to promote the utilisation of technological and social innovations in business enterprises with a view to accelerating the renewal of traditional industries. Ministries will assume greater responsibility as strategic development organisations and as users of social innovation.

With a view to promoting more favourable conditions for innovation, the resources of the Academy of Finland and the National Technology Agency need to be increased to enable them to take care of the development of new growth fields, research-based innovations and innovation environments.

Research organisations must be developed as active and dynamic cooperation partners for business and industry. University legislation must be amended to encourage universities to develop actively education, researcher training and research and to promote the utilisation of research findings. The Science and Technology Policy Council will evaluate the structures of the public research system by the end of 2004.

Investment in basic information society skills must be continued. The measures for enhancing mathematical and scientific knowledge must be carried on and researchers' career prospects must be improved on the basis of relevant evaluations.

Research and innovation financing must be increased with a view to accelerating the internationalisation of the innovation system and to improving the overall conditions for innovation. There are three main targets: (1) to develop education and career prospects in research and to step up research on a wide front; (2) to strengthen social and technological innovation; and (3) to develop innovation financing flexibly and expertly.

Knowledge at the core of regional development

Regions face the same internationalisation challenges which influence the national level. In order to be able to give a successful response to these, regions need to enhance their own factors for development.

Higher education institutions and local units of research institutes have a particular task in contributing to the regional knowledge capital and to put it at the disposal of users. Relating to this, the anticipation of labour and educational needs must be urgently developed.

The national and international networking of the regions must be intensified in collaboration between public and private players with a view both to utilising knowledge available elsewhere and, especially, to improving innovation services needed by small and medium-sized enterprises.

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Towards a national strategy

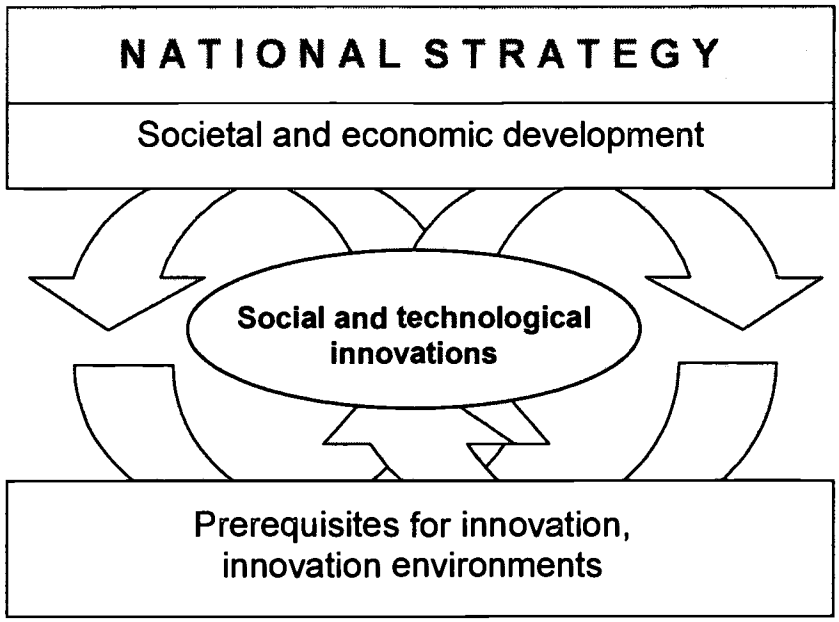
In the early 1990s Finland underwent a severe economic recession. The means by which Finland managed to recover from it was essentially a determined effort to increase exports based on the development and utilisation of high technology. The rapid economic boom in the latter half of the nineties was similarly founded on new technologies and their successful utilisation.

Finland's recent economic and social development is exemplary in many respects. This is evidenced by a number of international competitiveness reviews and other comparisons, in which Finland has gradually climbed to the top. This is not only a question of economic development, but, for instance, of success in combining it and sustainable environmental policy. Alongside this positive development, there are other factors in which Finland has not fared as well. One legacy of the recession is the most severe problem currently facing Finland, unemployment, which remains at a high level despite the improving employment situation. Other phenomena include diverging regional development, dating from the nineties, and a growing threat of exclusion and poverty in the domain of social development. In addition, the overall information society development in Finland is only at an average international level.

Finland had to renew its industrial, economic and social structures in a way which could be called dramatic. At the same time this improved Finland's position in international competition. The advanced education system and other high-standard infrastructures geared to implement Nordic welfare thinking provided decisive support in the transition. Finland's strong input into research and technological development have further improved our development potential.

One crucial future challenge to sustainable economic and social development is how Finland is able to keep itself attractive for business, jobs and more generally as a living environment in growing competition.

What the nineties taught above all was that *success in creating innovations* is a key asset for both business enterprises and societies. There is open, constantly growing international competition for innovations and their producers. Speed and flexibility, together with high-standard knowledge and know-how, are a strategic advantage in this competition. Countries which have these assets have an edge on others in seizing the opening opportunities. At present Finland is among these countries.



This line of action, which has proved successful, must be continued and further strengthened. Its central aims must be expanded to include the prevention of factors causing negative societal and social development. Finland must make even more determined input into producing both technological and social innovations. The set of actions thus determined will form the nucleus of the *national strategy* in the coming years.

1 Finland as part of the global community

The *globalisation of the economy and technology* has accelerated internationalisation and the removal of traditional boundaries. As a phenomenon, globalisation is closely linked to network-building. Both are characterised by an aspiration to speed, flexibility and, through them, to improved efficiency and effectiveness. Business tends to seek locations which offer the best production factors and markets. The impetus for internationalisation has come above all from the business world, but public-sector players have also had an active role.

The *internationalisation of science and research* is similarly progressing towards global networking. Internationalisation, competition and cooperation improve quality, reduce overlapping knowledge production and help to pool existing resources and allocate them to important targets.

Globalisation not only challenges the economy, technology and research, it also affects countries and regions to their very core. Alongside industry and the economy, social structures are also changing and renewing. National decision-making must be able to make the most of globalisation by reinforcing the positive aspects of the trend. Speed and flexibility and high-standard knowledge are strategic assets for decision-making.

Globalisation has a profound effect even on big countries. For a smaller country, the impact is all the more momentous. For a Nordic welfare society like Finland, it means a special challenge i.a. to secure welfare services in the face of a rapidly ageing population and the ensuing fiscal pressures. This challenge will only grow with the enlargement of the European Union and a rising technical level in the developing countries. A case in point is the future of our own traditional industries. A capacity for renewal and improved productivity are a precondition for keeping production and jobs in Finland.

Our present strengths are largely endogenous: the education and research systems, a competent work force, good infrastructures – the basic factors for high-level knowledge and know-how. Finland's attractiveness in the global competition essentially rests on these factors. We must take care to maintain and develop these strengths. This entails making efficient use of the opportunities available through international cooperation. The challenge is particularly important in the area of bilateral cooperation.

Finland's interests in research and business cooperation extend to all parts of the world: Europe naturally, but notably also North America and the Far East. The reasons are simply quality, access to markets and the benefits of cooperation in relation to the resources at the disposal of a small country and its business and industry: the United States is still the largest producer and commercialiser of new knowledge. Japan and Europe are the other leading centres of research and technology. Many developing countries, especially in Asia, are rapidly catching up with Europe, even passing it. The ambition to optimise international cooperation leads to rational choices. Global internationalisation and European cooperation are developing side by side.

At the *European level* the internationalisation of science and technology is currently most tangibly influenced by growing cooperation due to the enlargement of the EU, the European Research Area (ERA) and the Sixth EU Framework Programme. At the same time, the EU member states seek to boost their national research activities by stepping

up international cooperation. This aspiration is most concretely seen in the effort to create a common research area. More competition is also needed in European research. This is a question not only of European development, but development more generally in the global sense.

The aim of the European Research Area is to mobilise research and researcher training of the highest standard with a view to raising scientific and technological performance and, through it, the industrial and economic competitiveness of the continent to the world top. Europe's success in global competition will also improve Finland's development prospects in the long term. It is in our interests to try to speed up the development of European knowledge and know-how.

Apart from competitiveness, development challenges also relate to the social and cultural dimensions of innovation, operational prerequisites and public opinion, which determine the line of action and essentially influence the member states' commitment to developing research and innovation. A broadly defined innovation system based on good cooperation between the public and private sectors has long been a key concept in Finnish policy for knowledge-based development. Finland's contribution to the development of the European research and innovation area could well be to highlight a holistic approach to the innovation system in the European debate and the resulting enhancement of European cooperation in the development of different innovation sectors.

The *enlargement of the European Union* will introduce important new features in the research entity perceived as European. European innovation can only flourish in diverse interaction with other areas and countries. The enlargement will, however, mean a considerable development challenge and require additional investments before the national systems of the new member states have been integrated into the Union's activities and the contribution of these countries to European research and innovation is felt. Similar special attention is needed with regard to research and innovation in the developing countries.

2 National development challenges

Finland has succeeded in combining the large-scale production of knowledge and its economic exploitation with other social and societal aims, such as promoting welfare and sustainable development. It is an immense challenge to maintain this good standing and to carry on the positive development in the circumstances of ever-growing international competition. One key factor will be a rise in productivity and employment rates. Success in this will require effective social and technological innovations. The most important prerequisites for enhancing welfare will be systematic investment in knowledge and know-how and the development of internationally thriving business based on it.

2.1. Special challenges of internationalisation for the system of innovation

On a more general level, the internationalisation of the innovation system involves two challenges: on the one hand, the Finnish system must be *able to compete* for competent researchers and other research resources, projects and business research and development with other countries' systems and, on the other hand, Finnish players must be *able to enter and make use of* the opening markets.

The national innovation system is at the core of the overall internationalisation in many ways. The policy-maker is in a position to influence the opening of the system, to speed it up or take development in a given direction. The public sector does not, however, operate alone – the private sector, enterprises in particular, are involved in the process in various ways. Good collaboration is an intrinsic part of successful internationalisation strategies: the role played by effective cooperation and partnerships is no less important in internationalisation than the one customarily given to them at the national level.

The challenges of internationalisation go both ways. A systematic effort to develop science and technology cannot be limited to the national setting and traditional international cooperation. The next logical step in development is to seek to internationalise at the systems level and to internationalise national science and technology institutions. The aim is to bring about a virtuous circle: active international opening will yield the best results if one has an equal input to make in cooperation and, on the other hand, the requisite for equality is participation in the expanding cooperation, because the alternative would be to lag behind international progress. Activity in developing cooperation also increases opportunities in the domestic setting: dynamic operational environments have international appeal.

The most interesting scientific problems are often found in the interfaces of traditional disciplines. Correspondingly, the most promising research opportunities in these problem areas are often found in international cooperation. It is in researchers' interests to make full use of the opportunities on offer. The pooling of intellectual and material resources makes it possible to achieve results which would be out of reach for one organisation or country – at least impossible in the same time frame – as exemplified by human genome research. "The opening of the world" increases multilateral research cooperation and opens up national research to other countries or to international cooperation.

The development of Finnish science and research on a wide front is directly linked to the international cooperation pursued, its extent and quality. Research, especially its expansion in the 1990s, has improved our chances of taking an active part in

international top-level research and exploiting its results. Alongside EU cooperation, one important channel for this is participation in *international science and technology organisations* and their projects. These represent a substantial part of top international research in both qualitative and quantitative terms. A small country like Finland does not always have the material and intellectual resources needed for major projects in either the production or utilisation of knowledge, which only emphasises the need to consider participation case by case. On the other hand, there is need for a more general policy regarding Finland's participation in international organisations and large-scale projects.

The European Research Area ERA is a tool for intensifying cooperation and network-building with a view to systematically improving the quality and competitiveness of European education, research and knowledge-intensive business vis-à-vis other leading centres. When realised, it will strengthen horizontal cooperation both at the European and the national level. From the Finnish viewpoint, ERA also provides opportunities to intensify the Northern Dimension of the EU and cross-border and Nordic cooperation.

The opening of national research programmes and organisations to foreign participants will increase the chances of our own researchers and research organisations to operate outside Finnish borders. Especially for a small country this means growing opportunities and access to wider expertise. This entails, however, that the level of domestic knowledge is sufficiently high. At the moment, Finland is in a position to benefit from the opening opportunities in many fields. Greater researcher mobility, increasing multinational research projects and closer networking between centres of excellence will also boost domestic research and raise its quality.

In terms of the *performance of the innovation system,* the challenge of internationalisation entails removing systems failures and rigidities. This is best achieved in collaboration between the public and private sectors. More generally this involves, for instance, legislation: provisions concerning taxation, intellectual property rights or university studies, among others, have a major impact on the extent of international cooperation and domestic opportunities for internationalisation. The decisive factor is, however, quality – the higher the level of domestic work, the better the chances to move on to new openings in international forums.

It is the *players in the research domain* that encounter internationalisation most concretely. They contend with the great demands made on them by the opening of research programmes; international opening for funding and vacancies; the upgrading of internationalisation knowledge and skills, starting with language skills; and the internationalisation of funding instruments. Similarly, the expanding international cooperation area calls for more selective decision-making. Being at the forefront – for instance, in networking research successfully at the pan-European level – in most cases demands new kinds of thinking and attitudes, new knowledge and skills from national players. The change is necessary, however, for there are no purely national operational environments.

The international activities of *enterprises* have diversified and investments abroad have increased in recent years, as has foreign investment in Finland. Despite the flagging economy, business enterprise research and development investment appears to continue to grow – especially research investment abroad has been expanding. The majority of Finnish industrial research and development is still done in Finland. The rapid

growth in research and development carried out abroad is an indication of both the growth of companies and their internationalisation and possibly of the limitations of domestic competitiveness and growth potential.

Although the growth of business research and development has been exceptionally strong in Finland, the concurrent growth in international cooperation and network-building has led to a situation in which new knowledge is increasingly based on research carried out abroad. There are at least two reasons for this. Firstly, the number of research units of multinational corporations has grown with the decentralisation of activities to different countries, which in turn has increased the internationalisation of companies' internal research and development. As a result, the relative share of research and development carried out by foreign enterprises has been growing in most countries. Secondly, the numerous international networks and cooperation agreements have increased international research cooperation of public and private players.

The internationalisation of Finnish industrial research and development and the increase in Finnish investment abroad have not generally led to a decrease in domestic activity: internationally successful enterprises often increase their domestic activities as well. Apart from the increase in research and development investments abroad, there has also been an increase in mergers, acquisitions of international companies, and strategic *alliances*, which focus on ever wider domains. Companies' primary reason for building alliances is to strengthen their research and development, technology transfer and licensing, as well as to gain access to markets.

