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FINANCING FOREST SECTOR RESEARCH:

Theory and European Experiences

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Matti Palo
Birger Solberg

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PREFACE

The current tendency of governments to reduce public expenditures has led to severe budget cuts in many IUFRO member organizations. Consequently, forest scientists have become increasingly interested also in other funding sources. There are, however, many reasons why forestry research should be more dependent on public funding than many other disciplines.

In their timely article Eeva Hellström, Matti Palo and Birger Solberg give a sound theoretical framework for forest research funding as well as provide readers with empirical findings on the role of forest sector research in Europe. In addition, case studies conducted in Finland and Norway give interesting information on challenges which the private involvement in forest science can bring.

In spite of many positive effects that privatization and the increasing diversity in funding sources may cause, public expenditure, ownership and decision making should dominate forest science also in the future. We at IUFRO hope that this article helps to understand the role of different stakeholders in forest research and will prove useful when the restructuring of research is considered.

Risto Seppälä
IUFRO Vice-President for Programme

CONTENTS

Financing Forest Sector Research: Theory and European Experiences[1]

Eeva Hellström, Matti Palo, and Birger Solberg[2]

ABSTRACT. *The need to reduce public expenditures has brought about the question of privatization of research in many countries. Research can be privatized by increasing private involvement in research funding, in the ownership of research organizations, or in decision-making on research activities. In this paper, a theoretical framework for research investment and criteria for public and private involvement in forest sector research are presented. Then, findings from a European survey of private and public forest sector research, and case studies on the impact of changing funding levels and patterns on research activities in the forest sectors of Finland and Norway are presented. Theoretically, there exist many reasons to expect public funding to dominate in forestry research. This was also empirically confirmed: excluding research conducted in individual firms, only nine per cent of European forestry research is conducted at private organisations. Both Finland and Norway have promoted increased private involvement in forest sector research, but with slightly different science policies. A major challenge has become maintaining the present intensity of research in Finland, and a sufficient level of basic and theoretical research in Norway. Both countries have faced decreased freedom of research and an increase of short-term projects. The findings of these surveys give strong support to the presented theories, and as a result, recommendations on organising forest sector research and future studies are given.*

Keywords: Forestry research, funding, privatization, Europe, Finland, Norway.

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[1] The article is based on a paper presented at the XX IUFRO World Congress in Tampere, Finland, in August 1995.

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1. INTRODUCTION

During centuries, varying political systems, ideologies and schools of economic thought have guided governments' reliance on public and private sectors. Privatization policies based on neoliberalist ideology and squeezed public budgets have to some extent been pursued in most Western countries since the recent economic recession. Especially the privatization efforts of Ronald Reagan's and Margaret Thatcher's governments gained popularity and publicity in other countries as well.

As a consequence of the advancement of the neoliberalist ideology, utilitarian demands for science have widened, and the applications of science to production services have become increasingly important [2]. Simultaneously, the need to squeeze public budgets has legitimised a decreasing level of public funding and increasing control of funds granted for research. Accordingly, privatization has become an actual question of public science policy in many countries.

Research can be privatized in at least three principal ways: First, the *funding* structure of a research organisation may be privatized by increasing the share of (private) contract research. This is a strategy often adopted in order to increase the efficiency of public research organisations. Secondly, the *ownership* structure of a research organisation may be privatized. The third form of privatization of research is the increase of private involvement in *decision-making* in science policy and in the government of research organisations.

Among the most relevant questions regarding privatization efforts in forestry research are: How does the private sector react to cuts in public research funding? Is there reason to expect private funding to substitute for reduced public funding? When research is privatized, to what degree do research priorities shift towards the interests of the private bodies involved in decision-making and capable of funding forestry research? How do different forms of privatization affect research activities?

The purpose of this paper is to address some of these questions by:

1. reviewing theories related to investment and public/private involvement in forest sector research,
2. testing the theoretical criteria on public/private involvement in forest sector research with empirical findings, and
3. assessing the applicability of privatization policies in forest sector research.

The theoretical framework and the empirical findings to be presented in this paper are largely based on two research projects conducted at the European Forest Institute in 1994. In the first [16, 17, 18, 19], the roles of public and private forest sector research were charted in Europe. In the second [15], national case studies on the effects of changing funding patterns and policies on research activities were conducted in Finland and Norway as an initiative for further comparative studies in Europe.

2. THEORETICAL FRAMEWORK

2.1. Increased Innovation as a Motivation for Privatization

Privatization of research is often motivated by *the scarcity of public funds* available for research, and the need to *increase the productivity of research* through improved interaction between the producers and the users of research results. The basis for both arguments lies in a strive for creating innovations. They may be novel products or services, novel methods, processes, systems or devices and biological, technological, economic, social or administrational by character. The model of the national innovation system (figure 1) can be used as a basis for understanding the arguments presented above. In the model, public R&D, education, training and extension are viewed jointly with private similar activities and with interactions between producers and consumers as a system leading to innovations and

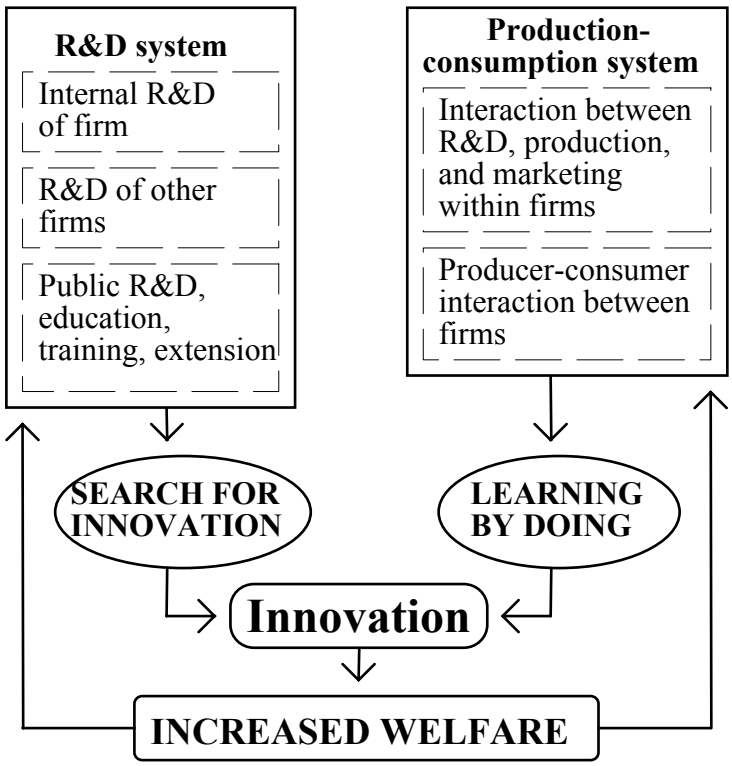


Figure 1. A model of a national innovation system (modified from [23]).

increased welfare. Two factors especially affect the amount of innovations: learning by doing and the input in the search for innovations.

Learning by doing is affected by linkages between R&D, production and marketing within the same firms as well as by increasing interaction between producer and user firms (figure 1). Particularly, the privatization of decision-making in science policy and research administration aim to improve these interactions. However, such activities not only increase innovations through learning, but also have various other affects on research activities and orientations of research, some of which will be examined in section 3.2.4.

In today's situation where a need for substantial savings in public expenditure exists, the privatization of research funding, in order to maintain the present level of input in the *search for innovations*, or to even increase it, is viewed as an attractive alternative in many research fields. However, before this argument is accepted, the roles of public and private funding should be considered in the framework of economic theory and empirical findings (section 2.2, and chapters 3 and 4).

2.2. Research Funding and Economic Theory

2.2.1. Research as a Financial Investment

Research and development projects are investment projects both from a private business point of view as well as from a national economic point of view. Their return has been studied less than conventional investments in goods and services, but over the past decades analytical literature around them has grown[3].

