SCANDINAVIAN FOREST ECONOMICS
No. 40, 2004

Proceedings
of the Biennial Meeting of the
Scandinavian Society of Forest Economics
Vantaa, Finland, 12th-15th May, 2004

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Vantaa

This on-line version differs from the printed Proceedings 2004.
Ragnar Jonsson's paper is included in this version, but is missing from the paper copy.

SCANDINAVIAN SOCIETY OF FOREST ECONOMICS

SSFE Board 2002-2004

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BUSINESS ECONOMICS AND FORESTRY & FOREST MANAGEMENT PLANNING
Richard Brazee

FOREST POLICY (INCL. MULTIPLE USE)
Heikki Pajuoja

FOREST INDUSTRY & PRODUCTS' MARKETS
Anne Toppinen and Jussi Uusivuori

TROPICAL AND INTERNATIONAL FORESTRY
Lars Lönnstedt

Scandinavian Forest Economics
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Scandinavian Society of Forest Economics

ISSN 0355-032X

Foreword

This volume contains a collection of the papers presented at the Biennial Meeting of the Scandinavian Society of Forest Economics, May 12-15, 2004 in Järvenpää, Finland. It was a joint event, organised by Finnish Forest Research Institute (Metla), Forest Economics Forum of the Finnish Society of Forest Science and the University of Helsinki.

On behalf of the SSFE I would like to heartly thank our keynote speakers Prof. Darius Adams, Oregon State University and CEO, Dr. Olli Haltia, Infudor Oy, as well as our panelists in the panel session on topic: "Challenges for Forest Economic Research", namely President of IUFRO, Prof. Risto Seppälä, Deputy Director, Prof. Sten Nilsson, IIASA and Dr. Jussi Uusivuori, Metla.

During the meeting a cultural tour at Tuusula Lake was made. It included a visit to Ainola, the home of Jean Sibelius, where we had the possibility to enjoy his music. For research work, as well as for composing, peace is needed for creative endeavours.

The organizers and participants express their sincere appreciations to Samnordisk Skogsforskning for indispensable financial support to the conference. We also thank Dr. Heimo Karppinen and Anne Viljakainen for their efforts in helping to organize the meeting and Sisko Salminen and Essi Puranen for the layout-work of this book.

Vantaa, September 2004

Heikki Pajuoja

Note:
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BUSINESS ECONOMICS AND FORESTRY
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Developing the Business: Logging Contractors' Strategic Choices for Profitability and Work Environment

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Abstract

Logging contractor profits have been reported to decrease substantially in Swedish forestry in later years. During the same period there have been reports on a declining work environment in logging leading to difficult recruitment of personnel. Previous research has shown needs for both business and work environment development in the logging industry. This article continues our efforts at describing and analysing the strategic choices logging contractors make in order to develop or transform their companies to improve profitability and work environment.

We have interviewed logging contractors and other representatives of the logging industry regarding contractor incentives for investing in and developing new products and services as well as existing business activities. We have explored the same themes in seminars with contractors, employed machine operators, and buyers of logging services. The contractor strategies we identify are about creating and appropriating value by utilising the resources of the firm and market possibilities.

Keywords: ergonomics, investment, market possibilities, qualitative research, strategy

Introduction

Outsourcing of logging operations by forest industry and subsequent contracting of logging services has increased drastically in Sweden since the 1970's. Presently, contracting accounts for at least three quarters of the mechanised logging (Synwoldt & Gellerstedt 2003). Contractors are usually very small enterprises; the median firm might have four or five employees. Contractors usually work for forest industry companies or forest owners associations. Profitability in the contracting business used to be good. Nowadays it is frequently claimed to be problematic (Lundberg 2000). Previous research on contractor business development has shown several obstacles to the development of logging contracting into a more profitable business. Logging contractors have a great dependency on their customers, hence the prerequisites for business development is also determined by the contractor's clients. Contractors as well as their customers frequently lack important aspects to their business competence, e.g. negotiation technique and leadership. The low profitability in the logging activity limits the resources available for new efforts and investments (Norin 2002).

Lidén (1995) gave a summary of the logging contractors' situation in Sweden. Having a contracting firm she described as a way of living. The incentive for becoming a contractor often was an aspiration for independence and seeking of a challenge. However, the contractors often regarded the economic situation as problematic, a view which was exacerbated by the one sided dependency on one or very few customers. Pontén (2000), as well, pointed to the problematic economic situation in logging contracting. Norin (2002) explained the dependency of logging contractors upon their customers by an over establishment of contractors, alternatively a lack of alternative customers to the contractors. A well functioning co-operation between customers and contractors seemed to be of great importance for the contractor to be able to satisfy the needs of the customers. Norin also described how negotiations usually were formed on a yearly basis. One problem in the negotiation process was often the role definitions between the negotiators; neither customers nor the contractors themselves regarded the contractors as independent businessmen.

According to Stuart (2003), a contractor-customer interdependency was common in the logging sector around the world, stemming from the previous organisation of logging inside the forest industry organisations. Mäkinen (1997), studying successful logging contractors, applied Porter's model of competitive strategies being dependent on mainly external factors. Focusing on success factors for Finnish forest machine contractors he showed that the most successful contractors had one customer with whom they had had a very long-term relationship – up to twenty years – a sufficient capacity utilisation, and a not too large operating radius. Contractors with more customers or shorter relationships reached lower capacity utilisation and performed worse economically. Prudham (2002) showed that in Oregon, US, two distinct patterns of logging contracting had developed. One pattern consisted of relatively open bidding involving more of an arm length´s relation between the negotiators. The other pattern involved repeated contracting between the same parts over a long period of years. Prudham discussed advantages and disadvantages of both contracting patterns and how both patterns may be in the interest of forest industries as well as contractors.

Ergonomic problems in forest machine work were observed more than twenty years ago (Bostrand 1984). Repetitive and monotonous tasks in the machines have resulted in illness among the machine operators, e.g. acute aches and pains in the neck and shoulder regions. A work organisation permitting greater variation in the tasks performed could increase the productivity as well as decrease the level of occupational diseases (Gellerstedt et al. 1999). Joint initiatives by the Swedish work and health authority and the logging industry focusing on solving the ergonomic problems were presented by Synwoldt & Gellerstedt (2003). However, the possibilities of organising work in a more varied way were seriously limited due to lack of meaningful and profitable complementary occupation and limited economic opportunity for initiatives. Low profitability and a poor work environment were also forwarded as major reasons behind reported difficulties in recruiting new machine operators (Persson et al. 2003). Proper et al. (2004) showed that there might be economy in ergonomic interventions.

The aim of this paper is to continue our exploration of the strategic choices logging contractors make in order to develop and transform their companies to meet the demands on profitability and work environment (cf. e.g. Hultåker & Bohlin 2004). Based on qualitative research we explore contractor strategies for development. We have studied contractor incentives for utilising and developing market possibilities, thus developing and investing in existing business activities as well as new products and services.

Theory

Business development

In economic theory development is closely connected to the concept of entrepreneurship. At least two traditions exist, using the concept in different ways. A unifying factor is the view that development is a dynamic process requiring both entrepreneurship and innovation. In the Schumpeterian tradition (Schumpeter 1926) the concept of entrepreneurship is derived from the technology innovation function. The entrepreneur disturbs existing market equilibria by his innovative activity of introducing new ways of production and new products. Another tradition stems from Kirzner (1993/1973). Kirzner argues that the core issue of entrepreneurship is the discovery of hitherto unexploited opportunities, thus, in contrast to Schumpeter, taking care of market disequilibria. Gick (2002) summarises the perspectives of Schumpeter and Kirzner as being complementary. Kirzner focuses on individual action; Schumpeter focuses on the market process. Both the Kirznerian and the Schumpeterian entrepreneur calls for the firm in order to be able to explain how the entrepreneurial process is connected to the utilisation of resources.

Penrose (1968/1959) introduces the concept of enterprising, thus meaning the attitude to investigate possibilities for development. The enterprising attitude is a character of the growing firm, meaning to commit effort and resources to speculative activity in hope of gain. Being enterprising is a prerequisite for growing in the long run. Penrose presents three explanations why the firm may grow and why there may be limits to the growth of the firm – internal conditions (managerial ability), external conditions (product or factor markets), and combined internal-external (uncertainty and risk). While uncertainty refers to the confidence the entrepreneur has in estimates and expectations risk refers to the outcomes of action.

According to Moran & Ghoshal (1999), there is a mutual dependency between the firm and the market, where the firm is the dynamic element shaping the prerequisites for exchange. Through the exchange process firms and market together bring about adaptive efficiency, thus shaping the prerequisites for innovative activity and contributing to economic development. They state three necessary conditions for deployment of a firm's set of productive opportunities: First, someone must have or have access to all needed resources; second, someone must benefit from the execution of the deployment; and third, someone must see the act of deployment as a viable act anticipating a service.

Strategies

The literature stresses different aspects of business strategies. This is illustrated by Mintzberg (1987a) presenting five different definitions of strategy. (i) As a plan strategies are made in advance and continuously being developed consciously and purposefully. This plan may be general or specific. It deals with how leaders establish direction for organisations. (ii) Strategy may as well be a ploy; i.e. be regarding a single intended activity. The plan or ploy may eventually be realised or not. (iii) Strategy may be described as a pattern, a pattern in a stream of action. This pattern of action emerges into a realised strategy. (iv) The notion of strategy may also be used for the positioning of resources in an environment. In this meaning strategy looks at organisations in their competitive context. (v) Finally, strategy may be used to describe a perspective in perceiving the world. The five definitions of strategy are interrelated and complement each other. Mintzberg (1987b, pp. 28-29) holds that all five notions of strategy are "needed to reduce uncertainty and provide consistency…, in order to aid cognition, to satisfy intrinsic needs for order, and to promote efficiency under conditions of stability…". The aim of strategy is to allow people in an organisation to take some things for granted in dealing with reality. However, effective strategy must not render organisation blind to changes in the environment (Mintzberg 1987b). According to Mintzberg (1994), viable strategies have both emergent and deliberate qualities.

Weick (1987) focuses on substitutes for strategy. The core issue of management, thus, is to encourage action. As Weick poses it, improvisation may have a greater importance in the management of firms than is usually accepted. Often strategy is a construction following the action that has taken place, giving meaning to the preceding action. The management, according to Weick, rests on presumptions and improvisation to a high degree. He thus introduces the notion "just in time strategy". This is not saying that action is stochastic. Both presumptions and improvisation contain order.

Grant (1991) claims that one important aspect of strategy is the deployment of the existing capabilities of the firm; another is the development of the firm's resource base. The competitive advantage of the firm is mostly dependent on the resources that are "…durable, difficult to identify and understand, imperfectly transferable, not easily replicated, and in which the firm possesses clear ownership and control." (Grant 1991, p. 129) Others, as Porter (1980), stress the importance of external factors for gaining competitive advantages. Porter models five factors influencing the state of competition in an industry; competition within the industry, the negotiating strength of suppliers, the negotiating strength of customers, the threat from new establishers, and threat from substitutes. As Moran & Ghoshal (1999) pose it, firm-level strategy is about value appropriation and value creation and they ask how these two requirements might be balanced. They make a differentiation between strategies focusing on competitive advantage and shareholder wealth on one side and the creation of new rent sources on the other. Effective firm-level strategy has to deal with the internal resources of the firm as well as with the external environment. Storey (1997/1994) explicitly uses the notion of strategy about ways to achieve goals once in business.

