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Convergence of national science and technology policies: the case of Finland

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Abstract

It is a commonly held view that differences in national histories, cultures, political contexts, and the timing of a country's entry into the industrialization process are reflected as diversity among countries in their goals, priorities, boundaries, directions, ranges, instruments and also in the performance of science and technology policy. This article, which examines development processes of Finnish science and technology policy, concludes that instead of divergence there is such startling convergence of organizational forms and practices. Finland has largely adopted its policy doctrines and instruments from the countries, which from the Finnish perspective, have been considered legitimate and successful.

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1. Introduction

1.1. Institutional and organizational diversity versus convergence

Much of research on science and technology policy has been directed towards the search for variation rather than congruence in the structure and behavior of national policies, or more largely national innovation systems. Several authors have pointed out that public policies tend to follow certain nationally and historically rooted trajectories which frame the choices of individuals and organizations (Nelson and Winter, 1982; Lundvall, 1992; Nelson, 1993; Ergas, 1986; Freeman, 1987). Differences in national histories, cultures,

political contexts, the timing of a country's entry into the industrialization process, and the mix of industries are reflected as diversity among countries in their policy doctrines, goals, boundaries, priorities, organizations, instruments, ranges, and also in the performance of science and technology policy.

However, although there certainly are durable and important differences in national characteristics that shape national systems and policies and constrain their evolution, these systems have shown striking adaptability (Nelson and Rosenberg, 1993). Countries learn from each other and copy each other. National governments attempt to form and implement national science and technology policies, but in a world where business as well as science and technology are increasingly transnational, policies tend to become more and more alike. These developments have both stimulated and been reinforced by the rise of transnational public

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programs of R&D support, such as Eureka, and the increasing activity of organizations such as the EU. All this raises the question, to what extent does it make sense any more to talk about “national science and technology policies?”

Using the development of Finnish science and technology policy as an example, the paper examines the convergence of the content, as well as institutional and organizational forms and practices of science and technology policy. The analysis of science and technology policies in the bigger OECD countries (Salomon, 1977, 1985, 1987), the Swedish studies (Elzinga, 1980; Fridjónsdóttir, 1983; Premfors, 1986; Weinberger, 1996), and the rich if unsystematic data collected and analyzed by OECD (1985, 1988, 1991, 1994a, 1996, 1999) give strong support to the hypotheses that the convergence of science and technology policy has been the overwhelming trend in all OECD countries. From diverse positions they have moved toward a more common form on basic dimensions of the policy field.

The basic process of convergence, or isomorphism as DiMaggio and Powell (1983) call it, is fairly straightforward. Large parts of literature assume either explicitly or implicitly that much of convergence takes place through imitation (copying, modeling), which is “a major principle of human action” (March, 1999, p. 46). Organizations imitate the experience of other organizations, and countries the experience of other countries, through the transfer and diffusion of coded and encoded experience in the form of policy formulations, organizational arrangements, procedures, and similar measures. Thus, convergence is an integral part of an organizational learning process oriented, on one hand, to the exploration of new possibilities and, on the other hand, to the exploitation of old certainties (March, 1999).

The factors behind imitation and through the convergence in science and technology policy are twofold: competitive and institutional (Meyer and Scott, 1992). The fundamental thrust of a national science and technology policy is to seek competitive advantages to the country in question. Major organizations of science and technology policy compete with one another, and a significant feature of that competition is competitive imitation. Organizations seek to emulate the performance successes of others by emulating their organizational forms and practices.

This practice is even institutionalized through the concepts of “best practice” and “benchmarking” and in the activities of media and consultants (March, 1999).

However, organizations of science and technology policy compete not just for better performance vis-a-vis their foreign counterparts, but inside their countries they fight for resources, political power and institutional legitimacy, for social as well as economic fitness (DiMaggio and Powell, 1983). Pressure on organizations to demonstrate that they are acting on collectively valued purposes in collectively valued ways leads them to copy ideas and practices from each other. In particular, organizations are rewarded for their similarity to the organizations of their field which are perceived to be forerunners or most successful.