Criteria for the funding of forest sector research from the private business point of view can be examined in *the regular framework of supply (S) and demand (D) functions*[4]. In the model, research breakthroughs cause a decrease in production costs, or a downward shift in the supply function (S_1 to S_2 in figures 2a and 2b), and the market clearing price-quantity relationship shifts from a to b. As a result, greater quantities can be sold with lower prices.

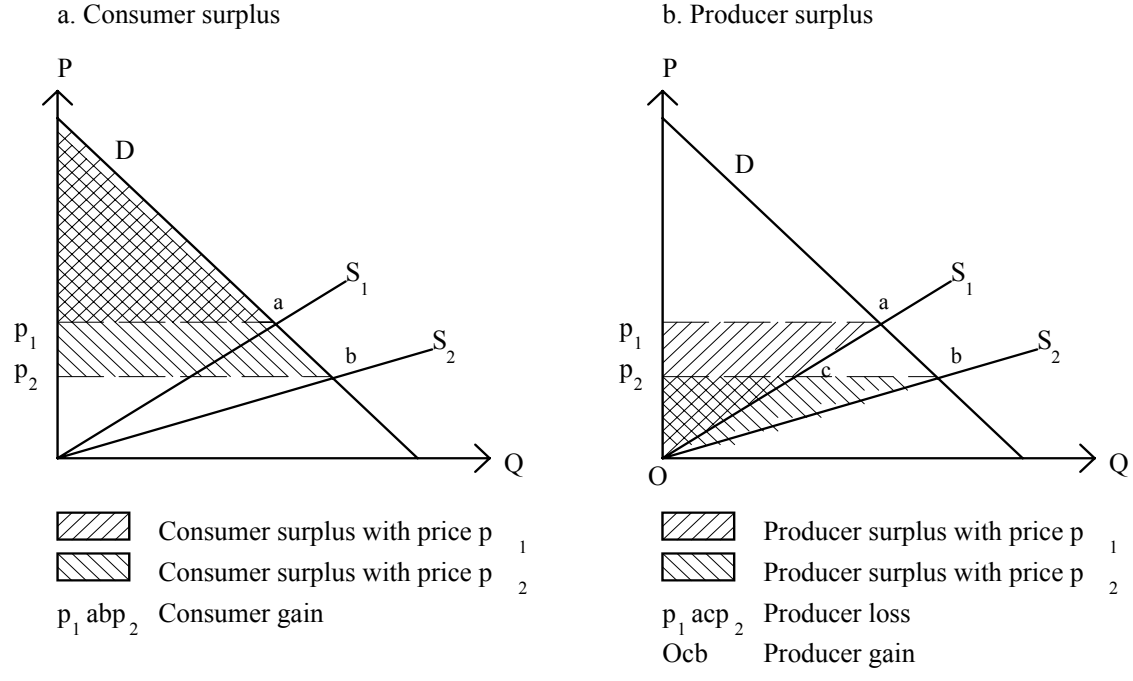


Figure 2. Consumer and producer returns to research [15, 17, 18].

[3] Dasgupta and Stiglitz [8] give an early overview.
[4] In forestry research, the framework has been applied by, for example, Willam F. Hyde [21, 22].

To understand the presented model, the concepts of consumer and producer surplus have to be used. *Consumer surplus* is the difference between the maximum price, which each consumer would be willing to spend on the products, and what they actually spend. Accordingly, *producer surplus* is the difference between the price at which the product is sold, and the minimum price at which the producer would be willing to sell the product. When the price shifts from p_1 to p_2 as a result of an innovation, the consumer surplus increases by p_1abp_2 (figure 2a). In the initial situation with supply function S_1, the producer surplus is represented by p_1a0. With the supply function S_2, the producer gain is represented by p_2b0. In this process, the producers lose p_1acp_2, but gain Ocb (figure 2b).

In order for the private sector to have incentive to invest in R&D, the gains have to cover the research and development expenses, as well as a sufficient rate of return. The rate of return is dependent on how the supply and demand curves are transformed as a consequence of innovation. This is largely affected by the structure of the market and the conditions of competition.

Already in 1942 Schumpeter [28] introduced the idea stressed later by many mainstream neo-classical economists that a monopoly has greater incentive for creating innovations when it can gain the whole respective profit whereas under a competitive market the contrary holds. This can be illustrated with the case of parallel research where different research designs may be used for solving the same problem. Only the best research design will give a return, and the other research investments become duplicate investments with zero worth. Dividing the aggregate gains of the best innovation among each firm does not leave a sufficiently large gain to pay for the research investment [6, 22].

The patent system attempts to protect a return on private research investments by restricting the research gains to the initial successful innovator as a property right. However, rapid and inexpensive duplication around the patent may dissipate all gains for the patent holder. The innovator gains from the innovation only when he can maintain a patent advantage over other producers for long enough to recover his costs

of innovation. This creates some interesting portfolio problems, and introduces the question of optimal patent length [6, 22].

Investments in non-parallel research are analysed by Dasgupta and Stiglitz [7], and the question of correlation between research projects, as well as the optimal combination for society as a whole and for private industries are analysed by Dasgupta and Maskin [9].

Whether or not producers are willing to invest in research depends not only on whether their final gain is larger than their loss, but also on the expected *period of payoff* of the investment. The time scale is a crucial aspect in research funding in two respects. Firstly, in any research, a period of time is needed before the research investment can produce financial gains. This lag may be short as in many industrial processes, but also very long as in some research related to forestry management. In such engineering related fields of research as harvesting and transport, research projects have only a short delay until payoff. On the other hand, after a typical biological research project, the new knowledge has to be realised in a growing stock of timber, and only after decades, an eventual expanded harvest can be expected. Long lags in this respect are disincentives particularly for private research investments. The time aspect is also important in the respect of how long it takes for the research breakthrough to deteriorate over time. [22]. The time element of research (the race for patents, and the race for superiority knowledge) when one has substantial external effects, is analysed also by, for example, Katz and Shapiro [23].

The relation of a research investment to *uncertainty and risk* is twofold. First, the uncertainty of the future which is a disincentive for other financial investment, may be the basic driving force behind research investment. In fact, one important motivation for research is to produce information that would reduce the uncertainties related to other financial investments by estimating the risks involved. Secondly, risk is also an elementary component of research investment per se.

A substantial degree of uncertainty exist particularly in many forestry management research investments, since both the production process and the future markets are

difficult to predict. Thus, risks related to forestry research are often closely related to the time lag discussed above. Basically, three kinds of risks are involved in forestry research. First, it is the basic nature of research that the research results cannot be fully anticipated. Thus, research investments face a risk of what results are achieved. Results with a novel character have greater potential to increase gains from other financial investments. Secondly, research results may only provide additional support for various theories, or initiate new theories, but cannot verify them. Research results are never one hundred per cent reliable, but include some uncertainty or risk. Thirdly, in order to produce gains, the research results have to result into innovation through learning by doing (see previous section). Thus, even though reliable and potentially beneficial research results are obtained, a risk still exists in that the results do not result in innovations. Privatization of research can be seen as one strategy to reduce this kind of risk.

2.2.2. Incentives for Public Research Funding

During the first part of this century, J.A. Schumpeter introduced clearly the idea that new products and new processes were the main source of dynamism in economic development. During the latter part of the 1950s, Robert Solow in the United States and Olavi Niitamo in Finland arrived in econometric estimations at substantial economic growth effects by R&D [13]. OECD along with other international organisations, as well as a number of national governments, adopted the increase of public R&D as an explicit strategy in the promotion of economic growth. This paradigm was particularly strong during the 1960s and 1970s.

Economic theory classifies the right for government intervention in the operation of the economy into 1) allocation, 2) distribution, and 3) stabilisation [4, 26]. Related to the criteria of *allocation*, one reason why most governments have adopted the role of the principal sponsor of forestry research is that the results of forestry research are

mostly produced either in the sphere of missing markets, or within markets with inadequate competition. In addition, the results of forestry research are mostly collective goods, as they usually are published in order for their scientific creditability to be tested by the science community.