Firm level goals

The different aspects of strategy, whether deliberate or emergent, all have a connection to action and indicate that action is conscious and directed towards goals. According to Cyert & March (2003/1992), individuals have goals while collectives do not. In the firm, being a coalition of individuals, a goal has to be some shared objective. There is not any need for perfect consistency between different goals at different times or at different places. Penrose (1968/1959) views the firm as a set of more or less unique productive opportunities. She claims that the over all incentive behind growth of the firm is to use the available resources as fully as possible. Snehota (2002/1990) uses the notion of goals or driving forces as the guidance of behaviour. The business activity is the gain achieving entrepreneurial action of exploiting market opportunities through exchange processes. According to Moran & Ghoshal (1999), the goal of the firm seems to be the creation and appropriation of value.

Firm, enterprise, and organisation

The definitions and delimitations of business firms, enterprises, and organisations are not very clear. The use and meaning of the different notions differ between different authors. Cyert & March (2003/1992) start using the concept coalition for organised activity but later tends towards using organisation. Penrose (1968/1959) uses firm throughout. Snehota (2002/1990) explains the concept of organisation, stemming from sociology, as meaning a collective of actors related through joint activities of some members. The concept of firm stems from economics, being an entity with the primary task of transforming inputs into outputs thus creating value. Snehota prefers the concept of business enterprise, thus meaning a pattern of activities with focus on generating market transactions. This is not always in coherence with other authors. However, our intention in this paper is to follow the notion from Snehota.

Formation of an interpretative framework

Our interpretation of the literature is that business development is a dynamic process requiring entrepreneurship and innovation. Without an enterprising attitude the business will not develop in the long run. Strategies are the ways the people forming the coalition of an enterprise act and intend to act in order to achieve the best use of their collective productive opportunities with regard to value appropriation and creation. The acting is guided by objectives operationalised at different levels of detail (Figure 1).

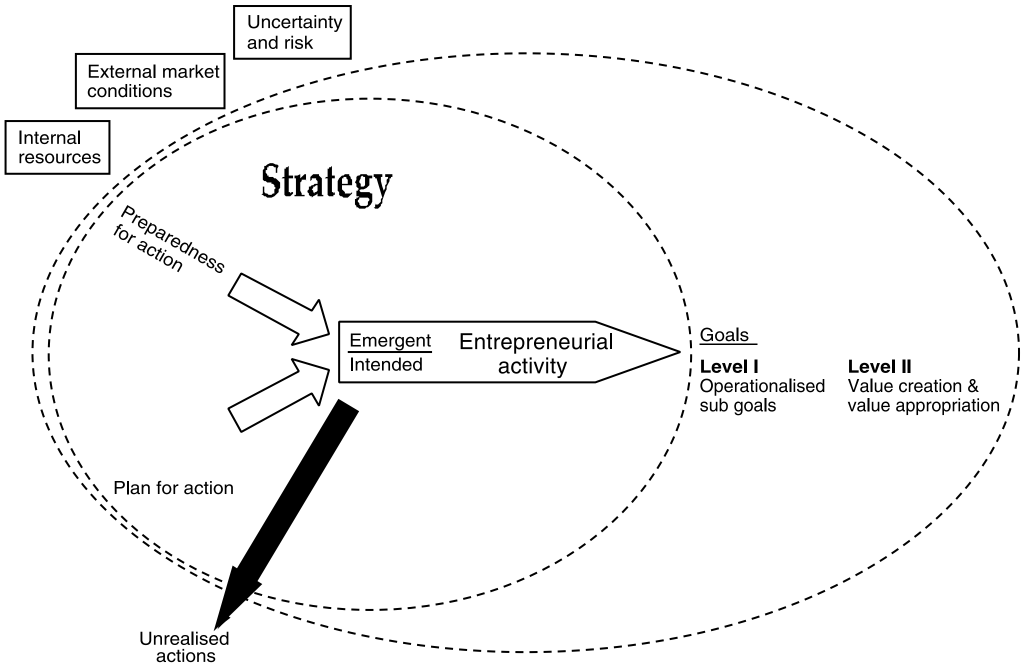

Figure 1. Interpretative framework of the business development process.

Our notion of strategy is built on Mintzberg's (1987a; 1994) ideas on strategy having both deliberate and emergent qualities. Weick (1987) provides a perspective of retrospectivity and makes a clear distinction between strategic planning and management. The strategy concept is merged with notions of business development and entrepreneurship. From Penrose (1968/ 1959) we include three factors behind business development; internal resources, product or factor market conditions, and uncertainty and risk. According to Grant (1991), the competitive advantage is mostly dependent on the resources of the firm. Moran & Ghoshal (1999) give the development activity guidance by formulating the over all goal of value creation and value appropriation. Gick (2002) tells us that there is a need for a firm in order to connect the entrepreneurial activity to resource utilisation.

Essential for the understanding of strategies for business development and the goals of the contractors are the three driving forces behind development of the enterprise: Internal resources and external market conditions as well as the experience of uncertainty and risk. The enterprising attitude becomes manifest in the entrepreneurial action, which is guided by a striving to appropriate and create value by deployment of existing capabilities as well as development of the resource base into beneficial services or products. The strategies may be formal plans of intended action, which may be realised in action or go unrealised. The strategies may as well be of a more emergent quality. However, the emergence of entrepreneurial activity requires some preparedness for action. The preparedness is one manifestation of an enterprising attitude.

Methods and material

With the objective to investigate the potential for diversifying a logging contractor business, interviews were carried out building on traditional qualitative methods in social science, e.g. grounded theory (cf. Strauss & Corbin 2003/1998). The results have been discussed in seminars with participants from different sectors of the forest industry (cf. Gustavsen et al. 2001). Interviews and seminars have been conducted indiscriminately in order to successively form a theoretical framework (cf. Dubois & Gadde 2002).

Interviews

A first set of sixteen interviews was carried out in 2002. Respondents known as successful logging contractors were chosen in order to investigate different contractor characteristics. Customers of logging services were also interviewed as were machine manufacturers and a machine operator (Hultåker et al. 2003). A second set of interviews, three new and eight complementary with previously encountered contractors, was carried out in the summer of 2003. This time, respondents were chosen in order to study different contractor experiences of diversification (Hultåker & Bohlin 2004). A third set of ten interviews was carried out in late autumn of 2003. The main purpose was to study work environment issues. In this set, new respondents were chosen aiming at giving a good representation of different company sizes and different parts of Sweden.

Seminars

In November 2002, a seminar on the diversification of logging business was organised, where decision makers from all three forest sub-sectors participated – 1) logging contractors, 2) representatives of forest companies and industries and forest owners' associations, and 3) forest machine manufacturers (Hultåker et al. 2003). In the spring of 2003, interview results on diversifying businesses were discussed with networks of logging contractors within the forest machine contractors' association in Sweden – Skogsmaskinföretagarna (SMF). This gave the opportunity for contractors to expand upon our ideas for diversification and for us to find out what interest they have in broadening their activities (Hultåker & Bohlin 2004). In February 2004 two more seminars were conducted together with SMF aimed at discussing work organisation and work environment. This time the participants were logging contractors, representatives of forest companies and industries and forest owners' associations, and machine operators.

Results

During the interviews we identified three different contractor intensities of development activity: (i) The contractors who were taking active initiatives trying to develop products and services for supply to the market, (ii) the contractors who were reacting on expressed customer demands but not taking initiatives of their own, or (iii) all passive contractors making no efforts to develop new products or services. The contractors' development efforts were in many cases triggered by external factors out of control of the contractor. However, there also seemed to be a need for preparedness for development prompting action when opportunities appeared. Many of the contractors we studied had experienced a steady cooperation with the same customers for many years. The other contractors often were newly started enterprises.

The contractors interviewed performed different activities besides logging offered to the existing customers or to new ones. The entrepreneurial efforts of the contractors had emanated from, on the one hand, different local opportunities and, on the other, from contractor competence and interests. We identified different contractor driving forces as well as constraints for development of the logging contracting enterprises. Driving forces for investing in and developing specific new products and services frequently differed from contractor to contractor according to local opportunities. The product or service offered by one contractor may seem a sheer loss to another. The contractor competence differed or the customer need or demand differed. The contractors proposed several driving forces for developing new products or services:

- Utilise personnel or machine resources or the company's competence more effectively, thus increasing the productivity.
- Give opportunities for more varied tasks, thus increasing the productivity or creating a better work environment.
- Satisfy curiosity or other special interests of the contractor.
- Meet explicitly expressed demands or requirements from customers, thus being able to continue working for the customer, or ambition to supply customers with more valuable products and services, thus strengthening the contractor's market position.
- Reduce or spread risks, e.g. reduce dependency on single customers or single products or services.
- Make co-ordination profits or get parts of profits in other parts of the forestry sector.
- Provide employment for people asking for work in the company.
- Utilise changes in the market structure, e.g. liquidation of neighbouring companies.

The main constraints for developing new products or services were lack of competence or resources, poor profitability, difficulties to effectively combine new and existing tasks, lack of interest, and the structure and attitudes within the market.

Concerning re-investing in the provision of existing logging services the main driving forces named were operating reliability, reducing maintenance work, increasing the productivity, or improving the work environment. Investment in new equipment was often guided by the needs in the production chain of a customer. Several contractors said that having a good work environment is a way to compete for the personnel in a situation with lack of skilled operators. The main constraints for re-investing in existing logging equipment were lack of long-term contracts as well as low profitability.

Discussion

The contractors seldom express their development efforts with the notion of strategies. The contractors rely on confidence and improvisation, not on clearly formulated strategies. This calls for an emergent view on strategy as patterns of action. The contractors may say that they have goals, which seems to be strongly connected to the opportunities at hand. If the notion of strategy is to be used, the strategy formulation has to be done by us – the researchers – while analysing the contractors' statements.

The contractors develop their businesses due to conditions within their enterprises, e.g. competence and resources, or due to external market conditions, e.g. demand from customers. The contractors' tacit goal is to create the best possibilities for their businesses with regard to the resources available, thus creating and appropriating value and shaping the prerequisites for market exchange. Some of the strategies emanate from within the firms – e.g. better resource utilisation, need for more diversified tasks for the employees in order to reduce monotonous work, or the contractors' ambition to supply customers with more valuable products and services. Other strategies emanate from outside the firm – e.g. customers claiming more of existing as well as new services from the contractors. There is also an element of curiosity in the development effort, a curiosity that, within limitations, is allowed to conflict with the full resource utilisation. The additional products and services developed may all give separate incomes and better opportunities for more varied tasks. However, new tasks often seem to be performed by the contractor himself or by new personnel not operating the machines, which reduces the possibilities of a more varied work, at least initially.

The different development efforts identified are aimed at creating new value or aimed at appropriating value. The different driving forces and constraints identified and the different levels of development activity are explanations behind development efforts. The results of different contractors and in different environments show the dynamics of the enterprises and the dependency of the enterprises upon their environment. There are contractors able to shape their own possibilities for exchange.

The notion of strategy for business development introduced in this paper relies on an enterprising attitude aiming at improved value creation and appropriation. The logging contractors might be passive and not develop their businesses, e.g. only answering on demands expressed by existing customers or being all passive. However, our results show that there are contractors developing their businesses by an enterprising attitude actively trying alternative ways to use their resources as fully as possible. We would label this enterprising attitude entrepreneurship.