The internationalisation of innovation systems enhances the role of *education and training*. Apart from investment in quality, special measures are also required, starting from the opening of international schools and increases in courses and programmes taught in foreign languages at different levels of education. One key factor is education for internationalism and international action. This requires investment at all educational levels and especially in researcher training. Not all partners are equipped for this, nor is the international education market nearly as advanced as the corresponding open research market. This is a question not only of barriers, such as legislative and other obstacles to mobility, but also of the need to enhance individual competencies for international activities.

The internationalisation of the national innovation system is a major undertaking, even though advances are often made in small steps. Swiftness and flexibility are assets in this process as well. To some extent, internationalisation has an intrinsic value, for example when geared to increase knowledge in general. Nor do all practical objectives have material aims, as exemplified by the aim to increase the stability of the international system.

From the national perspective, however, the development of one's "own" research and technology and growing opportunities to use the results of international cooperation provide the strongest impetus for internationalising national innovation systems. The capabilities for using results domestically must be given more attention. The essential factor in terms of outcome is to conceive of the notion of one's "own" more broadly than it traditionally is. At the EU level it means accepting that more advanced research cooperation will give both the EU and its member states and regions more added value

in its broad sense than mere national action, and acting accordingly. This is also the best way to promote social development and competitiveness in Europe.

2.2 The Finnish setting

The success of the national knowledge-based strategy entails

- The capability for constantly generating new high-standard and relevant knowledge
- Efficient and unimpeded diffusion of knowledge and know-how
- Advanced capability for exploiting knowledge produced abroad
- Effective horizontal partnerships in the domain of knowledge which permeates society, as a result of which
- Network-building across sectoral boundaries comes naturally.

The strategic choices made in both the public and the private sector will play a growing role in the future. It is crucial to identify clearly the main knowledge and know-how areas – the *national competencies* – and to invest in their determined and ambitious development.

Characteristics of the innovation system

Measured by relative indicators, the Finnish innovation system is efficient and competitive. In the light of international, e.g. OECD and EU comparisons, the system works well. It is a rational system and its operation is built on good collaboration between public and private partners. For over a decade the science, technology and innovation policy pursued by Finland has been based on a broad definition of the concept of 'innovation system', which partly explains the good ranking – since other countries have adopted this approach later. The development of innovation environments also has wide political support in Finland. These, mainly endogenous assets provide a good basis for further developing the Finnish innovation environments on a wide front and for making them still more competitive and attractive internationally.

The Finnish *education system* is comprehensive and relatively well-resourced and has been commended in international comparisons of learning outcome and quality. Apart from knowledge and skills, growing attention must be paid to supporting intellectual and social development. In Nordic welfare thinking, education and training are largely seen as a public service and as everyone's civic right. The establishment of polytechnics alongside universities in the early 1990s has proved a good solution. Education provided as a public service has been criticised for not offering sufficient incentive either to educational institutions or to students, which weakens the matching of education and working life. On the other hand, the more education and training a person has, the better the chances of finding a permanent job. Finland has reflected on questions like these extensively in recent years, and invested in developing the structure of the education system.

The *volume of research and development* has grown strongly and rapidly, as has relative investment in knowledge and technological development. Finland is among the world leaders in terms of research and development investment as a percentage of the GDP. The proportion of research and development personnel of the employed in Finland is

clearly the largest in the OECD. At the same time, the level of education among research personnel has been steadily growing. One reason for this is that Finns are traditionally highly motivated to study and also value academic research very highly. The rise in national and international competitive funding has been one of the major factors for the significant rise in the quality of Finnish research over the past decade.

In other respects, too, the *prerequisites for innovation* are, relatively speaking, in order. Systematic investment has been made in international science and technology cooperation in recent years, and, with the strong growth in information industries, knowledge-intensive economy and business have been developing favourably. However, entrepreneurial activity is not at the desired level in Finland. The legislative framework favours entrepreneurship and innovation funding has also been strengthening in other areas besides research and technological development. This is also roughly the picture indicated in international competitiveness reviews.

But the Finnish innovation system has other characteristics as well. One is the *small size of the system*. This is reflected in the fact that having to resort to its own resources alone Finland would find it difficult both to realise sufficiently large and internationally interesting research entities and to achieve new research openings on a large scale. Correspondingly, it is often difficult to translate research findings into commercial or other innovations because of the small domestic market. It is indispensable to build international networks in research and education because the majority of knowledge will continue to be produced outside Finland. The benefits of small size, which do exist, mainly relate to the uncomplicated innovation system and smooth collaboration. But even a good collaborative spirit needs to be cultivated.

Because of the limited educational and research resources, it is especially vital to make appropriate investment in promising research fields and to achieve sufficient volume and quality in them. The same applies to new knowledge-intensive growth areas and support to their development. In view of this, it is justified to build up a *distinctive profile* and target international research cooperation at strong cooperation partners, whenever quality criteria are met. The proliferation of networking both in research and in business also improves the chances of smaller high-standard research teams and units.

Knowledge produced abroad, its utilisation and a large-scale influx of foreign students, researchers and experts into Finland are of primary importance for continued growth and societal development. The proportion of foreign researchers and experts in Finland is still the smallest in the EU. However, talented foreign students, experienced experts and distinguished researchers are drawn to Finland by the very core of our national and international competitiveness: the high quality of basic knowledge, education and research. The oft-cited disincentives, almost catchwords by now, are the strange language, high taxation and the harsh climate.

Technological development and *technological innovations* are generally considered the strongest area of Finnish innovation. The specific development challenges involved are thought to relate to *intellectual property, entrepreneurship and innovation funding*. Well-deserved attention has begun to be paid to the relative weakness of *social innovation* in the entity of innovation. Its development alongside technology is a major challenge for society and the economy. As yet Finland has no clear development strategy for social innovation. The challenge concerns both the organisations responsible for social

development, the development of working life, and the safeguarding of individual development and opportunities by means of research-based innovations.

In the global view, it is necessary to gain a better understanding of environmental phenomena like climate change, as well as of cultural and social interaction from the individual level to the national and global levels.

Structural change adds to development pressures

The *industrial structure in Finland* has become significantly more knowledge-based in a short time, which has raised the educational requirements of the labour force. The change will continue to be rapid in the coming years. New jobs are increasingly created in fields requiring a high level of knowledge. The relative share of the highly educated and those doing research work has grown and will continue to grow, but the volume and growth of research and development vary from one industry to another. The *information industries* have grown fastest especially in relation to overall industrial growth, exports and research and development. This is exemplified by the fact that over half of business enterprise research and development is conducted in one branch, the electrotechnical industry. The relative employment effect of the information industries in Finland is in fact the largest in the OECD.

It is estimated that the information industries will have a growing role in the development of the world economy. Despite the current slowdown in the branch, future growth prospects are still very favourable. The implementation of information society entails not only that the growing knowledge needs in information industries are met but also that information technology skills are developed on a wide front. Apart from more ICT professionals, it is increasingly important to ensure a good matching of demand and supply in different fields and levels. This is also of major importance to employment in other fields. The critical question is how Finland, faced with a shrinking recruitment base due to the ageing of the population, will succeed in this. The problem is general but most severe in fields where recruitment needs are the greatest.

A substantial part of the economic growth and new jobs is created in the *services sector*. Further, knowledge-intensive service industries in particular may have a great impact on the growth and development of other fields: efficient and effective business services often actively promote reform in other fields, too. Services are rapidly internationalising, which will mean stiffer competition, as well as higher quality and productivity requirements. In Finland, growth has been particularly rapid in knowledge-intensive services, such as research and development and telecommunications services. This development must be stepped up through input into international business know-how in the services sector.

The general prerequisites for innovation are largely the same in the services industries as in other branches. Service innovations are often not technical but rather gradual improvements in existing processes. Research and development is typically carried out in cooperation with clients and suppliers of technical solutions. This is why the protection of intellectual property, for instance, may be of crucial importance to all parties concerned.

The market structure in services often differs from the market for manufactured goods. In some fields the public sector plays an important part as a service supplier, as a regulating force or as a procurer of services. Structural rigidities may slow down the development and internationalisation of services. The creation of service innovations may also greatly depend on the level of individual employees' knowledge and skills, and knowledge needs will grow, especially with the growth in knowledge-intensive services. In the planning of education and training, greater attention must be paid to the knowledge needs of internationalising and knowledge-intensive service industries.

Measured by most indicators, Finland can be classified as a *new or a clearly renewing economy*. The development is accelerated by ICT, the globalising world economy and the corporate and industrial structures, which have taken the shape of networks. The changes have brought new permanent features into business and industry. To stay competitive, business and industry must be able to respond to international competition with high-level technological and business know-how.

The particular assets of Finnish business and industry are the ICT cluster, the forest cluster and the metal cluster. Finland must be able to ensure favourable conditions for their renewal and growth in the future as well. At the same time, determined efforts must be made to further enlarge the industrial base by promoting the development of both traditional and promising new fields and the production of knowledge in support of them. Such fields are for instance the life sciences, environmental sciences, new materials, information technology and software know-how, the well-being cluster, and knowledge-intensive services.

The need to integrate the old and new economies was raised in the international assessment of the additional appropriation for research 1997-1999 (Appendix 2). This is a question of integrating new technologies, new kinds of business models, and knowledge more generally into business activities in all fields. Recommendations to this effect were also put forward in the innovation policy outlined by the Science and Technology Policy Council on 23 May 2001 (Appendix 3). It was recommended that, in addition to securing favourable conditions for the setting-up and growth of knowledge-intensive businesses, special attention should be paid to boosting productivity in traditional industries and speeding up other development in them. One means to this end is to encourage small and medium-sized enterprises in the traditional industries to exploit the opportunities inherent in the new economy in order to increase their added value and enhance their efficiency, as well as to provide favourable conditions for the setting-up and growth of new business. As to the development of the work force, the challenge is chiefly to raise the overall knowledge level and improve the matching of education and the labour market. Responding to the changing knowledge needs also entails that companies undertake staff development and make in-service training an intrinsic part of work.

The *full utilisation of* the growth and development in *research and development* both commercially and for the benefit of society as a whole will constitute a significant development challenge to the national innovation system. The challenges of commercialisation primarily involve removing obstacles by joint public and private sector measures: strengthening business know-how, protecting intellectual property and ensuring venture capital investment in start-up companies. Development is also needed to promote rapid internationalisation of new technology-based enterprises and exports. In

societal and social development, the main responsibility for the utilisation of knowledge rests with the public sector, and measures must be taken to strengthen its capacity for taking care of these increasingly demanding expert and development tasks. The need to make efficient use of research capabilities only grows with efforts to build a humane information society.

2.3. Development of innovation dynamics

Finland's high rating in international reviews of knowledge and competitiveness means, among other things, that there will not be ready models to follow to the same extent as before. Yet Finland is facing major challenges and will thus have to be able to open new development tracks.

Expanding society-innovation interfaces

For a long time innovation policy was governed by a need to increase technological innovation in particular. This was one of Finland's central aims in tackling the recession, and was a resounding success. But innovation also provides impetus for social and cultural development, and this area of innovation is equally important. Technological innovation is a precondition for social development, but needs to be supported by effective *social innovation* in all sectors of society. Conversely, without social innovation the benefit of technological innovation will remain at least to some extent untapped.

The key role of innovation has also been discovered in public administration. The strategic starting point is to make systematic use of research in order to increase the knowledge capital and thereby create favourable conditions for innovation within the central government. According to a report published by the ministerial working group on governance in 2001, the capacity for effective utilisation of research findings is a requisite for efficacious work both in ministries and at the government level. The ministries must be able to operate as a network. Achieving set aims requires that decision-making on information and knowledge systems is sufficiently centralised to ensure compatibility.

With regard to innovative activity, business enterprises are primarily responsible for economic development based on technological and other innovations, while the public sector has to take care of societal development based on social and other innovations. The ministries have a constantly growing role as strategic development agencies and are responsible for developing technologies in their own sectors in cooperation with e.g. the National Technology Agency of Finland (Tekes). Government research institutes must be developed in the same direction. The ongoing transformation also warrants intensified cooperation with other partners. The enlarged mission also requires appropriate resources.

Good cooperation between the public and private sectors with a view to increasing social innovations and enhancing their utilisation, and thereby improving employment, is one of the key factors for overall economic and societal development. Successfully functioning horizontal and vertical networks are central here. With their help, innovation financiers, public and private research organisations, and the users of the results can develop especially their thematic cooperation in programmes and projects across organisational and sectoral boundaries in Finland and in the international context.

One central task for the public sector in a knowledge society is to develop and maintain basic prerequisites for innovation, i.e. *creative innovation environments*. Education, research, varied support for innovation and the removal of obstacles, high-standard infrastructures, the promotion of international scientific and technological cooperation, etc. are crucial for successful innovative action. Effective cooperation with the private sector has become very important in all these areas.

In practice the realised and ongoing changes mean that the roles of traditional players are extending to new areas and that the promotion of innovation becomes a matter for others besides those with primary responsibility for it. The former phenomenon will be discussed below. The latter especially highlights the need to strategically develop sectoral research and to broaden the perspective of the ministries into innovation and its utilisation.

In the *ministries,* the need for strategic development relates to two simultaneous change factors in public sector activities. Firstly, the *strategic role of the ministries is undergoing change*. Networking with stakeholders and other partners is an increasingly important element in their basic mission, too. They need more comprehensive, in-depth sectoral knowledge for the shift from traditional action models to strategic network-based development and influence. Secondly, the *development of sectoral policies is increasingly built on research findings produced in Finland and abroad, social and other innovations and their effective utilisation.* The ministries must be better equipped to absorb and use new knowledge in their own work. This entails that the system of management by outcome is constantly developed in the ministries and in the research institutes operating in their sectors. All in all, the ministries are faced with broadening responsibility for development, one answer to which is to develop sectoral research and widen their perspective towards innovation.

In its previous review, the Science and Technology Policy Council recommended assessing the uncommitted research funds at the ministries' disposal. Ministries have jointly commissioned such evaluations. On the basis of findings already available, the ministries have launched strategic development projects to give a sustainable response to the challenge. There is also a clear qualitative change taking place, notably through increased programme activities.

Response to challenges and full use of the opening opportunities entail *an active approach, in most ministries this also involves larger research and innovation resources and to some extent their reallocation*. This will enable them to adopt a line of development which integrates social and technological innovation in a balanced way.