1.2. Emergence of science and technology policy in the OECD countries

Science and technology policy is determined by the idea of a deliberate integration of scientific and technological activities into the fabric of political, economic, military and social decisions. According to the traditional and widely used OECD definition (1963, 1971), science and technology policy means the collective measures taken by a government in order, on the one hand, to encourage the development of scientific and technical research (policy for science and technology) and, on the other hand, to exploit the results for general political objectives (policy through science and technology). It was the last mentioned aspect, the establishment of science and technology as a national asset, and accordingly, the direct intervention of governments in the direction and range of R&D activities, which marked a new and irreversible turning point in the relations between science and technology, and the state (Salomon, 1977).

Science and technology policy can be understood as an organizational field (Giddens, 1979), which means those organizations that, in the aggregate, constitute a recognized area of institutional life with the aim to serve the explicit and implicit interests and conceptions defined by policy-makers and other interest groups of the field. In science and technology policy, these organizations are typically R&D performers, sectoral ministries, financing agencies, advisory bodies, professional associations, international and supranational organizations, etc. The process of

institutionalization of science and technology policy then consists of an increase in the interaction among organizations in the field, the emergence of sharply defined inter-organizational structures, an increase in the information load with which organizations in the field must contend, and the development of a mutual awareness among participants that they are involved in a common enterprise.

In the leading or the biggest OECD countries, it was first the Second World War, and after that the national security considerations and the evolution of the Cold War which lead to the emergence of science and technology policy (Salomon, 1977; Freeman and Soete, 1997). The cry of alarm raised by the first Sputnik launched by Soviet Union in 1957 was especially significant to the formation of the field. First, the US and soon other industrialized countries gave science and technology policy institutional recognition through new governing bodies, support mechanisms and procedures, and growth in public R&D budgets, as well as in bureaucratic staff concerned with these issues.

2. The process of convergence in Finnish science and technology policy

2.1. *The formation of basic structures in the 1960s and 1970s*

The institutionalization of science and technology policy began in Finland in the early 1960s, which was later than in larger and more developed OECD countries. In Finland, the main background factor for the rapid emergence of science and technology policy in the 1960s was economic. In the whole industrialized world, the early 1960s were an era of intensified internationalization and liberalization of trade. This placed new strains on Finland's production structure, which was one-sided (high dependence on the forest industry), and its level of technology, which was low compared with Finland's main competitors. Research and development was considered an important instrument of industrial renewal. Catching up with industrially and technologically more advanced countries, like Finland's neighbor Sweden, became the factor which significantly shaped Finnish activities and structures in science and technology for decades.

The 10 years from the mid-1960s on were an era of the modernization of Finnish society. The decade opened up a lot of opportunities for collective and private initiatives, and created new procedures for cooperation and competition. Actors and interest groups concerned with science and technology were particularly well prepared to make use of new opportunities. Thus, in a short period science and technology policy became a significant and widely accepted part of the Finnish "modernization project" (Paavolainen, 1975; Immonen, 1995).

Five important changes occurred in these years in the institutions and organizations of Finland's science and technology policy. Firstly, the policy doctrines (conceptual fundamentals of science and technology policy) were created. This included the definition of science and technology policy and R&D, the major arguments for the role of government in R&D and for the growth of R&D investments, and arguments and instruments for the promotion of industrial R&D. These policy doctrines were adopted from Sweden and OECD (Luukkonen-Gronow, 1975).

When the first actual Finnish science and technology policy programs were written in the early 1970s (Central Board of Research Councils, 1972; Science Policy Council, 1973) they were to a large extent translations of OECD documents. Particularly influential was the Brooks Report (OECD, 1971). Its main recommendations on the role of science and technology in social and economic development, and accordingly for closer relationship between policies for science and technology and all socio-economic concerns and governmental responsibilities found a fertile soil in Finnish science and technology policy-making. This led to the implementation of new planning mechanisms and to the introduction of the first Finnish plan for increasing the financing of R&D.

