



EUROPEAN FORESTRY RESEARCH — PUBLIC AND PRIVATE INVOLVEMENT E. HELLSTRÖM & M. PALO*

ABSTRACT

This review identifies theoretical criteria for both private and public funding of forestry research, and compares the presented theory with empirical findings from a survey of European forestry research organizations. In most situations, these criteria favour public funding of forestry research. As a European average, approximately only 9 % of forestry research is conducted at private institutes, 40 % at universities, and 51 % at other public research organizations. Thus, the findings give strong support for the presented theoretical criteria. Accordingly, instead of privatization policies adopted by many countries, the findings of this survey support the adaptation of a new policy strategy of active argumentation on the behalf of public funding of most forestry research.

Keywords: Europe, forestry, funding, private, public, research.



INTRODUCTION

Since the early 1980s, the question of public spending has been an essential object of political debate in most industrialized countries. Increasingly in recent years, many governments have reduced public research funding and sought for more systematic criteria and procedures for decisions on research priorities. As a result of such policies, universities and public research institutes in many countries have been forced to seek increasing collaboration with the private sector. Under the prevailing economic recession also forestry research has faced the pressure of reducing public funding. However, differences and even trends between individual countries are considerable.

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The paper was initially presented at the Symposium on the Management of Forest Research, IUFRO, Subject Group of S6.06 in Cape Town, South Africa in September 1994. This paper is a review of a research report on "Public and Private Funding of Forestry Research in Europe" by Eeva Hellström and Matti Palo. The research was carried out at European Forest Institute in Joensuu, Finland. It was initiated and funded by FAO and is expected to be published in FAO Forestry Papers during 1995.

The process of increasing private funding has been criticized by scientists for leading to increasing client dependency and privacy of the research results, and to decreased freedom and objectivity of research. Traditionally, research results are published for criticism, comments, and discussion by the relevant science community. This process has been considered the only valid one in evaluating the credibility of research results. Mostly, research results produced with public funding are publicly available as collective goods, which has made the described validation process possible.

Reduced research funding not only affects the amount and orientation of research, but also its scientific standard, as decreased funds force research organizations to reduce spending, for example, for the acquisition of scientific publications and equipment. Worries have also been presented that strategic planning and targeting, as well as the demand for increased efficiency, have resulted in over-centralization of decision-making in science. In fact, too much steering of science might add to the costs of bureaucracy (Irvine *et al.*, 1990).

This paper presents a review of a study (Hellström & Palo, 1995a;1995b) which was conducted at the European Forest Institute under an agreement with FAO (The Food and Agricultural Organization of the United Nations). The paper has three research tasks as follows. First, hypotheses based on economic theory will be formulated in order to find out *criteria for a rational division of public and private funding of forestry research*. Further guidance from political and institutional theory will be sought. Secondly, an *empirical survey* will be conducted concerning the organizations conducting forestry research in Europe. Thirdly, it will be analyzed, *to what extent the findings support the presented theories and hypotheses*.

In Europe, we have not found any earlier similar research where the distribution of both public and private research institutes would be charted and used to support theoretical criteria for a rational division of public vs. private research funding. Consequently, the study should be considered as a *pilot study* charting the general distribution of private and public research institutes, and pointing out areas of interest for further investigations.

Research investments have, on many occasions, been examined with a focus on the economic benefits of forestry research, especially in the USA (for example, Hyde *et al.*, 1992). Also, the performance of numerous individual research institutes has been examined. Because of limited funding and schedule, and limitations on the availability of data, no econometric, multi-variable analysis could be conducted, or time series analyzed. Thus, the comparison of productivity of private and public research establishments, as well as the evaluation of research benefits compared to the research inputs, were out of the scope of this study.

THEORETICAL FRAMEWORK

Economic Theory and Private Research Funding

Hyde (1986) has examined criteria for forestry research funding by private enterprises, based on support given to economic theory by an empirical analysis of forestry research organizations. The following presentation is based on Hyde's investigation. In *the regular framework of supply (S) and demand (D) functions* (Figure 1), research breakthroughs cause a decrease in production costs, or a downward shift in the supply function (S_1 to S_2). The market clearing price-quantity relationship shifts from b to d. As a result, greater quantities can be sold at lower prices.

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. The consumer and producer surpluses are presented in Figure 1.

Whether or not producers are willing to invest in research depends also on if their gain is larger than their loss, on the expected period of payoff, and on the expected risk of the investment. Naturally, the gains also have to cover the research and development expenses, as well as a sufficient rate of return.

