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FINLAND'S RESEARCH CLUSTERS: IMPORTANT ASSETS FOR A NEW MEMBER OF THE EUROPEAN UNION

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ABSTRACT:

In 1995 Finland spent 2.35% of her GDP on R&D, well above the European Union average of 1.95%. The nationally accepted goal is to increase research funds to 2.9% of the GDP by 1999. Private companies finance more than 60 per cent of Finnish research. During the last 10 years, Finland's R&D high-tech exports have increased more rapidly than in most comparable countries.

In Finland nine industrial clusters have been identified: Forestry, Metals, Energy, Environment, Telecommunications, Health and Social Services, Transport, Construction and Foodstuffs. To a large extent these clusters are based on science, technology and innovation.

Highly qualified human resources are necessary for the continuation of Finland's expansion of her clusters. Finland has decided to establish national graduate schools that contribute to the already successful co-operation between universities, industry and research institutes. Quality is also enforced by supporting centres of excellence and by evaluations carried out by impartial, widely recognised experts, normally from abroad.

Finnish regional policy is increasingly based on raising knowledge and research capacity. The new universities established during the 1960's and early 1970's have had a remarkable impact on economic activities and cultural developments in their regions, and in terms of regional policy the new universities have been more successful than many other regional policy measures in Finland. Finland has established 11 regional centres of expertise with the aim of further increasing synergy between universities, research institutes and business.

KEY WORDS: Clusters, European Union, research, and public policy.

Executive Summary

Since the early eighties the expenditure on research and development in Finland has tripled. In 1995 Finland spent 2.35% of her GDP on R&D, well above the European Union average of 1.95%. The nationally accepted goal is to increase research funds to 2.9% of the GDP by 1999. Private companies finance more than 60 per cent of Finnish research.

Many of Finland's research strengths relate to her natural resources, location and climate. Finland's social and economic structure and traditions are other sources of new developments. In Finland nine industrial clusters have been identified: Forestry, Metals, Energy, Environment, Telecommunications, Health and Social Services, Transport, Construction and Foodstuffs. To a large extent these clusters are based on science, technology and innovation. The goal is to optimise the industrial, economic and social benefits of the clusters.

During the last ten years the stock of university graduates has increased by 40% and the number of PhDs has more than doubled. The share of female PhDs has also risen. Highly qualified human resources are necessary for the continuation of Finland's expansion of her clusters. Qualified researchers are also the most important condition for a policy of expanding high-quality research. Finland has decided to establish national graduate schools with 950 full-time positions for PhD students. Many of the graduate schools have been established jointly by several universities. They also contribute to the already successful co-operation between universities, industry and research institutes.

Quality is an important goal for Finland's science and technology policy. It is widely acknowledged that after entering the European Union, Finnish research is competitive only if the standards of her scientists and the quality of the research proposals are high enough. Quality is enforced, for example by supporting centres of excellence and by ex-ante and ex-post evaluations.

Many of Finland's institutions of higher education were founded in different regions during the 1960's and early 1970's. The new universities have had a remarkable impact on economic activities and cultural developments in their regions, and in terms of regional policy the new universities have been more successful than many other regional policy measures in Finland. Finnish regional policy is increasingly based on raising knowledge and research ca-

pacity. Finland has established 11 regional centres of expertise with the aim of further increasing synergy between universities, research institutes and business.

During the last 10 years, not only have Finland's R&D expenditure tripled, so have its high-tech exports. High-tech exports have increased more rapidly than in most comparable countries and Finland is one of the few EU countries where high-tech exports exceed imports.

Finland has embarked on a policy of development based on rapid utilisation of research results, long-term commitments to a high level of education, science and technology, co-operation between the public and private sectors, and internationalisation. The future of Finland's economy, employment, intellectual and material well-being relies heavily on a strong, yet flexible system of innovation.

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Elisabeth Helander

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1. Introduction

Research and development form an important share of the activities of the European Union. As a new Member State from the beginning of 1995 Finland's strategy aims at relating her research system to that of the European Union.