Acknowledgement

This study has been funded by Vinnova – Swedish Agency for Innovation Systems and with a travel grant from Bo Rydins Stiftelse för vetenskaplig forskning.

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A two-option Approach to Solving the Decision Problem of Regeneration

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Abstract

Real option theory has for some decades been used in forest economics to analyse decision problems which involve irreversible and stochastic decisions. One such decision is when to harvest a stand and with what species to regenerate. The latter decision can be postponed for some time, making a species change possible if favoured by the value development or if regeneration of the present species is unsuccessful. This problem is analysed here as an extension of the traditional two-option problem, by involving several stochastic elements.

Key words: stochastic decision theory, optimal harvesting, dynamic programming, real options.

1. Introduction

In forestry a major task is to decide when it is optimal to harvest a stand. Economically it can be seen as a matter of finding the optimal rotation age in a perpetual series of identical rotations. However, this is an abstraction because conditions will change over time. It is most obvious when we want to convert the present stand into something else that may later prove inoptimal, perhaps making the first stand preferable. -So, the use of decision analysis under uncertainty is encouraged, particularly if actions are irreversible. Establishing a new stand is irreversible in the sense that it may be too costly to undo the decision. However, if the decision can be postponed, this possibility may have an option value.

Stochastic decision analysis has for some decades been applied in natural resource economics. Early contributions were Samuelson (1965) and Arrow and Fisher (1974). After McDonald and Siegel's (1986) paper on the option value of waiting to invest, the development gathered momentum in forest economics, e.g. Brazee and Mendelsohn (1988), Morck et al. (1989), Clarke and Reed (1989), Thomson (1992), Plantinga (1998). The focus has mainly been on optimal harvesting when observing stochastic timber prices. Over time the applications have been extended to include more and more problems, such as differentiated timber prices (Forboseh et al., 1996), uneven-aged management (Haight, 1990) and multi-species stands (Jacobsen and Thorsen, 2003).

Other applications relate to the investment problem of stand establishment which cannot necessarily be treated as a single-option problem. In a situation with two options the problem can be analysed by looking at the relationship between them, provided it is constant. This is shown in Dixit and Pindyck (1994) and forestry applications are, e.g. Reed (1993), Conrad (1997) and Abildtrup and Strange (1999). Thorsen (1999a) analyses the choice of tree species for afforestation as a real option problem, and Thorsen and Malchow-Møller (2003) extend it to a two-option problem with two mutually exclusive options (two tree species), where exercising one option implies losing the other. This paper extends the model of choosing between two options, as analysed by Reed (1993), Conrad (1997) and Abildtrup and Strange (1999), to include a situation where there are fixed costs and hence no constant relation between the two options. This approach is similar to Thorsen and Malchow-Møller (2003), but the two options are not mutually exclusive in the present paper and it includes fixed costs.

The main problem of interest in managing even-aged monocultures all over the world is final harvest and regeneration. Many forests in Western Europe are dominated by secondary Norway spruce (*Picea abies* (L.) Karst.). A main reason is that this species is relatively easy to establish on poor soils, but probably due to their extension far beyond the natural habitat the health condition of such stands is often poor (Spiecker et al., 2003). Transformation and conversion of even-aged monocultures of Norway spruce is becoming a much discussed topic in Europe (a few examples are Hanewinkel and Pretzsch, 2000; Hanewinkel, 2001; Knoke et al., 2001; Sterba and Zingg, 2001; Spiecker et al., 2003). The issue is also discussed in Danish forestry, especially in relation to stand regeneration on former heathlands. Main reasons for transformation are a high risk of windthrow and generally poor health conditions. The optimal time of the final harvest has been analysed by, e.g. Thorsen and Helles (1998) who treat windthrow risk as an endogenous problem, and Meilby et al. (2001) analyse the problem by taking neighbouring stands' stability into account. Thorsen (1999b) extends the problem by including stochastic prices, and Nord-Larsen and Holten-Andersen (2002) by assuming that conversion is necessary. These studies all assume that the value of the future stand is given. However, when deciding on a stand's future, foresters have expectations about the future development, based on present prices and conditions despite knowing that they are uncertain. Under suitable conditions a stand may be regenerated naturally, which is cheap or even gratis. But if an alternative tree species will perform better, it may be preferable to change even though investment is necessary. This is of course particularly likely if there is a risk that natural regeneration will prove unsuccessful. This is the problem analysed below, based on the example of Norway spruce on poor soils in Denmark.

2. Model

The point of departure is a stand of Norway spruce which at some point has to be regenerated using one of two options – Norway spruce or oak (*Quercus robur* L.). Norway spruce has zero investment costs since it comes naturally whereas establishing oak requires a high investment. There may be some species-independent costs. The expectation value of both species evolves stochastically, depending on external factors (e.g. price) and moreover the natural regeneration has a risk of failure, making regeneration with oak necessary.

Let the expectation value of Norway spruce be *A* and that of oak *B*. They follow the two stochastic processes:

$$dA = \begin{cases} \alpha_A A dt + \sigma_A A dz & with \quad probability \quad 1-\gamma dt \\ -A & with \quad probability \quad \gamma dt \end{cases} \tag{1}$$

$$dB = \alpha_B B dt + \sigma_B B dw \tag{2}$$

where α_A, α_B, σ_B and σ_A are parameters, and *dz* and *dw* are increments of the two respective wiener processes. Furthermore, there is a possibility, γ, of *A* failing, driving the process to zero. Therefore, A is a mixed geometric Brownian motion and Poisson jump process, and B is a geometric Brownian motion. They may be corre-lated with the parameter ρ, i.e. $E(dzdw) = \rho dt$.

Given that we have a regenerated Norway spruce stand, or that we want to decide which of the species to establish, we can express the value of future income by V:

$$V = max\{B-C_B, (1+\delta dt)^{-1}E[V(B+dB, A+dA)]\} \quad (3)$$

where δ is the risk-adjusted interest rate. If A is chosen, conversion to B is still possible, so the value in the next period depends on both A and B. If B is chosen, the conversion option is lost. Therefore, B is chosen only if this stopping value (the first term) is larger than the continuation value (the second term). At each point in the continuation region the value function must satisfy:

$$V = (1+\delta dt)^{-1}[V+E(dV)] \Rightarrow \delta V = E(dV)/dt \quad (4)$$

Using Ito´s lemma we get:

$$\delta V = \alpha_A AV_A + \alpha_B BV_B + \tfrac{1}{2}\sigma_A^2 A^2 V_{AA} + \tfrac{1}{2}\sigma_B^2 B^2 V_{BB} + \rho\sigma_B\sigma_A BAV_{BA} - \gamma [V(A,B)-V(0,B)] \quad (5)$$

where V_A is the derivative of V with respect to R, V_B is the derivative of V with respect to B, and V_{AA}, V_{BB} and V_{BA} are the second derivatives of V with respect to A and B. Eq. (4) must be satisfied for all points in the continuation region. Notice that even though A reduces to zero with probability γ, we still have the possibility of changing to B. Inserting in the Bellman equation we get:

$$V = max\{B-C_B, (1+\delta dt)^{-1}[V+ \alpha_A AV_A + \alpha_B BV_B + \tfrac{1}{2}\sigma_A^2 A^2 V_{AA} + \tfrac{1}{2}\sigma_B^2 B^2 V_{BB} + \rho\sigma_B\sigma_A BAV_{BA} - \gamma [V(A,B)-V(0,B)] \quad (6)$$

Hence to find the switching point we must have the value-matching condition:

$$B - C_B = (1+\delta dt)^{-1}[V + \alpha_A AV_A + \alpha_B BV_B + \tfrac{1}{2}\sigma_A^{2A} A^2 V_{AA} + \tfrac{1}{2}\sigma_B^2 B^2 V_{BB} + \rho\sigma_B\sigma_A BAV_{BA} - \gamma [V(A,B)-V(0,B)] \quad (7)$$

and the smooth-pasting condition:

$$V_{A|A=A*} = V_{B|B=B*} \quad (8)$$

$$V_{A|B=B*} = V_{B|A=A*} \quad (9)$$

Furthermore, we need some terminal conditions. $A = 0$ and $B = 0$ are absorbing states; the processes will never increase again once zero has been reached and hence the pro-blem reduces to single-option problems with $V(A,0) = V^*(A)$ and $V(0,B) = V^*(B)$, where V^* is the optimal value function for the single option. However, we have to choose and exercise one of the options and hence the terminal conditions just be-comes $V(A,0)=V^*(A)=A$ and $V(0,B)=V^*(B)=B-C_B$.

When we are not at the terminal state the two-option problem is non-trivial to solve. If the value of *V* were proportional to the development in *A* and *B*, looking at the ratio between them would enable us to treat it as a single-option problem of the ratio (see, e.g. Dixit and Pindyck (1994) and Abildtrup and Strange (1999)). However, due to establishment costs of *B* and risk of destruction of *A*, this is not the case here and therefore we need to turn to numerical solutions.

The problem is solved by finite horizon dynamic programming, since it seems reasonable to assume that after some time it will always be inoptimal to change from Norway spruce to oak (Norway spruce regeneration has grown to big). We thus have an optimal-stopping problem with a maximum time horizon of 15 years. The process of dynamic programming is described in, e.g. Judd (1998). Solving the problem is made easier through logarithmic transformation of the two processes, so that the Brownian motion's jump size becomes relative and hence independent of state. This is similar to what is done by, e.g. Thorsen and Malchow-Møller (2003) and described in more details in Thorsen and Malchow-Møller (2002).

3. Data

The method is applied to Norway spruce on poor heathland in Denmark, assuming YC5 West-Nielsen (1950), and for oak YC4 Møller (1933). Norway spruce regenerates naturally when shelterwood regime is initiated. Soil treatment is assumed to be necessary for both tree species. Oak is established by seeding at 10,000 DKK/ ha[1] (Madsen et al., 2003). The value functions *A* and *B* are based on the expectation value of Norway spruce and oak, respectively. Depending on prices the values of both species lie in the interval 0 to 20,000 DKK/ha (exclusive of establishment costs C_B). It is assumed that final harvest decision depends on price development, so that no fixed rotation age exists.

Table1. Assumptions.

Parameter	Estimate	Parameter	Estimate
σ_A	0.13	α_B	0
σ_B	0.16	λ	0.08
ρ	0.49	δ	0.02
α_A	0.02	C_B	10000

Estimates of variance are based on Thorsen (1999a), whereas the annual risk of natural regeneration failure [3] is a rough estimate based on silvicultural experience. It is, however, highly dependent on the specific location. The assumptions are shown in Table 1.

4. Results

The problem faced is a present Norway spruce stand, which we can either convert into oak or regenerate naturally, given a certain level of the value of Norway spruce (*A*) and oak (*B*), but acknowledging that they may change in the future. Starting with a simple situation with no fixed costs C_B, no risk of failure and no correlation, we get free boundaries as shown in Figure 1. A free boundary is the combination of values of Norway spruce and oak for which the value of choosing each of them are identical. To the left of the lines oak is preferred and to the right Norway spruce. When the stand of Norway spruce has reached the age of 15 years

[1] 1 € H" 7.42 DKK

the problem ends, and the question is simply to choose the species with the highest expected present value. When Norway spruce is young, there are still many years left where switchingis possible and therefore the value of waiting is high, pushing the free boundary to the left. However, the difference diminishes, so it does not matter much to the result whether there are 10 or 15 years left until switching can no longer be done. But Norway spruce is also growing. So at ages above zero, Norway spruce has already been growing for some years, and consequently we would expect the value to be located a bit to right in the figure, making the species preferred more frequently. But if the value of Norway spruce drops dramatically, oak would still be preferred. It is seen that the biggest change in action through time caused by the value of waiting lies where the value of both Norway spruce and oak are high.