Secondly, a ministerial committee on science, the Science Policy Council (later the Science and Technology Policy Council), was established in 1963 as a new high-level political body for the formulation of science and technology policy guidelines, and for inter-ministerial coordination of science and technology activities. The model of the council was imitated mainly from Sweden (Forskningsberedning), which had earlier imitated it from the United States.

Thirdly, a significant reorganization took place in the Finnish science and technology administration

when new mechanisms for planning, coordination, and financing of university research were created. The most visible event was a reform of the research councils in 1969–1971 (the Academy of Finland) so that they might constitute a compact body better able to plan and direct R&D funds than the old system of a couple of separate research councils. The reform included the establishment of new research posts, and what was particularly important, new grants for project research. The new system was very much built on the basis of the Swedish model (Forskningsrådet).

Fourthly, a very important part of the construction of Finnish science and technology policy were the measures with the aim of improving the conditions of industrial R&D. A new fund under the authority of the Bank of Finland, the Finnish National Fund for Research and Development (Sitra), was established in 1967 to support industrial R&D. In addition, the Ministry of Trade and Industry began in 1968 to support the research and product development of firms, and it also received an additional appropriation for goal-oriented technical research. A model for Sitra came again from Sweden (Riksbankens jubileumsfond), and the inspiration for industrial R&D grants and loans originated from Sweden and OECD.

Fifthly, the development of higher education in general played a significant role in the early years of science and technology policy. That paved the way for institutional and organizational changes outside the higher education system. There were three associated reasons for the central position of universities in the Finnish modernization process. One was a growing awareness of the importance of higher education and basic research for economic and industrial development, and accordingly, greater demand for employees with a university education. The second one was a regional dimension, i.e. political pressure to establish new universities outside the capital city of Helsinki. The third reason was the fact that the large post-war generation began to reach maturity, and enlargement of the institutions of higher education was a social and political necessity.

2.2. *Strengthening of technology orientation in the 1980s*

The era of enthusiasm in science and technology policy was broken in the midst by the 1973 oil crisis in

practically all OECD countries (OECD, 1975, 1981a; Salomon, 1977, 1985). Long rapid economic growth was succeeded by flagging growth, and above all by the simultaneous combination of inflation and unemployment. The research and innovation systems, and related policies, were not immune to these changes and pressures. Government support for R&D was constrained by budget cuts, and many of the efforts to plan and re-direct research activities toward the solution of economic and social problems were cancelled. This was very much true also in Finland in the late 1970s.

However, already the late 1970s saw the beginning of new priorities in science and technology policy. Pressed and encouraged by the Japanese economic and technological success, governments in OECD became increasingly involved in the stimulation and support of industrial innovation. On one hand, most of the OECD countries generally started to fund and orchestrate large national, cooperative programs for new technologies, primarily information technology, materials technology and biotechnology. On the other hand, they began to imitate Japanese organizations and institutions in integrating science, technology and industry. It was in the 1980s that the Japanese Ministry of International Trade and Industry (MITI) started to serve as the point of reference for the OECD countries (Salomon, 1987; Freeman, 1987).

This was very much the development path, which also Finland adapted, in the early 1980s. Active exploitation of the opportunities opened up by new technologies for the benefit of economic growth and employment became the new core of the Finnish science and technology policy. A new organization, the National Technology Agency (Tekes) was established in 1983 as the key planner and executor of the new technology-oriented policy. Tekes was designed after the Swedish Board for Technical Development (Styrelsen för teknisk utveckling). In line with the operations of Japan (and Sweden), in particular, national technology programs were developed to serve as new instrument by which Tekes could control R&D activities. As in several other OECD countries, the first programs were focused on information technology. The programs turned out to be an effective instrument to intensify cooperation between universities, research institutes and firms.