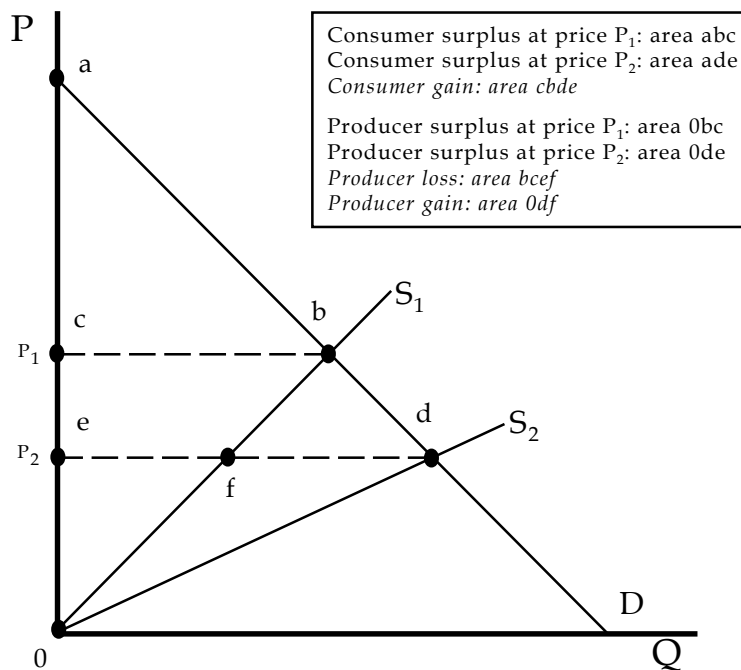


FIGURE 1. CONSUMER AND PRODUCER RETURNS TO RESEARCH

cess, the producers lose the area bcef, but gain 0df. Whether or not the area 0df is greater than the area bcef (producer surplus is positive) depends on the shapes of the demand and supply curves.

The transformation of the supply and demand curves also depends on the structure of the market. Thus, the effect of innovations on the price-quantity relationship is largely dependent on the conditions of competition. Already Schumpeter (1947) introduced the advantages of large scale production and monopoly on innovative performance, and the advantages of competition have continuously been stressed by mainstream neoclassical economic theory. Schumpeter's reasoning rests on the fact 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. Large scale can also facilitate R&D in an industry where the entry barriers of development are high, for example in space, nuclear power or pulp and paper.

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In addition to the forest industry, there exist some highly profitable research investments within traditional forestry. However, research projects may vary greatly with respect to the period of delay until payoff. For example, in such engineering related fields of research as harvesting and transport, research projects have only a short delay until payoff. On the other hand, such biologically orientated fields of research as forest management intensification and tree breeding may require decades of delay until payoff. After a typical biological research project, the new knowledge has to be realized in a growing stock of timber, and only after decades, an eventual expanded harvest can be expected. A substantial degree of uncertainty exists in such research investments, since both the production process and the future markets are difficult to predict (Hyde, 1984).

In the case of tree breeding, the delay until final payoff is connected to the rotation period of the tree species, and varies, therefore, according to the geographical locations. However, with new methodologies in tree breeding, project periods may in some cases be shortened. Still, even after a period of genetic testing, usually the growth of another tree generation is needed until the innovation produces profits at a larger scale.

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 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. The same kind of problem also exists in the fragmented sawmilling and woodworking industries. In fact,

public R&D is theoretically relevant when small firms and competitive markets are prevailing. Accordingly, it is theoretically relevant to maintain strong public R&D in the fields such as forestry and sawmilling under, for example, the Scandinavian conditions. However, already Schumpeter himself recognized the advantages of new small innovative-entrepreneurial firms. Even if the large firms have later on accounted for more than two thirds of R&D and of all innovations the small firms have continued to increase their share of innovations (Freeman, 1988).

Economic Theory and Public Research Funding

The classical economists, such as Adam Smith and Karl Marx, had a deep interest in the relationship between research, technological innovation, and the market. However, J. A. Schumpeter (1947), was the person who introduced more 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 estimated econometrically the effect of technological change on economic growth. They arrived at substantial growth effects by R&D as a residual, which were later somewhat criticized. (Freeman, 1988).

OECD and some other international organizations, as well as a number of national governments, adopted the increase of public R&D as an explicit strategy in the active promotion of economic growth. This paradigm was particularly strong during the 1960s and 1970s. Since the middle of the 1980s Romer (1990) and some other economists have been pioneering in the modeling of economic growth by having R&D as an endogenous factor. According to these results R&D may be regarded among the most important policy means to promote economic growth.

The theory of economic policy, on the other hand, classifies the legitimization for government intervention in the operation of the economy into 1) allocation, 2) distribution, and 3) stabilization (Boyd & Hyde, 1989; Palo, 1994). Public involvement on the ground of allocation has a long tradition in the policies pursued by most governments. The criteria of distribution and stabilization are of more recent origin.

Market failures have traditionally been the economic reason for government intervention in the field 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 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, and by breaking down barriers of entrance to the markets by lowered prices, increased output, and increased productivity (Runge, 1983).

In most European countries, wood growing and also some branches of the forest industry are characterized by a large number of small entrepreneurs. Because small- and medium-sized enterprises generally spend little on research, publicly funded research may be vital for the existence of many small businesses within forestry and the forest industry. This is often emphasized by the fact that only rarely can the findings of forestry research be protected with patents or licences. Furthermore, 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.

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 environment is clearly a public good. For example, forests are in many areas intensively used for outdoor recreation. Water and wildlife are also important products of forests. Forests are an essential habitat for many endangered animals and plants. Forests also sequester carbon dioxide more effectively than 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 (Hyde, 1984). 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 promote stabilization of the economy. In addition, research may assist in producing important strategic plans and programmes for economic stabilization.

Sustainability in research funding is of utmost importance in fields of research where research projects are of long duration. In a survey of 45 forestry research institutions in developed countries, Bengston & Gregersen (1984) found stability of funding from year to year to be nearly as important to the research capacity of the organization as the actual level of funding.

Hypotheses Based on Economic Theory

The shares of public and private funding of R&D are influenced by the interaction of the supply of R&D output (performers of research) and the demand for R&D output (users of research results). This is specified in the form of hypotheses as follows:

A. Supply of R&D Output:

- Positive producer net gain of R&D investments,
- low risk of R&D investments, and
- short time for payoff of R&D investments

tend to give incentive for private funding of R&D.