In Figure 2 fixed costs of establishing oak are introduced. Notice that the y-axis is still the value of *B*, so the range is changed, and the value of establishing oak is B-C_b. Not surprisingly we see a shift upward for all ages by the size of establishment costs, but when we have the option to wait, the free boundary is pulled even more upward. The value of *A* and *B* can not drop below zero, but so can B-C_B and therefore a higher value of *B* is required before it is optimal to switch.

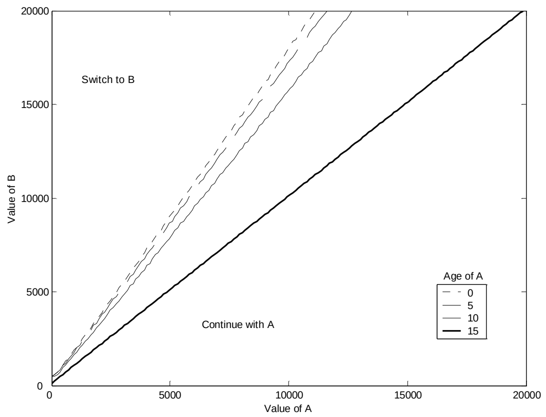

Figure 1. The free boundaries for combinations of values of Norway spruce (A) and oak (B) at different points in time (ages 0, 5, 10, 15 years). At time 15 the problem ends. C_B= 0, g = 0, r= 0. All values in DKK/ha.

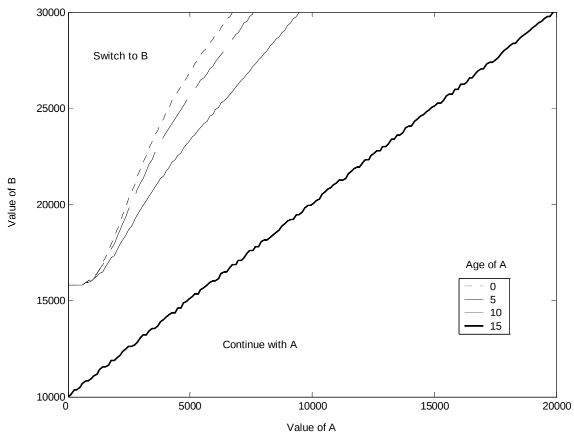

Figure 2. The free boundaries for combinations of values of Norway spruce (*A*) and oak (*B*) at different points in time (ages 0, 5, 10, 15 years). C_B = 10000, g= 0, r = 0. Notice that the value of establishing oak is B-C_B. All values in DKK/ha

As compared with Figure 1 we see that the value of waiting becomes higher, such that *A* is preferred more often in Figure 2. We also see a change in the shape of the free boundary. In Figure 1 the distance to the 45-degrees line (age 15) is increasing with increasing values, in Figure 2 it becomes more sigmoid.

From Figure 3 is seen that the correlation ρ between the value of Norway spruce and that of oak has significant effect on the shape of the free boundary. If the correlation is negative, Norway spruce is preferred more often (Figure 3a). On the other hand, if the correlation is positive (Figure 3b), oak is preferred more often, and the value-matching lines are pushed back towards the free boundary for the terminal date. The shape caused by including fixed costs for establishing oak is still seen.

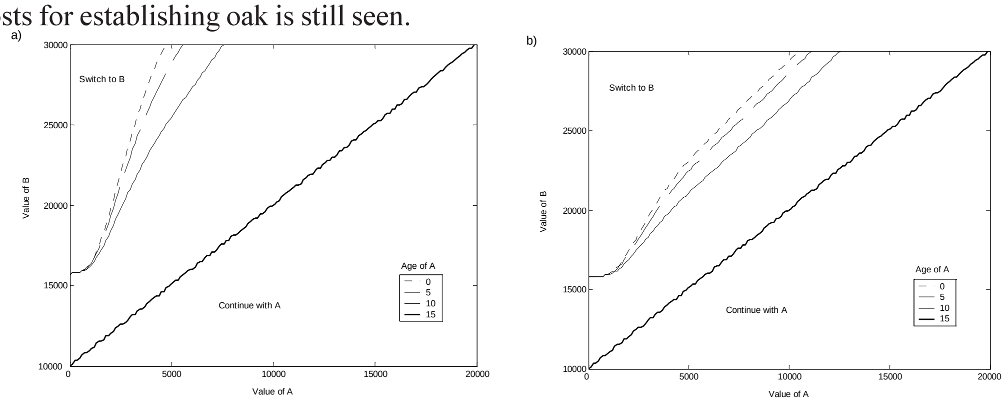

Figure 3. The free boundaries for combinations of values of Norway spruce (A) and oak (B) at different points in time (0, 5, 10, 15). Cb = 10000, g = 0, r = -0.49 in a) and 0.49 in b). Notice that the value of establishing oak is B-CB. All values in DKK/ha

The risk of natural regeneration failure is seen from Figure 4a to have the effect of choosing oak more often as compared with Figure 3b, which is not surprising since the risk is related only to Norway spruce. The risk is here set at 1% per year and in the case of failure it is possible to establish oak. Alternatively, if in case of destruction of *A* we could not choose *B* instead, we would see a more dramatic effect (Figure 4b).

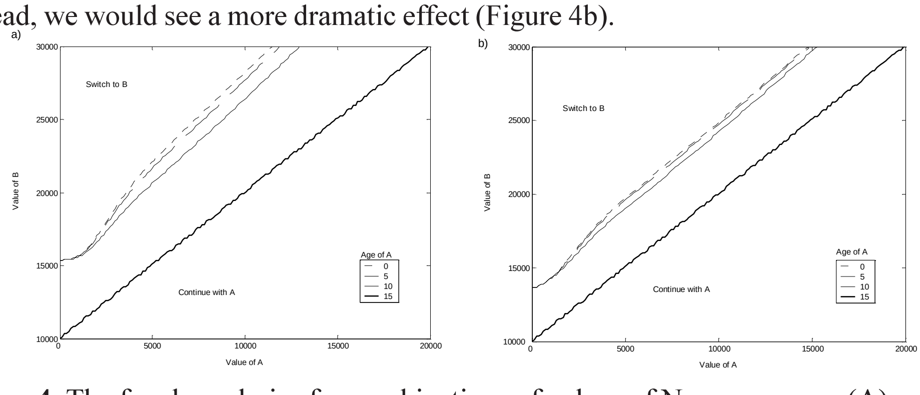

Figure 4. The free boundaries for combinations of values of Norway spruce (A) and (B) at different points in time (0, 5, 10, 15). Cb = 10000, g = 0.01, r= 0.49. a) In case of failure of A, B can be applied. b) In case of failure of A, B cannot be applied. Notice that the value of establishing oak is B-CB. All values in DKK/ha.

In Figure 5 the value *V* is shown for different points in time, using the same assumptions as in Figure 4a. It is seen that at 15 years, *V* is simply the maximum value of *A* or B-C_B, and the longer we can postpone the decision, the larger and flatter *V* becomes (given *A* and *B*). The biggest difference lies though between ages 15 and 10 years, as is also seen from Figure 4a. For small values of Norway spruce, the value is equal to the situation in the terminal condition, i.e. the value of choosing oak, because that option is exercised. For small values of oak, however, we will see a value of waiting, though small. The highest value of waiting lies where it is likely that the maximum value changes from *A* to *B* or opposite and therefore the value function changes from V-to U-shape.

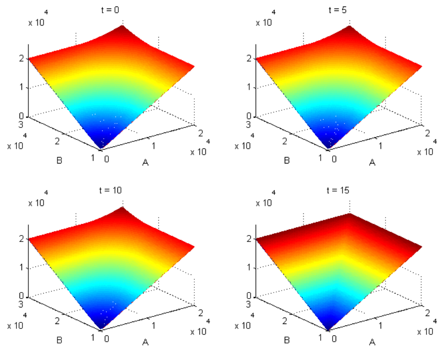

Figure 5. Value V of having the two options A (Norway spruce) and B (oak), depending on state space (A, B). CB = 10000, g= 0.01, r = 0.49 at different points in time (0,5,10,15). All values in DKK/ha.

5. Discussion

A main question is what tree species to chose when the choice involves an option value. It is evident from the figures that involving establishment costs for one of the options changes the shape of the free boundary from convex to more sigmoid (compare Figures 2 and 1). The original convex shape is also found by, e.g. Abildtrup and Strange (1999). The reason for the change in shape is that a big part of the value of $B\text{-}C_B$ is now fixed, so that the volatility becomes relatively higher compared to the value of establishing oak, $B\text{-}C_B$, because it is related to *B* alone (cf. eq. (2)). This is especially the case for small values of *B*. The larger the value of *B*, the more the effect of increasing volatility dominates and therefore the effect of fixed costs diminishes.

We see that the fixed costs of establishing oak cause the value of *B* to be much higher than the difference between A and B before oak is preferred (see Figure 2), the reason being that it is suddenly possible for the value of establishing oak, $B\text{-}C_B$, to drop below zero which it is not for *A* or *B* themselves. This is exactly the case if we establish a stand at high costs – the present fixed costs are certain, but the future output is uncertain, so the revenue can actually be negative. If we had no fixed costs, as here for Norway spruce, we could always choose not to harvest and hence the value would just be zero. Therefore, investing in stands that require high investment costs must require a higher expected benefit than the difference in expected values before chosen.

As also Thorsen and Malchow-Møller (2003) show, the correlation between the two options has a major effect on the value of waiting as reflected in the free boundary. We furthermore see, as in all option problems, that the value of waiting increases by time left in the rotation, but the difference decreases. However, Norway spruce is growing. Apart from making Norway spruce more preferred than oak, it also causes that we, as time passes, will be in a situation with higher values of Norway spruce. Naturally it will then require higher levels of oak before switching, so the growth of Norway spruce increases the value of waiting. But the risk of destruction of Norway spruce reverses this effect. It is interesting to see that there are in fact situations where oak would be preferred, and they are not so extreme as to be unlikely, even after Norway spruce has been growing for some years. Though often criticised among foresters, it is economically optimal to switch tree species even late in the regeneration phase if the value of the present stand is sufficiently low. On the other hand, even if including a high risk of failure, natural regeneration might be worth trying – simply because changing is possible in this case and establishment can be relatively inexpensive. The assumption in the model is, however, that failure of regeneration of Norway spruce has no effect on the value of establishing oak afterwards. In reality we would probably see the costs of establishing oak increase if made after a Norway spruce regeneration that has failed due to weed. This would reduce the value of waiting, causing a situation more as shown in Figure 4b. In sum, fixed costs, correlation and risk do not pull the value of waiting in the same direction, though it will still be positive, causing continuing with Norway spruce to be optimal for a wider range of values than if assessed deterministically.