In addition, and again in line with several other countries, a great number of schemes and organi-

zations for technology transfer, diffusion and commercialization were created in Finland. Nation-wide networks of technology parks and centers of expertise were set up. The technology parks initiated spin-off projects and incubators. Technology transfer companies were established to commercialize the results generated in universities and research institutes. Public and private venture capital operations also increased. Some of these arrangements were created at the national level, but many came into being on the basis of local and regional initiatives, albeit with national funding.

2.3. *Building of a knowledge-based society*

In many respects, by the beginning of 1990s, Finland had managed to achieve the targets, which had been set in the 1970s and early 1980s to the development of science and technology policy. It had a well working system of universities and government research institutes. It had new and renewed mechanisms for planning and funding public and private R&D. Finland's R&D expenditure in relation to GDP reached a good international level of 2%. It was oriented and equipped toward stimulation and promotion of industrial innovation. All in all, in its policy doctrines, goals, priorities, organizations, instruments, and ranges, the Finnish science and technology had become not only comparable but also even identical with the mainstream of OECD countries.

The main thrust of Finnish science and technology policy in the early 1990s came from a strong need to secure the further development of science and technology under the circumstances of economic recession associated with high unemployment. After the favorable economic development of the 1980s, the Finnish economy was suddenly plunged into an exceptionally severe crisis in the early 1990s (Pajarinen et al., 1998). After the active efforts which were made in the 1980s for industrial innovation, the recession led to a legitimate crisis or at least to a threat of it in science and technology policy. Because of unusually high unemployment, 20% as it heights, there was in Finland a new and urgent need to seek wide-ranging and coherent policy reforms to enhance growth, productivity and jobs.

The major building blocks of the Finnish science and technology policy doctrine of the 1990s were

the national innovation system, and thereafter the knowledge-based society. The concept of a national innovation system was made an important instrument of Finland's science and technology policy by the [Science and Technology Policy Council \(1990\)](#). Most of the influences came from the OECD's Technology and Economy Programme which had been launched in 1988 (OECD, 1992), but also from the works by [Freeman \(1987\)](#), [Lundvall \(1992\)](#), and [Nelson \(1993\)](#). The Finnish interpretation of the concept has stressed that a national innovation system is a whole set of public and private factors influencing the development and utilization of new knowledge and know-how. The concept has given policy planners and decision-makers' arguments on the central role of R&D and education in industrial and economic development. In addition, it has supported efforts to intensify national and international R&D cooperation.

In the mid-1990s, when recovery from the recession was already underway, the [Science and Technology Policy Council \(1996\)](#) launched the concept of knowledge-based society as the key concept of the Finnish science and technology policy strategy of the late 1990s. This concept and thinking behind it came from the OECD Jobs Study, an extensive program that had been launched in the early 1990s (OECD, 1994b, 1996, 1998). The OECD recommendations adopted in Finland were based, on the one hand, on the observation that knowledge-intensive growth is of undeniable significance for the national economy and, on the other, on the experience that macroeconomic or labor market measures do not alone ensure adequate preconditions for knowledge-intensive growth. Above all, the promotion of knowledge-intensive growth requires various innovation policy measures relating to R&D, education, competitive conditions, laws and regulations for the protection of intellectual property, national and international cooperation networks, and technology transfer and exploitation. The new concept complemented in an appropriate way the concept of the national innovation system.

The years of deep economic recession in Finland in the early 1990s resulted in a science and technology policy which put strong emphasis on the mobilization of the whole national innovation system to increase knowledge and expertise through education and R&D, with information technology and communications industries as a priority area. The major building blocks

of this policy were foreign borrowings, but at least in one respect, Finland stood in the 1990s out from most other OECD countries. A significant single act was the government's recommendation in 1996 to increase investments in R&D so that the GDP share of R&D expenditure would rise to 2.9% by the year 1999. As a result of this decision, state funding for research rose annually in the years 1997–1999 by about 25. This level has been achieved and even exceeded, which means that the Finnish GDP share of R&D expenditure is one the highest among OECD countries. However, it is worth mentioning that it is not only the government's investments in R&D but more Nokia's investments which account for a major part the growth in Finnish R&D expenditure in the latter half of the 1990s (Ali-Yrkkö et al., 2000).