- Consumer net gain exceeding producer net loss of R&D investments,
- high risk of R&D investments, and
- long time for payoff of R&D investments

tend to give incentive for public funding of R&D.

B. Demand for R&D Output:

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

Constraints to Economic Theory

It is not probable that the existing patterns of funding of forestry research in all cases follow the rationalities presented above. Instead, many ideological, political, cultural, institutional, and in small countries also personal factors, may affect decisions on research funding. Accordingly, the problem of research funding is both theory dependent and also a function of perceptions and power.

On the question of reliance on public and private sectors, national governments are mostly guided by *varying political systems and ideologies, and schools of economic theories and policies*. For a couple of centuries mercantilism advised the governments to favour deep public involvement in running the economy and other matters of state concern. During the last century, liberalism then broke the detailed state control of mercantilism. In the communism and socialism that arose in several European and other countries during this century, priority was again given to the public sector. Meanwhile, in the creation of the welfare state in many other countries, social liberalism allowed government intervention also in fields outside the internal and external security. The keynesian revolution of economics just before and after the Second World War authorized the state again with more responsibility.

The actual prevailing ideologies can be considered as fixed facts to be seriously considered when they are 'in' the political agenda. However, ideological factors affect funding decisions only when they are combined with *political power*. For example, the privatization efforts of, particularly, Ronald Reagan's and Margaret Thatcher's governments were strongly promoted using the rhetorics of monetarism and neoliberalism.

Another example of the effect of political power on research funding is found in France, where the research organization is very centralized, and where the priority of research funding depends heavily on the views of the President and the government. At the time that the German Christian-Democrat-Liberal coalition government, as well as conservative governments elsewhere, sought to cut back publicly funded research and development in order to release resources for other needs, the socialist governments in France actually increased research funding as a weapon against the economic recession. The conservative Chirac government, which took office in 1986, was much less favourably disposed towards R&D. It abolished the Ministry of Research and Technology, and introduced 5–10 per cent cuts in research expenditure in its first budget. However, the re-election of the socialist government in 1988 brought about the immediate increase of 7–8 per cent in the 1989 R&D budget and the re-establishment of the Ministry of Research and Technology (Irvine *et al.*, 1990).

An extreme example of the influence of the political system on research funding is found in the former centrally planned economies of Eastern Europe. In the centrally planned economies, the responsibility for research funding was totally that of the public sector. Even though the political system has dramatically changed in most countries, and eventually there will be increasing private involvement also in some forestry research, there is reason to expect that the basic structure of research funding may be so deeply institutionalized that it is not easily altered.

In addition to attitudes towards science in general, different political ideologies forces may be sympathetic to different fields of research and development.

EMPERICAL SURVEY

Material

In this review, the concept of forestry research consists 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 environmental aspects of forestry was, for practical reasons, included in the study only when it was conducted at research establishments with a permanent forestry input. The same criteria existed also for other forestry related fields of research such as wildlife, agroforestry, and land use.

According to similar principles, industrial production was included in the study only when it was conducted at institutes with a permanent input in forest products research. Research and development conducted within individual enterprises were also, due to missing data, out of the scope of this study.

Periodic data describing national funding levels by individual sources and by fields of study would have been optimal for the study, but such data with European coverage were not readily available. Considering the restrictions in time and resources accorded to this study, it was not possible to send a questionnaire, to gather detailed data from national sources, or to conduct case studies. Thus, the only means available for collecting national data was from libraries. Material used for the study included international directories of forestry research organizations (FAO 1986, 1993; Agricultural ... 1988) as well as forest and science policy related literature. Additional information was collected by a few interviews of representatives of some European countries.

The review covers Europe as it is defined in the FAO directories of forestry research organizations and other FAO publications concerning European forest policy. According to this, countries of the former Soviet Union are excluded, and Israel and Turkey included. Because of the ongoing war in the former Yugoslavia, only Croatia and Slovenia are included in the study. All together, the review covered 29 individual European countries with 205 individual research organizations, and a total of 7,879 researchers.

Findings

According to the directories of forestry research organizations, Poland has clearly the largest research staff. However, since a large amount of research is in Poland done at