6. Concluding remarks

The decision problem of how to generate a Norway spruce stand is analysed in this study as a two-option problem. It is found that when we face a fixed cost for one of the options, which does not evolve stochastically as do their values, the threshold for choosing that option becomes higher than the actual difference in values. This may explain the awareness among some foresters to establish expensive stands. A risk of failure for the option where switching is possible is also included in the study. This lowers the value of waiting considerably, the magnitude being dependent on whether or not it is possible to switch to the other option in case of failure.

The study extends previous analyses made on choice of regeneration. This is done without considering the relation between the time of harvesting the existing stand and the value of the future stand. This seems as an important extension that would be interesting to include in future research.

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A Hybrid Heuristic Algorithm for Harvest Decision of Mixed Species Stand under Price Risk

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Abstract

In this article, a hybrid heuristic algorithm based on Genetic Algorithm and Hooke and Jeeves is described for solving a complicated forest harvest decision problem, which involves optimization of thinning and final felling under price risk for a mixed species stand of spruce and pine. The strategy consists of two optimal stocking level functions and one reservation price function; in which, there are ten variables need to be optimized. The hybrid heuristic algorithm consists of two stages. At the first stage, Genetic Algorithm is applied to generate candidate initial solutions. At the second stage, the Hooke and Jeeves is applied to find the optimal solutions using these initial solutions. As benchmark, a pure Genetic Algorithm, Hooke and Jeeves, and Powell search are also tested. Results show that the hybrid heuristic algorithm is the best one among all of the tested algorithms. Genetic Algorithm ranks second, Hooke and Jeeves the third and Powell search is the worst.

Keywords: Harvesting decision, Genetic Algorithm, Hooke and Jeeves, Powell search

1. Introduction

The optimization of decision in forest management is usually complex due to the long planning horizon and high dimensionality. Consideration of uncertainty and multi-functionality of forest makes the problem becomes even more complex. The optimization of thinning and harvest decision under price uncertainty is one typical example. In such a case, the traditional optimization techniques usually can not be applied to solve the problem within a reasonable computation time. Simplification is one way to deal with this kind of problem, which, of course, will reduce the accuracy and correctness of the model for the real world problem. An alternative is using heuristic optimization techniques instead, to obtain the near optimal solution from complicated model which is more near the reality.

The aim of this study is to develop and test a heuristic approach for harvest decision problem (including thinning) of a mixed species stand of pine and spruce, when price uncertainty was considered. This approach is based on modified genetic algorithm and a traditional nonlinear optimization technique-Hooke and Jeeve.

The testing problem is come from a previous study of Lu and Gong (2004), in which an optimal thinning and final harvest strategy for mixed species stand of pine and spruce with price risk was developed. This strategy includes two optimal stocking level functions to guide the thinning decision for each species and a reservation price function for the final harvest decision. With this strategy, the thinning and final harvesting decision could be optimized simultaneously without any limitation on the number and intensity of thinning. Only the ten coefficients in the three functions need to be optimized through simulation. This was considered as an advantage compared with stochastic dynamic programming. In that study, a traditional non-linear optimization technique, Powell Search, was applied to optimize the coefficients.

However, it is not an easy task to optimize the ten coefficients in the three functions, due to the high dimensionality. Meanwhile, the computation burden for each iteration (objective function evaluation) in this problem is big, because of the complexity of the model. The forest stand growth is simulated by the single tree growth model of Söderberg (1986), which is the most complicated one among the stand growth simulation models. Furthermore, the thinning effect model of Jonsson (1980) and the natural mortality model of Bengtsson (1981) were also applied for the growth simulation, which, of course, make the model even more complicated. In addition to the complex stand growth simulation, 100 price scenarios were applied to simulate the stochastic price process, which means the stand growth simulation will be repeated 100 times for each iteration.

Using Powell Search, the satisfied result can only be obtained through certain numbers of repetitions with different initial guess. If some other kinds of risks (e.g. growth risk) are included, and /or more tree species are considered, the optimization problem would be more complicated. The function form of the optimal stocking level functions and the reservation price function used in the previous study is some how 'ad hoc'. More suitable function form could be found by further study, which possibly has more coefficients to be optimized, and therefore, an even higher dimensions problem needs to be solved. So a more efficient optimization approach is under high demanding.

2. Method

Before discuss the hybrid heuristic algorithm, we first illustrate the implementation of Genetic Algorithm, which is the main part of the hybrid algorithm, to the problem.

2.1 Implementation of Genetic Algorithm

Genetic algorithm (GA) is a heuristic optimization technique developed by Holand (1975). In the last twenty years, it has been applied to a wide range of areas. Together with other popular heuristic methods (Tabu Search, Simulated annealing, etc), GA also has been successfully applied to forestry to solve decision problems (Lu & Eriksson 2000, Öhman & Eriksson 1998, Wikström 2000). Based on a randomly generated initial population of solutions, GA improves these solutions by applying the basic genetic law: selection, crossover and mutation from generation to generation until certain stop criterion is met. The performance of a GA usually depends on the implementation details. Still, according to the no free lunch theory, GA does not necessarily perform better than other methods in all kinds of problems. In this study, in order to improve the performance of GA, a number of modifications were made, which will be illustrated in the following sections.

2.2 Coding of parameters

GA requires the natural parameter set of the optimization problem to be coded as a finite-length string over some finite alphabet (Goldberg, 1989). There are different ways for parameter coding, e.g. binary coding, real number coding, grey coding, etc. The binary coding method was used in this study. The ten parameters in the testing problem are continuous variables, so the coding of these parameters is also a process of discretion. In previous study, we determined the search scope for each of the ten parameters. If we let a binary string with length l to code one parameter with specified interval [U_{min}, U_{max}] , then the map between the cod and the value of the parameter is:

$$\underbrace{000..........0}_{l} \rightarrow U_{\min}$$

$$\underbrace{111..........1}_{l} \rightarrow U_{\max}$$

Others map linearly in between. The precision of this mapped coding is:

$$\pi = \frac{U_{\max} - U_{\min}}{2^l - 1}$$

When $U_{\min}$ and $U_{\max}$ is fixed, the precision could be controlled by choosing different value of (Goldberg, 1989). A smaller value of will reduce the search space and make it easier to find the optimal solution, but at the cost of lower precision. It will be the opposite if the value of is higher. In order to solve this problem, a multi-stage approach was developed in this study. At the first stage, with the original search scope [U_{min}, U_{max}], a relatively lower value of was chosen. This will simplify the problem but the precision was lower than the requirement. After the optimal solution was found, the second stage was started. and were adjusted accordingly and the interval was narrowed to half of the previous stage with the center of the optimal points found in previous stage. With the same value of , the precision will be improved in each succeeding stage . This process will be continued until certain criterion for the precision was met. In this study, we set for each of the ten coefficients. Therefore, the total length of the string is 70.

2.3 Generation of initial population

Finding a proper population size is important for the performance of GA. With a too small population, the algorithm tends to converge quickly and stop at local optima, while a too large population will increase the burden of calculation. A population size of 100 was chosen for our study problem after preliminary test. The initial population was created randomly, that is every position on the string has an equal probability of being 1 or 0. Each of the 100 strings will correspond to a set value of the ten parameters, a solution of our optimization problem.

2.4 Local improvement

The fitness of every string is evaluated according to its objective function value (directly or indirectly). The simple and straightforward principle is: the higher of string's objective function value, the fitter of it. However, this evaluation method will neglect the potential value of each string, especially at the initial search stage. This can be illustrated through a simple example of a one-dimensional maximization problem (figure1). The solution point P_1 is obviously better than point P_2 if their fitness is evaluated in terms of the objective function value. Nevertheless, the solution point P_2 is potentially better since it is near the global optimal point, and this fact will be neglected by normal fitness evaluation and selection. This can be improved to some extents by local improvement. For each string, we set a narrow search scope [U_1, U_2] (one tenth of the original search scope) and apply a simple random search with only five randomly generated solutions within this scope. Using the best one among the five solutions replaces the original strings if it has a higher value, otherwise, the original string keeps unchanged.

Local improvement will increase the burden of computation; therefore it is only applied in the first two stages. At later stages of the search process, it tends to converge to an optimal point (local or global), and all the candidates will gather at a smaller scope. Therefore, the local improvement is not as necessary.

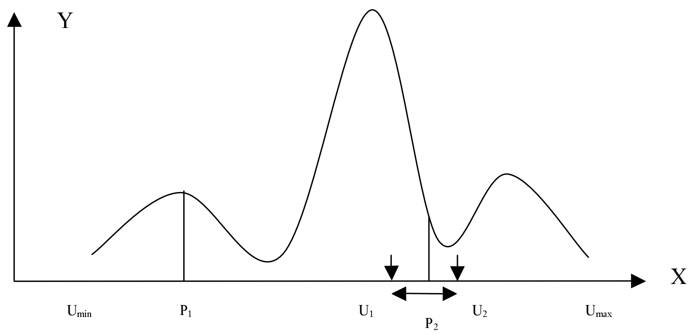

Figure 1. illustration of local improvement for one dimension maximization problem

2.5 Fitness scaling

Each string corresponds to a solution with an objective function value. Using the objective function value directly to evaluate the fitness of each string is usually not effective due to the following three reasons:

1. At initial stage, some strings with high objective function value could dominated the population; the others with low objective function value could be kicked off too early in the search process. This would be the reason for early convergence and stop at local optimal

2. At the final stage, the difference among the strings is small. The good string with high objective function value could not be favor enough and this will slow down the convergence process.

3. Some strings are infeasible solutions and their objective function values are zero; yet they still could carry useful information (genes), which could be used to create good new strings with other strings through crossover. If the fitness is evaluated by the objective function value directly, this kind of strings will be eliminated directly.

In this study, the following strategy was used for fitness scaling:

1. Determine the rank number N_i of string i in the population according to its objective function value. The best string (with the highest objective value) is assigned the rank number 1, while the worst string is assigned the rank number 100.

2. Using the following equation assigns new fitness value for each string:

$$Z_i = X^{100-N_i+1}$$

Z_i is the new value for each string.
X is adjustable coefficient. It ranges from 1 to 1.1.

The new value of a string not only depends on its rank number *N*, but also depends on the coefficient *X*.

For example, if we set the value of *X* to be 1.02, then the new value for the best string would be: 1.02^{100} while that for the worst string is: 1.02.

2.6 Selection

Roulette selection approach was applied in our study based on the new value for each string. The strings with higher value have high probability of being selected as candidate parents for the next generation. Since we use the new value to evaluate the fitness for each string, we can adjust the extent to favor the high value string by choosing different values of *X* during the selection. It is not difficult to find the most suitable value of *X* for selection. However, fixed value of *X* is not the optimal way for selection. In order to avoid the premature result, at the initial stage, it is suitable not to favor the good strings too much, and to keep the search in a wider range. At the final stage, in order to speed up the convergence process, the good strings should be favored more. Therefore, at different stages of the search process, different strategies should be applied. In stead of a fixed value of *X*, we designed a dynamic selection strategy which uses a relatively small value of *X* at the first stage and a higher value of *X* at the final stage. It is difficult to determine the value of *X* during different stages. The number of generation is not an accurate indicator of the process of convergence. We use the following equation to control the value of *X*:

$$X = X_1 + X_2 * \delta$$
$$\delta = (RE_2 - RE_1) / RE_1$$

in which
X_1 and X_2 are coefficients to determine the relation between X and δ
δ is the relative improvement of objective function value
ob^1 is the initial objective function value
ob^1 is the latest objective function value

During the selection, the 'reposition of the best' strategy was applied. That is, the best string in all generations so far will go to the next generation automatically. This is more important during the initial stage, when the diversity is high and the value of *X* is low (which mean that the good strings are not favored very much).