So far Finnish researchers have been doing quite well in the competition for European Union research funds. However, a successful Finnish science and technology strategy should not only be measured by the success rate of Finnish researchers when applying for EU funds. For a small country like Finland the benefits gained from the contacts with high-level research via the EU programmes are even more important. Research co-operation offers the possibility to raise the level of national research environments and to get inspiration resulting in interesting and useful research results and new developments.

It is, therefore, important for Finland to create synergy between Finland's science and technology policy and that of the European Union. Finland's ambition is to be an attractive and competitive partner in the international knowledge market and information exchange. In order for this ambition to be fulfilled, Finland must have high-quality research groups and internationally recognised centres of expertise. Only good research environments attract foreign researchers.

In Finland there is wide acceptance and consensus among all political parties, as well as within the private sector, that the economic future and social well-being of Finland as a new Member State of the European Union can only rest on a strong basis of education, high-quality research and know-how. Finland is a research-oriented country that integrates into the scientific and technological collaboration of Europe.

2. Solid infrastructure for research

Since the early eighties the expenditure for research and development in Finland has nearly tripled. In 1995 Finland spent 2.35% of her GDP on R&D, well above the European Union average of 1.95%. The nationally accepted goal is to increase research funds to 2.9% of the GDP by 1999. Both public and private funds for research have increased. Private companies finance more than 60 per cent of Finnish research.

Finland has 10 universities, 3 universities of technology, 3 business schools and 4 schools of art, including industrial arts and music, altogether 20 institutions of higher education. That gives a considerable national coverage, considering that Finland is a small country of 5 million people.

The universities of Helsinki and Turku are the oldest, but high quality research and good facilities can also be found in many of the new universities and specialised schools established in the 1960's and 1970's.

There are a number of research institutes in areas traditionally considered nationally important, such as forestry, agriculture, geology and public health. Finland hosts Scandinavia's biggest technical research centre (VTT); most of its laboratories are located in the vicinity of universities or faculties of engineering. Finland's Institute of Occupational Health is considered one of the world's best.

