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EXPERTISE AND RESEARCH ACTIVITIES AT THE METLA

This paper provides some basic information about expertise and research projects at the Finnish Forest Research Institute (Metla), collected, firstly, with the help of information published at the institute's website by participating researchers, and, secondly, using research reports, summaries and research plans compiled or collected by the author.
The studies concern the Finnish innovative system and innovation performance of the Finnish woodworking industry, co-operation activities of Finnish SME's in the sawmilling and wood construction industries, process and wood product innovations, horizontal cooperation in forestry and organizational innovations in timber procurement and forestry services, innovative techniques that support horizontal cooperation of NIPF-owners in forest management planning. The paper provides some suggestions for developing future research projects.
JEL: O32, L23, Q23

1. RESEARCH ON THE INNOVATION SYSTEM AND INNOVATION PERFORMANCE[2]

The expertise on the innovation system and innovation performance at the Finnish Forest Research Institute (Metla) concerns innovation activities in the Finnish woodworking industry and the characteristics of the sector innovation system. The main topics are as follow:

1. Innovation Performance and Sector Patterns of Innovation

Here the paper investigates the question of why firms succeed in a varying degree to create new competencies and identifies the structural feartures explaining the sector patterns of innovation. The theoretical framework to be adopted is located within the context of the resource-based theory of business strategy.
The suggested study describes the innovation activities of the industry in terms of innovation inputs and outputs and the characteristics of the innovation system in terms of:

- number of innovations commercialized;
- degree of novelty of new products (new to the firm, new to the market);
- degree of complexity and knowledge intensity of new producs;
- sector usage of new products;
- new process technologies;

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- nature of innovations (incremental, radical, modular, architectural innovations);
- R&D intensity;
- customer-orientedness of innovation activity;
- organisational patterns of innovation activity;
- firms' incentive for innovations;
- sources of innovations (exploration, exploitation).

2. *Structural Characteristics of Organisations and Their Relationship to Organisational Innovativeness*

Here, the research makes an effort to reveal structural characteristics associated to the organisational innovativeness of firms. Initially an appropriate and measurable concept of innovativeness for SME's in the woodworking sector is designed.
The suggested study deals with organisational and managerial structures and their relationship to innovative activity of the industry.

3. *(New) Industry Characteristics and Their Relationship to Innovative Activity as a Basis for Policy Suggestions*

Here, the aim is to analyze the present situation of the industry with respect to innovative activity and its determinants. The research will provide information necessary for the working-out of policy suggestions to improve innovativeness in the woodworking industry. Opportunities for innovation can be created and the implementation of innovative solutions of an industry (innovativeness) can be improved by policies which attend to:

- improve the creation of technological opportunities by supporting basic research and by creating demand for new products and processes;
- improve the investor's return on investment in innovation by improving appropriability conditions;
- lower the risk of investment in innovation;
- improve the absorptive capacity of firms;
- improve economies of scale in knowledge-creation;
- improve the scale of operations by managing innovations (networking);
- support the diffusion of knowledge;
- improve availability of financial and physical resources.

3.1. The Sources of Technological Opportunities

The government contributes to new technological opportunities by reducing cost of innovation by conducting and subsidizing research activities and disseminating technological knowledge. The contribution of government activities to technological opportunities differs across industries and within the same industry also across countries. The government may contribute to the technological opportunities of firms in a varying degree depending on characteristics of the firms, such as size or technology. Other important sources of technological opportunities external to the firm are upstream suppliers of materials and equipment, downstream users of the firm's output, universities and private service providers. Closeness to sources of technical knowledge external to the industry were found to explain substantially the innovative activity of an industry.
The studies suggested:

1. Survey study of the sources of technical knowledge which determine the technological opportunities of the industry.
   - interview, questionnaire
2. Regression study of technological opportunities as a determinant of innovative activity of the industry.
   - regressing innovative activity on variables measuring technological opportunities;
   - measures inter-firm, inter-industry and intra-industry differences in the role of technological opportunities as a determinant of innovative activity, in case of the latter between groups determined by size or technology;
   - uses cross-sectional data.