2.7 Crossover

In order to create new strings with the selected strings through selection, crossover was performed in hoping that the new strings could have higher fitness. The pair of parents was randomly chosen from the selected population, and with a pre-assigned probability P_c (crossover rate), the parents performed the crossover and created two new strings. If no crossover takes place (with probability 1- P_c), then form two new strings that are exact copies of the two parents.

We tested five different crossover strategies with different numbers of splice point through 1-5. The result showed that the four point crossover is the best one. The value of crossover rate P_c was also was decided by preliminary test.

2.8 Mutation

Mutation is considered as a secondary mechanism of GA, which performed after selection and crossover. Crossover only shuffles the substrings contained in the population. The substrings of the optimum have to be present in the population; otherwise a search by recombination is unable to locate the optimum (Muhlenbein, 1997). Therefore mutation is essential since its role is to recover some potentially useful genetic material (1's or 0's at particular locations) which is not available in the initial population (Goldberg, 1989). Since we use binary coding in our problem, the mutation is simply occasional changing from 1 to 0 and vice versa. The probability of this changing for each position is called the rate of mutation.

2.9 Stop Criterion

As mentioned in the coding section, in order to meet the precision requirement and keep the length of the string short, we divided the search process into stages, with the search scope being narrowed at each succeeding stage. The stop criterion for the whole process is that a pre-specified precision being met. And for each stage, we set a specified number of iteration without improvement as the stop criterion to end that stage.

The results of this GA strategy developed here will be presented, discussed and compared with others later.

2.10 Designing the Hybrid Heuristic Algorithm

GA has the population based structure and is a parallel random search with centralized control through selection schedule. Instead of improving one solution points step by step, GA evolves a certain number of solutions- the population simultaneously. This character makes GA powerful to locate the optimal point. However, due to the same character, GA also has the drawback of slower convergence after the optimal point being located, compared with some traditional hill climbing methods. This fact motivates the study on hybrid algorithm of GA and other optimization approaches. The idea is using GA to locate the mountain (the rough position of the optimal points), and let others to climb the mountain. In this study, we designed hybrid heuristic algorithm, which is GA plus Hooke and Jeeve (HJ). We also tested GA plus Powell Search, which is not as good as GA plus HJ.

There are two important things for this hybrid algorithm. One is choosing the right time of switching from GA to HJ; the other is selecting the solutions among the populations of GA to be used as the initial solution points for HJ.

It is difficult to deicide the right time to stop GA and start HJ. There is no sign to indicate if GA has really found the position of optimal solution or not. By examining the performance of GA developed previously, we can see that the improvement of the objective function value is mainly made during the initial stage of GA. This gives us a hint that we can stop the GA after the main improvement. In this study, we set a limited number of generations for GA and after this limitation is reached, GA will be stopped. 50 generations was used as the limitation for GA. That is to say, we let GA run 50 generations, and then switch to HJ.

Then the second question is which of the solution among the population should be used as the initial solution for HJ. Intuitively, the best solution among the population should be chosen as the initial solution. However, is there any value of the other solutions? Would it be helpful to take average of some of the other solutions? In order to answer these questions, we tested ten candidates solutions selected from the population. The first five is the five best solutions among the population, then, the sixth is the average of the five best solutions, the seventh is the average of the ten best solutions, the eighth is average of the twenty best solutions, the ninth is the average of the fifty best solutions, and the tenth is the average of all the population (100 solutions).

3. Result

Besides GA and the hybrid algorithm, we also tested random search, Hooke and Jeeve, and power search, and used their results as benchmarks to check the performance of the first two algorithms.

The parameters of GA were determined after preliminary test. The mutation rate is 0.01, crossover rate is 0.8, and the value of the two parameters X_1, X_2, which were used to determine the selection rate, is 1.005 and 0.06, respectively.

Through examining the convergence process of GA, we found that, in most of the situations, the improvement is mainly made during the first 50 generation. Therefore, for the hybrid algorithm, the GA will be stopped and switch to HJ after 50 generations. Of course, if GA is given more generations before switching to HJ, the quality of the initial solutions for HJ will be higher, and the finial results for each run would be better. However, this will increase the time for each run, and decrease the overall efficiency.

Since it is impossible to get the real optimal results, and in order to compare the performances of different algorithms, we set the same fixed computation time for each of the algorithms and just take the ten best results from them. Due to the same reason, the relative deviation index (RDI) (Kim and Kim, 1996) was used to compare the results of different algorithms. The definition of RDI is:

$$RDI = (TI - TW)/(TB - TW)$$

Where *TI, TW, TB* are respectively, the objective function value of result I, the worst result and the best result.

The results were shown in table2:

Table 2. The mean RDI of the ten best solutions determined using different algorithms

algorithm	RM	PW	HJ	GA	HB1	HB2
Ten best results	0.346	0.935	0.953	0.940	0.964	1.000
	0.283	0.820	.0775	0.920	0.964	0.962
	0.219	0.385	0.733	0.847	0.937	0.941
	0.187	0.363	0.672	0.791	0.933	0.925
	0.110	0.363	0.653	0.748	0.924	0.920
	0.071	0.355	0.466	0.461	0.918	0.919
	0.068	0.327	0.449	0.443	0.762	0.916
	0.027	0.318	0.303	0.416	0.740	0.885
	0.014	0.317	0.292	0.369	0.701	0.885
	0.000	0.308	0.279	0.355	0.560	0.885
Average	0.133	0.449	0.558	0.629	0.840	0.924

The fixed computation time is the time needed by GA for ten runs. Since other algorithms cost less time for each run compared to GA, the ten results listed here is the ten best results among their total results. From the results in table 2, it is clear that the hybrid algorithm performs best among the five tested algorithms, while random search is the worst one. The modified GA developed in this study is better than the two traditional optimization algorithms, HJ and PS; while HJ is better than PS.

As mentioned before, for the hybrid algorithm, ten solutions from the GA stage were used as the initial solutions for the HJ stage. We run 150 times for the hybrid algorithm in order to test the performances of different initial solutions. The frequency of the best result occurred from different initial solutions was presented in table 3.

Table 3. Frequency of the best result occurred from 10 initial solutions

No. of initial solution	1	2	3	4	5	6	7	8	9	10
Frequency of best result	43	18	16	19	21	6	4	10	7	6
Percentage (%)	28	12	10	13	14	4	3	7	5	4

It is not surprising to see the highest frequency of the best result occurred when the best solution of GA stage was used as the initial solution for the following HJ stage. However, there is still a very high percentage (72%) of the best solution being found when other solutions from the GA stage was used as initial solution for HJ stage. This is to say, the best point (the point with the highest objective function value) got from GA is not necessarily the best starting point for HJ to climb the top of the mountain. Since each run of HJ takes relatively little time, it is worthwhile to try multiple initial starting points, in order to improve the performance of this hybrid algorithm.

4. Discussion and Conclusion

In this study, a hybrid heuristic algorithm, which is based on Genetic Algorithm and Hooke and Jeeve, was tested for a forest harvest decision problem under price risk. Genetic Algorithm, random search, Hooke and Jeeve, and Power Search were also applied to the problem. The results show that if properly implemented, GA will perform better than the traditional algorithms tested in this study for continuous variables optimization problems. An even better performance was observed for the hybrid algorithm based on Genetic Algorithm and Hooke and Jeeve. This indicates that heuristic optimization approach is promising for complicated forestry decision problems.

The performance of GA is problem specific and a successful application is highly based on the preliminary work for the right way to implement it. Besides the work for finding the right value of parameters for different operations (selection, crossover, mutation), it is also very important to interpret the problem properly, that is, finding the suitable way to code parameters in the problem. In this study, we use the traditional binary coding system to cod the variables. Since the variables are continuous, to code them is also the process of discretion. A dynamic search scope strategy was developed in order to keep the length of strings relatively short and meanwhile satisfied the precision requirement. The speed of narrowing the search scope as stage goes on is low, (the scope of any stage is half of that of previous stage), to avoid missing of the real optimal point.

A strategy to map the objective function value to a new fitness unit was developed. In this strategy, the fitness of each string will depend on its position in the order which made according to its original objective function values. By this strategy, the relative fitness of each string is adjustable, and this gives us the chance to develop a dynamic selection strategy. That is, at the initial stage, the good strings (with high objective function value) are favored less compared to that in the final stage. This is controlled by adjusting the relative fitness in deferent stages, and the relative improvement of the objective function value was used to indicate the stage process.

Different ways to combine GA and Hooke and Jeeve to form the hybrid algorithm were tested. It turns out that ending the GA at its early stage (after 50 generations) and then switch to Hooke and Jeeve is the most efficient way. This result is due to the fact that GA is more capable of locating the rough position of the global optimal point and Hooke and Jeeve is faster in convergence to local optimal points. The five best solutions from the last generation (generation 50) of GA were used as the initial solution of HJ. Besides that, another five solutions were derived from the GA solutions (the means of the five best solutions, ten best solutions, twenty best solutions, fifty best solutions and total solutions respectively) were also tested. The result showed that using the best solution from GA as the initial solutions of HJ has the highest tendency to reach the final best solution. However, among the 150 tested cases, 72% of the best final solutions were obtained using the other initial solutions. The overall efficiency was improved by using multiple initial solutions for HJ instead of one initial solution.

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Production Cost and Wood Quality in Spruce Plantations: In Pursuit of Economically Efficient Silvicultural Strategies

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Abstract

Economic optimisation of silvicultural strategies is usually based on maximisation of (expected) present value, prices and costs being based on historical information. However, in some cases forest owners may have strong opinions regarding the character of future timber markets, conflicting with the use of historical price information. For example, a forest owner may expect wood quality to become much more important than it is today. Costs can often be observed to vary less than sales prices of timber and, therefore, if the focus is on the wood quality offered by various silvicultural alternatives and historical price information is considered invalid, it may be a reasonable alternative to compare strategies using estimates of production cost and product quality. In this paper such measures are used to identify the most robust and efficient silvicultural strategies, i.e. strategies forming a frontier where products of a given quality are produced at minimum costs and are thus most likely to prove profitable. However, while the method may lead to robust and quite efficient strategies it does not ensure welfare maximisation.

Keywords: Norway spruce, ring width, thinning regime, plant number, rotation age

1. Introduction

The economics of forest stands is influenced considerably by the applied silvicultural strategy. Many studies have emphasised the search for economic optimal thinning strategies (e.g. Näslund 1969; Roise 1986; Pukkala et al. 1998; Meilby 2001). Simulation studies reveal that many local optima may exist, typically on a major ridge of the response surface (e.g. Roise 1986, Pukkala et al. 1998). Usually the optimal solution is searched for under a fixed set of historically based assumptions regarding prices and costs. The uncertainty characterising such assumptions is considerable and, therefore, some studies include price uncertainty in the evaluation of stand management strategies (e.g. Haight & Smith 1991, Teeter & Caulfield 1991, Abildtrup 1999, pp. 191-214). However, forest owners and managers may have strong personal opinions regarding the quality preferences of future markets, conflicting with the use of historical price information.