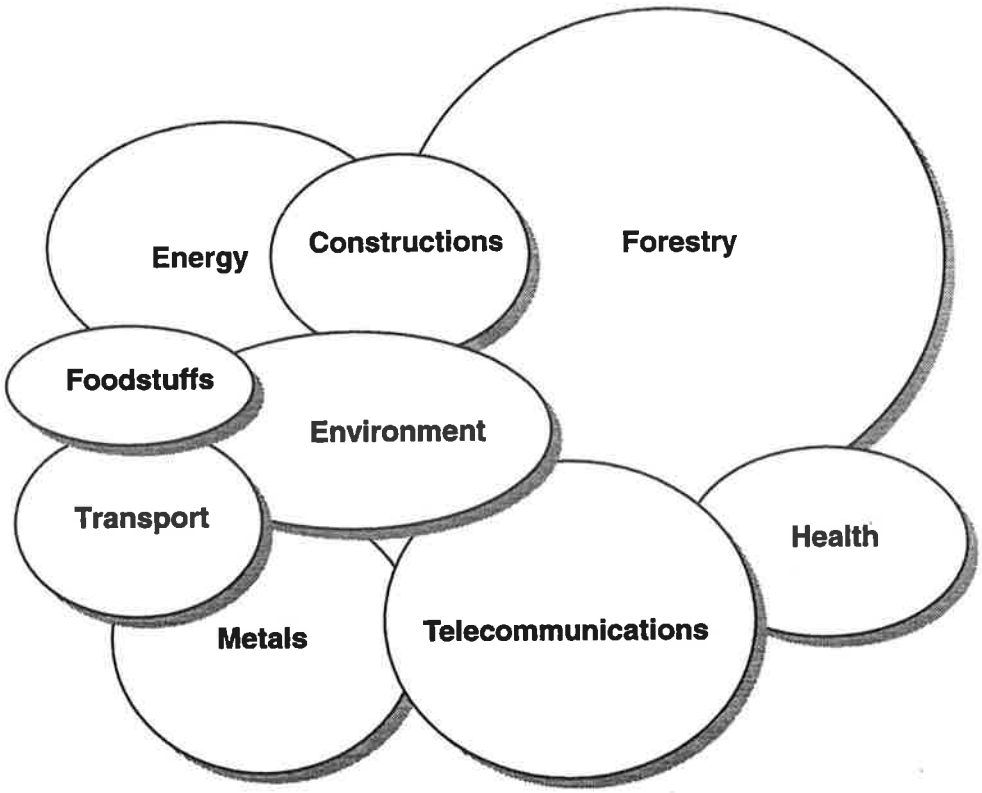
3. Examples of areas of strength

Knowledge is the only production factor that can grow without boundaries. Knowledge explains important differences in economic growth and productivity between different countries. Countries with a good education system and abundant human capital have tended to achieve more rapid growth than other countries.

Traditionally Finnish industry has specialised in production that has been intensive in capital, energy and raw materials. During the last 10-15 years there has been a move towards knowledge-intensive production enforced by the disappearance of national and international boundaries for competition and a rise in Finland's technological, scientific and educational level.

Many of Finland's research strengths relate to her climate, location and natural resources. Finland's social and economic structure and traditions form another basis for research competence.

It seems useful to characterise Finland's dynamic research areas using the industrial cluster model of Michael E. Porter. According to Porter clusters are groups of enterprises producing services and goods. The enterprises interact by flows of know-how and technology, vivid competition and demanding customers. Networking with research establishments enforces innovations and new developments.



All the Finnish clusters have strong research components. A brief description of the nine clusters identified in Finland can thus serve as an illustration of the country's research strengths. The clusters described have been developed on the basis of a recent book on the competitive advantages of Finnish industry by Hernesniemi, Lammi and Ylä-Anttila (*Advantage Finland*, Taloustieto 1996).

A traditional cluster in Finland is based on *Forestry and Forest Industry*. Forest covers 70% of Finland and they are the natural base for the production of pulp, paper and wood products. Technological and environmental challenges to the forest industry have brought about developments in machinery, process management, paper quality, logistics and consulting.

Many of Finland's research strengths relate to aspects of this strong cluster:

- Forestry: forest ecology and management, plant molecular biology
- Chemistry: fillers, materials, impregnants
- Biotechnology: new products, environmentally-sound processes
- Information technology: microelectronics, measuring and optimisation equipment, mechatronics

The *Metals* cluster's expansion was due to the rapid industrialisation after the Second World War and Finland's desire to repay her war debts quickly. Today the whole cluster from

mining to refinery and the production of specialised products is strongly internationalised. The share of research-based products is increasing. Finland has some special technological advantages relating, for example to metallurgic technology, copper cooling equipment (developed in conjunction with researchers in low temperature physics), and sea, arctic and off-shore technology.

The *Energy* cluster relates to the needs for energy in Finland's forest and metal industries. Life in a cold climate also requires efficient production of energy. Energy production has never been monopolised in Finland. Accordingly, domestic competition has continuously been vivid and challenging.

Finland's competitive advantage lies in the efficient and environmentally friendly production and use of energy. Finnish strengths are, e.g., in the technologies for generating energy from solid fuels (fluidised bed), in electronic equipment for saving and optimising the use of energy in industrial processes, and in the combined production of power and community heat. Combining power and heat production is extremely energy efficient and, consequently, saves the environment.

The *Environment* cluster is strong in areas where Finland has had special problems and thus applied strict legislation early. Demanding clients have enforced innovative solutions especially in the forest industry and in preventing water pollution. Finland has more than 180.000 lakes, but they are shallow and thus vulnerable to pollution. The same is true for the Baltic Sea. When developing measures and new methods to prevent water pollution, it is important to also involve the other states surrounding the Baltic Sea.

In Finland environmental protection focuses to an increasing extent on changing production technologies rather than on cleaning methods for waste produced. The aim is to prevent pollution already at the source. Environmentally friendly production methods have been developed not only in forestry but also in other industries such as power generation, mining and metal industries.

As forestry is crucial for Finland, it is not surprising that an important part of a major national research programme on climate change has been devoted to exploring possible effects of climate change on forest ecology and management.

4. Clusters based on social structure

Social traditions and needs can be important catalysts of innovative solutions, science-based processes and products. Several of Finland's clusters stem from social and economic structures rather than from abundant natural resources.