In practical forestry, market failures in the form of inadequate competition are caused by, for example, a small number of buyers or sellers, imperfect knowledge, and obstacles for entries into and exits from the markets. Public research can increase competition by improving the knowledge base of buyers and sellers. It also breaks down barriers of entrance to the markets owing to lowered prices, increased output, and increased productivity [27]. In addition, because small- and medium-sized enterprises generally spend too little on research, publicly funded research may be vital for the existence of many small businesses within forestry and the forest industry.

Research results are also considered to be worth public support due to their strong positive external effects, which can occur both in and over time. In addition to promoting the generation of innovations, growing attention has to be put on development in a broader context. Particularly, the increase of environmental awareness in most countries is bound to be reflected in the funding of forestry research, because the forest environment is clearly a public good. For example, forests provide clean water, protection, and possibilities for outdoor recreation. Forests are also an essential habitat for many endangered species, and forests bind carbon dioxide more effectively than most other land use forms.

Distributive impacts of public policy can be motivated with strengthening the economy by increased competition, with democracy and with ethic criteria. Distributive impacts of forestry research include allocation of research benefits and costs both among factors of production and between producers and consumers [20]. Forestry is practised mainly in rural areas, and innovations within forestry mostly benefit rural land owners. In countries with small private forest holdings, forestry innovations may improve the regional balance. On the other hand, in the case of harvesting, innovations improving mechanisation may even cause an increasing imbalance between regions due

to a decrease in rural employment.

Inputs in research and development might also promote *stabilisation* of the economy by producing information needed by decision-makers about economic conjunctures, market conditions, the employment situation, etc. Furthermore, research can assist in producing important strategic economic plans and programs for economic stabilisation.

Public funding of forestry research is also supported by *sustainability* reasons particularly in fields of research where research projects are of long duration. In a survey of 45 forestry research institutions in developed countries, Bengston and Gregersen [3] found stability of funding from year to year to be nearly as important to the research performance of the organisation as the actual level of funding.

2.2.3. Criteria: Public or Private Funding?

In the conditions of USA, it has been found that public investment in R&D is necessary from the social optimum point of view [22]:

1. where research requires large initial investments, where a long lag in investment-productivity is expected, and where these results are highly uncertain;
2. where the industry demand is highly inelastic or the supply is elastic, and research benefits are rapidly and largely transferred to competitive higher level producers and final consumers; and
3. even where demand may be more elastic or supply more inelastic, many firms may share the positive aggregate production gains due to research. Therefore, the individual firm's gains are insufficient to cover the full research costs, even though each firm must invest these full costs independently in order to obtain any part of the industry's total gain.

In the US conditions, the first class is more familiar to other industries (e.g. space and defence) than forestry. The second class describes the sawmill and woodpulp industries, and the third class both the sawmill industry and forestry, and it may even describe the softwood plywood industry. However, these US experiences are only partially transferable to other developed countries with differing market situations and policy incentives. Most likely, forest products research opportunities for developed countries are comparable to the US, but more differences can be found in forestry research. Particularly Japan and the most of the developed countries of western Europe may suggest a different situation from, for example, USA, Canada and Russia where land and wood are relatively less scarce factors of production than labour and capital. However, even the benefits of forestry research in other developed countries may be affected by the import of wood from, for example Canada and Russia [22].

On the basis of the economic model presented in figure 2, and partial support from previous studies [20, 22], three hypotheses of private research funding within the forest industries are formed for the European conditions. The demand function of the *sawmill industry* is relatively inelastic (close to vertical), and the supply function is relatively elastic (close to horizontal). Research benefits are rapidly and largely transferred to competitive higher level producers and to final consumers. Accordingly, little private research is expected to be conducted within this industry. Secondly, in the *wood working and furniture industries*, producer gains may often be positive. However, in most countries, the small market shares of individual enterprises within these industries suggest that innovative enterprises may be unable to claim a large proportion of the gain from their innovations. In such cases the pooling of research expenditures and sharing of research results may seem the rational way to invest in research and development. Thirdly, in the *pulp and paper industry*, the demand function is more elastic than in the sawmill industry. Therefore, gains from research inputs can be expected to be larger. The pulp and paper industry is also more concentrated and capital intensive than the diverse wood industries, and can even provide for larger initial research investments. Thus, considerable private research investments can be expected

to be found from the pulp and paper industries.

In addition to the forest industry, there exist some highly profitable research investments within traditional forestry as well. If property markets functioned perfectly, research gains from biological forestry research would immediately after innovation increase the value of the property, and thus create immediate potential return. Since this is not the case in most countries, private investors may be unwilling to invest in long-range research projects, despite of the economic efficiency of the investment. Nevertheless, perhaps the most important obstacle for privately funded traditional forestry research is the scattered pattern and small scale of forest holdings in many countries, which results in the same kind of problems as in the case of sawmill and other wood industries presented above.

The hypotheses can also be presented in the more general framework of the supply of R&D output (performers of research) and the demand for R&D output (users of research results) as follows [19].

According to the *supply view for R&D output*,

- a positive producer net gain of R&D investments, a low risk of R&D investments, and a short time for payoff of R&D investments tend to give incentive for private funding of R&D, and
- a consumer net gain exceeding producer net loss of R&D investments, a high risk of R&D investments, and a long time for payoff of R&D investments tend to give incentive for public funding of R&D.

According to the *demand view for R&D output*,

- the existence of capital intensive or strong unions of private entrepreneurs in forestry, harvesting, and processing tend to give private incentive for funding R&D, and
- the existence of social benefits for public at large and future generations tend to give public incentive for funding R&D.

Yet, it is not probable that the existing patterns of funding of forestry research in all cases follow the rationality presented above. Instead, many ideological, political, cultural, institutional, and in small countries also personal factors, may affect decisions on research funding. In addition to attitudes towards science in general, different political ideologies and forces may be sympathetic to different fields of research and development. Accordingly, the problem of research funding is both theory dependent and also a function of perceptions and power.

3. EMPIRICAL FINDINGS

3.1. The European pattern

3.1.1. Purpose and Material

The purpose of the European study [16, 17, 18, 19] was to formulate criteria for a rational division of private and public forestry research and to test these criteria with a survey of forestry research organisations in Europe. The material for the study was collected from international directories of forestry research organisations [1, 11, 12] as well as forest and science policy related literature. Additional information was collected by a few interviews of representatives of some European countries. All together, the material covers 29 individual European countries with 205 individual research organisations, and a total of 7,879 researchers.

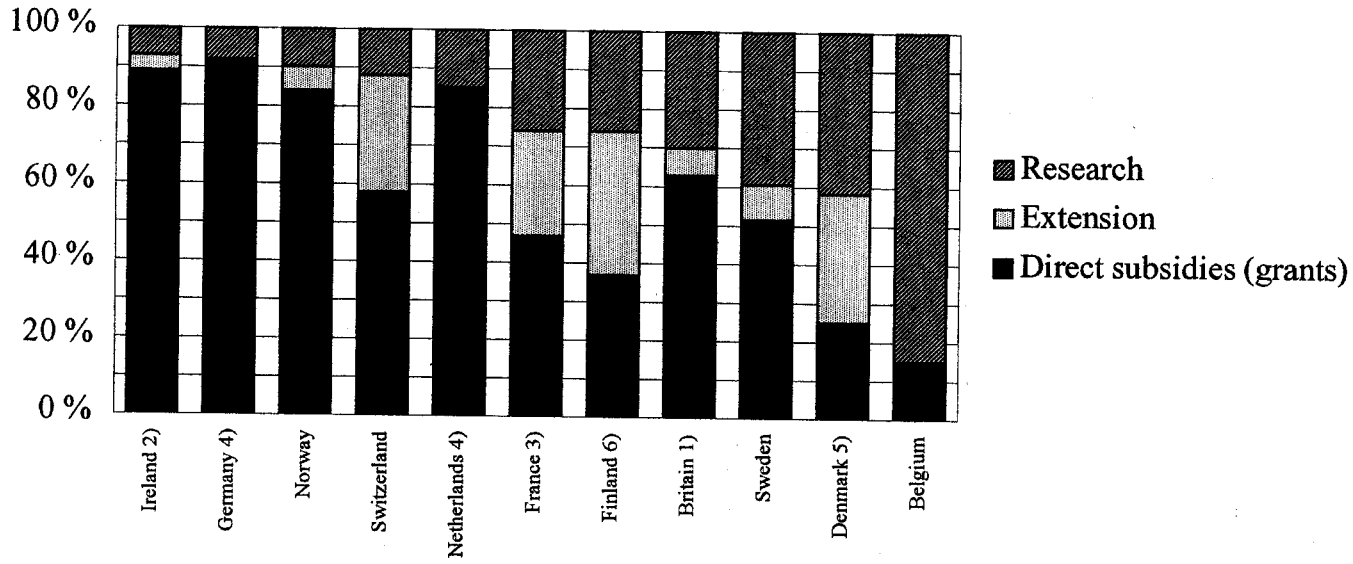
The concept of forest sector research consisted of both traditional forestry research and forest products research. The structure of forestry research can vary according to the degree of basic and applied research, as well as development work. In these aspects and others, the material available for the study determined to a great extent the scope of forestry research included in the study. For example, research in many forestry related fields such as environmental aspects of forestry, wildlife,