Since 1995, when Finland became a full member of the EU, the formal and informal mechanisms of the EU have become more and more important also in scientific and technological fields. In science and technology policy, the EU has so far concentrated very much on the development R&D cooperation through the framework programs for R&D (Luukkonen, 2000; Luukkonen and Hälikkää, 2000). In Finland, the direct influence of the EU on the national science and technology policies has been fairly modest with one exception. The regionalization of innovation policy has been one of the major new trends in Finnish science and technology policy in recent years. To a large extent, this development has been due to political pressure from the EU, assisted by financial aid from the EU's structural funds.

3. Mechanisms of convergence

3.1. Formal and informal interaction of experts

As an organizational field, science and technology policy seeks to serve the explicit and implicit interests and conceptions defined by policy-makers and other interest groups of the field. In that pursuit, organizations and individuals process information, formulate plans and aspirations, interpret environments, generate strategies and decisions, monitor experiences and learn from them. These processes may be based on rational adjustments and considerations. However, this paper has taken the stance that the development

of science and technology policy is largely dependent on social and institutional processes like imitation and fashion. Countries learn from each other and copy from each other either directly or through international organizations, and the result is increasing convergence of policies.

There are several mechanisms through which institutional convergence of a national science and technology policy may occur (cf. DiMaggio and Powell, 1983). Models are diffused explicitly or unintentionally through interaction of people involved in science and technology policy. The growth and elaboration of professional networks that span organizations of the field in different countries has led to the formation of elites who through interaction and cooperation define appropriate models of organizational structure and policy. Convergence also results from formal and informal pressure of such supranational organizations as OECD and EU. This pressure is not necessarily direct and explicit, but rather subtler and less explicit, and stems from political influence and the problem of legitimacy.

All the time the main carrier and user of foreign models has in Finland been a fairly small group of civil servants of a few central organizations. Another important channel for the transfer of foreign models has been the work done by national fixed-term committees and working groups. In Finland, the role of this steering mechanism has been particularly important in the days of transformations associated with uncertainties and potential political tensions. The reforms of the early 1980s or the whole reorientation of Finnish science and technology policy more towards technology and innovation were prepared by a committee appointed by the prime minister (Technology Committee, 1980). The committee made a great number of surveys on trends and mechanisms of science and technology policy in OECD countries, and many of its recommendations were based on the models of forerunners.

3.2. OECD as a standardizer and source of inspiration

From its founding in 1961, the OECD has actively worked for the growth of R&D resources, and designed policies to promote scientific and technological development for the good of economic and social

progress. Of official OECD institutions for the implementation these functions one of the most significant has been the Ministerial Meeting on Science and Technology, which has been held approximately every other year since 1963. The first meeting was attended by only four ministers (Salomon, 1987). Three years later, a great majority and gradually practically every country was represented by a minister responsible for science and technology.

Finland attended for the first time in 1968. The expansion of the ministerial meeting reflects very well both the institutionalization of science and technology policy in the OECD countries, and the growing role of the OECD as a catalyst for R&D efforts. The analysis, conclusions and recommendations of the meetings have always had a significant influence on the science and technology policies of the member countries. The recommendations have not been binding legally, but they have created social pressures on national decision-makers. On the other hand, the recommendations have been used as an aid to legitimate national initiatives and aspirations.

Another OECD mechanism which has served convergence has been confrontations or evaluations of national policies in the fields of science, technology and innovation. This mechanism has been widely and successfully used in economic policy, but also in science and technology policy it has been a recognized method to bring high-level expertise from abroad. In Finland, two confrontations have been organized. One was in 1981 on Finnish social sciences policy (OECD, 1981b) and the other in 1987 on Finnish science and technology policy (OECD, 1987). The latter in particular was very positive for the Finnish authorities responsible for the reforms in Finnish science and technology policy in early 1980s. “Our general impressions of science and technology policy in Finland are indeed very favorable” (p. 114). In a small country, you can hardly find a better legitimization for policy efforts than the statement by OECD examiners.