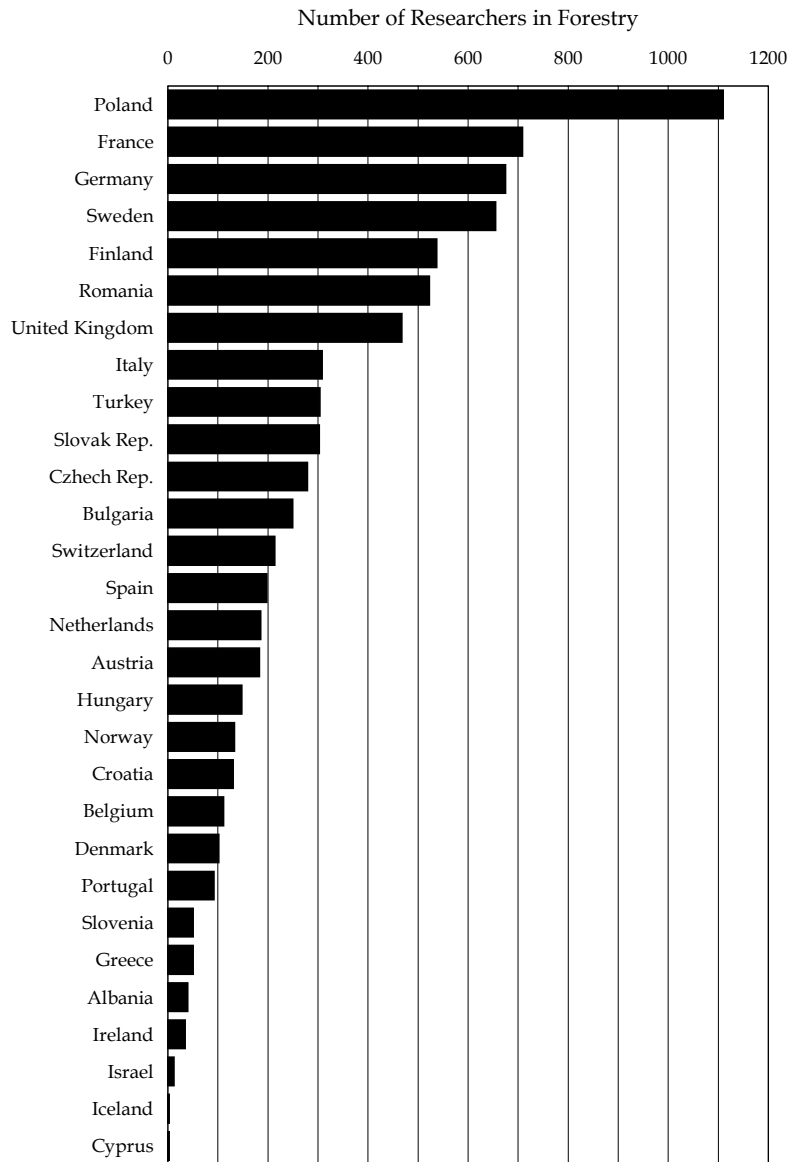


FIGURE 2. NUMBER OF RESEARCHERS IN FORESTRY

The number of graduate research staff in forestry in European countries in 1983–92. Includes also forest products research when conducted in research institutes, but not within firms. (Data from FAO 1986 & 1993 and Agricultural... 1988.)

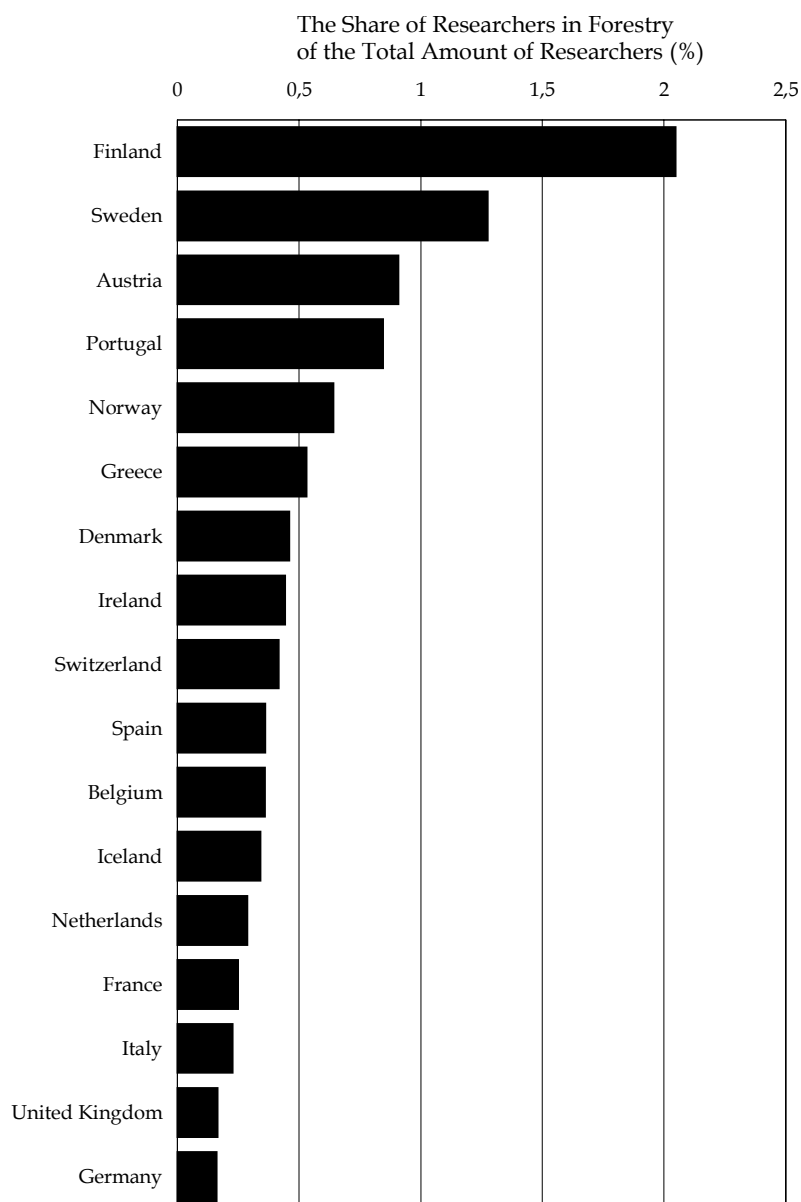


FIGURE 3. SHARE OF RESEARCHERS IN FORESTRY

The share of researchers in forestry of the total amount of researchers in European countries in 1983–92. Includes also forest products research when conducted in research institutes, but not within firms. (Data from FAO 1986 & 1993, Agricultural... 1988 and OECD 1989.)

universities, the personnel resources may be significantly smaller, when measured in man-years (Figure 2). Of the West-European countries, the major economies of France, and Germany, followed by Sweden and Finland, have the largest graduate research staff in forestry.