agroforestry, land use and forest products were, for practical reasons, included in the study only when it was conducted at research establishments with a permanent input in forest sector research.

The material contained three main deficiencies. First, R&D conducted within individual enterprises were also, due to missing data, not included to the study. Therefore, it is probable, that private research and development efforts are underestimated in countries with a large forest industry. Secondly, the study focuses on the sectors of performance (type of institute) rather than on the source of funds. Thirdly, the number of researcher staff is used as an indicator of financial resources. Difficulties arise particularly from the definition of researcher which may have varied among the countries, and from the fact that not all researchers do research work full-time (e.g. university staff who also have educational duties). However, the number of researchers as a measure of national R&D efforts has the advantage of not being complicated by changes in currency values internationally and over time.

3.1.2. Forestry Research as Forest Policy and Science Policy

Forestry research has a dual role in public policy. It may be considered both as a part of science policy and as a part of forest policy. In the European OECD countries, forestry represents 0.32% of the total graduate staff in R&D. Forestry research has the most important role in *science policy* in countries with a smaller economies and high forest cover (for example Finland, Sweden, Austria, Portugal and Norway). On the other hand, countries with the least forest resources (for example Denmark, Ireland, Netherlands, Iceland and Greece) place more emphasis on forestry research compared to other research fields than the major economies with significant forest resources (for example Germany, France and Italy) [16, 17, 19].



Sources: Data for Finland are from the Ministry of Agriculture and Forestry and [14]. Data for other countries are from [13]. Figures for Finland are from 1994, for Ireland from 1991, and for other countries from 1990.

Notes: 1) excluding costs on tropical forestry, 2) including EC-funded projects, 3) excluding arboriculture, 4) excluding extension, 5) excluding shelterbelts, hunting and landscape research, 6) support for private forestry includes only funds from the Ministry of Agriculture and Forestry.

Figure 3. The structure of public expenditure in support of private forestry in some West-European countries in 1990-94.

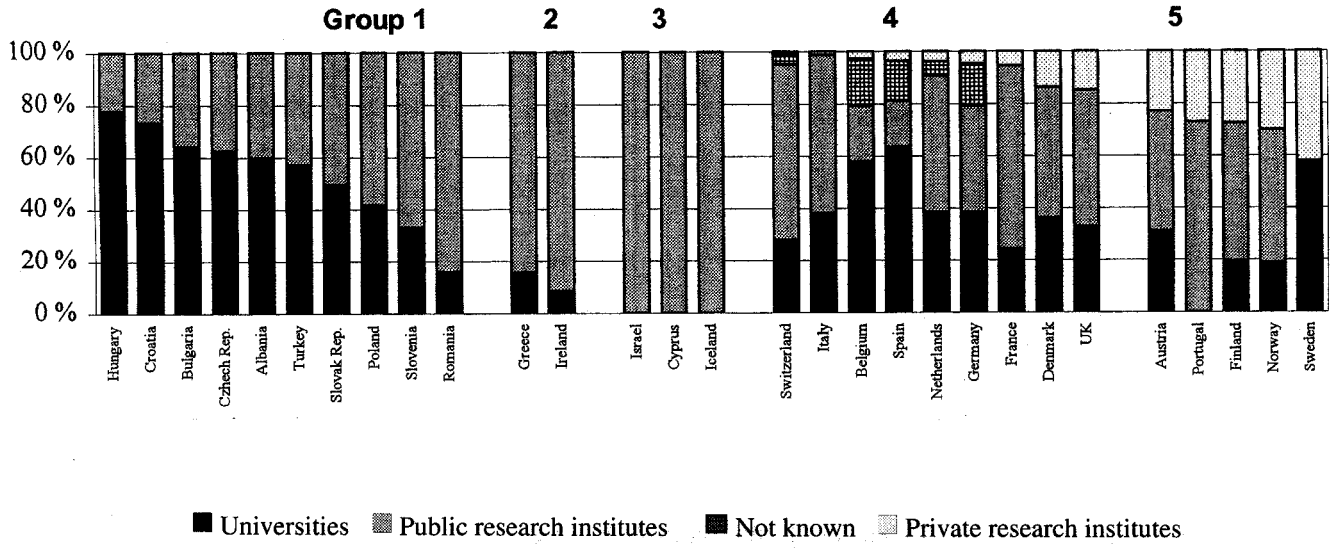
The role of forestry research in public *forest policy* varies also greatly within different European countries. Grayson [14] has evaluated the role of public research expenditure on the behalf of private forestry in several West-European countries (figure 3).Belgium, for example, allocates nearly 6 times as much in research in the favour of private forestry as it does in forestry grants. However, the high share of research may be to some extent an overestimation, because funds for extension are not taken into account. Other rather research oriented countries are the United Kingdom, France, Denmark, Sweden and Finland, which allocate 25-40% of their public support to private forestry into research purposes. Ireland, Germany, and Norway, on the other hand place less emphasis on research as a form of public forest policy than other countries. In these countries, research represents less than 10% of the total public support to private

forestry.

3.1.3. Public and Private Research

In Europe as an average, 40 per cent of forestry research is conducted at universities, 49 per cent at public research organisations, and 9 per cent at private research organisations. The type of institute was not known for 2% of researchers, but most likely, the organisations marked as unknown are public research organisations. If only West European countries are considered, the share of forestry research conducted at private institutions is 15 per cent.

European countries can be divided into five groups according to the existence and dominance of various sectors of performance in forestry research (figure 4).



Note: Because the directories used as a source of data are not complete, because the status of the organisations is not always given in the directories, and because inconsistencies exist between the directories and other written sources, some uncertainty exist within the figures obtained for certain countries in respect of the shares of different sectors of performance. For example, no information was available from the Portuguese universities involved with forestry research. For Switzerland, staff data was not available for two institutes engaged in forest products research. At least in Italy, the private sector is clearly underestimated because of the existence of numerous semi-private research establishments. Accordingly, the figures presented above have to be considered as a crude estimate only. Because the figures don't include R&D conducted within individual enterprises, the role of the private sector is underestimated especially in countries with a large forest industry. International research institutes are not included in the figure.

Figure 4. The share of researchers in forestry by type of institution in European countries in 1983-92. Includes also forest products research when conducted

in research institutes, and not within firms. ([15, 16, 18], original data from [1,10, 11]).

The *first group* comprises East-European countries, where forestry research has traditionally been conducted at universities and national research institutes only. The *second group* consists of those West European countries, where no researchers in forestry are employed by the private sector (Greece and Ireland). In addition to small forest resources, these countries have a small proportion of privately owned forests (17% in Greece and 22% in Ireland) in common. In the *third group* belong the three European countries with the smallest forest resources (Cyprus, Iceland and Israel). In these countries, forestry research is conducted only in single public research organisations with a very small research staff (3-4 graduates). The *fourth group* consists of a variety of countries with a rather small private sector in forestry research. The group is rather heterogeneous, consisting of both major and minor economies, and of countries with small and large forest resources. The five countries of the *fifth group* (Sweden, Norway, Finland, Portugal and Austria) all have substantial forest resources, and the private sector employed over 20 % or the total forestry research staff in 1983-92.