3.3. *Sweden as the main model of organizational arrangements*

From the early years of Finnish science and technology policy, i.e. from the mid-1960s onwards, Finland has largely adopted its policy doctrines and institutional and organizational models from

the countries which from the Finnish perspective have been considered legitimate or successful. For Finland, Sweden was a significant source of inspiration and imitation until the late 1980s. Most of the key organizations of Finnish science and technology policy originate from Sweden, which had 5–10 years earlier imitated them from the US and the UK. In the 1980s, Japan was the institutional model of science and technology policy for practically all of the OECD countries. This demonstrates that big countries are probably as exposed to the process of institutional isomorphism or convergence as small countries.

The popularity of Sweden as a model can be explained by historical reasons. As neighboring countries, Sweden and Finland have had close relationships for centuries. After the Second World War when the Nordic countries began to intensify their economic, political, social, cultural, and scientific cooperation, Sweden as the biggest and wealthiest country was an obvious leader of the Nordic cooperation. In Finland, the post-war years were a period of intensive construction and reconstruction. For this work, Finland did not have to seek models upon which to build from further than Sweden. Not only in science and technology policy, but also in several other sectors of public administration Sweden was the natural source of inspiration and imitation.

3.4. *Professionalization of policy-making*

The central actors of Finnish science and technology policy, the Academy of Finland and the National Technology Agency, nowadays employ altogether more than 350 scientific, technological, and policy design experts. In the 1990s also, the sectoral ministries hired more experts for R&D planning and coordination. This professionalization of science and technology policy-making implies that the mechanism for institutional and organizational development in Finnish science and technology policy is changing. It rests more on organizational learning conditioned by cooperation and competition with other domestic and international (supranational) organizations.

The growing popularity of benchmarking (OECD, 1999; Porter and Stern, 1999) in recent years in Finland as well as in many other countries is a representative example of convergence which proceeds

through professionalization. Another example is R&D evaluation based on the use of international experts of the field. In Finland, the evaluation of publicly funded R&D activities grew significantly in the late 1980s and the 1990s (Oksanen, 2000). In most instances, the evaluation is undertaken by a group of foreign experts. One of the leading principles in such evaluations is that the quality and performance of Finnish science and technology is compared with the international level. Accordingly, the conclusions and recommendations of evaluators are usually in favor of convergence of mechanisms and practices rather than building on national specificities.

3.5. Rule-based action

Along with a more or less direct imitation and exchange of information and experiences between professionals, a rule-based action has been an important form of convergence in Finland. As organization research (March, 1999; March et al., 2000) has pointed out, a conception of decision-making resulting from consequential, preference-driven choice cannot be accepted as axiomatic. Much decision-making behavior reflects the routine way of following rules in both defined and ill-defined situations.

Throughout nearly four decades, rules made on the basis of R&D statistics have been a central element of the Finnish decision-making logic. From the late 1960s until quite recently, the most significant single aim of Finnish science and technology policy has been the growth of R&D expenditure in relation to GDP. The first official OECD-based R&D statistics which were published in the early 1970s showed that Finland was lagging behind most other OECD countries. The Science Policy Council (1973) set the goal of attaining the average international level by the year 1980. This did not come about, but the rule-based action gained strength. When the average level was achieved by the end of 1990s, Finland began to aspire to the leading edge of the OECD countries. Now this aim has been achieved as well.

Other significant Finnish rules based on international R&D statistics have been the relative importance of the public sector (universities and government research institutes) versus the business enterprise sector, the share of the universities in total R&D expenditure, and the share of government financing in

the total R&D expenditure of the business enterprise sector. The main criterion in all these items has been the average international level, but there has been some variation. Additional criteria have been the level or the proportions in the leading countries (in Sweden in particular) or in countries with which Finland is competing. However, only occasionally have the competitors been mentioned explicitly. Unlike total R&D expenditure, the attitude towards these aims has been more flexible. They have been changed if warranted by an inevitable development in the R&D system.