Abildtrup (1999) included a price premium on quality. However, a basic assumption in many studies is that the proportion of the timber production which can be marketed as saw logs depends on thinning regime only to the extent that thinning influences the diameter distribution. However, as recognised in studies like those of Briggs & Fight (1992) and Eriksson & Kyrkjeeide (1992), this is hardly an adequate description of reality. An example illustrating how the quality aspect of thinning strategies can be handled within the present value framework is found in Meilby (2002).

Sales prices are often characterised by a greater variation than costs. For example, data from private forest estates in Denmark yielded the following coefficients of variation for the 22-year period 1981-2002: average sales prices of coniferous timber: 0.28, harvest costs of coniferous timber: 0.24, administration costs: 0.11, and total harvest-independent costs (including administration): 0.14 (Danish Forest Association, 1982-2003; prices were deflated using a consumer price index). Moreover, as illustrated in the example in Figure 1, even for minimal discount rates at least 40-50 per cent of the total discounted costs over the life span of a planted stand are costs that are not likely to vary much (harvest-independent, fixed costs) or costs that are known with a high degree of certainty at the time of planting (regeneration costs). Accordingly, provided that the forest owner has a firm notion of the quality preferences of future markets, an approach mainly based on costs and product quality might be deemed a more reliable and pedagogic tool for choosing a suitable silvicultural strategy than a present value approach, even if it does not necessarily lead to welfare maximisation. Therefore, in this paper a highly simplified product quality description is used in combination with an estimated production cost. By using such tools along with expected future price structures (effect of diameter and quality on price) those silvicultural strategies may be identified, which have the greatest chance of being profitable.

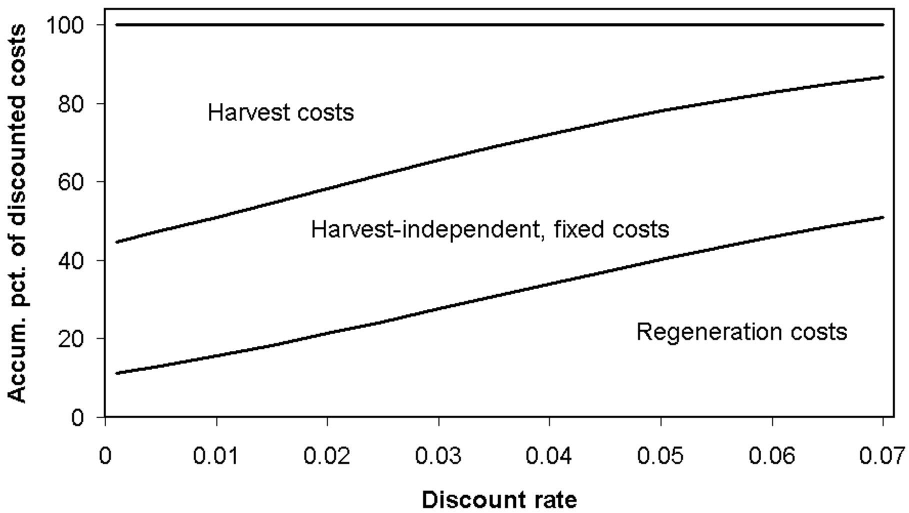

Figure 1. Distribution of discounted costs for a rotation of spruce including four thinnings: age 25: V = 50 m^3ha^{-1}, D_g = 12 cm; age 35: V = 150 m^3ha^{-1}, D_g = 18 cm; age 45: V = 200 m^3ha^{-1}, D_g = 22 cm; age 55: V = 100 m^3ha^{-1}, D_g = 26 cm. Final harvest at age 65: V = 500 m^3ha^{-1}, D_g = 30 cm. Regeneration cost: 3000 €ha^{-1}, annual harvest-independent cost: 140 €ha^{-1}, harvest cost (€m^{-3}) = 5 + 250 / D_g.

2. Method – the production cost criterion

2.1 Production cost

The exact cost of producing a given log cannot easily be stated. Of course, one may calculate the costs of cutting away branches, crosscutting the stem and transporting the log to the road. Likewise, the costs of marking and felling the tree may be distributed to the logs. However, regeneration costs, management costs and silvicultural costs are defrayed at other points in time and are related to the whole rotation. Consequently, we will apply a simple definition based on the soil expectation value, *S*, expressed as:

$$S = \frac{(1+b)^{T-a}}{(1+b)^{T-a} - 1}\left(- C_0 - C_p N_0 + \sum_{t=a}^{T} B(t)\left[V_h(t)\left(P(t) - C_h(t)\right) - C_G(t)\right]\right) ,$$

(1)

where T is rotation age, a is the age of transplants when planted, b is discount rate, C_0 is the density-independent regeneration cost (soil preparation, fencing), C_p is the cost per plant, N_0 is the initial density of plants (ha^{-1}), $B(t) = (1+b)^{-[t-a]}$ is a discounting factor, $V_h(t)$ is the harvested volume at age t, $P(t)$ is the average sales price of wood, C_h(t) is the average cost of harvest and transportation at age t, and $C_G(t)$ are annual fixed costs (administration, management, taxes, road maintenance).

For plantation forests to be profitable the soil expectation value has to be greater than or equal to zero. Accordingly, a reasonable measure of production cost corresponds to that sales price which leads to a soil expectation value of zero under the applied assumptions regarding the costs: C_0, C_p, $C_h(t)$, and $C_G(t)$. Setting the left-hand side of equation (1) to zero and defining that $\forall t : \tilde{P}_C = P(t) = P(T)$, we can express the production cost $\tilde{P}_C$ as:

$$\tilde{P}_C = \frac{C_0 + C_p N_0 + \sum_{t=a}^{T} B(t)\left[V_h(t) C_h(t) + C_G(t)\right]}{\sum_{t=a}^{T} B(t) V_h(t)} , \qquad (2)$$

in other words, the production cost of a cubic metre of wood is defined as discounted costs defrayed over a rotation, divided by discounted volume yields. Note that in this definition of production cost the opportunity cost of the silvicultural strategy is assumed to be zero.

2.2 Product quality

The industrial utility value and, hence, the relative price of a given quality of timber depends on diameter as well as homogeneity, strength and stiffness of the wood. The only measure of diameter that is directly available as output from a forest growth model is the diameter at breast height and, to be more specific, for a stand growth model it is the quadratic mean diameter of thinned or harvested trees. To characterise the outcome of a silvicultural strategy a single measure of diameter is needed. An obvious candidate measure is the volume-weighted quadratic mean diameter. However, while this metric yields a fair description of the size of stems produced, it appears inappropriate that it attaches the same weight to volumes harvested in the near and far future. Therefore, it may be chosen to use a discounted and volume-weighted quadratic mean diameter instead. The two alternative metrics are thus defined as:

$$\overline{D}_g = \frac{\sum_{t=a}^{T} V_h(t)\, D_g(t)}{\sum_{t=a}^{T} V_h(t)} \quad \text{and} \quad \overline{D}_{gW} = \frac{\sum_{t=a}^{T} B(t)\, V_h(t)\, D_g(t)}{\sum_{t=a}^{T} B(t)\, V_h(t)} \;. \quad (3)$$

As regards the wood quality of the timber, we cannot apply the visual and subjective classification rules that are used in practice. Instead wood quality must be quantified using a simple index that can be derived from growth model output. For simplicity and to avoid introducing additional models it is chosen to apply the average ring width at breast height. For a stand that reaches breast height at age t_{bh} the average ring width at breast height can be estimated as: $R(t) = D_g(t)/(2[t-t_{bh}])$. To obtain measures that characterise a whole silvicultural strategy we use the same principles as above, i.e. either a simple, volume-weighted average ring width or a discounted and volume-weighted average ring width:

$$\overline{R} = \frac{\sum_{t=a}^{T} V_h(t)\, R(t)}{\sum_{t=a}^{T} V_h(t)} \quad \text{or} \quad \overline{R}_W = \frac{\sum_{t=a}^{T} B(t)\, V_h(t)\, R(t)}{\sum_{t=a}^{T} B(t)\, V_h(t)} \;. \quad (4)$$

2.3 Price structure

As mentioned in Section 1 one of the premises of this paper is that the forest owner or manager has a firm expectation regarding the future price structure, i.e. the relative effects of diameter and quality on prices, but no idea about price level or variation. Moreover, he or she wants to avoid introducing historically based assumptions about prices. Evaluation of the relative economic efficiency of silvicultural strategies is therefore done by (i) calculating the production cost and weighted diameter and ring width according to (2)-(4); (ii) proposing a relationship between diameter, ring width and sales price using an arbitrary price level, and (iii) measuring the difference between the hypothetical sales price $P(\cdot)$ and the production cost $\tilde{P}_C$:

$$\Delta = P(\overline{D}_{gW}, \overline{R}_W) - \tilde{P}_C \;. (5)$$

The greater the value of H, the more likely the silvicultural strategy is to be profitable under the applied assumption regarding price structure. Note that as long as the same price function $P(\cdot)$ is used for all strategies the actual level of the function does not matter. To keep the system as simple as possible the basic price function applied in this paper is:

$$P(\overline{D}_{gW}, \overline{R}_W) = p_0 + p_D \overline{D}_{gW} - p_R \overline{R}_W \;, \qquad (6)$$

where p_0 is the (arbitrary) price level and p_D and p_R indicate the price structure.

Figure 2 illustrates the strategy evaluation. Among the five alternative silvicultural strategies shown in Fig. 2 the one yielding the greatest H is Strategy E, no matter the level of the price surface. The poorest performance is observed for Strategy A.

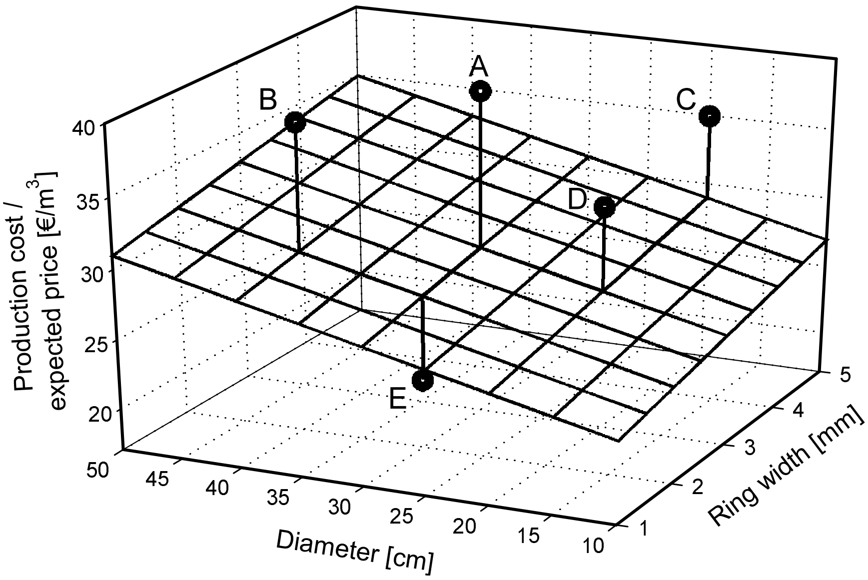

Figure 2. A hypothetical price surface with slopes defined by the forest owner is compared with the production costs, $\widetilde{P}_C$, estimated for five silvicultural strategies (A…E).