One of Finland's most rapidly expanding clusters comprises *Telecommunications*. A Finnish company, Nokia, is the second largest in the world in the area of mobile phones and the company is also strong in transmission systems and the planning and construction of telephone networks. Multimedia can open up new possibilities and promising new products combining information and telecommunications technologies.

Several social and economic reasons have contributed to the rapid growth of the telecommunications sector during the last few years:

(1) Finland has a tradition of many telephone companies. The telemarket was opened for competition between operators in the 1980's.

(2) Finland has a well-developed national infrastructure in information technology and telecommunications.

(3) The low population density, long distances and harsh climate of Finland have been challenges for the operation of teleservices and products resulting in advanced technical solutions.

(4) The Nordic countries agreed early on common standards for mobile phone transmission, thus expanding the market available.

(5) Research related to telecommunications has been supported for more than 10 years and human resources have systematically been developed in the field. Today, several research groups in Finland work at the cutting edge in microelectronics and computer science. Strong Finnish research areas comprise digital signal transmission, software development, computer linguistics and computational mathematics.

A new cluster is that of *Health and Social Services*. Health care in Finland is publicly financed, comprehensive and organised in a cost-effective way. Finland has been selected as one of the model countries for WHO's *Health for All by the Year 2000* programme. A growing population of the elderly and their increasing needs for health and social services, however, put new and challenging demands on the services and products provided.

Finland has a highly trained work force in the field, and extensive epidemiological data and statistics. This is the background for a research tradition ranging from studies of life styles and food consumption behaviour to studies of biochemical processes in cells. Research is strong in many areas of public health as well as in biomedical research. Genetic research enlarges and supports the cluster development further.

Some examples of research contributing to the Health and Social Services cluster:

(1) Traditionally, a major Finnish problem has been a high incidence of heart and coronary diseases. Today the death rate from heart diseases is about 50% less than 20 years ago. Finnish research has a considerable share in this dramatic improvement.

(2) Due to an extraordinarily homogenous population, Finland has a high incidence of certain hereditary diseases that are now subject to extensive research. Some of the genes involved have already been identified and therapies are being developed.

(3) There are considerable advances in the development of pharmaceuticals. Finland is, e.g., in the international forefront for connective tissue research, the development of drugs for fibrotic disorders affecting the liver and lungs, genetic kidney disease and some areas of cancer research.

A new perspective is opened by advances in telecommunications and materials research supporting the Health and Social Services cluster. Health care and medical equipment can benefit from, for example multimedia giving access to adequate medical specialist knowledge and thus facilitating and speeding up long distance diagnostics. Electronic alarm devices support the independence and security of the elderly. Successful research in biomaterials has opened the possibilities for a wide range of surgical products.

The *Transport* cluster is yet another area of potential expansion. Logistics has traditionally been strong in Finland due to her remote location in relation to the main markets and the necessity to develop efficient means of transportation. Transit traffic and the emerging Russian markets are expected to give new impetus for growth. Finland is actually the only European Union country with a Russian border.

Moreover, Finland's geographical closeness to the Arctic with its huge prospects for the use of natural resources and new sea routes give promises for an enlarged application of arctic and off-shore technologies already well developed in Finland.

In Finland there is presently a growing interest in studying Russia and Eastern Europe. This is a field where Finland in view of her historical and geographical position has a strong tradition. Promoting the understanding and knowledge of the political, economic and cultural changes in Russia and Eastern Europe is important for all Europe. It might be added that Finland has a Slavonic Library where the collections for certain periods of history are more extensive than can be found in any library in Russia, as many of the Russian collections were destroyed during historically turbulent periods.

The *Construction* cluster has been one of Finland's most important ones as a result of rebuilding after the war and the rapid industrialisation and urbanisation in the 1950's and 1960's. Due to lack of competition in the domestic market, technology developments have been scarce. At present, the whole field of construction is facing a major restructuring. The future of the Construction cluster depends on the possibilities to accumulate existing competence and to develop new ones. Present Finnish strengths are, e.g., architectural design, the management of building projects and products, methods for building in cold climate and the efficient use of energy in houses.