4. Summary and conclusions

The case of Finland demonstrates that development of science and technology policy is not dependent only on rational adjustment and considerations, but very much on social and institutional processes like imitation and fashion. Organizations which are involved in policy-making capture the procedures and routines of other organizations through the transfer of encoded and tacit experience. Consequently, organizational actors making rational decisions construct around themselves an environment that constrains their ability to seek for diversity based on national specificities.

The process of convergence clearly indicates that countries and their organizations have been inclined to seek competitive advantages rather through conformist than deviant behavior. However, for the development of national science and technology policies this raises a question, do conformist organizations do what they do any more efficiently than do their more deviant peers. Convergent processes may be expected to proceed in the absence of evidence that it increases internal organizational efficiency. Attempts at replicating the practices of other organizations often result in unintended changes which rather decrease than increase efficacy and performance.

Finland's development strategy in science and technology policy has been based on catching up with the high international level or with the models of countries and international organizations which, from the Finnish perspective, have been considered legitimate and successful. To a large extent, that target has now been achieved, which means that there are less than

earlier models to be selected and initiated from. Instead of exploitation, the new Finnish science and technology policy should be built more on exploration. This sets new requirements for the knowledge base and instruments of policy-making.

References

- Ali-Yrkkö, J., Pajja, L., Reilly, C., Ylä-Anttila, P., 2000. Nokia—A Big Company in a Small Country. ETLA, Helsinki.
- Central Board of Research Councils, 1972. Programme of Science Policy. Government Printing Centre, Helsinki.
- DiMaggio, P., Powell, W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *American Sociological Review* 48, 147–160.
- Elzinga, A., 1980. Science policy in Sweden: sectorization and adjustment to crisis. *Research Policy* 9, 116–146.
- Ergas, H., 1986. Does technology policy matter? In: Guile, B., Brooks, H. (Eds.), *Technology and Global Industry: Companies and Nations in the World Economy*. National Academy Press, Washington, DC, pp. 191–245.
- Freeman, C., 1987. *Technology Policy and Economic Performance: Lessons from Japan*. Pinter, London.
- Freeman, C., Soete, L., 1997. *The Economics of Industrial Innovation*. Pinter, London.
- Fridjónsdóttir, K., 1983. *Vetenskap och politik (Science and politics)*. Malmö: Förlaget Akademilitteratur Ab (in Swedish).
- Giddens, A., 1979. *Central Problems in Social Theory: Action, Structure, and Contradiction in Social Analysis*. University of California Press, Berkeley.
- Immonen, K., 1995. Suomen Akatemia suomalaisessa tiedepolitiikassa 1970-luvulla (The Academy of Finland in Finnish science policy in the 1970s). *Otava, Keuruu* (in Finnish).
- Lundvall, B.-Å. (Ed.), 1992. *National Systems of Innovation: Towards a Theory of Interactive Learning*. Pinter, London.
- Luukkonen-Gronow, T., 1975. Suomen tiedepolitiikan kansainväliset esikuvat (International models of Finnish science policy). In: Bruun, K., Eskola, K., Viikari, M. (Eds.), *Tiedepolitiikka ja tutkijan vastuu*. Tammi, Helsinki (in Finnish).
- Luukkonen, T., 2000. Additionality of EU framework programmes. *Research Policy* 29 (6), 711–724.
- Luukkonen, T., Hälikkää, S., 2000. Knowledge creation and knowledge diffusion networks. In: *Impacts in Finland of the EU's forth Framework Programme for Research and Development*. Tekes, Helsinki.