3.2. Appropriability Conditions of Innovative Activity and Performance of Industry

By their influence on spillovers, appropriability conditions indirectly affect the efficiency of the firm's innovative activity. Appropriability conditions are a key factor for the amount of innovation in an industry. The more of the return to her investment in innovative activities the innovator can appropriate, the more he invests in innovation. Firms typically protect the profits due to invention with a range of mechanisms, including patents, secrecy, lead time advantages and the use of complementary marketing and manufacturing capabilities. Spillovers from intraindustry or extraindustry sources such as government agencies or universities may improve the efficiency of the firm's innovative activity by improving the technological opportunities of a recipient firm.

Spillovers as the result of imperfect appropriability conditions affect also the incentive of the firm to engage in innovative activity. Intraindustry spillovers may reduce the firm's own innovative efforts in terms of R&D expenditure. Consequentially, they may also reduce the willingness to participate in innovative activities executed in cooperation with government agencies. The recipient firm of spillovers may reduce its innovative efforts to achieve a given level of innovative performance or it may increase its innovative efforts to invest in its absorptive capacity. Slackening appropriability conditions, i.e. increasing the ease of imitation, may raise the imitative R&D expenditures of the industry but reduce the innovative R&D expenditures of the industry. The net effect of the appropriability conditions on the incentive to engage in innovative activities is therefore a priori indeterminable and may be specific to an industry.

Studies suggested:

1. Survey of the mechanisms used by the industry to protect inventions.
2. The effect of appropriability conditions on the innovative activity of the industry.
3. How to develop appropriability conditions to improve innovative activities of the industry.
4. Appropriability conditions and the incentives or disincentives of firms to cooperate with government agencies in their R&D activities.

3.2. Innovative Activity and Complementary Assets

Mostly responsible for low appropriability conditions and subsequent low level of own innovative activities in the case of SMEs are absorptive capacity deficiencies and insufficiency of complementary assets. In many cases, effective legal protection of a new technology is dificult to obtain, and other firms who have better

manufacturing or distribution assets can imitate the innovation. When a technology itself is difficult to protect, the firm must develop alternative barriers to imitation such as specialized manufacturing, a distribution system, or after-sales support. In the case of SMEs' especially difficulties to access funding, a poor understanding of the patent system and the low degree of assistance are suspected to be the reasons for many good ideas not being developed.
Studies suggested:

1. The role of complementary assets as a determinant of the innovative activity of the industry.
2. The role of absorptive capacity as a determinant of the innovative activity of the industry
3. Improving absorptive capacity as a condition to stimulate the innovative activity of the industry.
4. Access to funding as a condition to stimulate the innovative activity of the industry.

2. RESEARCH ON COOPERATION ACTIVITIES OF FINNISH SME'S IN THE SAWMILL AND WOOD CONSTRUCTION INDUSTRIES[3]

The research in this topic in the frame of the work undertaken in the Metla concerns business networks, resource usage, strategy choices and their influence on financial success in SME's in the finnish sawmilling and wood construction industries
Material procurement is an important part of business activities in all wood processing industries, and because of that, the companies of the industry do not have only reciprocal connections but also strong connections to forestry. Knowledge of the needs of the customers using wood in their production would help in finding novel possibilities to create new value in forestry, and support the sustainability of the forest sector.
In Metla two reseach projects with strong links to the issues of vertical cooperation havw started in 2004. In the first one the focus is on Finnish non-integrated sawmills, while in the second one the aim is on Finnish small and medium scaled enterprises (SMEs) operating in the wood construction branch. An important part of the research concerning cooperation in the sawmilling and wood construction businesses is to define the financially successful horizontal and vertical cooperation models, and to have a chance to receive ideas of new, innovative ways of cooperation in the sector.
For sawmills wood is the most critical resource among other tangible and intangible factors of production. Receiving new knowledge of the resource acquirement and

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the role of horizontal and vertical cooperation in different business strategies in Finnish non-integrated sawmills are two of the focus areas of the first research project. The main objective is to study with which strategies Finnish non-integrated sawmills would be able to compete in the rapidly changing environment. This is done by finding out what have been the strategically important resources for Finnish non-integrated sawmills with different strategy options, what strategic choices concerning resource usage and their acquiring have led to better financial results than the others, and what has been the role of horizontal and vertical cooperation in different strategies. In addition, the project provides information of the operations of forest owners and their representatives from their customers' perspective (the wood processing industry). By interviewing the sawmill owners and managers knowledge of the cooperative models between sawmill industry and forestry can be received.