In the European OECD countries, forestry represents 0.32 per cent of the total graduate staff in research and development. National variations in the status of forestry research in the total research and development sector are great. Countries with a high forest coverage and a rather small population seem to put the most emphasis on forestry research (Finland, Sweden, Austria, Portugal, Norway). On the other hand, countries with the smallest forest resources (Denmark, Ireland, Netherlands, Iceland, and Greece) put more emphasis on forestry research compared to other research fields than the major economies with significant forest resources (Germany, France, Italy) (Figure 3).

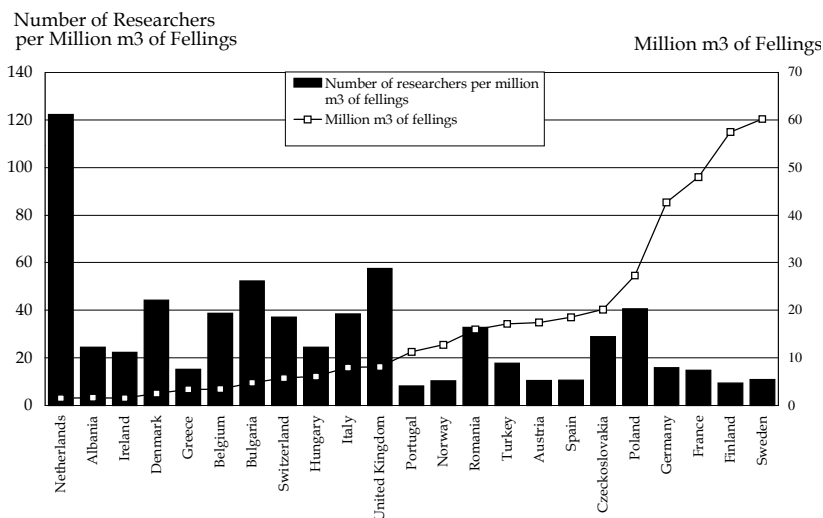


FIGURE 4. NUMBER OF RESEARCHERS PER UNIT OF PRODUCTION

The number of researchers in the forest sector per unit of production (m³ 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 production. (Data from FAO 1986 & 1993, Agricultural... 1988 and UN-ECE/FAO 1992.)

Furthermore, forest resources may have a special existence value in areas where they are scarce (the Netherlands, Denmark, Ireland, Belgium, the United Kingdom).

In Europe as an average, 40 per cent of forestry research is conducted at universities, 49 per cent at public research organizations, and 9 per cent at private research organizations. The type of institute of two per cent of researchers remained unknown. However, most of the organizations marked as unknown are probably public research organizations. The share of researchers in the private sector in the whole of Europe is nearly the same as the sources of funds provided by the private sector presented by another survey (9.6 %, Gregersen, 1984). If only West European countries are taken into consideration, the share of forestry research conducted at private institutions is 15 per cent.

On the basis of the empirical survey, European countries can be divided into five main groups according to the existence and dominance of various sectors of performance in forestry research (Table 1). In the six countries (Sweden, Norway, Finland, Portugal, France, and Austria) forming the *first group* the private sector employs over 20 per cent of the total forestry research staff. The share of researchers employed by the private sector is the highest in Sweden (42 %). This exceptionally high proportion of forestry research conducted at private institutes is mostly due to the joint research efforts of the forest industry in two large research institutes involved with forest products research. Most countries have long traditions in organizing private forestry research, however, all the Portuguese and Spanish private forestry research organizations listed in the directories have been established in the 1980s. Because the researchers within the university sector are not included in the Portuguese figures, the figures give a slight overestimation of the situation.

Also in most other Western European countries, the private sector is involved with forestry research. The *second group* (Table 1) consists of a variety of countries with a rather small private sector in forestry research. The group is rather heterogenous, consisting of both major and minor economies, and of countries with small and large forest resources. The involvement of the private sector in for-

estry research is underestimated, at least in the Italian data, because of the existence of numerous semi-public research institutes.

The *third group* consists of the three European countries with the smallest forest resources (Cyprus, Iceland, and Israel). In these countries, forestry research is conducted only by public research organizations. These countries all have only one forestry research organization with a very small research staff (3–4 graduates), and a limited scope of activity, concentrating mainly on tree improvement and silviculture. Another common feature to these countries is that forestry research was started at a research division of the national forestry authority. However, in Israel, the research activity was later transferred to a ministry dependent agricultural research organization.

The *fourth group* consists of all other West European countries (Greece and Ireland) where no researchers in forestry are employed by the private sector. In addition to small forest resources, a common feature that might explain the organizational model of these countries, is the small proportion of privately owned forests (17% in Greece and 22% in Ireland). In fact, all other Western European countries have proportionately more private forests than Greece and Ireland.

The *fifth group* comprises countries of Eastern Europe. In these countries forestry research is conducted at both universities and national research institutes. In the long run there might be expected changes within this group, as state involvement in the former centrally planned economies decreases. The picture may also change because of the new states formed by the divisions of the former Czechoslovakian and Yugoslavian states. In the division processes, research institutes cannot be equally divided between nations. Therefore, organizational changes and changes in research priorities may also occur.

In forestry research, the *international sector* is very limited, consisting of only two individual institutes (the European Forest Institute in Finland and the Hamburg Institut für Weltforstwirtschaft in Germany). These institutes are not included in Table 1.