3.1.4. Research Intensity

The two most common ways to describe research intensity is to compare research and development expenditures on the value added, or to the value of production. Here, such data was not available to the degree that reliable international comparisons would be possible. Instead, the number of researchers per unit of production (m3 of felling) is used as a crude indicator of research intensity (figure 5).

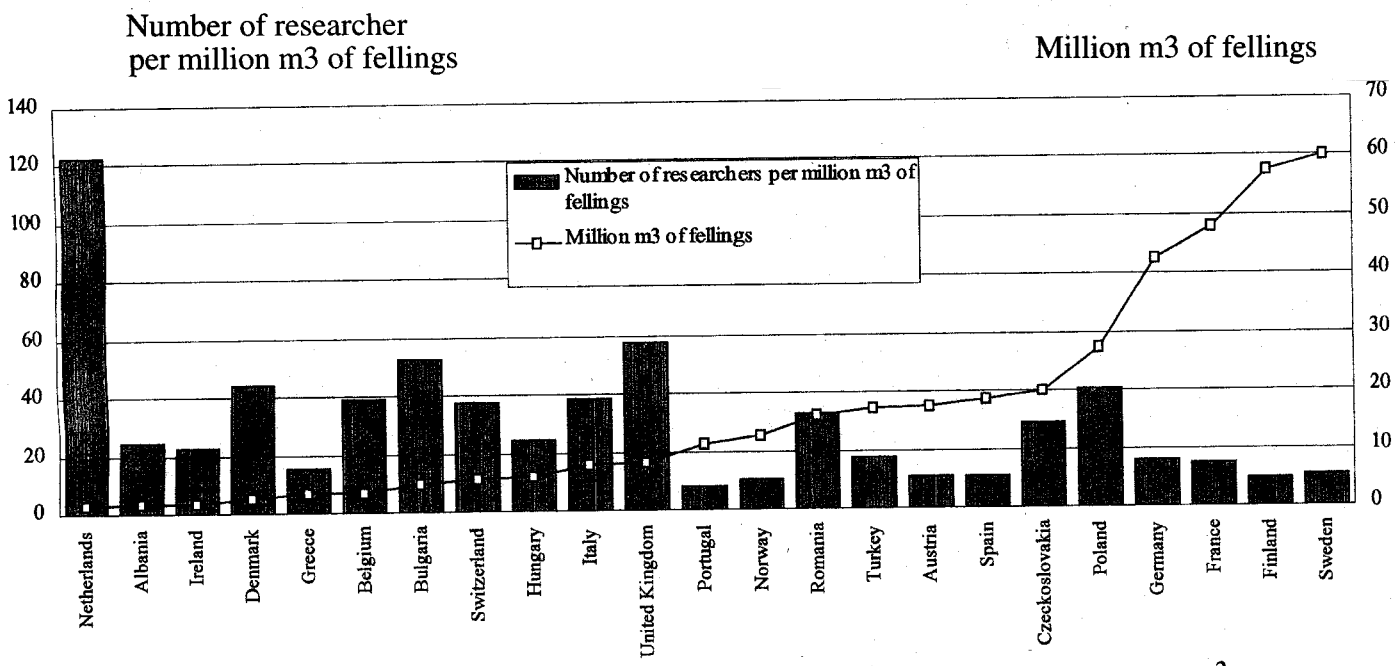


Figure 5. The number of researchers in the forest sector per unit of production (m^3 of fellings) in European countries in 1983-92. Includes also forest products research when conducted in research institutes, but not within firms. The countries are presented in ascending order of roundwood produced. ([15, 16, 18], original data from [1,10, 11]).

In countries with a high level of wood production (m3 of felling), less researchers are employed per unit of production (m3) than in countries with a low level of forestry production. In the countries with a high level of production, also proportionately more research is done in the private sector than in other countries. Even though there exist great variation in the resources reserved for forestry research, the eight West European countries with the highest level of wood production (Sweden, Finland, Germany, France, Spain, Austria, Norway and Portugal), have about the same amount of researchers per unit of production (m3), which is in fact the lowest of all the European countries. This equality is a most interesting finding. The East European countries with the most significant wood production (Poland, the former Czechoslovakian state and Romania) have more researchers per unit of production than the West European countries with a corresponding level of production.

Several factors can be found to explain the high intensity of forestry research

compared to units of production in other West European countries. For example, many of the mentioned countries have a strong prior colonial tradition, which is today reflected in interest in research on tropical areas. In some countries, the environmental function of forests may be more dominant than in others. Moreover, forest resources may have a special value in countries where they are scarce. The definition of "researcher" may also vary. For example, some countries may include technicians and other supporting staff in their figures.

Similar trends are found in data collected by the European Commission [10]. Namely, the three West-European countries with the greatest number of forestry research staff compared to the level of wood production are the Netherlands, Great Britain and Denmark, whereas the countries with the most substantial forest resources have a rather low but equal input in forestry research. The data by the European Commission also offers the possibility to discover very different types of trends in the relationship of production volume and relative research volume. In pulp and paper technology, a high production volume (tons of produced pulp and paper) tends to increase the relative volume of research, whereas in forestry a high production volume (m3) does not seem to have significant impact on the relative research volume. As in the case of the three countries mentioned above, there may even exist negative correlation between production volume and relative research volume.

3.2. Case Studies: Finland and Norway

3.2.1. Purpose and Material

The purpose of the comparative study between Finland and Norway [15] was to 1) describe changes of funding of research in the forest sectors of Finland and Norway during 1983-93, 2) analyse the influence of both economic and institutional factors on the funding structure, and 3) analyse the effects of different funding patterns on the

activities of the research organisations. Finland and Norway were chosen as case study countries for an in-depth investigation because the operational environments of forestry in Finland and Norway, their culture, political organisation, as, their natural conditions as well as the structure of forestry research resemble each other in many respects. However, the countries pursue slightly different science policies. Accordingly, the study offered a possibility to compare the effects of varying science policies on research that is otherwise conducted in rather similar circumstances.

The study involves ten research organisations in Finland, and seven in Norway. Multiple sources of evidence were used. First, such factors as the pattern of funding, the client structure, the type of research projects, the organisation, as well as the dependency of the organisation on other organisations, were charted. This information was mostly available from annual reports and other publications. Secondly, information about the effect of economic and institutional factors that were likely to affect the level and pattern of funding as well as information about the effect of changing funding levels and patterns on research activities were collected through focused interviews of specialists in the object organisations. Thirdly, figures from national statistics on R&D were used to the research input of individual industrial enterprises.

3.2.2. Public and Private Research

In both Finland and Norway, research conducted at universities represent only a minor share of research in the forest sector (5% in Finland and 4% in Norway). The major difference between these two countries is that in Finland, a higher proportion of research in the forest sector (50%) is conducted in individual firms than in Norway (35%). On the other hand, in Norway relatively more research in the forest sector is conducted in research institutes (36% in public and 26% in private research institutes) than in Finland (28% in public and 17% in private research institutes). A further important difference between Finland and Norway is that the principal research institute

for wood technology is a public institute in Finland (The Forest Products Laboratory of the Technical Research Centre of Finland, VTT) and a private institute in Norway (The Norwegian Institute of Wood Technology, NTI).

Despite some structural differences in the organisation of forest sector research in Finland and Norway described above, the funding structures of various research fields are surprisingly similar (figure 6). In both countries, *forestry research* is mostly financed directly from the State Budget. Owing to differing accounting systems of research expenditure, all public research grants are included in the respective category in Finland, whereas in Norway other public research grants than those of the Research Council of Norway (NFR) are included in the category of 'other funding'. Thus, the only significant difference in the funding structures of forestry research in these two countries is that also industrial membership fees are used for financing forestry research in Finland (Metsäteho). In Norway, the forest industry is not involved in funding forestry research on a regular basis. This is because very little logging in Norway is conducted by the forest industry, which also owns rather little forests.