Resource usage and strategy issues in sawmills are mapped using interviews (qualitative data), while financial success is measured by using financial statements that are assessed with the methods of financial analysis (quantitative data) for getting estimates of the profitability, solvency, liquidity, and growth of the interviewed companies. Interconnections between qualitative and quantitative data are analysed statistically, e.g. with cluster analysis.

The second research project concentrates on horizontal and vertical cooperation modes both within the forest-wood-chain and between the forest-wood-chain and other industry branches from the view of SMEs operating in the wood contruction industry. The main objective of the study is to define practical models of business networking, by which the operations of Finnish wood construction SMEs could be developed and their competitiveness and financial performance enhanced. This is done by mapping in what kind of operations these companies cooperate, what is the role of networking in firm-level business strategies, in what kinds of operations firms operate, what kinds of objectives do different cooperative groups have, how the decision-making at firm and network-level is carried out, and how different types of business networking are reflected in firms' financial performance.

Different types of networks are defined by using "The multilateral SME cooperation model" developed by Varamäki and Vesalainen (2003). Issues concerning cooperation and firm-level decision-making are clarified by interviews made to the owners and managers of the companies, while financial information is received from financial statements of the interviewed companies. Financial statements are analysed in order to receive measures of profitability, solvency, liquidity, and growth. The interconnections between qualitative (interviews) and quantitative (financial statements) data are analysed with regression techniques.

3. RESEARCH ON PROCESS AND PRODUCT INNOVATIONS IN FOREST-WOOD CHAIN

Technical Quality, Sorting and Organising the Procurement of Wood Raw Material for the Manufacturing of Special Wood Products[4]

This former project (terminated in 2001) addressed the question of how to organise wood procurement in the forest-wood chain with respect to the requirements of specialised users of wood raw material in the woodworking industries, especially of SME's. The project addressed questions of the technical properties of different wood raw materials and the feasibility of their utilisation in primary, intermediate and further processing of sawn goods and wood products.
Business opportunities offered by the utilisation of selected sources of wood raw material were examined along the forest wood chain including forest producers and forest service providers (roundwood market services, logistical services in roundwood harvesting and transport).
The main tasks were:

1. to provide information about idle domestic sources of wood raw material, their technical characteristics and alternative utilisation potential considered from the view of the technical specification defined for specific consumer wood products;
2. to investigate development needs in roundwood procurement of SME's in the wood-processing industry;
3. to further develop principles and methods in measuring quantity and quality of wood raw material to be used in special wood products.

The wood raw materials and special wood products under investigation were:

- birch (*Betula pendula*) in veneer production;
- birch (*Betula pendula*, B. *pubescens*), alder (*Alnus incana) in special sawn products*;
- peatland Scots pine, Norway spruce and birch (*Betula pendula*) in special sawn products and plywood;
- Southern Finland proveniences of Norway spruce in sawmilling;
- Scots pine and Norway spruce from thinnings in various sawn products and unhewn wood products.

Properties and Utilisation of Domestic Wood Raw Materials in Mechanical Wood Processing[5]

The results of two Wood Wisdom research projects in wood technology carried out at Metla in 1998-2001 as a subproject under the umbrella the project aforementioned are summarised in the following sections. The projects delt with the properties of domestic hardwood (birch, aspen and alder) and Scots pine from first and subsequent thinnings and their utilisation in mechanical wood processing.