Managing change also entails that ministries constantly rethink their own roles and integrate their research and innovation strategies into overall development. In most sectors this will require updating the strategies with a focus on needs, foresight and impact analysis. In this context they also need to consider how government research institutes should be further developed: what the ministries' new development responsibilities entail from their "own" research institutes and their international cooperation.

Active horizontal cooperation between sectoral ministries is a prerequisite for significant advances in information society development within the central government

(*eGovernment*). In this respect, Finland's progress is not particularly good in international terms – reaching the world leaders will require determined collaborative development.

Larger and closer cooperation between science and industry

Efficient industry-science linkages and flexible forms of cooperation greatly promote the diffusion of research knowledge, through it, new innovation and knowledge-based companies. Similarly, they reflect the capacity of the research system to react to changes in business and industry and to respond to research challenges stemming from it. The internationally small volume of education and research in Finland also makes special demands on networking and cooperation.

There are several general development factors at work behind the rapid growth in linkages. Thanks to information technology, the search, distribution and communication of research findings are faster, easier and more affordable. Companies also have greater need for and interest in research cooperation, because innovations are increasingly based on multidisciplinary expertise. The fact that economic growth has been most rapid in fields where innovations have a solid scientific base has increased the commercial value of research knowledge and findings and created a global market for them.

From companies' standpoint, the profound knowledge found in universities, research institutes and polytechnics is a critical factor for cooperation. The high-standard and independent basic research conducted by universities and its appropriate linkages with industry are also indispensable for business and industry. In its 2001 innovation policy statement, the Science and Technology Policy Council recommended reinforcing strategic basic research in universities and research institutes and increasing their cooperation (Appendix 3).

Not only knowledge but also researchers constitute a vital resource for business and industry. In fact, business enterprises are increasingly aware of the opportunities inherent in cooperation, although the benefits to be gained from cooperation do not come automatically. Success entails mutual benefit and trust. This is why it is important that the cooperation principles and practices and cooperation agreements between research organisations and industry are clear and provide incentive for all parties.

The role and significance of universities in promoting innovation will inevitably continue to expand. This will happen both in education and in research. According to a study on Finnish university researchers' linkages with business and industry published in 2001, the most important incentive for cooperation with business is to obtain financing for research. But in assessing the benefits of cooperation, researchers rated a better understanding of the needs of industry higher than financing. Applied to the institutional level, these findings mean that the *overriding principle in university-industry cooperation is to disseminate high-standard and relevant knowledge and know-how to a wider range of users through the participation of all the partners*. The same applies to research institutes and their partnerships.

When science-industry cooperation is examined from the universities' perspective, the emphasis is often on the university's "third", societal mission, which will be discussed in more detail below. This view assigns a larger, more active and dynamic role to universities in knowledge society. The varied partnerships of the university are backed by

the whole institution and its whole basic mission. The same also largely concerns polytechnics.

Effective use of knowledge and know-how entails that universities and polytechnics have the necessary juridical, economic and other operational wherewithal as well as sufficient incentives for obtaining results. The operational and juridical framework in universities has not, however, been able to respond adequately to growing expectations. Especially in universities, the nature of cooperation has changed from research undertaken by an individual researcher to extensive collaborative projects, with the close participation of business and industry. One precondition for cooperation is that ownership and utilisation rights are clearly defined with regard to all the partners. The current legislation concerning intellectual property rights dates from 1967, when there was no corresponding need to provide for large joint projects carried out by higher education institutions. Changes in research work have resulted in varying funding practices and complicated contractual arrangements.

According to a Ministry of Trade and Industry committee (June 2002), the current statutes do not provide a sufficient basis for clarifying and enhancing the utilisation of inventions made in higher education institutions. The committee recommended new unambiguous statutes to that effect. In practice, this would mean amendments to the Act governing in-company inventions and the Universities and Polytechnic Acts and the enactment of totally new legislation. As regards inventions made in polytechnics, the committee proposed that the matter be further studied. The committee did not deal with copyright issues.

The university in the innovation system

Ever since education and research – knowledge and know-how – took centre stage in the development of societies, systematic input has been made into their development. The quality, quantity and right targeting of education and research pose a challenge to all industrial countries. The best universities compete for the best students, and universities have expanded their international provision abroad. Various research, studies and pilots are being conducted to find out the measures needed to obtain the best results from the inputs made into education and research and the best impact from outputs in terms of both efficiency and quality-based productivity. One major question is how the *university as an institution* will be able to manage the pressures and growing expectations directed at it with regard to social, cultural and economic development – whether the university has the internal capacity for renewal needed to lighten its work load in the face of constant new challenges.

The traditional mission of the university is to promote free research and scientific education and to provide higher education based on research. The burning question in today's debate how to include the duty to *promote the utilisation of new knowledge* in the Universities Act the as the university's third mission. This question arises from both the growing expectations directed at universities by the users and from the legislative issues involved in efforts to reconcile the university's administrative culture, business and research ethics. The need to address these questions is tangible, because the *change taking place in universities' mission and funding structure is systemic, shaking up the institution to its core.*

Internationalisation is necessary for both the development and utilisation of research. A new challenge for universities is to combine in-depth specialised knowledge with versatile expertise for the benefit of users in contract research and in joint projects with them. A special challenge for a small country is the question of critical mass: the capacity for fully participating in international top-level research, while maintaining the capability to create new competencies. In this, too, Finland has to seek its own solutions, which can only be based on smoothly running cooperation.

A related question, which is also of similar consequence in the international context, is the future of higher education as a whole: how its different components – in Finland universities and polytechnics – shape over time both jointly and separately. This relates to both operations and institutions.

Another question for universities is to what extent they are able to organise their economies and administrations in a way which will enable their actual provision to evolve and ensure a strong developmental outlook in education and research. At present these demands are not always fully met. The important thing in the face of rapidly advancing internationalisation is to maintain high quality and relevance, internal efficiency, a balance between e.g. educational and research missions, and the capacity of both the disciplinary structure and the administration to accommodate growing demands for multidisciplinarity. Ultimately the question is how the university itself promotes the education of good teachers and researchers, their career prospects in the university and their recruitment outside the university. Without young researchers the university cannot maintain its dynamism and capacity for constant renewal.

Success is manifested in the university's ability to create dynamic operational environments. For this, external impetus for development is not enough, however efficiently it has proved to encourage universities to apply for competitive funding both home and abroad. The best results in competitive funding are achieved when long-term core funding is in order. A large-scale knowledge reserve, a capacity for exploiting the scientific opportunities available and the capacity needed for renewing education in response to even weak signals require vision, courage and initiative, as well as material resources for rapid response. *The implementation of the national strategy entails that university core funding is increased as part of the development of a humane information society.*

Innovative environments are characterised by a strong commitment to research, determined quality enhancement and competence building and a genuine desire for results. They are flexibly organised, their linkages with society work well and external financing has an important role in operations. Other features of innovative environments are a clear research strategy and well-defined objectives, great weight given to recruitment policy, and a strong international orientation.

In practice, dynamic, innovative research environments vary greatly, but the organisations which have achieved the status of centres of excellence are typically such. They are also more attractive as work and study places for the most promising young researchers; in other words, they accumulate competence. This adds to the significance and critical mass of top-level activities. The same level of excellence – dynamic, innovative and attractive research environments – must also be achieved in new fields, not only in those which have already shown their strength.

In brief, it can be said that universities must address the same international, national and regional challenges as the innovation system at large. This reflects the key role of universities both as innovative environments and as a part of the innovation system.

Dynamic structures

The performance of the Finnish innovation system has been rated very highly in a number of international comparisons and analyses. It has especially been commended for its clear financing structure and the coordinating role of the Science and Technology Policy Council. But the structure alone does not explain the competitiveness of our national innovation system; the structures are, after all, similar to those in most European countries. Its competitiveness can be seen to rest largely on determined, large-scale input, active operational development of the system and the Finnish stakeholders' positive attitudes towards development.

The most important finding in international comparisons of innovation systems is probably that there is no single, readily identifiable ideal model or structure for innovation systems. Instead, there are several features and qualities typical of effective innovation systems, and development efforts should be targeted at these. The same kind of conclusions were drawn in the international comparison of innovation system structures commissioned by Tekes. But in addition the study identified two development trends typical of effective innovation systems: (a) *decentralisation of activities* in the innovation system and *concurrent specialisation* through the deployment of services close to end-users and the transfer to smaller units, and (b) an aspiration towards *more effective coordination and steering* in the decentralised innovation system by means of enhanced support to decision-makers in the form of foresight, innovation research and advisory bodies.

As a planning model, the *national innovation system* has significantly helped to develop, specify and analyse innovation policy, especially interaction and coordination among the stakeholders. The structural development of the innovation system has been given less attention, because of its good performance. Another frame of reference, partly parallel to the national innovation system, which has been used since the early 1990s, is the identification of industrial clusters and their use as a tool for targeting technology policy. As proposed in the 1996 review of the Science and Technology Policy Council, part of the additional research appropriation 1997-1999 was allocated to cluster programmes administered by ministries.

As a concept, the national innovation system does not readily accommodate parallel concepts, such as regional innovation systems or clusters. This is partly why efforts have been made to find complementary frameworks which examine the national innovation system in terms of individual players. A typical example is the concept of *innovation environments of enterprises*, which is currently being applied in an assessment commissioned by the Ministry of Trade and Industry.

From time to time the Science and Technology Policy Council has called for structural development of the national innovation system, most recently when it discussed the internationalisation of the research system. The purpose was to see if the structures created in the early 1980s (Tekes was founded in 1983) were still sufficiently

comprehensive, flexible, capable of development, supportive and efficient with a view to future innovative activity. The last time innovation system structures were discussed in depth was 1994. Since then there have been substantial changes in both research and business.

The most important structural reform concerned the *piloting of the polytechnic system and its establishment on a permanent basis*. Parliamentary discussion of science and technology policy was substantially reinforced by the establishment of the Parliamentary Committee for the Future. The employment and economic development centres, which were established in 1997, have contributed to regional development. In addition, numerous *institutional and programme evaluations* in the 1990s called for improvements in institutional and other structures. In recent restructuring of the *research institutes,* the agricultural and agro-economics research centres were merged into Agrifood Research Finland, and the national veterinary and food agency was regrouped into a National Veterinary and Food Research Institute when the National Food Agency was established.

It has proved a sound decision to centralise the administration and allocation of competitive research and development funding to the Academy of Finland and Tekes. It has improved expertise in research and research funding, and the system is clear, transparent and efficient. According to the evaluation of the additional research appropriation 1997-1999, the funding policy pursued by Finland has been successful overall (Appendix 2). The missions of the Academy and Tekes have proved flexible. It has been possible to modify them in response to the larger scope of innovation policy without major organisational restructuring.

Sitra, the National Fund for Research and Development, was evaluated in 2002. It has succeeded well in corporate financing and its other operations. Its administrative structure was found capable of accommodating future needs. The challenge is to carry on this productive line of action as a factor for change in the rapidly transforming environment and increasingly in cooperation with national and international players.

Whereas science and technology policy is a matter for public decision-making, the setting of research priorities concerns all players in the innovation system. In Finland prioritisation is largely done in collaboration between major funding and expert organisations and with other public and private players. A key question in the steering of the system is how well the existing structures support the processing of new kinds of research and development projects geared in response to needs expressed in different quarters.

For continued competitiveness, one increasingly important question is how well the innovation system can *address, specialise in and flexibly adjust to different changes in the environment*. The qualities required for this include flexibility; capacity to respond; comprehensive knowledge fields and their weighting; competition and incentives; and quality and competence. Apart from structural flexibility and strategic choices, one basic requirement for a smoothly running innovation system is to anticipate different societal and technological development tracks and to analyse their impact.

Knowledge clusters promote development

Active development of cluster cooperation has been carried out in Finland since the early 1990s. It was based on cluster analyses conducted by the Research Institute of the Finnish Economy (ETLA) and on the cluster-based national industrial strategy devised by the Ministry of Trade and Industry in 1993. The evaluation of competitive industrial clusters in connection with the strategy also provided a basis for subsequent deliberations about the allocation of sectoral research funding to cluster programmes.

The success of Finnish business and industrial clusters largely stems from the development of new technological applications. The competitiveness of the Finnish clusters and major challenges facing them will relate to efficient use of technology and knowledge also in the future, albeit in a more global environment. It is important for Finland to be able to continue offering a good operational environment for a variety of internationally competitive business and industrial clusters as well as for potential ones. The key to this is a sustained high level of knowledge and flexible combinations of knowledge from different fields.

In the evaluation of the additional research appropriation, the assessment and development proposals were based on separate cluster studies commissioned by the evaluation team. In the final report, the team noted that *"The cluster programmes have made it possible to initiate fruitful cooperation between various sectors ... 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."* Overall, the evaluation team saw the clusters as an experiment based on the idea that development can be efficiently accelerated through improved linkages between different partners in the economy. The greatest new opportunities were seen to exist in areas which are creating totally new linkages, for instance those geared to improving public services and those offering innovative industrial products and processes needed to realise them.

There have also been other evaluations of cluster programmes in recent years. The findings and experiences have mostly been positive. It is generally seen that the action model as such is both successful and applicable to other collaborative action besides the industrial clusters. As to ministries' research programmes, the Science and Technology Policy Council has noted that those built like cluster programmes provide *an efficient and effective way of combining need-based and researcher-based viewpoints.* The ministries have reiterated on several occasions their interest in continuing and expanding the cluster programme model.

In its new technology strategy *The future is in knowledge and competence,* Tekes, together with industry and research organisations, identified national knowledge clusters. The aim was especially to identify competence areas in which Finnish knowledge has or might win a growing share of the world market and in which the world market is also growing. The strategy is built on three crucial generic areas: ICT, biotechnology and generic materials technology. In the Tekes strategy, the most promising application targets are linked to intelligent products, processes and services, well-being applications, sustainable development applications and services. Success in these areas entails mastering the network economy and relevant business know-how.

Understanding technological development and its economic and social impact in the targeting and development of innovation policy require considerable expertise. Related research is carried out in 50-60 units in Finland, but on the whole the field is still dispersed. Accordingly, the science and technology administrations have a particular duty to ensure conditions for development in their fields, to take part in network cooperation and to make effective use of the results in their own operations.

Technology studies have been considerably boosted by the *ProACT* research programme launched by the Ministry of Trade and Industry and Tekes. It has substantially increased research volume and improved international visibility. At the same time it has brought new research areas and fresh approaches to technology studies. The selected projects are well placed to conduct challenging long-term research and as part of a wider research organisation in which users play a significant part. The foremost development challenges in the future will relate to enhancing high-level knowledge and needs-based applied research.