The *Foodstuffs* industry has to a large extent been based on a domestic market with very little competition from abroad. The key elements of a possible cluster are products that have already successfully been exported, such as chocolate and sweets, enzymes, fish, crispbread and children's food. A recent success product is Benecol, a new kind of margarine which has the effect of diminishing the content of cholesterol in the human body. The market of the Finnish foodstuffs industry now has expanded from 5 million to 350 million consumers in the EU area. There are promising research-based new products in the non-food area, e.g., paper chemicals based on potatoes, barley and wheat.

In summary, Finnish clusters can be categorised as strong, medium sized and potential clusters with considerable growth potential. The Forestry cluster is by far Finland's strongest cluster. Its future development is strongly dependent on research and new technologies.

Potential clusters are growing and show promising prospects. Growth is presently rapid in the Telecommunications, Environment, and Health and Social Services clusters. Knowledge is a key element in all of them.

5. Structural measures to support quality

The strive for quality is a dominant feature in Finland's science and technology policy. It is generally realised that Finnish research can only be competitive if the standards of her scientists and the quality of research are high enough.

Quality is pushed in different ways. Increasingly research funds are allocated on the basis of peer review of competing research proposals. Research fields, research institutes and whole universities are evaluated ex-post by impartial, widely recognised experts, normally from abroad. As a rule the ensuing evaluation reports are made public and discussed in open seminars.

In Finland the creation of centres of excellence is an important policy measure. The Academy of Finland has been requested by the Ministry of Education to select centres to be designated as national centres of excellence in research. The main criteria in this selection have been: the research units' scientific merits and future prospects, their significance for researcher training and the larger research community, and their involvement in high-level international scientific co-operation. So far, 17 centres of excellence have been designated.

Another concern of national science and technology policies is to ensure the application of research results. Co-operation between industry, universities and research institutes is continuously improving in Finland. The balance between producing research results that can be put into practice immediately with those of scientific excellency as measured by articles in international scientific journals of top quality is, however, delicate, especially for research institutes.

Finnish regional policy is increasingly based on raising knowledge and research capacity in different parts of the country. Finland has established 11 regional centres of expertise creating synergy between universities, research institutes and business.

Qualified researchers are, however, the most important condition for a policy of expanding high-quality research and developing successful Finnish clusters. Finland has decided to establish national graduate schools with 950 full-time positions for PhD students. Many of the graduate schools have been established jointly by several universities. They also contribute to the already successful co-operation between universities, industry and research institutes. The aim is not only to expand the training of PhD graduates, but also to improve and enlarge the scope of their training and to speed up PhD studies.

6. Impact of Finland's science and technology policies

Finland's R&D expenditures have almost tripled during the last ten years. Finland now ranks third among the EU countries when relating research expenditures to the GNP. During the same period the share of Finland's high-tech exports has tripled. High-tech exports have increased more rapidly than in most comparable countries. Finland is one of the few EU countries where high-tech exports exceed imports.

An important effect of the policies to enlarge higher education and research has been the rise in the number of university graduates as well as qualified researchers. Since 1985 the stock of university graduates has increased by 40%. Finland counts third among the EU countries when comparing the numbers of university graduates in the youngest segments of the work force (25-34 years). Half of all university graduates are women.

The number of PhDs has more than doubled since 1985. The share of female PhDs has also risen (it is now 37%) showing that Finland understands the value of nurturing scientific talent. Highly qualified human resources are necessary for the continuation of Finland's expansion of clusters based on science, technology and innovation. The goal is to optimise the industrial, economic and social benefits of these research-based clusters.

Many of Finland's institutions of higher education were founded in different regions during the 1960's and early 1970's. At the time the establishment of these institutions caused intense debate, especially among researchers in the older universities. It is probably still too early to make a conclusive evaluation of the effects of all these institutions. However, there is no doubt that the new universities have had a remarkable impact on economic activities and cultural developments in their regions. In fact, it seems that in terms of regional policy the new universities have been more successful than many other regional policy measures in Finland.