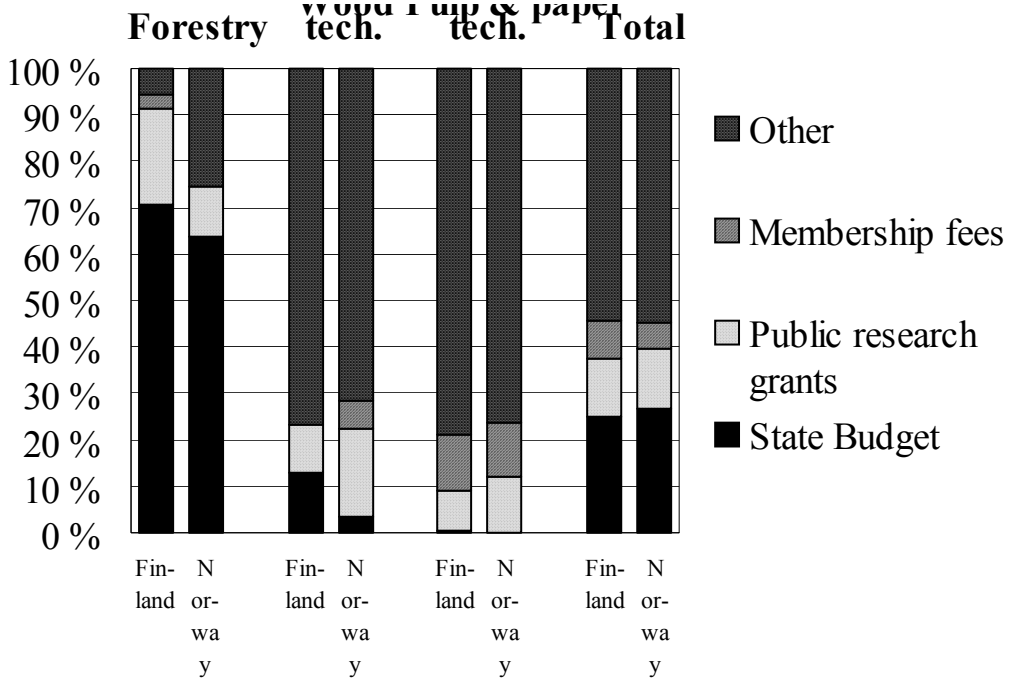


Figure 6. The shares of various sources of funding of research in forestry, wood technology, and pulp and paper technology in Finland and Norway in 1991-93 [14].

In *wood technology*, the share of public funding is roughly the same in both countries despite the very different organisational pattern of research in this field. The difference between these two countries is that in Finland, basic funding mostly comes from the government budget, and in Norway from NFR. A further distinction is that in Norway, membership fees are also collected from the industry. Also the funding structure of research in *pulp and paper technology* is very similar within the two countries.

3.2.3. Research Intensity

Research intensity, measured by using the share of research expenditure of the gross domestic product as an attribute, is in forestry and wood technology rather similar in both Norway and Finland. However, in the figures concerning forestry, the intensity of research is significantly overestimated in both countries because non-market products such as biodiversity, carbon balance, recreation etc. are not included to the production figures. (Figure 7).

Research intensity in pulp and paper technology is significantly higher in Finland than in Norway. One possible explanation to the large differences between research intensity in pulp and paper technology is that the Finnish forest industry is to a

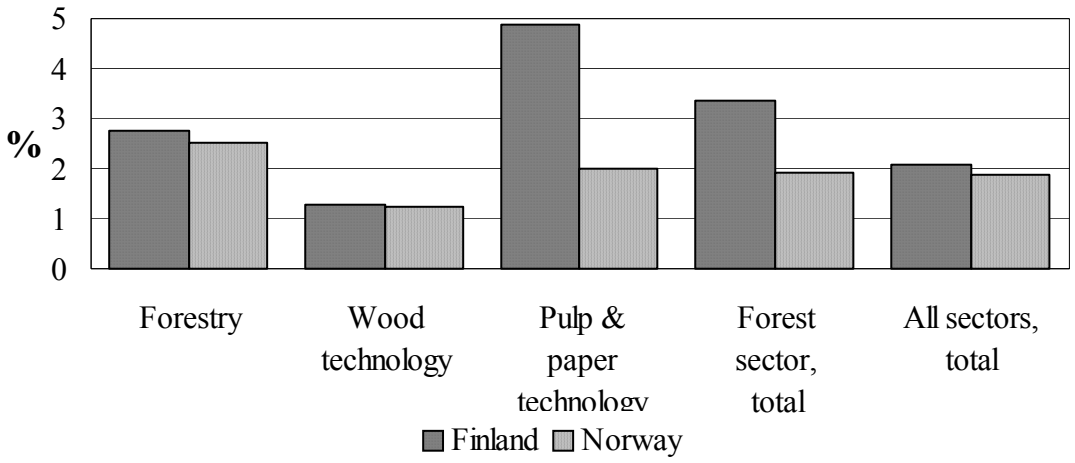


Figure 7. Research intensity (research expenditure / GDP) in the forest sectors of Finland and Norway in 1991-93 [14].

large degree also involved with machine development. Another reason for this may be that more efforts are put in research in an area of such high national importance as the forest industry is in Finland.

3.2.4. Science Policies and Research Activities

Forestry research in both Finland and Norway faced a period of significant growth during the 1980's. In the early 1990's, on the other hand, the total level of research funding has decreased in Finland, and stagnated in Norway. However, differences between single institutes are considerable. Generally, tightened funding results in two different kinds of policies: attempts to *increase the efficiency* of the use of funds, and attempts to *increase the level* of funding from external sources. Even though both policies have been applied in both countries, it seems that more focus has in Finland been put on the first strategy, and in Norway on the second. These different trends have caused partly different problems for research activities in the two countries.

In Finland, the basic elements of science policy that have affected research in the forest sector has been output-control and reduced public funding. As a result, the down-sizing of forestry research organisations dependent on public support has become a major problem. On the other hand, due to a shift in government funding from direct support to institutes into program funding, research activities have expanded at universities. In Finland, also the availability of private funding has been reduced due to the economic recession. However, private institutes have mostly been able to compensate for this loss by increased public grant funding.

In Norway, the major strategy in science policy has been user-orientation, which includes increased private involvement both in research funding and in the planning of research activities. Subsequently, the basic problem related to research funding has become maintaining scientific competence through a sufficient level of funding for basic research (measured by the amount of researchers with a doctoral degree, scientific

competence is high in Norway). The problem is mainly caused by increased intervention of politics into decision-making on research orientations. In addition, as the share of program funding and the requirements set on research orientation by the public authorities have increased, less funding has been available for 'free' research and other competence building activities. Especially difficult the situation was in wood technology until 1994, because the Norwegian Research Council (NFR) did not grant sufficient amounts to basic research during some years prior to 1994, and because the fragmented sawmill and other wood working industry was not able to agree on a sufficient amount of basic research to be conducted with the common funding of their common research institute (the Norwegian Institute of Wood Technology, NTI). Similar difficulties have not existed at the research institute of the pulp and paper industry, which serves a more concentrated branch of industry.

The research policies of both countries have raised pressure to increase private funding. In Finland, this pressure is mainly caused by decreasing public funding, and in Norway by the policy of increased user-orientation. However, in the interviews reported in Hellström (1995), research leaders in both countries were pessimistic of being able to significantly increase the share of private funding in forestry research. Research fields affected most by the various changes in financing in both countries are those using long-term field experiments. Also, due to changes in the funding structure, mutual problems exist for example in personnel policy, and in the acquisition of research equipment.

4. DISCUSSION

4.1. Theory and Empirical Findings

In section 2.2.3, economic criteria for a rational division of public and private funding of forest sector research were presented. Mostly, the empirical findings of the studies

presented in the previous chapter support the presented criteria. However, data for the studies were collected on an institute basis, and not according to individual fields of research, which to some degree restricts the scope of conclusions on the basis of these studies.