Anticipating future developments and taking them into account in the targeting of activities is a natural part of all research organisations' strategy formulation. Foresight is increasingly conducted in international cooperation. The aim is to undertake extensive technology foresight relevant to their own operations and only in rare cases purely anticipate technological development. Research institutes must be able to anticipate changes and phenomena more effectively in collaboration with the administration and other partners, develop new opportunities and solution models for sectoral policies and critically appraise the policy pursued. It is also important to develop foresight procedures.

Certain major organisations, such as the Technical Research Centre VTT, Tekes, the Academy of Finland and some universities, have intensified their systematic technology foresight. Foresight stemming from regional needs is also conducted by employment and economic development centres in connection with regional technology strategies.

Most ministries also accord an important place to anticipatory research and its utilisation, seeing it as an intrinsic part of operational development. The major challenge relates to the resources and knowledge needed for foresight. In this respect, horizontal cooperation between ministries and administrative sectors has apparent advantages, for instance in implementing joint projects, developing foresight methods, sharing experiences, and exploiting the results of foresight exercises on a wide front.

After an in-depth investigation of the national organisation of foresight and relevant needs, it is evident that it is time to proceed to more extensive and concrete projects. Finland has the prerequisites for a national foresight exercise. Network-building and the monitoring of foresight methods and needs are not enough to keep up interest in the futures outlook among researchers, business enterprises and other players and to encourage them to contribute to foresight.

Constant development of intellectual resources

The internationally *high level of education and well-performing education system* are clear strengths for Finland. In practice the whole age group completes compulsory schooling. International learning attainment comparisons show that the Finnish

comprehensive school is of a good standard. Learning outcomes naturally can, and should, always be improved.

Secondary education comprises the upper secondary school and vocational education and training. This level of education is considered the minimum requirement for jobs in a knowledge society. Slightly under 85 per cent currently complete this level. This is all the more reason to feel special concern about those 10,000 young people who annually discontinue their secondary education or training or do not even start it. The unemployment rate among those without secondary training in Finland was the highest in the EU in 2000, namely 19 per cent, as compared to the EU average of 12 per cent. Further, youth unemployment is high: 20 per cent in 2001, when the overall unemployment rate was 9 per cent. Thirdly, the rate of employment among young people aged between 15 and 24 is very low in Finland, only around 30 per cent. Finland has not paid sufficient attention to the social, psychological and other factors at work behind the visible disinclination to pursue education and training at the individual level, and behind the inadequate attraction of the education system to the extent that it outweighs the threat of social exclusion.

In this context it is worthwhile to note that the overall annual number of upper-secondary certificates is nearly 70,000, or computationally almost 110 per cent of the size of one youth age group. Half of these certificates are vocational qualifications. This obvious paradox is due to the fact that many matriculated students study for vocational qualifications. This could be called overlapping education, but the end-result is a relatively large and crucial group of competent workers. It is an indication of the national importance attached to education and training that supply is not a hindrance to secondary qualifications. But constant attention needs to be paid to the quality and relevance of education and training in terms of labour market needs.

Up to half of the vocational qualifications are in the fields of technology and natural resources. The corresponding enrolment figure is slightly lower. The debate on the development of secondary training has largely focused on *the lack of popularity of mathematical and science subject*s among upper secondary pupils. This both affects the knowledge and skills needed in an information society and narrows the recruitment base for higher education. Higher education debate has especially highlighted the need to enhance girls' interest in mathematical subjects. This is well-founded as girls make up 60 per cent of the upper secondary school pupils in Finland, but only 30 per cent of them opt for advanced courses in mathematics. The corresponding figure among boys is over half.

One of the strengths of Finnish society and education system is Finns' willingness to participate in education and training, including higher education. The aggregate intake in higher education institutions, the universities and polytechnics, corresponds to 70 per cent of the youth age group in computational terms. Yet there is stiff competition for these places. In 2001 the number of entrants in universities was 20,000 and in polytechnics still higher: 25,000. The aggregate number of applicants in higher education was over 120,000.

In 2001 the number of polytechnic graduates was 14,000 and the number of master's degrees awarded by universities over 11,500. In computational terms, this represents 40

per cent of each of the 20-30 age group. In addition, universities awarded 1,900 postgraduate degrees in 2001.

These figures are large in relation to both the population (5.2 million) and the size of the age groups. All in all, it is fair to say that the level of education in Finland and of Finns is of a good international standard, and rising. Apart from input into educational quality, one important factor has been the system of polytechnics, which have only operated for ten years and which have played a decisive role in increasing educational supply. The introduction of polytechnics was a success in terms of quality, too. This was confirmed by the OECD review completed in summer 2002.

The *technological and natural sciences* represent a large proportion of higher education in Finland. In 2001 there were 18,500 entrants in these fields, which makes 40 per cent of the total number of new students in higher education and, in computational terms, as much as 30 per cent of a whole youth age group. Yet many more young people apply to these fields than can be admitted: in universities a little under and in polytechnics slightly over 40 per cent of applicants gained admission.

Despite such large applicant and admission numbers, the under-representation of women, which has already been noted with regard to the upper secondary school, is the most striking feature in Finnish technological education: the proportion of women varies between one fifth and one fourth in universities, whether counted from new or all undergraduates, graduates, postgraduate students or new PhDs. Yet for a long time over half of all university students and graduates have been women, and at present already 45 per cent of PhDs are women.

The share of women students in technology and transport in polytechnics is similar to that in universities. From 1996 to 2002 Finland carried out a joint national action to increase knowledge in mathematics and natural sciences. One of the aims was to raise the proportion of women students in technological fields to over 30 per cent. This was not achieved although the disparity between girls' and boys' mathematical and scientific knowledge has narrowed down and in many areas disappeared altogether. However, this has not effected any significant changes in the choice of higher education subjects, at least not yet.

The under-representation of men in higher education is similarly cumulative. Male students make up less than one fifth of students in education science, psychology, health sciences and veterinary sciences, in health sciences even under 10 per cent. Special concern has been voiced concerning gender distribution among comprehensive school teachers: 70 per cent of class teachers are women. The situation is not improving: fewer than one fourth of new entrants between 1997 and 2001 were men. In 2001 only 12 per cent of all those studying the social and health fields in polytechnics were men. No change has taken place here either.

Interest in scientific postgraduate education can be seen in the number of applicants to the competitive student places in graduate schools. There are on average five applicants for each opening. In the technological and natural science fields, where the competition is not equally severe, there are four applicants for each opening. The impact of the graduate schools, which were introduced in 1995, is seen both in the annually growing

number of new PhDs and their constantly lowering age. The annual number of new PhDs has grown from 700 in 1994 to over 1,200 in 2001.

The employment situation among PhDs is good, and in the growth fields there are more jobs than PhDs. One of the challenges facing education is to combine in-depth specialised knowledge with more comprehensive expertise. Future development will be facilitated by a study on the need for PhDs in different disciplines and the placement of new PhDs in the labour market, which the Academy of Finland is currently carrying out at the request of the Ministry of Education.

Education and training are a basic prerequisite for a knowledge society. At the population level, it is a question of both raising the level of education and preventing exclusion, the aim being that in principle the whole age group studies for a secondary certificate. This is also the level on which the important choices concerning further education and careers are made. It is for society to guarantee the citizen's right to basic education and opportunities for further education and training.

The future development of an economy which increasingly rests on knowledge-intensive business and industry essentially depends on appropriately educated work force. In a small country, the limits of the recruitment base are reached fairly soon. Attempts can be, and have been, made to push them back in many ways: there have been proposals for eliminating obstacles, such as long waiting times in educational tracks, long overall study times and drop-out, which in some programmes is considerable. Another way is to extend the recruitment base to include citizens of other countries. As regards the adult population, the key words are lifelong learning, including self-motivated and staff-development training, and measures geared to improving job satisfaction and well-being at work. All development measures are needed, including those improving the response of the education system to changes in working life.

Finland's asset is that the population is highly motivated to educate and train themselves. Unlike in many other countries, research careers also attract young people. Connected to this is the finding of the 2001 Science Barometer that Finns highly value research, technology and researchers. Over two per cent of the employed are involved in research, which is clearly the highest figure in the OECD. However, research can be further increased without compromising the competence and educational level of research personnel. This is why Finland is exceptionally well placed with regard to internationalisation and the exploitation of international cooperation, especially in its strong research areas. Care must only be taken to mobilise the necessary education and research resources – high-standard research is not possible without high-standard researchers. Measures must be taken to increase the career options open to researchers and incentives for research careers. Scientific research must be made into a viable career option for talented young people in financial terms as well.

The development of intellectual resources has a positive effect at all levels, from the individual's options to regional development, the success of the national strategy and better use of international opportunities. This development challenge affects the knowledge society and the whole innovation system at their very core.

Financing of innovation

The trend in Finland has been that the *research volume* doubles every ten years. This has happened at least since the 1970s, when official research statistics began to be collected in Finland. Towards the end of the 1990s the rate accelerated to the extent that the volume, measured in funding, grew 2.5 times from 1991 to 2000. From 1970 the volume has grown tenfold. In the late 1990s there were both major increases in ICT-related research and the additional research funding programme. The end result in 2001 was that over 4.5 billion euros was invested in research and development in Finland, which was about 3.4 per cent of the GDP. In relative terms, Finland is among the top research and development investors in the world.

The rapid and accelerating increase in funding mirrors well both the rate of structural change and its significance. It is noteworthy that the corresponding increase in personnel has been accompanied by a constantly rising level of education among those involved in research. There are several factors contributing to this, notably the graduate school system introduced in 1995 and a clear increase in the number and proportion of well educated women among research personnel.

According to assessments, the growing research funding has had a positive effect on the economy, employment and business. Reliable impact analysis is difficult in many ways but the existing material indisputably bears out the positive picture of Finnish development.

The steep increase in research funding has raised various development issues. One is the debate concerning *university core funding*, which relates to measures for creating an extensive basic research and knowledge base, on the one hand, and building up intellectual resources, notably researcher training, on the other. It is vital to consolidate the knowledge base with a view both to the utilisation of knowledge produced abroad and to new opportunities opening in the future. Post-doctoral education and the placement of young PhDs have also been discussed. All these are geared to a sustainable response to the growing demand for knowledge.

Another discussion topic has been the *development of innovation funding* with a view to ensuring that the results of growing research activities are efficiently translated into technological and social innovations. Studies show that there are still clear shortcomings in this respect.

The third question concerns the *ratio between public and private research funding*, which decreased rapidly during the nineties. Whereas in 1991 public funding represented 45 per cent of the overall research funding, it had fallen below 29 per cent by 2000. This trend has been considered detrimental in many ways, even though the GDP share of public research funding is one per cent, which is high in international comparison. This discussion on the balance between public and private financing involves concern about the internationally small proportion of public research and development in the whole of business enterprise research and development.

The fourth issue concerning funding is the *ratio of research organisations' core and external funding*. One purpose for the increase in external funding has been to improve the quality and relevance of research and to gain practical benefits from it. The core

funding allocated to universities and research institutes must be substantial enough both in absolute terms and in relation to other financing to guarantee a scientific knowledge base, irrespective of the interest shown by external players. The present 50:50 situation has been achieved in about ten years; in the early nineties, core funding amounted to two thirds of research expenditure in universities and research institutes. The roads to the current situation have been different for universities, in which the volume of core funding for research grew by 50 per cent from 1989 to 2000, and research institutes, where the corresponding volume fell by 10 per cent.

The additional research appropriation mentioned above increased the volume of public research funding by one fourth from 1996 to 1999. At its highest in 1997 the GDP share of government research funding rose over 1.1 per cent. As the real growth of research financing came to a halt in 1999, the GDP share has been gradually falling and is estimated to be under one per cent in 2003, the same as in 1996, before the additional appropriation. This means that over the period 1996-2003, the development of government research funding has closely followed the growth in GDP. Measured like this, the weight given to public research financing has thus not grown after all – despite the additional appropriation programme.

The additional resources were primarily allocated to public financing and expert organisations – Tekes and the Academy of Finland – and to universities as core funding. One of the justifications for this was the *desire to increase competitive research funding*. In fact, competitive funding makes up over 40 per cent of all government research funding at present. This is the most important structural change in public research funding in recent years. The additional appropriation programme also provided for cluster programmes within the purview of specified ministries. These have shown potential and will be continued and further developed on the basis of recent evaluations, as described above.

The development of public research funding is necessary with a view to eliminating bottlenecks and facilitating new openings. *One important area in need of new kind of input is the promotion of social and cultural innovation*. This entails that research and funding organisations, ministries and other users are committed to collaborative innovation. Public resources in particular have not been quantified in all respects to provide for the financing and efficient utilisation of such activity.

The overall growth in *business enterprise* research and development funding has been very rapid from the mid nineties onwards. But behind this positive development lies a strongly divergent research intensity in different branches. The electrotechnical industry has increased its research and development in Finland to the extent that the 2000 volume, 1,725 million euros, already exceeds 55 per cent of the overall business-sector research and development and represents some 40 per cent of the national research and development input. Research and development in the branch is also international by nature. The largest corporation in the sector, the Nokia Group, invested over 2.5 billion euros in research and development in 2000. Companies at the internationalisation stage in all industries typically conduct an increasing part of the growth of their research and development abroad.

In other industries growth has been slow. While the electrotechnical industry nearly doubled its research and development input over the period 1997-2000, other major

branches, the metal, chemical and wood processing industries, raised their input by about one quarter. On the other hand, business enterprise research and development relating to knowledge-intensive services has been growing rapidly, at the same rate as in the electrotechnical industry.

The amount of public research and development financing and its relative share of business enterprise research and development naturally varies from industry to industry. The share is smaller in manufacturing than in the services sector, and smallest, under two per cent, in the electrotechnical industry. However, over 40 per cent of government research and development funding is targeted to promote economic development and industry (excl. the defence industry). This share is the second highest in the EU, where the average is 20 per cent.

Growing research and development inputs have yielded good results. This is evidenced both by international assessments and statistics as well as by separate reviews. The number of Finnish scientific publications and their bibliometrically measured quality have developed favourably. Finnish research has clearly gained more international presence and visibility during the nineties. Measured in relative terms, Finland is between the fifth and the tenth among OECD countries.

In the application of technology Finland is rated among the top in the ICT field, when measured, for instance, by the balance of high-tech trade or patenting in the USA. In other respects there are clear development needs, which to some extent can be addressed by means of *innovation funding* and its development. Efficient utilisation of research-based knowledge increasingly entails rapid and well-targeted inputs with a view to access to international markets. Especially for small technology-based companies this poses a great challenge.