Finland has embarked on a policy of development based on rapid utilisation of research results, long-term commitments to a high level of education, science and technology, co-operation between the public and private sectors, and internationalisation. The future of Finland's economy, employment, intellectual and material well-being relies heavily on a strong, yet flexible system of innovation.

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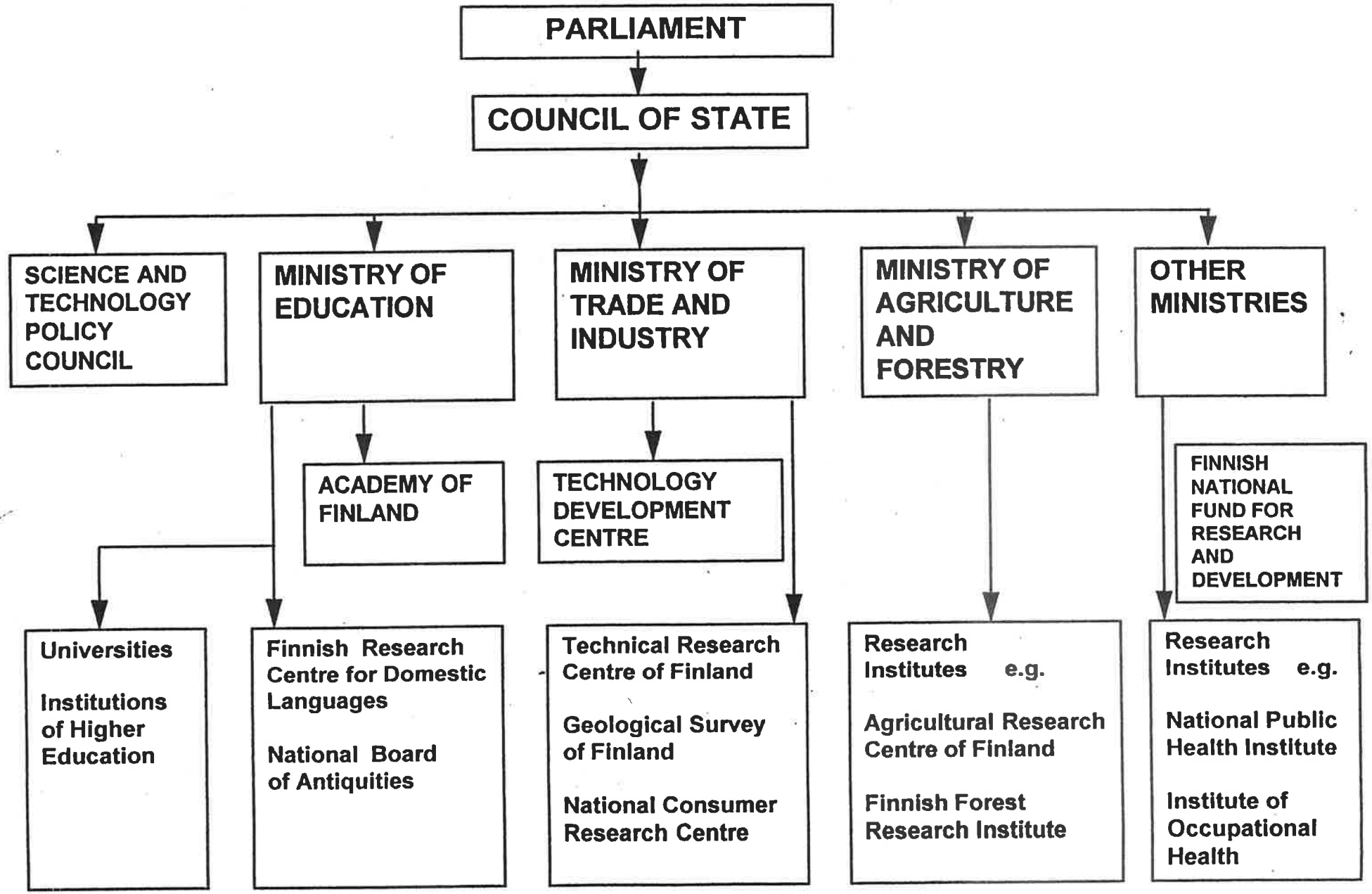

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