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The Finnish Forest Cluster Research Programme WOOD WISDOM (1998–2001) was a multidisciplinary cluster programme co-funded by the National Technology Agency Tekes, Academy of Finland, Ministry of Agriculture and Forestry, and Ministry of Trade and Industry of Finland. The programme combined basic and applied research with R&D targeting specific industrial applications. The aim was to raise the competitiveness of forestry and forest-based and related industries in today's changing operating environment. The focal point of the research was market-driven use of Finnish wood raw material in optimal wood and paper products. The purpose of two projects included in this multidisciplinary research consortium and carried out at Metla was to study the properties, availability and potential of the wood and timber from Finnish hardwoods (birch, aspen and alder) as well as Scots pine from thinnings in mechanical wood processing, both from the view of forestry and industrial processes and end-products. The last report will be published soon.
The projects provide new information about the properties and potential of Finnish hardwoods and pine from thinnings for sawmilling and further processing in Finland. It instructs forest owners about the optimal stand treatment and stand structure. There is new knowledge from experiments about the recovery of sawable logs per tree and sawnwood per log using short length bucking options. The information supports forest owner's decision making concerning the bucking options providing best value yield. The results inform about the mechanical properties of wood (density, knotiness) and how they can be identified from location parameter. The results provide also insight into the geographic variation in availability and quality of Finnish hardwood resources. The investigations yield new information valuable for the sawmilling industry on sawlog recovery, harvesting and transportation methods, sawing techniques and the respective revenues and production cost. The results of experimental studies on sawing and further processing especially by various drying techniques of hardwood lumber are reported. The requirements for high value yield in the mechanical wood processing of hardwoods, e.g. dimension and stem location of components are assessed also.

Utilisation Potential of Small-Sized Scots Pine and Birch Timber as a Raw Material for Engineered Wood Products – a Pre-Feasibility Study[6]

The study was carried out in 2002. It addresses the quantitative availability and technical suitability of specific small-sized roundwood material for construction wood products and evaluates the price competitiveness, market and the financial feasibility of innovative engineered-wood-products. According to the results of the study, domestic small-sized Scots pine and birch timber can be considered competitive on behalf of their technical characteristics as compared to alien species. EWP innovations are expected to improve financial feasiblity compared to established products. Examinations made about the cutting potential confirmed supply to be sustainable.

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Final Report: Small-Diameter Scots Pine and Birch Timber as Raw Materials for Engineered Wood Products. International Journal of Forest Engineering.

Subjects for further research:

- in-detail feasibility study of production for different regional locations;
- R&D requirements for manufacturing technologies;
- market-analysis for Europe and other export markets;
- integrating raw material supply and production into the supply and production chain of other wood-processing industries.

Product Innovations in Wood-Frame and Intermediate Ceiling Building Construction, Competitiveness of Wood Materials and the Socio-Economic Benefits to the Local Community of Wood Compared to Concrete Structures – a Case Study Concerning Metla's New Wooden-Frame Office Building[7]

The study addresses the following tasks:

1. (i) Product innovations used and emerging during the project: pilars, beams and intermediate ceilings, structures; (ii) the innovation process: ideas, testing, practicability, networks; (iii) reasons for choosing wood materials, what were the alternatives; (iv) further utilisation of innovations.
2. Differences in cost and material flows between competing wood and concrete structures and the impact of material consumption and weight of building masses on the process of construction and labor input.
3. Local and regional income and employment impacts of wood-based building construction: (i) origin of purchases of wood materials: local, regional non-regional sources; (ii) associated income and employment impacts; (iii) differences between wood and concrete structures.

The study will utilise life cycle data. It will be implemented in cooperation with the builder, other authorities and contractors participating in the construction project.

Potentials for the Utilisation of Finnish Roundwood and Other Wood Raw Materials in Wood Product Markets[8]

The objectives of this ongoing project is to analyse the possibilities to develop and increase the demand of Finnish wood products. The project involves detailed surveys of consumers, companies and forest owners in the forest-wood products chain. The questions to be investigated are what are the attitudes of consumers and companies towards wood products as well as towards wood in relation to its substitutes, what are the purchasing motives, what are the possibilities to find new geographic market areas and new ways of using for wood products.

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4. RESEARCH ON COOPERATION IN FORESTRY AND THE WOOD WORKING INDUSTRY

Competitiveness of Forestry and the Woodworking Industry[9]

The objective of this ongoing research project is to analyse factors affecting the competitiveness of forestry and the woodworking industry. Legal forms of companies and forms of cooperation are analysed and compared and investigations on economies of scale in production are made. The results will give support to forestry extension and forest policy. They will be helpful as a basis for decisions concerning new legal forms of companies and forest corporations.
There is few information about forestry activities in forest communities, forest corporations and forest co-operatives, although this kind of co-operation between private forest owners have a long tradition. The main focus in forest policy aiming to alleviate the negative impacts of fragmentation of forest ownership have been on regional co-operation in forest operations.
The other fields of research addressed in the project are:

- quality and environmental management;
- forest and forest industry as object of investment;
- investment and financing strategies;
- business planning and monitoring;
- and financing strategies,economic planning;
- the economy of forest regeneration and the economic performance of forest stands;
- strengths and weaknesses of alternative forms of business organisation;
- the profitableness of ownership and management frameworks;
- economies of scale in production.