In terms of commercial utilisation, the rapidly growing, high-standard research and development in Finland needs to be supported by business and internationalisation know-how, cooperation and distribution channels to the national and the international markets, and an adequate, well-functioning equity market. Indeed, *venture capital investment* has become one of the most important sources of financing for the utilisation of innovation and internationalisation. The effects are various: in addition to strengthening the company's capital, it improves the opportunities for further financing, international cooperation and distribution channels, as well as business know-how overall.

Public venture capital investment is mainly targeted to enterprises at the seed and start-up stages, which are critical for the commercialisation of research findings, whereas the growth and internationalisation of companies are more clearly the domain of private equity investors. Alongside these, direct investment by private persons, which is more difficult to quantify statistically, constitutes a significant part of the capital investment in new technology-based companies. Private investment should in fact be encouraged and the circulation of capital accelerated, for instance by means of tax arrangements.

Although growing in number, Finnish venture capital investments are still smaller in size than the international average. This adds to the need for foreign financing and collaboration between investors, especially in companies at the internationalisation stage. With the internationalisation of venture capital business, more foreign capital will

find its way to Finland. It seems that foreign investment to venture capital funds in Finland is hampered by unfavourable taxation compared to direct investment in companies. The absence of foreign funds holds back the development and internationalisation of the domestic venture capital market.

Recent stock market developments have clearly limited exit possibilities through listing and otherwise dampened growth in the field. It has become more difficult to raise new capital, and risk-taking has declined. Sensibility to economic fluctuations is reflected in greater selectivity in the choice of investment targets. Both investment targets and investors are expected to show more convincing evidence of their ability to internationalise and their business know-how.

Measured by relative indicators, Finnish innovation funding has developed at a top or at least average rate in international terms. The exception is the stagnation in the real growth of government research and development funding. In practice, however, the small size of the population and the national economy is a limiting factor. The conclusions to be drawn are two-fold: on the one hand, to go on systematically expanding "outward", that is to internationalise, and on the other, to expand "inwards", that is to intensify activities and invest in quality and content development. Quantitative growth is still not only possible but necessary. However, the narrow recruitment base, for one, is a clear limitation. Therefore attention must increasingly be paid to the field and branch specific distribution of research and development and technology funding and other input factors and to flexible expert development of innovation financing. It is still vital to take measures to strengthen the material and intellectual base on a wide front. Moreover, Finland must be able to clearly prioritise important and promising fields.

3 Knowledge and know-how at the core of regional development

The growing demands made by internationalisation on competitiveness and knowledge and relevant opportunities concern all regions, irrespective of their premise, location or size. They entail competitive innovation environments in the same way as at the national level.

Regional development is more and more clearly dependent on the way in which the *region's own development factors* evolve and how well they are made to interact both amongst themselves and with the national and international levels. Sustainable and balanced development rests on the enhancement of the region's own capacities and knowledge, such as basic information society skills. In this respect the situation differs from region to region.

Internationalisation creates two kinds of networking needs in regional innovation. On the one hand, the aim is to strengthen the *national innovation service network* and to better respond to the needs of the regions. Education, science, technology and innovation policies must be able to support and also guide regional development to ensure that measures taken at the national and regional levels reinforce each other. The challenge is to raise the knowledge and know-how and their utilisation to a level which withstands international competition in all regions while further strengthening their natural strengths.

On the other hand, the national innovation service network does not lessen the need for *specialised networking based on the region's own needs.* In order to supplement its own knowledge and cooperation, a region must be able, through networking, to acquire knowledge and know-how which is not directly available in its own area. The challenge is especially to put in place sufficiently large, internationally interesting and competitive knowledge clusters and systematically develop and use them. The smaller the region and the more specialised the knowledge, the more likely its need to find complementary knowledge, cooperation partners and larger user groups outside the region.

The role of *universities and polytechnics*, as well as the local units of research institutes, will continue to gain importance with the growing significance of knowledge and know-how. Higher education institutions are responsible for developing regional knowledge potential and increasingly also for making knowledge and know-how available to users through collaborative effort. Owing to a longer tradition, universities have more extensive and more effective contacts with business enterprises than polytechnics. For instance companies allocated nearly ten times as much research and development funding to universities in 2000 than to polytechnics. On the other hand, lack of business activity in a region may have the consequence that a university remains less embedded in the region than a polytechnic.

The issue in terms of national higher education policy is to merge this and regional development policy together in a rational and expedient way. The aim is to achieve internationally high quality, and structural development is required to meet this goal. The danger in a decentralised higher education system is that it is dispersed into increasingly small and numerous units. *Higher education units must be sufficiently large and versatile to achieve their aims.* It is to this end that a Ministry of Education committee on the regional development of higher education proposed further structural development of the national higher education network. Universities must carry on defining their profiles, and

smaller polytechnic units must be compiled into larger multi-field entities. The 29 polytechnics in Finland provide degree education in over 80 locations. As the first development measure, the Ministry of Education has called upon universities and polytechnics to draw up joint regional strategies by the end of 2002. The Ministry has also decided to enhance the regional impact of polytechnics by designating more centres of excellence in regional development.

In discussion of regional development in Finland, the basic unit most often used is the traditional province. But if the subject is the development of high-level knowledge and know-how this causes problems: dividing a small population of five million into 20 still smaller sets does not necessarily offer a good basis for national or region-based development. According to the Ministry of Education's regional development strategy 2003-2013, *the regional unit best suited for an examination of university education is larger than the traditional province, namely an area comprising several provinces. In the main, the division based on traditional provinces can be considered applicable to polytechnic education.* The division of traditional provinces further into 82 districts for regional development purposes is considered impracticable in terms of higher education. The same also applies to research.

Whatever the unit used, it is clear that regional development has been uneven ever since Finland emerged from the early-nineties recession. The major knowledge and know-how concentrations, notably the Helsinki metropolitan area, the Oulu economic area, the Tampere and Turku areas, have done well both internationally and nationally in relation to other regions in Finland. Major university towns have become development centres for the knowledge-intensive new economy. In addition to knowledge, new business, wealth and migration accumulate in their spheres of influence.

Two different conclusions have been drawn from the trend towards accumulation. Firstly, it is seen that the key to improving the position of the more slowly developing regions is to invest in the same targets as are behind the success of the stronger regions: notably to make input into ICT know-how through increased higher education provision and to attract ICT business to the region. Secondly, it has been seen that regional development primarily rests on the natural strengths of the regions, on the way in which their knowledge capital, enterprise stock and social capital work together to enhance regional development. In this sense, it is possible to achieve a level which withstands international competition in many other industries besides ICT, where the competition is hardest. This is a question of a "learning" economy in which systematic effort is made to increase the relative share of innovative companies in the overall enterprise stock. Success in this entails efficient cooperation and networking and mastery of the new technologies with a view to improving the quality and productivity of regions' natural strengths and thereby accelerating positive development.

The less knowledge and other strengths a region has, the greater the importance of networking. The network of national public organisations offering innovation services and expertise must be further strengthened to make the services more easily accessible through local units or through other regionally based units (e.g. employment and economic development centres, research institutes or higher education institutions). Alongside this, efforts must be made to intensify training catering for enterprises, activation measures, and feasibility studies geared to increase the knowledge and entrepreneurship potential. New opportunities in the region are created by systematic

collaboration between universities and polytechnics with a view to synergically complementary education provision. Especially for SMEs it is vital to have flexible access to the expertise of higher education institutions.

The matching of education and labour market is most concretely felt at the regional and local levels. Relevant foresight must be adopted urgently. Great regional disparities do not exist as regards education, which in itself offers a good basis for development. However, there is substantial disparity in the distribution of *business and jobs*, which is seen in the form of migration and differences in unemployment rates, and otherwise in welfare. The highest potential for the growth of productivity and other development exists where traditional industries can most speedily and efficiently exploit new technologies and know-how and apply them to business, products and production. An important contributing factor is a strong commitment to development on the part of the regional centres. This kind of strategic input into a versatile production structure also improves the chances of the most disadvantaged job seekers – the oldest and the youngest age groups – to find *employment*.

The *centres of expertise programme* represents the spearhead of regionally oriented development, which is based on knowledge and know-how of the highest level. It has proved to be effective, and the chosen fields of expertise show that versatile, internationally competitive development potential exists throughout the country. However, the interim assessment of the programme revealed differences in both the fields of expertise and the regional centres of expertise. Challenges identified for the future relate to the internationalisation of regional programmes; access to competent personnel; the role of the centres of expertise in the national innovation system; the utilisation of the potential created by the centre-of-excellence and polytechnic policies; and the development of venture capital for new knowledge-intensive business. To date, international cooperation has been relatively limited, and measures are especially needed to intensify knowledge-based cooperation with high-level foreign centres. A decision has been taken to extend and supplement the second centres of expertise programme (1999-2006) from the beginning of 2003. The extension will add to the challenge of keeping the programme at the forefront of regionally initiated development. It will entail constantly focusing the centres of expertise and sharpening the fields of expertise.

4 Conclusions and recommendations

Recent Finnish development has been exemplary in many respects, also in international comparison. However, the recession of the early nineties had repercussions which Finland has not been able to remedy equally well, notably unemployment, which remains high. Others include diverging regional development, which began in the second half of the nineties, and the growing threat of exclusion and poverty. In addition, our information society development is only average in international terms.

Finland's present strengths are largely endogenous. They include the education and research systems, a competent work force and strong infrastructures. Global opening, the globalisation of the economy and technology, has offered the challenge of international competition to the national systems. As a nation, Finland must be able to make the most of globalisation by reinforcing the positive aspects of the trend. This is a huge challenge in view of the growing internationalisation of business and the labour market and the enlargement of the EU, which will further accelerate change.

The most important lesson to be learned from recent developments is that *success in innovation* is a key to success overall. It makes for better business opportunities, the development of the public sector, enhanced productivity and higher employment rates. It will help to secure the economic basis for a welfare society of an ageing population in the years to come. The strongest area of Finnish innovation has been *technological development and technological innovation*. The clearly weaker area of *social innovation* must be substantially strengthened with a view to future development potential. This can be done by means of a jointly devised development strategy for social innovation.

The national line of development, which has proved successful, will be continued and further strengthened. In keeping with that, input will be made into the production of technological and social innovations and into the expansion of internationally successful business built on it. The set of measures thus determined will form the core of the future national strategy.

National innovation systems are at the heart of internationalisation. The factors behind the internationalisation of science and research are similar to those at work in globalisation and relevant networking more widely. Through internationalisation, competition and cooperation, Finland can improve the quality of research, reduce overlapping knowledge production, pool existing resources into larger entities and deploy them to important targets. The systematic effort to develop science and technology cannot be limited to the national setting and traditional international cooperation. Internationalisation should take place at the systems level and domestic activities and national science and technology institutions should be internationalised.

The challenges in internationalising the innovation system are twofold. Finland must be able to c*ompete* in terms of quality for competent researchers and research resources, projects and business enterprise research and development with other countries' systems, and Finnish players must be able to *participate and avail themselves of opportunities* opening up for cooperation.

Finland will make systematic input into international science and technology cooperation both in Europe and globally with a view to increasing knowledge, know-how and innovation. Similarly, internationalisation of education will be intensified by means of the research cooperation models.

In relation to the size of the national economy, the Finnish innovation system is effective and competitive. The education system is comprehensive, has relatively good resources and has been commended in international evaluations and comparisons. The research volume and investment in new knowledge and technology have been growing rapidly. In other respects, too, the prerequisites of innovation are, relatively speaking, in order. The *small size of the system* is a permanent drawback in international cooperation and competition. The domestic market for innovations is small. It is difficult to develop interesting, sufficiently large research entities and to create new research openings on a larger scale. One response to these challenges is to improve the availability of high-level expertise and the capacity of the system for renewal.

Strategic choices made in the public and private sectors will play a growing role in the future. The particular strengths of Finnish business and industry are the ICT cluster, the forest cluster and the metal cluster. Constant care must be taken to ensure their renewal and growth. At the same time, measures must be taken to promote the development of other important and promising new fields and to enhance knowledge to support them. These fields are found both within business and industry and in the area of social and cultural interaction. Structural change, which proceeds at a rapid rate, needs to be supported by stronger social innovation. Decision-making mechanisms must also be developed because there will not be ready-made models to follow to the same extent as before; Finland must also be able to o*pen development tracks itself.*

The foremost strengths in knowledge – *national competencies* – will be developed further. Moreover, it is especially important to invest in promising research fields and to achieve a sufficient volume and quality level in them. Such fields are the life sciences, the environment, information technology and software, the well-being cluster and knowledge-intensive services.

Full-scale utilisation of the growth and development of research will pose significant development challenges. In commercial utilisation this mainly involves removing obstacles. Of special topicality are questions relating to *entrepreneurship, innovation funding and intellectual property.* As for traditional industries, it is important to be able to use new knowledge and know-how to step up productivity, the internationalisation and other development of industries. In the field of societal and social development, the capacity of the public sector to perform its increasingly demanding expert and development tasks must be substantially improved.

Input will be made into removing obstacles to efficient commercial utilisation of research. The renewal of the traditional industrial fields will be accelerated through the promotion of the use of technological and social innovation in enterprises. Ministries will assume more responsibility as strategic development organisations and as users of social innovation which supports development.

One of the preconditions for successful innovation is the development and maintenance of *creative innovation environments*. This is a central task for the public sector in a knowledge society. Overall, the transformation in the economy and society will extend the tasks of the traditional players in the innovation system and the promotion of innovation will also concern other players besides those with primary responsibility for it. Players in the education and research systems and in the public administration are faced with larger development responsibilities. This also concerns overall information society development, which must be systematically accelerated. Answers are also being sought to these challenges in the process of public management reform.

> **With a view to strengthening innovation and favourable conditions for it, measures will be taken to enlarge the resources of the Academy of Finland and Tekes to enable them to take care of their growing responsibility for the development of new growth fields, research-based innovation and innovation environments. Ministries' research and development and expert resources will also be strengthened and partly redeployed.**

Better and closer linkage between research and business is a concrete indication of the expanding mission of universities, research institutes and polytechnics. One aspect of all research organisations' basic mission is to promote the utilisation of research findings. From the perspective of business enterprises, research cooperation rests on the in-depth knowledge of universities and other research organisations. Besides new knowledge, competent researchers are an equally important resource for business and industry.