According to support from the European survey of public and private forestry research [16, 17, 18, 19], the *following conditions were considered to be the most relevant ones for private funding* of forestry research:

- high rate of return of research investment,
- short delay and low risk of R&D investment (e.g. forest products research, harvesting),
- concentrated, capital intensive forest industry (e.g. Scandinavia),
- large private forest holdings (e.g. Portugal), and
- strong forest owner unions (e.g. Denmark).

Despite a clear need and the existence of private forestry research organisations in some well-defined research areas, there remains a wide range of *aspects that favour public funding* of most forestry research:

- missing markets for research results,
- imperfect juridical infrastructure (e.g. patent system, property markets),
- positive external effects in the form of innovations,
- forest environment as a public good,
- positive distributive effects in favour of rural areas,
- stabilisation of an economy in recession, and
- sustainability of R&D funding - scientific standard.

In the following, these criteria are discussed in relation to experiences in some research fields. For most *biological forestry research,* the conditions of short delay until payoff and low risk of investment are not fulfilled. Yet, investments in forest management intensification techniques, such as fertilisation and drainage, can produce gains in a

shorter time span than most other biological research. Another important factor affecting the existence of the private sector within biological forestry research is the forest ownership pattern. Generally, forest owners cannot be anticipated to finance biological forestry research, except in the case of very large forest holdings, such as within the forest industry in Portugal. In fact, public funding is highly dominating in most areas of forestry research, which is also supported by the fact that many areas of forestry research produce high social gains.

In the case of engineering related *harvesting and transport*, the delay until payoff is short, and the private sector can be expected to be involved with research funding. However, much depends on the employment structure in harvesting and forestry work in a specific country. In several European countries, private funding of harvesting related research does not seem to have a regular basis, but is focused on contract research on individual projects. Cubbage [5] reports a similar situation in the United States, where in spite of the economic efficiency of research in harvesting, it suffers from a paucity of funding and research scientists. On the other hand, in Finland and Sweden where a large share of forest work is conducted by the forest industry, it is the industry that is largely involved with research in harvesting methods. On the other hand, in Norway, most forest work is conducted by the numerous private forest owners, why the private company sector does not have the same incentive to invest in forestry research as in Finland and Sweden.

A particularly interesting finding in the comparison of research funding in Finland and Norway is the fact that despite of some differences in the organisational structure of forest sector research, the funding structures of forestry, wood technology as well as pulp and paper technology are very much alike in both countries. This suggests that economic criteria, such as presented above, strongly guide the funding structures of forest sector research despite of variation in organisational structures. This can be illustrated by an example from *wood technology* research. In Finland, such research is conducted at the Forest Products Laboratory of the Technical Research Centre of Finland (VTT) - a public institute, with also substantial public involvement in

research funding. The Norwegian wood industry, on the other hand, has a joint research institute (The Norwegian Institute of Wood Technology, NTI). As public support for this institute has decreased, it has become increasingly dependent on funding from the fragmented wood industry which has not been able to provide a sufficient level of funding for basic research. Thus, it seems that disregarding the ownership structure of research institutes within wood technology, regular public support is necessary owing to the fragmentation of the industry. Another main reason compared to the pulp and paper sector is the relatively inelastic demand of sawnwood which considerably restricts the producers' gain from innovations, and give most of the gain to the users of sawnwood.

On the other hand, private involvement in research funding in *pulp and paper technology* is dominating in both Finland and Norway, partly owing to the concentrated and capital intensive pulp and paper industry in these countries, and to the relatively elastic demand for pulp and particularly paper products.

4.2. Recommendations

Privatization of the funding of forestry research has often been motivated by the scarcity of public funding and the need to increase the productivity of research (section 2.1). However, both economic theory and our empirical findings give strong support for the continuing dominating role of public funding in most forestry research. We have not found support from theory or practice that decreased public funding of most forestry research would be compensated by increased private funding in the respective fields of research. In addition, if public funding of forestry research is cut, it means that research orientation is to an increasing degree controlled by the markets, which for forestry research are very narrow. Inevitably such privatization would shift research priorities towards the interests of the private bodies capable of funding forestry research.

Furthermore, there are several ways to increase the productivity of research without privatization of R&D funding. Increasing interaction between public and

private R&D institutions as well as education, training and extension services is one cost-efficient way of promoting the search for innovations. Also increased competition for research funds may activate the science community, when introduced at a reasonable scale. Research outputs can also be increased by changing emphasis of funding decisions from an ex ante assessment of potential achievements to an ex post assessment of previous achievements. Increases in research productivity can also be obtained through delegation of decision-making power in the use of existing funds from the top administrative level to smaller research units. Such delegation not only makes the use of funds more efficient, but also motivates the research staff.

Experiences on the effects of *privatization of the ownership structure* of forestry research organisations on their research activities were rather limited in this study. However, an experience from Norway, where the research arm of the Directorate for Nature Management and the Program for Applied Ecological Research funded by the Ministry of Environment was merged into a private research foundation (Norwegian Institute for Nature Research, NINA) in 1988, suggests that such privatization may have positive effects on research activities particularly in the form of increased flexibility.

The aim of *privatization of decision-making* in forestry research is mainly to improve the linkages between the producers and users of research results, in order to promote the learning process necessary to produce innovations (figure 1 in section 2.1). The science policy of the Norwegian Research Council (NFR) aiming at increased user-orientation can be seen as an example of this third form of privatization. In the new policy, the degree at which the use of public funds is made within the private sector has been increased. However, NFR's privatization strategy also includes the first form of privatization by increasing private funding of research and development. At large, the policy seems to have been successful in improving the interaction between the producers and users of research results. However, as a consequence of the new policy some research institutes have faced a situation, where enough funding is no more available for a sufficient level of basic research that is necessary for the maintenance of scientific competence. A further problem in user-steered research is that the quality of

research is given less priority.

Privatization of research has a negative sound among many scientists, as it is often feared to lead to decreased freedom and objectivity of research. Without underestimating these problems that have, in fact, come forth in the empirical evidence (section 3.2.4), it should be emphasised, that there exist many forms of privatization with varying effects on research activities, all of which could not be presented in this paper. Research leaders should therefore carefully consider the various forms of privatization and the motivations for such action, in order for the sustainability needs of forestry research to be satisfied. A sustainable level of research funding is necessary not only for a stable amount of research, but also for the maintenance of scientific quality, and for maintaining and increasing the value of previous investments in long-term research projects.

According to our views, *pressures for decreased public funding could be confronted with active debating on the behalf of sustained or even increased public funding of forestry research*. The criteria for public and private funding presented previously (sections 3.2.3. and 4.1) could form an important basis for such argumentation.

Even in countries like Finland and Norway with significant forest resources, research intensity in the forest sector is only slightly above the national average, and in wood technology even significantly below the national average (figure 7). Yet, because the high value of non-wood benefits of forestry is not considered in the presented figures of research intensity, the figures highly overestimate the real situation. In the European scale, the research intensities in Finland and Norway are slightly lower than in most other major wood producing West European countries (figure 5). These facts leave considerable scope for increasing research funding in both forestry and wood technology in several European countries, and particularly in Finland and Norway.

Owing to the reduction of grants for forestry in some Western countries during recent years, the relative role of forestry research in public forest policy has increased. In fact, *R&D in forestry could be increasingly regarded as one of several instruments of*

forest policy. In many cases, investments in R&D might produce larger gains for forestry than poorly designed subsidies. Again, the criteria set for private and public funding of forestry research could be considered as the primary criteria for balancing investment in R&D with investments in other instruments of forest policy.

4.3. Future Studies

This paper has focused on Europe, and more particularly on two countries with a rather similar funding structure of research in the forest sector, but with slightly different science policies. This has formed a good basis for testing the criteria of public and private funding and examining the effect of various funding policies on research activities. However, it would be equally interesting to see how research in the forest sector is affected by changes in funding levels and patterns in countries where the basic organisation and funding structure for research is different from the model presented in this study. The only way to increase our knowledge of such factors is to conduct further case studies in other countries with different conditions for research activities than in the countries of this study.