Comparison of Organisational Forms in Timber Procurement and Analysis of Competitiveness Requirements for Forest Service Providers[10]

These two closely related projects, terminated in 1997 and 2000, payed special attention to the wood supply of SME's in the woodworking industry applying customer-oriented business concepts. In the first project organisational forms in wood procurement were compared. Information was provided about how service costs reflect differences in the size of the business unit, ownership, organisation and the roundwood pricing system. Examinations about the impact of market deregulation on the business performance of transport contracting and the success of different business strategies in the new business environment were made.

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Information was provided about the differences in the form of integration between logging contractors and its impact on business performance and business strategy.
In the second project the competitiveness requirements for forest service providers were analysed. The project addressed the questions how the operations in the roundwood markets of the integrated forest industry companies possibly encumber the raw material supply of SME's, and how important are customer-oriented supply chain management concepts. The project compared the concepts of standwise sale and sale by timber assortment with respect to their ability to provide appropriate wood raw material. The project also gave a portrait of forest service providers, e.g. their sector distribution, number, kind of services produced, clients and future business perspectives. It also looked at the roundwood marketing services provided by the forest owners' forest management associations and their role in the roundwood supply of SME's. Investigations were made to detect differencies in the operational efficiency between forest management associations.

5. RESEARCH ON HORIZONTAL COOPERATION IN SMALL-SCALE NON-INDUSTRIAL PRIVATE FOREST (NIPF) MANAGEMENT

Models, Planning and Decision Support for Multi-Functional Forestry[11]

Optimality of forestry management planning of a single business unity – in the Finnish context NIPF-holdings – is dependent on the production decisions made in business unities located in their spatial proximity. Traditionally horizontal cooperation in forestry management planning aims at sustainability and cost efficiency in timber-production-related decision making. However, new demand for forest-based production of public goods, i.e. environmental, ecological and recreational services, has required a widening scope in joint decision-making in forest management planning.
To be efficient in aiming to produce public goods, market mechanisms should be included as well in decision-making methods. New policy instruments create new options for forest holdings of how to allocate their forest resources to the production of private goods – typically roundwood – and public goods. In the present policy context the production of public goods is subject to the forest owners' autonomous and decentralised decision on how to maximise his private net benefit, where net benefit is the difference between his private opportunity cost and his revenues from compensation payments. Cooperation in the production of public goods is advantageous for single NIPFs, since it creates pronounced scale effects in the production of the new services related to the size, mutual location of stands and the quality of their treatment. However, for implementing cooperative decision-making appropriate multiple-objective decision-making routines and instruments are needed.
At Metla models and management planning devises have been developed to support multi-functional-forestry decision-making. Ongoing research activities focus

[11] *Source: Protection of forest biodiversity in multi-objective forest planning. Summary. Project plan 2005-2009.*
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on methods, techniques and models for tactical and strategic forest management planning with multiple objectives, to be especially applied both at forest holding and area level. Special attention is given to the commensuration of different forest uses and objectives in management planning calculations, multi-objective forestry optimization, producing efficient production programmes in case of multi-functional forestry, applying optimization in group decision support, managing risk and uncertainty, integrating ecological and recreational objectives into multiple criteria comparison of alternative plans, modelling expert knowledge, spatial modelling and spatial optimization, integrating numerical tools into the planning process.
The applicability of the results in practical planning tasks is of great importance, therefore the results are tested and disseminated in close cooperation with forest owners and their representatives. Special attention has been given to the adaptability of planning procedures, methods and tools to be able to respond to the special requests of the planning exercise and the user's learning capacity.
In 2002-2004 Metla participated in a R&D programme called Modern Networked Periphery (MONEP). Activities have targeted on developing and applying innovative IT-technologies to create new business opportunities in four peripheral regions in Eastern Finland. Based on applications utilising an open-access data-base-network Metla headed a pilot project devoted to the development of forest-resource-inventory and forest management planning services to NIPF-owners.