> **Research organisations will be developed as active and dynamic partners with a view to strengthening linkages between research and business. At the same time, care will be taken to ensure a balanced development of their resources. Cooperation rules and procedures will be clarified and developed to provide more incentive.**

Universities meet the full force of expectations for social, cultural and economic development. The growing expectations involve open legislative issues concerning ways and means of reconciling administrative cultures, research ethics and business activities in universities. The ongoing transformation of the university mission and funding structure is systemic; it challenges the whole institution to its very core.

A new challenge for universities and the whole research system is to be able to combine in-depth specialised knowledge with versatile expertise for the benefit of users and in contract research and in joint projects with them. A question partly relating to this is the future of higher education on the whole: how its different parts will take shape jointly and separately.

Universities must have the possibility and capability for organising their economy and administration in a way which will enable their actual operations to develop flexibly. Ultimately the question is how the university itself promotes the education of good teachers and competent researchers, their career prospects in the university and their recruitment outside the university. Success can be seen in the *capacity of the university to create dynamic operational environments*.

University legislation will be amended to provide incentive for universities to actively develop education, researcher training and research and to promote the utilisation of research. The stress will be on the universities' own responsibility and capacity for renewal. University core funding will be strengthened with a view to the implementation of the national strategy and as part of the development of a humane information society.

The basic innovation structures are faced with international competition in the same way as innovative action overall. The structure of the Finnish innovation system has evolved with the establishment of polytechnics and employment and economic development centres in the 1990s. Otherwise the response to the new tasks and challenges has been to expand and redefine organisations' spheres of operation. For instance, the decision to assign the substantially increased co*mpetitive research and development funds* to be administered and allocated by the Academy of Finland and Tekes has proved a success.

The flexibility of the innovation system – its capacity to cope with, specialise in and adjust to changes in the international setting – will gain more importance as a factor for competition. The Academy and Tekes are key organisations in this respect, too. Both are currently being evaluated; the evaluation of the Academy will end in early 2004 and that of Tekes, which is included in the assessment of innovation environments of enterprises, will be ready in spring 2003. The structure of ministerial research and development financing has been developed especially in collaborative cluster programmes; these have proved an efficient and effective way to combine needs-based and researcher-based viewpoints. The programme model is also well suited for strengthening social innovation.

The flexibility of the innovation system will be improved through an increase in the competitive science and technology funding through the Academy of Finland and Tekes. Their operations will be developed and redirected, if necessary, based on the ongoing evaluations. Ministries will increase collaborative cluster programmes and their financing. The Science and Technology Policy Council will follow the structural development of the public research system and assess it by the end of 2004.

Apart from structural flexibility, one of the prerequisites for a well-functioning innovation system is to anticipate different societal and technological developments in support of strategic choices and to analyse the impact of relevant decisions.

In order to understand technological development and its impact on the economy and society and to link it to the targeting and development of innovation policy, decision-makers and authorities need the support of substantial expert knowledge. Anticipating future developments and taking them into account in the targeting of future action is a natural part of the strategic work done by all the players in the innovation system. The challenge is to carry out comprehensive foresight relevant to their own operations, which rarely is mere foresight of technological development. Foresight has already been organised nationally and relevant needs have been studied in depth.

It is time to move on to larger and more concrete foresight projects. What is needed is a foresight exercise from the Finnish viewpoint, to be conducted by the existing foresight network and geared to supporting the implementation of the national strategy and finding new development paths.

Finland's strengths are its internationally high level of education and well-functioning education system, along with by Finns' great willingness to educate and train themselves. Education and training are indeed a precondition for a knowledge society. At the population level, the challenge is to raise the level of education and prevent exclusion to the extent that the whole age group will study for secondary qualifications or certificates. We must make a determined effort to look into the social and other reasons why each year as many as 10,000 young Finns run the risk of being left without basic information society skills. The consequences will be increased difficulties in finding jobs, as well as persistent high unemployment especially among young people.

The *research career* is still attractive to Finns, even though little attention has so far been paid to the career prospects of young researchers. The employment situation among PhDs is good and competition for graduate schools stiff; there are 4-5 applicants per vacancy. This is also the case in technology and science fields, which otherwise lack attraction and are not sufficiently popular, especially in secondary education, to meet the needs of labour market.

The *matching of education and labour market* is a critical factor for social and economic development in terms of both quality and quantity. In rapidly growing fields, jobs fail to emerge and opportunities are left unused. The largest future challenge is to overcome recruitment problems due to the retirement of the large age groups and the ageing of the population in general.

Input will be made into achieving the target of basic information society skills. The measures for enhancing mathematical and scientific knowledge will be continued on the basis of the international evaluation. Input will be made into postdoctoral research careers, and career prospects will be improved in keeping with the findings of the PhD review of the Academy of Finland.

Research funding has developed favourably in Finland. Together with other *innovation financing* it has decisively stepped up structural change in society and the economy. An important contributing factor has been the additional research appropriation programme implemented from 1997 to 1999, which for its part accelerated research and development investment in the private sector and added to its positive impact. The programme showed clearly how crucial public science and technology policy measures are for the capacity for renewal in society and the economy and for the rate of renewal. Positive development was further promoted by good cooperation between different sectors.

The volume of publicly funded research has not grown since 1999. The GDP share of research funding will therefore fall back to less than one per cent, to the level prior to 1996, when the additional appropriation programme began. The structural change will continue, however, not least because of globalisation and other forms of

internationalisation. It also involves negative and unequalising features, which necessitate concrete action based on social and technological innovation. The ageing of the population gives a wholly new aspect to the need for new knowledge. Better welfare entails determined investment in knowledge and know-how and in internationally successful business based on them.

Efficient utilisation of research knowledge will increasingly require more effective innovation funding, rapid and well-targeted investment with a view to gaining access to international markets. Research and development needs to be supported by business and internationalisation know-how, cooperation and distribution channels both to domestic and international markets and by adequate, well-functioning venture capital markets. *Venture capital* needs to be developed with regard both to public and private investment and to foreign investment in Finland.

At present Finland's assets are increasingly based on knowledge and know-how, good education and high-standard research. Finland cannot afford to lose these strengths but has to develop them through collaborative effort to meet new challenges. Finland must be able to step up social and technological innovation and enhance national competencies in the international environment. This requires increased research and development financing and its partial redeployment. Without additional public investment, the innovation system cannot safeguard the growth potential for business and industry in the future.

> **Research and development and innovation funding will be increased to speed up the internationalisation of the innovation system and to further develop innovation in Finland. There are three main targets for the development of funding: (1) education, the development of research careers and broad-based increases in researched knowledge; (2) the strengthening of social and technological innovation; and (3) flexible, expert development of innovation funding.**

The Council's detailed funding recommendations are at the end of this chapter. At the same time, the recommendation will constitute the Council's proposal for the negotiations on the next government programme in spring 2003. In the Council's opinion, its is necessary to increase public funding faster than the estimated growth in GDP. In the case of research funding, this will mean a rise of 300 million euros from the 2002 level by 2007. Alongside these increases, the research and development funding organisations must continue developing their decision-making and intensify expert prioritisation of important and promising fields.

The role of knowledge, know-how and innovation has been constantly growing in *regional development* as well. This is above all a question of how regions' own development factors, *the knowledge capital, the enterprise stock and the social capital,* work together to strengthen regional development. The foundation for sustainable and balanced development is achieved through the improvement of the region's own prerequisites and knowledge. Well-functioning national and international cooperation is vital in order to achieve good results.

Internationalisation concerns all regions in Finland. Centres representing major concentrations of knowledge in Finland have done well both internationally and in

relation to other regions. The ICT sector especially has given a boost to growth and development. However, the greatest potential for the growth of productivity and, with it, other development exists where traditional industries can most speedily and efficiently exploit new technologies and know-how and apply them to business, products and production.

Development can be accelerated by means of two-fold networking. On the one hand, Finland needs to continue strengthening its *national innovation service network* and develop it to better meet the needs of the regions. On the other hand, *specialised networking based on the region's own needs* is required. The smaller the region and the more specialised the knowledge, the greater the need to find complementary knowledge, cooperation partners and larger user groups outside the region.

The role of *universities and polytechnics* in regional development will grow, as will the importance of their good cooperation in regions. This is a question of merging national higher education policy and regional development policy together in a rational and expedient way. The aim is to develop activities of internationally high quality, which also entails structural development measures. Higher education units must be sufficiently large and versatile in order to achieve their aims.

The *matching of education and labour market* at the regional and local levels is a concrete indication of the success of development measures, showing how the knowledge capital, enterprise stock and social capital of the region support each other in practice. The sharpest focus should be on the regions with the poorest matching and especially on measures to boost labour demand based on the region's own strengths. The key is to increase the number of innovative enterprises. Centres which are stronger than the surrounding region have a special task in enhancing their own regional impact in order to boost development.

Measures geared to enhancing regional development will be maintained and improved with a view to ensuring sustainable and balanced development throughout the country. Higher education institutions and local units of research institutes have a special task in adding to the knowledge and social capital of the region and making it available to users. National and international networking will be enhanced by public and private partners in collaboration in order to utilise knowledge and know-how available elsewhere and especially to improve innovation services needed by small and medium-sized enterprises.

RECOMMENDATIONS CONCERNING RESEARCH AND DEVELOPMENT AND INNOVATION FINANCING

The Science and Technology Policy Council sees that the level of public research and development and innovation financing should be raised from 2003 to 2007 by a total of 405 million euros according to the following table. The recommendation also constitutes the Council's proposal for the negotiations on the next government programme in spring 2003.

	Research funding, million euros 2002	increase*)	2007	Other financing increase, million euros
Universities:**)				
- Research funding	375	45	420	
- Other increase in core funding				105
Funding organisations:***)				
- Academy of Finland	185	70	255	
- Tekes	400	120	520	
Other research funding:				
- Research institutes	235	40	275	
- Ministries	205	25	230	
TOTAL:				
- Research and development financing	1400	300	1700	
- Other financing				105
INCREASES, TOTAL		300	+	105 = 405

*) In 2003 monetary value.

**) In computational terms, 30 per cent of the university core funding is spent on research. Thus, 45 million of the total increase of 150 million euros will be allocated to research and 105 million euros to other purposes. The increase of 150 million euros for 2003-2007 will contain a statutory increase of at least 30 million euros in core funding in 2003 and at least 20 million euros in 2004.

***) Comprising the Academy's and Tekes' commitment authority and operational expenditure and Tekes' review and development appropriations.

FOREMOST DEVELOPMENT NEEDS

Universities

- To develop undergraduate education in keeping with anticipated labour needs and regional needs in a way which will shorten study times
- To promote researcher careers through the development of postgraduate education and the university post structure
- Resources for the universities' "third mission", for social innovation, equipment stock, high-level business know-how
- New demands for internationalisation throughout the institution: to raise relevant competence requirements, to create linkages with foreign knowledge, to internationalise education.

Academy of Finland

- To implement the Academy's international strategy in the context of the European Research Area (ERA), to internationalise research programmes and to hire programme managers
- To promote researcher careers: graduate schools and their internationalisation, increases in post-doc researcher posts
- Selective research financing: centres of excellence in research, their international networking, openings to the development of new promising fields
- Expanded mission: to increase research-based social innovation together with ministries and other partners
- Increased operating expenditure necessitated by the internationalisation of the funding system and growing activities.

Tekes

- To promote the creation and growth of new technology-based enterprises
- To strengthen and integrate internationalisation and international technology cooperation
- Renewal of traditional industries, to enhance regional impact
- New fields, development of foresight, business know-how
- To promote social innovation in support of technological development, i.a. by means of cluster programmes, together with ministries and other partners.

Research institutes

- To strengthen internationalisation and national horizontal cooperation
- To promote knowledge-based social innovation i.a. by means of cluster programmes and, relating to this, to strengthen foresight
- Connected with the foregoing, to strengthen strategic basic research.

Ministries

- To promote social innovation and service innovations by means of joint cluster programmes and relevant strategic planning, and foresight to be conducted in international cooperation
- Connected with the foregoing, to strengthen the development of a humane information society and to make better use of the opportunities inherent in it (eGovernment)
- To consolidate the regional impact of polytechnics by improving their research and development prerequisites
- To develop innovation financing based on an international evaluation of innovation environments and the removal of fiscal obstacles to increased supply of foreign venture capital investment in Finland.

APPENDIX 1

Science and Technology Policy Council of Finland 2000-2002

The fifth term of the Science and Technology Policy Council of Finland started on 1 March 1999 and ended on 28 February 2002. The Council convened ten times during this term. There were two meetings around specific themes: on 25 October 2000 a joint meeting with the Economic Council to discuss "Regional development and regional policy in Finland" and on 8 November 2001 a meeting on industry-science relations. Both the science policy subcommittee and the technology policy subcommittee convened 20 times.

By virtue of an amendment made on 1 June 1999 to the Decree on the Science and Technology Policy Council, the Government can appoint up to four other ministers to the Council besides the four *ex officio* members, instead of the earlier two. As the former Higher Education Council was abolished, the parties represented on the Council were extended to include universities.

The independent expert team evaluating the programme on the additional appropriation for research published its final report on 12 December 2000. The Science and Technology Policy Council had planned the allocation of the additional funds with a view to enhancing the performance of the innovation system for the benefit of the economy, business and employment. An excerpt of the report of the evaluation team, which was chaired by Sitra President Aatto Prihti, is included as Appendix 2.

The Council's permanent tasks related to (1) the development of research and development and innovation funding and the effectiveness of the funding, (2) the development of sectoral research and cluster cooperation and (3) international science, technology and innovation policies. Regarding the third task, the Council published a memorandum on European research and innovation policy on 31 May 2000. Appendix 3 to this review is the Council's statement concerning the direction of innovation policy and Appendix 4 its statement concerning the strategic development of ministries' sectoral research; both were adopted at a meeting on 23 May 2001.

APPENDIX 2

Excerpt of the Sitra report
Assessment of the additional appropriation for research
November 2000

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 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.

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 spillovers.

- 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

APPENDIX 3

SCIENCE AND TECHNOLOGY POLICY COUNCIL OF FINLAND
23.5.2001

INNOVATION POLICY: *COMPETENT, LEARNING AND COMPETITIVE FINLAND*

1 Aims of innovation policy

International economic and technological developments have a strong impact on the national and regional industrial structures, business models and the competence requirements of the labour force and in society as a whole. These developments are influenced and relevant new opportunities utilised through innovation policy: through extensive and systematic cross-sectoral development of prerequisites for innovation. An efficient and effective national innovation system and regional systems are gaining more and more importance as factors for economic growth and social welfare.