The *educational sector* (universities) is dominant in Swe-

TABLE 1. RESEARCHERS IN FORESTRY

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. (Data from FAO 1986 & 1993 and Agricultural... 1988.)

GROUP	COUNTRY	ORGANISATIONS				Total Number
		Univer- sities %	Public Research Institutes %	Private Research Institutes %	Not known %	
1	Sweden	58	0	42	0	655
	Norway	19	51	30	0	133
	Finland	20	53	27	0	537
	Portugal	0	73	27	0	92
	Austria	31	46	23	0	183
2	United Kingdom	33	52	15	0	468
	Denmark	36	50	14	0	102
	France	24	70	6	0	709
	Germany	39	40	5	16	675
	Netherlands	39	52	4	5	186
	Spain	64	17	4	15	198
	Belgium	58	21	3	18	112
	Italy	38	61	1	0	308
	Switzerland	28	67	1	4	214
3	Iceland	0	100	0	0	3
	Cyprus	0	100	0	0	3
	Israel	0	100	0	0	12
4	Ireland	8	92	0	0	35
	Greece	16	84	0	0	51
5	Romania	16	84	0	0	523
	Slovenia	33	67	0	0	51
	Poland	42	58	0	0	1110
	Slovak Rep.	50	50	0	0	303
	Turkey	57	43	0	0	304
	Albania	60	40	0	0	40
	Czhech Rep.	63	37	0	0	279
	Bulgaria	64	36	0	0	249
	Croatia	73	27	0	0	131
	Hungary	78	22	0	0	148

den, Spain, and Belgium. In Ireland, Greece, Norway, and Finland, the educational sector employs the smallest proportion of forestry research staff (less than 20%). In Portugal the share of the universities was not known.

In Table 1, the different types of public research organizations are not separated. Yet, a few remarks can be made about national differences in the *public sector*. In the United Kingdom, the most dominant form of public forestry research organizations is that of the forest authority. In Germany, most forestry research is conducted not at the federal but at the state level. Considerable regional decentralizations also seem to exist in Italy and Spain.

Forestry research in the *private sector* is, in most countries, dominated by the forest industry. Still, such traditionally publicly financed research fields as tree breeding, environment and land use, energy production, and other traditional forestry aspects, are investigated by private institutions. According to the directories of agricultural and forestry research organizations, there are 37 private forestry or forest products research organizations in Europe. There is great variation among the organizational status of the private research institutes. Such forms of ownership are represented as associations, trusts, foundations, societies, research councils, and companies. Some institutions are wholly financed by private funds, but some receive public financial support on a regular or irregular basis as well.

Theory vs. Empirical Evidence

According to the theoretical review, private investment in forestry research is likely only in a situation where the expected gains of the innovations are greater than the expected losses caused by the shifting price-quantity relationship. Thus, the profitability of research depends mostly on the elasticity of the demand and supply curves of the products. In addition, the possibility to protect innovations with patents is also reflected in the willingness to invest in research.

In the case of the *forest products industry*, it could be theoretically expected that private research within the fragmented sawmill industry would not be profitable. In the furniture and wood working industry private research investments would be profitable for joint research efforts, but

not for single enterprises. In the capital intensive and concentrated pulp and paper industry, private research would be profitable for even single enterprises (Hyde, 1984, 1986). The empirical data gave general support for these inferences, even though some national variations exist.

In the theoretical review, two major aspects were found that support private involvement in *traditional forestry research*: a short delay until payoff of investment and a small risk in investment. For most biological forestry research, these conditions are not fulfilled. However, investments in forest management intensification techniques, such as fertilization and drainage, can produce gains in a shorter time span than most other biological research. Because forest management intensification is investigated in the same institutes as other biological forestry research, the general funding pattern of such research could not be separated from the general funding pattern of the organizations.

Tree breeding is investigated only at five private research organizations in Europe. However, a clear geographical pattern can be found in the funding pattern of the organizations practising tree breeding. As the rotation periods become shorter moving from the north to the south, the delay until payoff of the research investment also becomes shorter and the share of private institutes seems to increase.

Another important factor affecting the existence of the private sector within biological forestry research is forest ownership pattern. Generally, forest owners cannot be anticipated to finance forestry research except in the case of very large forest holdings, such as within the forest industry in Portugal.

In the case of engineering related harvesting and transport, the delay until payoff is even shorter, 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. For example, in Denmark harvesting is mostly conducted by owners of small forest holdings, who also finance an institute conducting research in harvesting through a strong forest owner union. In Finland and Sweden, on the other hand, 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.

Despite the profitability of research investment in harvesting, only a few private institutes have been established in Europe. Probably, in most countries, private funding of harvesting related research does not have a regular basis, but is focused on contract research on individual projects. Cabbage (1989) 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.

According to the findings presented above, *the following conditions were found 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 (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).

The described dominance of the public sector is not a coincidence. Despite a clear need and the existence of private forestry research organizations in some well-defined research areas, there remains a wide range of *aspects that favour public funding* of most forestry research:

- obstacles for private funding;
 - low financial rate of return of R&D investment (most environmental aspects),
 - long delay and high risk of R&D investment (e.g. tree breeding),
 - fragmented forest products industry,
 - large share of publicly owned forests,
 - large number of small private forest holdings, and
 - imperfect juridical infrastructure (patent system, property markets, etc.);
- missing markets for research results,

- positive external effects in the form of innovations,
- forest environment is a public good,
- positive distributive effects in favour of rural areas,
- stabilization of an economy in recession, and
- sustainability of R&D funding — scientific standard.