- March, J., 1999. *The Pursuit of Organizational Intelligence*. Blackwell, Malden, MA.
- March, J., Schulz, M., Zhou, X., 2000. The dynamics of rules. In: *Change in Written Organizational Codes*. Stanford University Press, Stanford, CA.
- Meyer, J., Scott, R. (Eds.), 1992. *Organizational Environment: Ritual and Rationality*. Sage, Newbury Park, CA.
- Nelson, R. (Ed.), 1993. *National Innovation Systems*. Oxford University Press, New York.
- Nelson, R., Rosenberg, N., 1993. Technical innovation and national systems. In: Nelson, R. (Ed.), *National Innovation Systems*. Oxford University Press, New York.
- Nelson, R., Winter, S., 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge, MA.
- OECD, 1963. *Science and Policies of the Governments*. OECD, Paris.
- OECD, 1971. *Science, Growth and Society, A New Perspective*. OECD, Paris.
- OECD, 1975. *Changing Priorities for Government R&D*. OECD, Paris.
- OECD, 1981a. *Science and Technology Policy for the 1980s*. OECD, Paris.
- OECD, 1981b. *Social Sciences Policy: Finland*. OECD, Paris.
- OECD, 1985. *Science and Technology Policy Outlook*. OECD, Paris.
- OECD, 1987. *Reviews of National Science and Technology Policy: Finland*. OECD, Paris.
- OECD, 1988. *Science and Technology Policy Outlook*. OECD, Paris.
- OECD, 1991. *Science and Technology Policy. Review and Outlook*. OECD, Paris.
- OECD, 1992. *Technology and the Economy: The Key Relationships*. OECD, Paris.
- OECD, 1994a. *Science and Technology Policy. Review and Outlook*. OECD, Paris.
- OECD, 1994b. *The OECD Jobs Study: Facts, Analysis, Strategies*. OECD, Paris.
- OECD, 1996. *Science, Technology and Industry Outlook*. OECD, Paris.
- OECD, 1998. *Technology, Productivity and Job Creation. Best Policy Practices*. OECD, Paris.
- OECD, 1999. *Science, Technology and Industry Scoreboard. Benchmarking Knowledge-Based Economies*. OECD, Paris.
- Oksanen, J., 2000. *Research evaluation in Finland*. VTT Group for Technology Studies, Working Papers No. 51/00.
- Paavola, J., 1975. *Linkomiehen komiteasta uuteen akatemiaan. Valtion tieteellisten toimikuntien 60-luku (The 1960s of the state research councils in Finland)*. Suomen Akatemia, Helsinki (in Finnish).
- Pajarinen, M., Rouvinen, P., Ylä-Anttila, P., 1998. *Small Country Strategies in Global Competition. Benchmarking the Finnish Case*. Taloustieto Oy, Helsinki.
- Porter, M., Stern, S., 1999. *The New Challenge to America's Prosperity: Findings from the Innovation Index*. Council on Competitiveness, Washington, DC.
- Premfors, R., 1986. *Svensk forskningspolitik (Swedish research policy)*. Lund: Studentlitteratur (in Swedish).
- Salomon, J.-J., 1977. Science policy studies and the development of science policy. In: Spiegel-Rösing, I., de Solla Price, D. (Eds.), *Science, Technology and Society. A Cross-Disciplinary Perspective*. Sage, London, pp. 43–70.
- Salomon, J.-J., 1985. Science as a commodity—policy changes, issues and threats. In: Gibbons, M., Wittrock, B. (Eds.), *Science as a Commodity: Threats to the Open Community of Scholars*. Longman, Harlow, pp. 78–98.

- Salomon, J.-J., 1987. Science and government: a European perspective. In: Brooks, H. (Ed.), *Science for Public Policy*. Pergamon Press, Oxford, pp. 27–36.
- Science Policy Council, 1973. *The Outlines of Finnish Science Policy in the 1970s*. Government Printing Centre, Helsinki.
- Science and Technology Policy Council, 1990. *Review, Guidelines for Science and Technology Policy in the 1990s*. Government Printing Centre, Helsinki.
- Science and Technology Policy Council, 1996. *Finland: A Knowledge-Based Society*. Edita, Helsinki.
- Technology Committee, 1980. *The report of the Technology Committee*. Government Printing Centre, Helsinki.
- Weinberger, T., 1996. *Nätverksentreprenören (Networkentreprenör)*. Falun: Kungliga Tekniska Högskolan (in Swedish).