Finland is excellently placed to make use of the ongoing development. The economic prospects are still good, employment has improved and unemployment gone down. Input into research and development has been growing rapidly, especially in the private sector. The Government has launched several measures for enabling publicly funded education and research systems to develop in pace with the demands for change in society. Government has recently submitted a proposal for statutory development of university core funding to Parliament. Another example of future-oriented input is a resolution adopted in spring 2000 concerning the income from the sale of state property to be accrued between 2000 and 2003 and the measures determined in it.

The public investment made in research and development in the late 1990s was well-targeted and productive in terms of the economy, employment and business activities. The Science and Technology Policy Council sees that this auspicious development line must be continued. New complementary, carefully targeted development measures will ensure that the national innovation system will stay competitive. The measures concern initial higher education and basic research, researcher training, the utilisation of researched knowledge and the development of favourable conditions for business. In addition, collaboration between the producers and users of knowledge needs to be intensified.

2 Education and research policy

Maintaining the competitiveness of the Finnish innovation environment and improving employment require that investment continues to be made both to raise the level of knowledge and know-how in all fields and to secure competent work force especially in rapidly growing, knowledge-intensive fields. It is particularly important to increase the share of women. Development measures must be implemented at all levels of education, including general and vocational education. In terms of innovation policy, the most urgent needs in higher education and research are to secure favourable conditions for universities, to constantly renew the structures and contents of education and to strengthen both basic and applied research.

University development

The Government has submitted to Parliament a proposal connected with the 2002 state budget concerning an amendment to Section 3 of the Higher Education Development Act. In addition to providing that universities' operational expenditure be raised by at least 40 million euros in 2002, by at least 30 million euros in 2003 and by at least 20 million euros in 2004, the amendment makes provision for changes in universities' salary expenditure.

The appropriation earmarked for securing university operations must be used to develop undergraduate and postgraduate education and to enhance study guidance with a view to accelerating graduation. Every university is expected to draw up a strategy for developing basic degrees, especially with a view to substantially curtailing study times.

Other educational development

The present level of supply of vocational education and training must be secured. *It must be particularly geared to meet the needs of fields relevant to the economy, employment and labour demand. Measures must also be taken to improve the quality and impact of education through the introduction of work-based training as an inherent part of initial vocational training and through the integration of skills tests designed in collaboration with labour market partners into vocational qualifications.*

The national information industry programme for 1998-2002 must be implemented and its extension for 2003-2007 prepared. The Ministry of Education is to devise an action programme for substantially increasing the number of foreign exchange and degree students in fields of rapid growth which demand advanced knowledge. All citizens must be given opportunities to acquire the information technology skills they need, with the aim that by the end of 2005 half of those currently lacking these skills will have acquired them.

Ensuring access to labour force and improving the employment rate require measures for enhancing training, upgrading competencies and updating obsolete qualifications especially by means of training supply geared to the middle-aged population.

Development of basic research and strategically targeted research

The knowledge base must be further enhanced on a wide front with a view to ensuring conditions conducive to social, economic and cultural development. To this end, care must particularly be taken to maintain and promote favourable conditions for the production of knowledge. Apart from university core funding, this requires increases in the resources of the Academy of Finland and Tekes for developing basic research, researcher training and creative research environments. The Ministry of Education will ascertain whether a special investment programme is needed to this end.

Special attention must be paid to developing research personnel, strengthening interdisciplinary research and enhancing linkages between basic and applied research.

Strategic basic research must be strengthened in universities and research institute and their cooperation increased. The ministries concerned and the research funding organisations must safeguard prerequisites for promising growth areas. It is important to nurture versatile development of industry-science relations. Measures in support of industrial growth and development are also needed in the life sciences.

Internationalisation of research and development

International cooperation and its utilisation must be intensified. The organisations responsible for domestic research and technology programmes must increase international interaction in them. In the European Union, Finland needs to promote programme cooperation on a voluntary basis, to see to the full participation of Finnish research units in centre of excellence networks and actively exploit other opportunities inherent in the European Research Area and in EU information society development (eEurope). Finland must intensify scientific, technological and financing cooperation with leading centres outside the EU.

3 Economic and industrial policies

Long-term development of the Finnish innovation system entails further enhancement of both the knowledge base and top-level knowledge and know-how. The systematic input made into research and development during the nineties can be seen in current quantitative and qualitative improvement. The results must be utilised to the full in both commercial and societal terms. Alongside measures to safeguard the setting up and growth of knowledge-intensive business, special attention must be paid to boosting the development of traditional industries.

Encouraging SMEs in traditional industries to capitalise on the new economy

The Ministry of Trade and Industry must launch a cooperation programme for developing new business models for enterprises in the traditional industries (based i.a. on electronic commerce) and new forms of management, organisation and production. A concerted effort with business and industry must be made to strengthen research into the needs and opportunities of traditional industries and relevant enterprises.

Promoting the setting up and growth of new business

Industrial policy measures must be upgraded in new knowledge-based growth areas with a view to diversifying the industrial structure. Examples of these growth areas are technology-based services, biotechnology and software products.

The resources of employment and economic development centres must be improved with a view to enhancing management and internationalisation training targeted at small business and to developing the operations and performance of business incubators. The challenge for the Finnish Industry Investment Ltd and Tekes is to support the joint creation of new kinds of virtual incubators and business accelerators using international experiences and models. Venture capital for start-up and early-stage companies must be increased by private and public investors in collaboration.

Commercial and societal utilisation of knowledge

The utilisation of research must be intensified and care taken to ensure that the benefits accrued are distributed equitably. The Ministry of Education and the Ministry of Trade and Industry must set up a committee to look into ways to clarify the regulations, practices and services relating to the protection and utilisation of intellectual property generated in universities. Universities' cost accounting and invoicing must be developed.

Tekes' resources must be increased with a view to further strengthening business know-how. In planning technology programmes and launching projects, it is important to stress the user point of view. Close cooperation with venture capital investors is vital from the outset. More attention must be paid to ensuring favourable conditions for SMEs to commercialise knowledge.

4 Labour policy and the development of working life

Finland's development as a knowledge society entails efficient measures in response to new knowledge needs at the workplace and to growing qualification requirements. Maintaining and upgrading the working-age population's competencies entail that working life and its cooperation networks are developed to improve the competitiveness of business and to boost employment. Similarly, measures are needed to promote the assessment of and research into knowledge needs and the adoption of new technology and new business models in SMEs.

Raising the overall level of knowledge and know-how and improving the matching of education and working life

In addition to education policy measures, raising the level of competence entails promoting the analysis of and research into changes in working life and the labour market and in the level of knowledge and know-how. The Ministry of Labour and the Ministry of Education must prepare a more detailed action programme to this end. Matching must be improved with fixed-term, field-specific programmes in keeping with the division of labour between the ministries. Special attention must be paid to the mobility of students and labour force and to immigrants' training needs.

Labour force and workplace development

Response to changing knowledge needs also entails that enterprises undertake development and make training an inherent part of work. Enterprises must be encouraged to espouse models of a learning organisation. The national Workplace Development Programme must be expanded to include modes of action based on the utilisation of new technologies and new networking models, as well as new forms of work which support them. The Ministry of Labour and the Ministry of Trade and Industry must launch a joint project in order to support enterprises in adopting new technologies and new business models.

5 Innovation in regions

Balanced and sustainable social and economic development in the regions entails an active and supportive innovation environment. The development of innovation in regions must be based on the region's own natural strengths and on networking with other regions and national and international players. Universities and polytechnics have a special task in this by producing new knowledge and diffusing it in collaboration with users.

Raising the capabilities of regions

The network of public organisations offering innovation services and expertise must be strengthened in regions in order to make services more accessible through their or other organisations' units (e.g. employment and economic development centres, research institutes or higher education institutions). In addition, measures must be taken to intensify training targeted at enterprises and to promote activation and feasibility studies for increasing knowledge and entrepreneurship potential. It is necessary to increase the basic resources of the centres of expertise programme in the way proposed by the Science and Technology Policy Council and to strengthen ongoing activities to better support the growth and development of the regions' own knowledge fields.

It is for the Ministry of Trade and Industry to monitor the targeting and impact of the regional and technology support and to develop them jointly with the ministries concerned. The activities of the employment and economic development centres as suppliers of development services must be strengthened by further enhancing their technology and business expertise and intensifying their cooperation with other players in the innovation environment.

Improving the regional impact of universities and polytechnics

The provision of universities and polytechnics must be targeted to enhance the knowledge level and to promote entrepreneurship in the regions. Universities and polytechnics must intensify their collaboration and networking with other players in the region. The possibilities of research and development financing must be used more effectively to promote regional

innovation. The polytechnics' special regional mission to develop and diffuse know-how and new business models must be strengthened.

6 Horizontal procedures

Cooperation among players in the innovation system must be further improved. Different sectors and players have their own roles and responsibilities, but the decisive thing is that the system works well as a whole. The major technology, social and cultural development programmes must be mutually supportive and all the sectors must see to it that major information society projects are consistent across sectoral borders. To ensure this, it is necessary to assess regularly the performance and effectiveness of collaborative innovation environments and to build up new knowledge bases for future development.

Enhancing domestic and international networking and cooperation

Cooperation between the administrative sectors, domestic and foreign research institutes, enterprises and public and private financiers must be further improved. Ministries and other responsible public organisations must operate in a way which promotes networking and other cooperation at the international, national and regional levels. Statutes and administrative regulations must contribute to the development of cooperation, as well as the overall development of society. Organisations planning and implementing extensive research and technology programmes have a special duty to ensure that their programmes also strengthen networking.

Sectoral ministries must increase their research cooperation. The Science and Technology Policy Council will prepare a recommendation for the development of research and development cooperation among sectoral ministries based on the experiences gained and models developed in the cluster programmes.

Developing science and technology studies, evaluation and foresight

The Ministry of Education and the Ministry of Trade and Industry are responsible for arranging science and technology studies, evaluation and foresight and promoting the utilisation of the results. Public financing and research organisations are responsible for constantly monitoring and evaluating developments in science and technology, undertake research and reviews to anticipate developments, and actively promote dialogue between researchers, citizens and decision-makers. The research programme "Interaction between technology, business and society", soon to be launched by the Ministry of Trade and Industry and Tekes, represents an important opening in this respect. Alongside it, measures must be taken to strengthen the basic university structures for science and technology studies, evaluation and foresight and to initiate systematic researcher training in these fields.

The science and technology administration, together with other parties concerned, will undertake an evaluation of Finnish innovation environments

in 2002. In the first phase the Ministry of Trade and Industry will carry out a strategic evaluation of foremost implementers of technology policy.

All the ministries must have evaluated their uncommitted research and development and its financing by the end of 2002 based on ongoing evaluations (the Ministries of Transport and Communications, of Labour, and of the Environment).

7 Costs, implementation and follow-up

The implementation of the policy outlined by the Council will require an increase in research and development funding. The responsible organisations must also reallocate existing resources to development targets determined in this decision. Apart from the statutory increase in university core funding, targeted increases are needed in public research and development and innovation funding in response to new challenges and to put right observed shortcomings in the performance of the innovation system.

The level of university core funding must be raised by a minimum of 90 million euros from 2002 to 2004, as proposed by the Government. The funding must be especially targeted to develop education and its prerequisites.

Public research and development funding must be raised to the level proposed by the Science and Technology Policy Council, i.e. to 1.04 per cent of GDP, by 2004. This means a rise of 230 million euros from the 2001 level.

The responsibility for preparing, implementing and monitoring the measures proposed here is shared by the Council, the Cabinet Committee on Economic Policy, the Prime Minister's Office and ministries.

To ensure appropriate allocation of the financing and other measures in the coming years, the Ministry of Education and the Ministry of Trade and Industry must jointly see to it that an independent assessment is made of the use of the funds by the beginning of 2003.

APPENDIX 4

SCIENCE AND TECHNOLOGY POLICY COUNCIL OF FINLAND
23.5.2001

STRATEGIC DEVELOPMENT OF THE MINISTRIES' SECTORAL RESEARCH

Abstract

The strategic role of the ministries is changing in a more knowledge-intensive direction. Development and influence based on networking add to the importance of in-depth and comprehensive sectoral knowledge. At the same time, the development of sectoral policies is increasingly built on reliable researched knowledge and its efficient utilisation.

Managing change entails that ministries continuously assess their own roles and integrate their research strategies closely into overall development work. In most administrative sectors, this requires updating the research strategies with emphasis on needs-orientation, foresight and impact assessment.

In addition, the national and international networking and other cooperation of sectoral research must be further strengthened. Measures must be taken to increase research cooperation in the form of programmes especially based on experience gained in cluster programmes and relevant evaluations. Structural obstacles in the way of cooperation – rigid and outdated statutes, organisational encumbrances, operational drawbacks due to inappropriate divisions of labour, etc. – must be identified and removed.

Sectoral research resources must also be increased both through the budget, where possible, and through increased pooling of resources and more efficient acquisition of competitive research funding in the open research market. All ministries must evaluate their uncommitted research funds by the end of 2002.

The concrete development recommendations issued by the Science and Technology Policy Council to the ministries in February 1999 continue to be topical and ministries should actively continue implementing them in order to intensify the performance of the national innovation system as a whole.

SCIENCE AND TECHNOLOGY POLICY COUNCIL OF FINLAND
23.5.2001

STRATEGIC DEVELOPMENT OF THE MINISTRIES' SECTORAL RESEARCH

The development of sectoral research has been part of the permanent mission assigned to the Science and Technology Policy Council of Finland by the Government since 1993. Over the time the Council has issued several recommendations to ministries concerning the development of sectoral research, most recently in February 1999. The statement in hand continues this long-term development line. It stresses the role of *networking and the user viewpoint* in future development measures. Actions will be stepped up by the ongoing evaluation of ministries' uncommitted research funds and the strategic policy lines issued by ministries for their use.

Recommendations issued in 1999 and their implementation

In its previous statement, the Council looked at developments that had taken place over the nineties and estimated future development needed on this basis. The general estimation concerning the direction of development measures was positive throughout. On the other hand, the Council saw that development in all the administrative sectors must be carried on and accelerated, if possible. The overall view was based on the themes scrutinised, which included the research institute evaluations conducted and other institutional development, development measures taken by the ministries, the development of research funding in ministries and research institutes, and development carried out at the regional and local levels. The Council's most critical opinion concerned the lack of horizontal cooperation in the operational development of research institutes within the purview of the ministries.