Considering the criteria presented above, a surprising finding in the survey was the existence of private organizations involved with biological forestry aspects traditionally considered, in many countries, as fields of public responsibility. The backgrounds and orientation of these organizations vary greatly. Most organizations exist in the form of foundations, trusts or societies, even though a few companies with industrial backgrounds were found. Some organizations are private for historical reasons, but a wholly new development was detectable from the mid 1980s, as seven new private forestry research institutes involved with biological and especially environmental aspects of forestry were established. This development reflects an increasing concern from the private sector (including the forest industry) in research areas of primarily public concern. Even though private involvement in biological forestry research has increased, such institutions represent a very marginal share of forestry research and can only be expected to supplement and not to substitute existing public research activities.

It can be argued that the forest industry will have an increased interest in environmentally orientated forestry research, as their customers demand more information and guarantees on the environmentally acceptable origin of the raw materials. However, if a growing interest appears from the private sector in financing such research, for credibility reasons, it is more likely to be conducted at independent public research organizations.

DISCUSSION

Implementation and Reliability

The first research task was the formation of a relevant theoretical framework. It was composed of elements of economic and political theories. The principles of economic

theory were used to create hypotheses for a rational division of private and public funding of forestry research. A rather similar economic approach has been used, for example, by Runge (1983) in his research plan for a study on balancing public and private sector forestry research. Despite some deficiencies of the presented theories, the support given to them by the empirical survey, as described above, suggests that the chosen theoretical framework is relevant for the investigation of the problem of funding of forestry research, even though it may not cover all sources of variations of funding of forestry research.

The second task of the survey was to conduct an empirical survey concerning the organizations involved with forestry research in Europe. The data collected for the empirical survey contains three major deficiencies. First, the empirical study focuses on the sector of performance rather than the source of funds. Secondly, the number of staff is used as an indicator of financial resources, with some limitations to be kept in mind. Difficulties arise particularly from the calculation of the full-time equivalent researchers, or the number of the man-years devoted to R&D. However, the number of personnel is a measure of national R&D efforts with the advantage of not being complicated by changes in currency values internationally and over time. Thirdly, research and development conducted at the research units of individual industrial enterprises was not included in the survey. Therefore, it is probable that private research and development efforts may be underestimated in countries with a large forest industry.

Three important questions were to be answered on the basis of the empirical data. First, it was to be discovered to what extent nations vary in the level and trends of support for forestry research. Figures for the actual sums of research expenditure were not available, but by using the number of researchers, a general level of the activities of both the private and public sector in each country could be described. However, the limited data did not make it possible to form any general conclusions on the general trend of funding of forestry research. Secondly, it was to be examined what role does the private sector have in forestry research in Europe. The share of the private sector research organizations in each country, as well as the research

orientations of all private research organizations, could be identified in the survey.

However, the role of single enterprises in forestry research, which was out of the scope of this study, was not discussed. Yet, it might play an important role in some countries. In Finland, for example, nearly 80 per cent of R&D within pulp and paper making is conducted within research units of individual enterprises. In the mechanical wood processing industry, the parallel figure is about 40 per cent. Due to this fact, the shares of private R&D are underestimated in this survey especially in countries with a large forest industry. The third question to be answered in the empirical survey was, if some nations place more emphasis to particular funding mechanisms than others. The information available on funding structures was rather limited for several countries, which is why more emphasis was put on organizational structures than on actual funding patterns.

The third research task of this study was to analyze to what extent the national findings support the presented hypotheses and theories. Generally, the findings of the empirical survey support the hypotheses presented on the basis of economic theory. However, as anticipated, national variations caused by political, institutional, and personal factors are significant (for country descriptions, see Hellström & Palo, 1995a). Due to the inadequacy of empirical data no proper econometric modeling was feasible in the empirical testing of our hypotheses. Consequently our results have a character of pilot findings.

A further question of interest is whether or not these results are comparable to results found in other research. To our knowledge, this review is the first one where the criteria for both public and private funding of forestry research are discussed on a basis of political and economic theories in Europe. However, research activity on the economic questions of forestry research has already been initiated in the United States, since science budgets were squeezed during the Reagan government (for example Runge, 1983; Hyde, 1984, 1986; Hyde *et al.*, 1992). However, the U.S. experiences are only partially transferable to the European conditions. In the case of forest industries with large markets, transferability is better than in the case

of traditional forestry research, where the conditions of individual countries play an important role in research investment.

Policy Recommendations

If research activities are, despite increasing pressures to cut funding, pursued as usual, research budgets will, most likely, eventually be cut, and as a consequence, research outputs will decrease. We have not found support from theory that decreased public funding of most forestry research would be compensated by increased private funding in the respective fields of research. Mostly, the industry invests a particular share of its budget into research. During an economic recession, this share is more likely to decrease than increase. Also, many private foundations finance their research grants with interest from investments. During an economic recession, there is no possibility to increase such income.

Reduced funding affects the productivity of research in a number of ways, most of which affect the capacity of the research organization, even after a 'normal' level of funding is reached again. 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. For obvious reasons, long-term sustainability of research funding cannot be provided by the private sector.

In this section, *two main strategies for research leaders are presented* for situations where there exists pressures to cut back on public research appropriations. These strategies are not exclusive of each other, but could also be pursued simultaneously.