In the European survey of forestry research [17], Poland was found interesting for the high amount of researchers in forestry, Italy for the high share of semi-public research institutes, France for the centralised system of public research institutes, Germany for the dominance of sub-national institutes, and Portugal for the recent emergence of several new private research institutes. Sweden would be an interesting object for such studies owing to the dominating role of research conducted at universities, and the United Kingdom for a large share of forestry research that is being conducted by the forest authorities.

Outside Europe, particularly New Zealand could be an interesting country for further studies, as the public Forest Research Institute was reconstituted as a partly commercialised research institute. In the new policy, government funding was to be reduced to a level sufficient to support only 60% of the research programmes, so that

retention of the remaining 40% depends on how effective the institute is in selling its capacity and services outside the public sector [25].

Another interesting example is Chile, where public forestry research conducted at the Chilean Forest Research Institute (INFOR) was dramatically cut by the military junta in the middle of the 1970s. The number of researchers was reduced from 500 to 35, and evidently, the private sector was not able to compensate for this loss. Even today, with the ongoing reconstruction of the institute, it is difficult to compensate for the loss that the interruption of sustainability in research activities has caused (Gerardo Mery, oral note).

Subsequently, science policy and research leaders in other countries are encouraged to initiate such work, and to join this research effort in order to enlarge and improve our common knowledge of research funding, which is the precondition of all research activities, but which is poorly investigated. Such information would be of value to research leaders and policy makers in decision-making on research funding both nationally and internationally. Especially interesting questions here are the analysis of what is a reasonable/optimal input level in forestry research, and the optimal combination of public and private funding in various research fields. Such information could be used to support a policy of sustainable productivity of forestry research.

In addition, as indicated by the European survey of the funding of forest research organisations [17], very little data exist on research investments in the forest sector at the European level, and international comparisons are difficult to make. In fact, European forestry research would benefit from the creation of an international data-base of research activities, where the funding of different types of institutes would be presented according to both sources and uses of funds. For example, FAO which has published world-wide directories of forestry research organisations, could take the general responsibility for creating such a data-base. The data-base project could be divided into sub-projects according to 3-4 geographical areas. Besides FAO, data for some regions could be collected by suitable research institutes, such as CIFOR and EFI, under contract with FAO.

References

[1] Agricultural Research Centres. 1988. A world directory of organizations and programmes. Ninth edition. Vol. 1 and 2. Longman Group UK Limited. 1065 p.

[2] Alestalo, M. 1991. Science and the Polito-Economic System. Social change, transformation of political structures, and the social value of science. Publications of the Academy of Finland 2/91. Helsinki. 96 p.

[3] Bengston, D.N. & Gregersen, H.M. 1984. An Assessment of Factors Affecting Forestry Research Capacity in IUFRO Member Institutions. Proceedings of the XVIII IUFRO World Congress. S4.05-05 Valuation of Forestry Research. Ljubljana, Yugoslavia.

[4] Boyd, R.G. & Hyde, W.F. 1989. Forestry Sector Intervention. The impacts of public regulation on social welfare. Iowa State University Press/Ames, Iowa. 295 p.

[5] Cubbage, F.W. 1989. Timber Harvesting. In: Ellefson, P.V. (ed.). Forest Resource Economics and Policy Research. Strategic Directions for the Future. Westview Press, San Francisco & London. p. 193-208.

[6] Dasgupta, P. 1990. The Economics of Parallel Research. In Hahn, F. (ed.): The Economics of Missing Markets, Information and Games. Clarendon Press, London.

[7] Dasgupta, P. & Stiglitz, J.E. 1980. Industrial structure and the nature of innovative activity. Economic Journal 90:266-293.

[8] Dasgupta, P. & Stiglitz, J.E. 1980. Uncertainty, industrial structure and the speed of R&D. Bell Journal of Economics 11:1-28.

[9] Dasgupta, P. & Maskin, E. 1987. The simple economics of research portfolios. Economic Journal 97:581-595.

[10] Eriksson, L., Lacaze, J.F., Noack, D., Pardos, J.-A. and Seoane, I. (eds.) 1994. Inventory of Scientific and Technical Research Resources in Forestry, Wood and Wood-Based Products, Pulp and Paper. Report EUR 15922 EN. European Commission, Cost ad-hoc Technical Committee, Forests and Forestry Products. 313 p.

[11] FAO. 1986. World compendium of forestry and forest products research institutions. FAO Forestry Paper 71. Rome. 613 p.

[12] FAO. 1993. Directory of Forestry Research Organizations. FAO Forestry Paper 109.

[13] Freeman, C. 1988. Innovation. In: Eatwell, J., Milgate, M. & Newmand, P. (ed.): The new Palmgrave. A dictionary of economics. Vol. 2. The MacMillan Press Ltd. London. P. 858-860.

[14] Grayson, A.J. 1993. Private Forestry Policy in Western Europe. CAB International. Short Run Press Ltd, Exeter. 329 p.

[15] Hellström, E. 1995. Patterns and Policies of Research Funding in the Forest Sector.

A comparative study between Finland and Norway. European Forest Institute Research Report 4.

[16] Hellström, E. & Palo, M. 1994. Forestry Research in Europe: The Roles of Public and Private Funding. Proceedings of the IUFRO subject group S6.06 Symposium on the management of forest research in September 1994 in Cape Town, South Africa. Vol. 1. P. 14-34.

[17] Hellström, E. & Palo, M. 1995. Public and Private Funding of Forestry Research in Europe. In: The Role of the Private Sector in Forestry Research. Food and Agriculture Organization of the United Nations (FAO), Rome, 1995, p. 5-71.

[18] Hellström, E. & Palo, M. 1995. Theoretical Framework of Research Funding.

[19] Hellström, E. & Palo, M. 1995. Public and Private Forestry Research in Europe. Forthcoming in the Journal of Forest Economics No. 3. 16 p.

[20] Hyde, W.F. 1984. Some Preliminary Experiences in Forestry Research Evaluation in the United States. Proceedings of the IUFRO World Conference held in Thessaloniki, Greece in August 1984. Vol. 1. p. 187-200.

[21] Hyde, W.F. 1986. Gains from Public Forestry Research: Methods and case studies in biological forestry and forest utilization. Proceedings of the XVIII IUFRO World Congress S4-05-05. Valuation of Forestry Research. Ljulbljana, Yugoslavia, September 1986.

[22] Hyde, W.F., Newmann, D.H. & Seldon, B.J. 1992. The Economic Benefits of Forestry Research. Iowa State University Press, Ames. 249 p.

[23] Katz, M. & Shapiro, C. 1987. R&D rivalry with licencing or imitation. American Economic Review 77:402-420.

[24] KTM. 1993. Kansallinen teollisuusstrategia. (A National Strategy for the Industry. Published in Finnish by the Ministry of Trade and Industry of Finland.) Kauppa- ja teollisuusministeriön julkaisuja 1/1993. 156 p.

[25] Leslie, A.J. 1995. Private Research in Forestry in New Zealand and Australia. In: The Role of the Private Sector in Forestry Research. Food and Agriculture Organization of the United Nations (FAO), Rome, 1995, p. 145-160.

[26] Palo, M. 1994. From Deforestation into Sustainable Forestry: A transition based on markets and policies. Scandinavian Forest Economics. No. 35, 1994. P. 391-397.

[27] Runge, C.F. 1983. Balancing Public and Private Sector Forestry Research: Rationale and Plan of Study. In: Hyde, W.F. (ed.). Economic Evaluation of Investments in Forestry Research. p. 68-85.

[28] Schumpeter, J.A. 1942. Capitalism, socialism and democracy. Harper, New York.

[29] UN-ECE/FAO. 1992. The Forest Resources of the Temperate Zones. Main Findings of the UN-ECE/FAO 1990 Forest Resource Assesment. Rome. 32 p.

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