The aim of the opinion issued by the Council was to develop research institutes based on operational cooperation. There were two basic alternatives for this: *cooperation based on networking* and the *structural development of the institutes*. These are parallel, both can be used, if necessary, to strengthen the viewpoint of holistic development of the research system, instead of institutional, sectoral or sector research viewpoints. In concrete terms, the research institute field was examined according to a division into institutes studying nature or natural resources, institutes studying the human being as an individual or in an operational setting, and institutes studying culture and society. These groupings were seen to offer several possibilities for developing operations or cooperation. Seen against the Council's 1999 opinion, there are still several unused avenues for development.

The most evident changes in the research institute field since 1998 are the merger of the research centres of agriculture and agro-economics into *Agrifood Research Finland* as of 1 March 2001 and the change of the national veterinary and food agency into a *National Veterinary and Food Research Institute* from the same date. The food control duties were transferred to the National Food Agency established at that time.

The 1999 recommendations concerned the *functional development of research institutes*, chiefly *operational development within the purview of the ministries*, and the necessary *further reviews*. These were recommended among other things with a view to developing social science research in the sectors and their institutes; the reviews have not been undertaken yet. Another recommended target for review was cooperation between research institutes and universities in certain enumerated fields. These were social sciences and economics, agriculture and forestry, and geology. The review of geology is being launched by the Ministry of Education and the Ministry of Trade and Industry in collaboration. Questions relating to cooperation between the Forest Research Institute and universities have been examined in a committee report, but in other respects the recommendation has led to no action. Of the operational recommendations directed at ministries, the one directed at the Ministry of Social Affairs and Health concerning the evaluation of its "research EVO" funds has produced concrete results: a report concerning the use of the funds has just been published.

The means envisioned for the *development of networking* were prioritisation of research programme activities and cluster cooperation, which has been launched. Both were seen to improve networking and to produce more significant research entities in terms of funding. It was seen important to develop cooperation between research institutes, universities and business. Cluster cooperation was seen as a natural way to reinforce contacts between the funding organisations – Tekes and the Academy of Finland – and research institutes.

At the research institute level, the means available for improving horizontal cooperation were seen to include joint and part-time posts, personnel exchanges, reciprocal cooperation in researcher and other training, and the development of the network of centres of excellence.

> *The development recommended by the Council in 1999 is still topical. At a more general level, the emphasis in sectoral research is increasingly on the international operational environment, notably the emergence of the European Research Area (ERA), and the strategic significance of versatile networking across sectoral boundaries.*

New reviews and recommendations

Review 2000

The Review published by the Science and Technology Policy Council in January 2000 concentrates on the challenges of knowledge and know-how from the public sector viewpoint. It highlights support for social, economic and cultural development. *"The rationale is the need to continually improve the quality, relevance and impact of sectoral research, which is recognised as a strategic resource for ministries."*

Efforts have been made to develop sectoral research and its organisations as part of the public research system and central government simultaneously. Ministries have a key role in this development. *"The extent to which and how speedily new knowledge is applied to societal development largely depends on the ministries' ability to utilise sectoral research. This is why it is especially important that each ministry's leadership is committed to implementing a knowledge-based management culture throughout the*

organisation. This also enables the ministries to steer sectoral institutes by target outcome better and to act, where applicable, as a knowledgeable and demanding customer in the development of the administration and the public service systems."

According to the 2000 Review, the *ministries' uncommitted research funding* was the most important public-domain research as yet outside systematic evaluation. The Council saw that ministries should have the use of their uncommitted research funds evaluated by external organisations. The ministries launched such evaluations in spring 2000 in collaboration. The report of the evaluation commissioned by the Ministry of Transport and Communications from the Finnish Institute of Public Management is ready and the report of the evaluation commissioned by the Ministry of the Environment forthcoming. These are examined below. The uncommitted research funds of the Ministry of Labour and the Ministry of Defence are also being evaluated. The Science and Technology Policy Council has proposed that

> *"other ministries should have their uncommitted research and development and the relevant financing evaluated by the end of 2002 based on the experiences gained."*

It is recommended that cluster activities (see the Appendix) be further developed and the networking model thereby created applied to other research programmes. The Council notes that *new programmes can also be launched in areas other than the traditional industrial clusters.* Examples of possible themes put forward have been the environment and health; environmental technologies; safety and risk management; and the benefits of Finland's northern location. The Council sees that the mechanisms of cluster cooperation are so advanced that the selection and launching of new programmes could follow the normal procedure, that is, competitive financing, which is already applied to the projects within the programmes. *"In practice this requires closer cooperation between the sectoral ministries and the two financing organisations, Tekes and the Academy of Finland, from the planning stage onwards."*

Transfer to the normal financing procedure in ministries also means that cluster programmes are not separate from the ministries' other research. The programmes and their financing constitute an important instrument for developing networking as part of a larger entity. As regards the funding organisations, the Council wanted to effect a more active approach to the development of the national innovation system.

Assessment of the additional research appropriation

By a separate decision, the government raised the level of research and development financing by 250 million euros from 1997 to 1999. The aim was to enhance the national innovation system *for the benefit of the economy, business and employment.* The expert team invited to evaluate the impact of the programme published its report in 2000. The report examines cooperation networks and cluster programmes separately. The team based its evaluation partly on studies it had commissioned, one of which was an economic evaluation of the cluster programmes launched with the additional funds.

The evaluation team, which was chaired by Sitra's President Aatto Prihti, notes in its report that

"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. 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."

The team sees further that the new kind of cooperation evolving from these programmes can be expected to yield research and development results which benefit the nation as a whole in the fields of welfare and the renewal of traditional industry, among others.

On the whole, the team regards cluster activities as an experiment in innovation based on the idea that development can be efficiently stepped up through intensified linkages between different players in the economy. The clusters have enabled substantial resources to be mobilised with relatively small investments. *The greatest new opportunities are seen to exist in areas where totally new linkages are created.* These include areas geared to creating better public services which have innovative industrial products and processes for effecting improvements. According to the report, the well-being cluster, in which products and services are fused together, represents the leading edge of innovation in that respect. Results are achieved when social and health service providers are brought together with industry and private services. Those responsible for creating the overall prerequisites for service provision in the ministries are also involved.

Assessment of uncommitted research funds

The assessment of the uncommitted research funds began in spring 2000 in collaboration between several ministries. One aim is to produce comparable material, identify good practices and, through it, improve the prerequisites for horizontal cooperation. The assessments help to ascertain the *roles and purposes of the ministries' uncommitted research and development and the development factors influencing them, the appropriateness of management and relevant cooperation procedures, objective-setting, and the utilisation and impact of results.*

Based on the experience so far gained from the assessment, it is possible to put forward certain general viewpoints, which also provide the background to the development recommendations presented below:

The credibility and acceptability of the administration and policies increasingly entail research-based evidence and confidence-inspiring expertise. This can be realised only with closely integrated strategic work, management and research strategies.

Ministries should increase the role and weighting of research and development in the preparation of their own sectoral policies, in their strategic work and sectoral steering, and in evaluations relating to them.

Inter-ministerial cooperation is necessary and useful especially in research and development cooperation. The division into administrative sectors is less and less suited to analysing societal problems and processes. Joint

research creates the knowledge base and know-how needed to address cross-sectoral issues. Research programmes play an important part in this.

Financing of sectoral research

The additional appropriation allocated for research between 1997 and 1999 effected a substantial increase in the research resources available to Tekes, the Academy of Finland and universities. The increase in the direct financing of government research institutes is insignificant in comparison. The change in the ministries' other research funding has been negative. This is due to two factors: firstly, the government real estate office became a state-owned enterprise in 1999, which reduced the Ministry of Finance research funding recorded in statistics. Secondly, sectoral ministries' actual research funding has not grown, despite the cluster financing included in the additional research appropriation. There has even been a sizeable nominal decrease in the research resources of those ministries that receive cluster funding, with the exception of the Ministry of Labour. A budget analysis made by the Academy of Finland found the following development in resources between 1997 and 2001 according to the actual budgets (million euros):

	1997	2001	Change, %
Universities	265	350	+ 32
Academy of Finland	95	185	+ 94
Tekes	276	400	+ 45
Government research institutes	196	221	+ 13
Other research funding	211	194	- 8
Total	1 043	1 350	+ 29

According to the Statistics Finland, the decline in the research funding allocated to government research institutes, which began in the early 1990s, continued in 1999, as shown in the next table (million euros):

Government research institutes	1993	1997	1999	Change, % 1993-1999
Core funding	215	203	201	- 6
External financing	111	152	194	+ 75
Total	326	355	395	+ 21

At the same time, the proportion of external financing in the institutes' research volume rose from 34 per cent to 49 per cent. According to the Academy's analysis, the institutes' financing structure has remained similar since 1999: external financing (commissioned and co-financed research) is estimated to have represented on average 48 ½ per cent in 2001. Only two institutes, the Technical Research Centre of Finland VTT and the Finnish Environment Institute, have above-average external funding. In three small institutes (Finnish Geodetic Institute, Finnish Institute of Marine Research, Research Institute for the Languages of Finland), it falls short of 10 per cent. Of the larger institutes, the Finnish Forest Research Institute has the smallest share of external financing, 11 ½ per cent. The user and cooperation perspective should in fact be given more weight in management by outcome and development strategy in more research institutes than now is the case.

In summation, both ministries' and research institutes' core funding has remained at approximately the same nominal level for several years.

> *The increase in research volume was due to success in the open research market, and this trend should be continued: the growing challenges facing research can only be addressed with growing research and financing cooperation.*

Strategic development of sectoral research

The need to develop ministries' sectoral research strategically relates to two simultaneous factors for change in public sector operations. Firstly, the *ministries' strategic role is undergoing change*. Networking with interest groups and other stakeholders will play a growing role in the ministries' basic missions. Comprehensive, in-depth sectoral knowledge is needed in the transition from traditional administrative models to strategic network-based development and influence. Secondly, in terms of content, the *development of sectoral policies is increasingly based on research knowledge produced both in Finland and abroad and its efficient utilisation.* Ministries must be able to acquire and use new knowledge to a growing extent in the execution of their duties. All in all, ministries are faced with a larger development responsibility, to which sectoral research offers one solution.

Successful implementation of a knowledge-based strategy entails well managed sectoral research. The entity of a ministry's research activities involves several factors. These include

- A *sectoral research strategy* in support of the overall development strategy in the sector;
- The *financing, steering and commissioning of sectoral research* through management by outcome in the research institutes and their core funding and through the uncommitted research funds;
- In some cases still through the *ministry's own research*;
- *Acquisition and utilisation of research knowledge* from different sources;
- *Varied and improved collaboration* both with other ministries and financiers and with research organisations, business and industry and the rest of society.

International cooperation is more and more clearly a feature permeating research within the ministries' purview. Long-term, *programme-form research* has been gradually strengthening.

The Science and Technology Policy Council has examined these factors on different occasions and given its recommendations concerning them. Expanding on its former opinions, the Council notes the following:

> *The ministries' strategy work must be further developed and the development of the sectoral research strategy must be integrated more closely into it. This entails that the ministry's top management is committed to knowledge-based development.*
>
> *A research strategy departs from needs according to the principle of extended responsibility for development, which was discussed above. Apart from general demands made on research – quality, relevance, efficiency and effectiveness – central to a strategy are foresight of alternative courses of action, influence on future development and evaluation of activities.*
>
> *Successful implementation of a research strategy entails that ministries and research institutes have appropriate material and expert resources. As noted above, it is possible to respond to growing research challenges only through increased research and financial cooperation. Continuing attention must be paid to the capacity of research institutes to operate in open research markets in various contexts, such as in management by outcome.*
>
> *The development of networking entails that the partners have their own clear competence areas and mutually complementing interests, which encourage collaboration. Joint research programmes in the form of cluster programmes also provide an efficient and effective way to combine needs-based and researcher-based interests and resources.*

In some cases the prerequisites for cooperation can be improved through decisions on the location of research institutes. The Science and Technology Policy Council has already referred to plans for a closer relationship between the Research Institute for the Languages of Finland and the University of Helsinki. There are plans and preparations for moving several research institutes to more viable cooperation environments.

> *The cooperation and synergy to be gained from the physical location of research institutes must be used to the full. Topical examples are the location of the Finnish Meteorological Institute and the Finnish Institute of Marine Research in the Kumpula Campus and preparations for moving the Finnish Environment Institute to the Viikki Campus.*

APPENDIX

What is a cluster?

Originally clusters were understood as competitive, interconnected industrial development blocks within the national economy. Closely linked to them are potentially successful industries, which may evolve into competitive clusters. However, the term 'cluster' has gradually expanded to mean functional accumulations which may vary greatly in their nature. Apart from purely *industrial clusters*, there are *technology and knowledge clusters*. In regional policy, reference is made to *regional development clusters*: the accumulation of different regional development factors into an entity which has positive effects.

In all cases, a cluster is characterised by *simultaneous vertical and horizontal networking*. Success in it opens up new development prospects to all partners. The Science and Technology Policy Council has recommended that a cluster-type collaboration model also be applied to other programmes besides the original industrial cluster programmes. It is also positive that many administrative sectors intend to carry on the cluster activities in the form of new programmes. One concrete factor contributing to this is that so-called *cluster-ministries have been able to keep the additional research appropriations allocated to them between 1997 and 1999 in the their budget frameworks even after 1999*. The cluster model merges collaboration and competition in a balanced way – competitive research funding is pooled to carry out joint research programmes.

The first cluster programmes undertaken in the fields proposed by the Council were (responsible ministry in brackets)

- *Food cluster* (Ministry of Agriculture and Forestry)
- *Wood Wisdom cluster* (Ministry of Agriculture and Forestry)
- *Telecommunications cluster* (Ministry of Transport and Communications)
- *Transport cluster* (Ministry of Transport and Communications)
- *Well-being cluster* (Ministry of Social Affairs and Health)
- *Environmental cluster* (Ministry of the Environment).

This financing also provided for a programme for strengthening the *national Workplace Development Programme* (Ministry of Labour) and an appropriation to the Ministry of Trade and Industry for the *development of cluster cooperation*. Overall, the programme for the additional appropriation for research provided for the allocation of funds through appropriate ministries to targets proposed by the Science and Technology Policy Council. Instead of this top-down procedure, the Council proposed in its 2000 Review return to the normal procedure, as described in this memorandum.

APPENDIX 5

COMPOSITION OF THE SCIENCE AND TECHNOLOGY POLICY COUNCIL OF FINLAND

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