The first strategy consists of efforts aimed at *increased productivity of research*. The strategy is based on the idea that the amount of innovations could be increased, even in situations where additional funding for research is not available. Two factors especially affect the amount of innovations: the input in the search for innovations, and learning (Figure 5).

There are several ways to increase the *search for innovations* without increasing R&D funding. Increasing interac-

tion between public and private R&D, institutions as well as education, training and extension services is one cost-efficient way of promoting the research for innovations. Also increased competition for research funds may activate the science community, when introduced at a reasonable scale. However, too much reliance on either 'hard funding' or grant funding may be obstacles to productive science.

Increased contract research, especially when received from the private sector, may also have undesired effects on research orientation and the publicity of research results. Research productivity can also be increased by changing emphasis of funding decisions *from an ex ante assessment of potential to an ex post evaluation of achieved research results*. 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 lower research units. Such delegation not only makes the use of funds more efficient, but also motivates the research staff.

The other component of innovation production is *learning by doing*, which 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 5). This component of the innovation system has been particularly weak in forestry where only rarely in Europe the forest owners are entrepreneurs receiving most of their income from forestry.

Recently, in many countries investment decisions on research and development have mostly been based on the funds available from the state treasuries. One factor, which has enabled severe cuts in public funding of forestry research, and which has kept the science community relatively tolerant of the situation, has been the lack of well-organized interest groups speaking in favour of research investments in forestry. Accordingly, the second proposed strategy is that *pressures for decreased funding are confronted with active debates on behalf of sustained or even increased funding of forestry research*. The criteria for public and private funding presented in the previous section could form an important basis for such argumentation. The idea behind the second strategy is that *R&D in forestry has to be regarded as one of several instruments of forest policy*. The criteria set

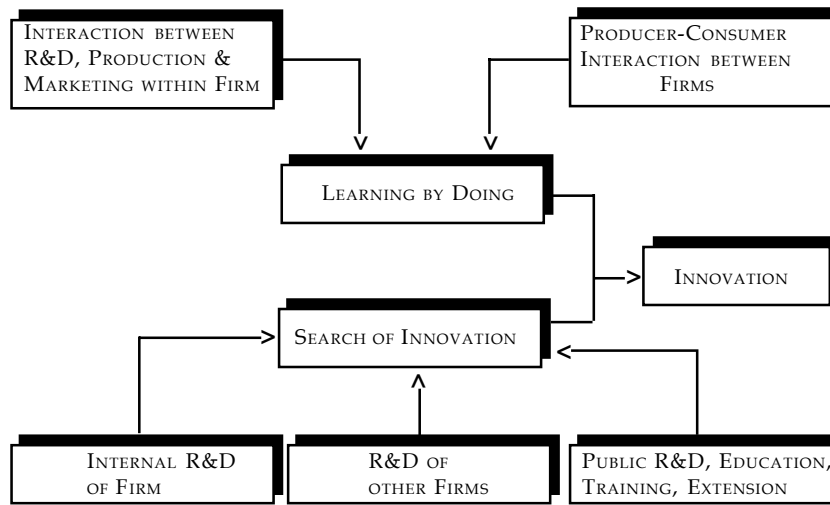


FIGURE 5. THE INNOVATION MODEL (KTM 1993)

for private and public funding of forestry research could then be considered as the primary criteria for balancing investment in R&D with investments in other instruments of forest policy.

For example, in an economic recession, instead of regarding R&D as an expense, it could be considered as one policy measure for stabilization of the economy. Investment in R&D directly creates some additional employment. In the long-range, research inputs produce necessary information and even strategies economic growth and indirect employment. The strategies of the French, Danish, and Dutch science policies of investing in research and development provide examples that could be taken into consideration in other economies as well.

Another example is based on the need to solve expanding environmental problems. The new international commitments signed at the UNCED Congress in Rio de Janeiro in 1992 and at the Ministerial Conference on the Protection of Forests in Europe held in Helsinki in 1993, emphasize the environmental values attached to forestry. Accordingly, the scope of forestry research is expanded with an important new field of study — forests and the environment. Also in this sense, increased research inputs in environmentally oriented forestry research should be considered as one important instrument of forest and environmental policies.

Further Studies

The empirical survey of European forestry research organizations pointed out the substantial lack of data on investment in forestry research in Europe. This is why the most recent developments in funding of forestry research, which in many countries include the most severe cuts in public funding, could not be presented, nor could the effects of the funding patterns be evaluated. For a deeper understanding of the role of funding patterns in forestry research, a comparative study between Finland and Norway was conducted in 1994 (Hellström, 1995). The purpose of the study was to produce information on the *causes and effects of different funding patterns on forestry research*, in order to guide the funding decisions of policy makers and research leaders in forestry. For the study, three research problems were identified:

1. to describe recent developments of funding of forestry research,
2. to evaluate the influence of both economic and institutional factors on the share of public vs. private funding, and
3. to evaluate the effect of the funding pattern on the performance of research organizations.

The comparison of Finland and Norway was found interesting for a further study because of the important roles of the private sector and forest products research in both countries despite different science policies. The European survey pointed out also other countries of special interest for further investigations. For example, Italy was found interesting for the high share of semi-public research institutes, France for the centralized 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. These countries, as well as others are encouraged to continue corresponding research efforts in the field of research funding. Such information would be of value to research leaders and policy makers, and could be used to support a policy of sustainable productivity of forestry research. Also in countries with adequate empirical data econometric analysis would be recommended.

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