2.4 Production cost vs. soil expectation value

The use of the production cost criterion is straightforward: if we consider two different strategies (1 and 2) and “$_1$ > “$_2$, we would prefer Strategy 1 to Strategy 2, just as if $S_1 > S_2$. What may not be quite as obvious is under what conditions the evaluation can be expected to lead to the same conclusion irrespective of the choice of criterion. Therefore, we will briefly consider the problem for a simple situation with only one product quality variable, Q. For a situation where Strategy 1 is preferred to Strategy 2 the production cost criterion can be written as:

$$\Delta_1 > \Delta_2 \Rightarrow P(\overline{Q}_{W1}) - \widetilde{P}_{C1} > P(\overline{Q}_{W2}) - \widetilde{P}_{C2} \ . \quad (7)$$

Using the production cost definition in (2), the discounted and volume-weighted quality measure in (3)-(4), and assuming that the price function $P(\cdot)$ is linear like in (6) and expressed as $P(Q) = \alpha + \beta Q$, the condition in (7) can be written as:

$$\frac{-C_0 - C_p N_{0,1} + \sum_{t=a}^{T_1} B(t)\, V_{h,1}(t)\big(\alpha + \beta\, Q_1(t)\big) - B(t)\big[V_{h,1}(t) C_h(t) + C_G(t)\big]}{\sum_{t=a}^{T_1} B(t)\, V_{h,1}(t)}$$

$$> \frac{-C_0 - C_p N_{0,2} + \sum_{t=a}^{T_2} B(t)\, V_{h,2}(t)\big(\alpha + \beta\, Q_2(t)\big) - B(t)\big[V_{h,2}(t) C_h(t) + C_G(t)\big]}{\sum_{t=a}^{T_2} B(t)\, V_{h,2}(t)} .$$

(8)

For Strategy 1 to be preferred to Strategy 2 the soil expectation value criterion implies that $S_1 > S_2$. By specifying S as in (1), setting $P(t) = P(Q(t))$, introducing $E(T)$ as short for $E(T) = ≻(1+E)^{T-a}]/≻(1+E)^{T-a} - 1]$, using the same linear price function as above, $P(Q) = \alpha + \beta\, Q$, and organising the expression in an expedient manner we find that:

$$E(T_1) \times \left(-C_0 - C_p N_{0,1} + \sum_{t=a}^{T_1} B(t) V_{h,1}(t)\big(\alpha + \beta\, Q_1(t)\big) - B(t)\big[V_{h,1}(t) C_h(t) + C_G(t)\big] \right)$$

$$> \quad E(T_2) \times \left(-C_0 - C_p N_{0,2} + \sum_{t=a}^{T_2} B(t) V_{h,2}(t)\big(\alpha + \beta\, Q_2(t)\big) - B(t)\big[V_{h,2}(t) C_h(t) + C_G(t)\big]. \right)$$

(9)

By comparing this expression with (8) above it is seen that agreement between the two criteria cannot generally be guaranteed. However, if $T_1 = T_2$, then the condition $\Sigma B(t) V_{h,1}(t) \leq \Sigma B(t) V_{h,2}(t)$ is sufficient to ensure agreement.

3. Example – applying the method in practice

3.1 Growth model

To enable evaluation of a wide range of silvicultural strategies, including strategies with high or low initial stem numbers, no thinning or heavy thinning, thinning from above or below, long or short rotations, or any possible combination thereof, a very flexible growth model is needed. Leary et al. (2004) developed a flexible stand growth model for Norway spruce in Denmark, which is formulated as a set of three difference equations, all including a common stand-specific coefficient (Φ), i.e. a site quality parameter. The applied, preliminary version of the model is expressed as:

$$\frac{\Delta H_{100}}{\Delta t} = \Phi\, H_{100} \exp\big(-0.1405\, H_{100}\big) , \quad (10)$$

$$\frac{\Delta D_g}{\Delta t} = \Phi 1.525\, D_g^{0.2202}\, \text{Ħ S}\left(-0.000156\, D_g^2\, 1\right) + \&+ (D_g) \;, \quad (11)$$

$$\frac{\Delta N}{\Delta t} = T_{thin}\, 0.000002\, N^{0.7858} \exp\left(0.001476\, D_g^2\, N\right) + CH(N) \;, \qquad (12)$$

where the top height, H_{100}, is the height (in metres) of the 100 trees per ha with the greatest diameters at breast height, D_g is diameter corresponding to mean basal area (in centimetres), N is the stem number (in 100 ha^{-1}), Φ is the stand-specific growth rate parameter, T_{thin} is the time since last thinning (in years), and $CH(D_g)$ and $CH(N)$ are the forced changes in D_g and N due to thinning, respectively.

In the simulations an initial age of 4 years was applied. At this age the top height is assumed to be 0.4 metres. First the height growth was simulated using model (10) until the top height exceeded 1.3 m. The breast height age (t_{bh}) was recorded. The mortality during this time was assumed to be 5% of the plants. Moreover, the diameter corresponding to mean basal area at this age was assumed to be 1 cm. The growth and mortality in the remaining part of the rotation was estimated using the three models (10)-(12). To estimate the total stem volume the volume function of Madsen C Heusèrr (1993) was used.

3.2 Silvicultural strategies

Stand development was simulated for stands with an initial stem number N_0 ranging from 2000 to 7000 ha^{-1}. A step length of 500 ha^{-1} was applied (i.e. N_0 = 2000, 2500, …, 6500, 7000 ha^{-1}). The rotation ages (T) tried out ranged from 35 to 75 years with a step length of 5 years, i.e. T = 35, 40, …, 65, 70. Each thinning was specified using two parameters, the proportion of the stem number removed $p_N = N_{thinned} / N_{before\ thinning}$ and the ratio of the quadratic mean diameter of thinned trees to the quadratic mean diameter of the stand before thinning $r_D = D_{thinned} / D_{before\ thinning}$. The applied thinning alternatives are specified in Table 1 and include both thinnings from below ($r_D < 1$) and from the top ($r_D > 1$). At each thinning occasion all possible combinations of p_{Ni}, $i = 0 \ldots i_{max}(t)$, and r_{Dj}, $j = 1 \ldots j_{max}(t)$, were tried out (note that i_{max} and j_{max} depend on age). The total number of different silvicultural strategies was 19,112,522. The applied growth rate parameter was $\Phi = 0.4$, which corresponds to a maximum average annual increment of roughly 20 m^{3}ha^{-1}.

Table 1. Applied thinning specifications.

Age	Proportion of trees thinned						Relative diameter of thinned trees				
[years]	p_{N0}	p_{N1}	p_{N2}	p_{N3}	p_{N4}	p_{N5}	r_{D1}	r_{D2}	r_{D3}	r_{D4}	r_{D5}
25	0.00	0.40	0.35	0.30	0.25	0.20	0.80	0.90	1.00	1.10	1.20
30	0.00	0.35	0.30	0.25	0.20		0.85	0.95	1.05	1.15	
35	0.00	0.35	0.25	0.15			0.90	1.00	1.10		
40	0.00	0.30	0.20				0.95	1.00	1.05		
45	0.00	0.25	0.15				0.95	1.05			
50	0.00	0.20					1.00				

3.3 Economic parameters

Production costs were estimated as expressed in (2). The cost parameters were: fixed cost of cultivation C_0 = 800 €ha^{-1}, cost per plant C_p = 0.50 €, harvest cost (€m^3) $C_h(t) = 5 + 250 / D_g(t)$, and the annual costs of administration, management, taxes, road maintenance, etc. were assumed constant: C_G = 140 €ha^{-1}. The applied discount rate was $b = 0.02$.

All strategies were examined using the principles expressed in (5) and (6), i.e. for a given hypothetical price surface $P(\overline{D}_{gW}, \overline{R}_W)$ those strategies that yielded the highest value of Δ were searched for, the objective being to examine the characteristics of strategies included in the resulting 'frontier' set, depending on the expected price structure. The frontier was defined as the best 0.01% of the 19,112,522 strategies, i.e. the 1,911 strategies above the 99.99% quantile of the distribution of Δ.

In Section 4 the characteristics of selected frontiers will be examined. To standardise the slope parameters of the price function (6) the function was reformulated as: $P(\overline{D}_{gW}, \overline{R}_W) = 20 + 5\times\left(\vartheta_D \overline{D}_{gW} - \vartheta_R 10\,\overline{R}_W\right)$, where $\overline{D}_{gW}$ is in centimetres, $\overline{R}_W$ is in milli-metres per year, and ϑ_D and ϑ_R express the price structure and vary within the range 0-1.

3.4 Strategy metrics

To describe the characteristics of the frontier strategies a set of metrics is needed. Consider a frontier including the strategies $m = 1\ldots M$. Strategy m includes $k_m = 0\ldots K_m$ thinnings (in some cases there are no thinnings). The stand basal area $G_m(t)$ is considered from the time when the stand reaches a height of 5 metres, $t_{5,m}$. The applied metrics are specified in Table 2.

Table 2. Applied strategy metrics.

	Single strategy (m)	**Set of strategies (1...M)**
Mean plant number	$N_{0,m}$	$\overline{N}_0 = \frac{1}{M}\sum_m N_{0,m}$
Weighted mean thinning age	$\bar{t}_{th,m} = \frac{\sum_{k_m} t_{k_m} p_{N,k_m} r^2_{D,k_m}}{\sum_{k_m} p_{N,k_m} r^2_{D,k_m}}$	$\overline{\overline{t}}_{th} = \frac{1}{M}\sum_m \left(\frac{\sum_{k_m} t_{k_m} p_{N,k_m} r^2_{D,k_m}}{\sum_{k_m} p_{N,k_m} r^2_{D,k_m}} \right)$
Mean basal area	$\overline{G}_m = \frac{1}{T_m - t_{5,m}} \sum_{t_{5,m}+1}^{T_m} G_m(t)$	$\overline{\overline{G}} = \frac{1}{M}\sum_m \frac{1}{T_m - t_{5,m}} \sum_{t_{5,m}+1}^{T_m} G_m(t)$
Mean relative thinning diameter	$\bar{r}_{D,m} = \frac{1}{K_m}\sum_{k_m} r_{D,k_m}$	$\overline{\overline{r}}_D = \frac{1}{M}\sum_m \frac{1}{K_m}\sum_{k_m} r_{D,k_m}$
Mean rotation age	T_m	$\overline{T} = \frac{1}{M}\sum_m T_m$

4. Results

In Figure 3 the distribution of the silvicultural strategies is illustrated with respect to and . Figure 3 also shows the distributions of the frontier strategies for four different market scenarios. For the scenario where $\theta_D = \theta_R = 0.0$ the frontier is found in the central part of the distribution and appears to include 4-5 subpopulations of strategies. If $\theta_D = 0.0$ and $\theta_R = 0.5$, narrow annual rings are prioritised and the frontier 'cloud' moves to the left. In this case the frontier appears to include 2-3 subpopulations. If $\theta_D = 0.5$ and $\theta_R = 0.0$, large diameter is prioritised and the preferred strategies are found in the uppermost right-hand corner. Finally, if $\theta_D = \theta_R = 0.5$, the frontier 'cloud' moves up and to the left. In this case the cloud is very thin and flat, so the frontier covers a wide range of mean ring widths and diameters.

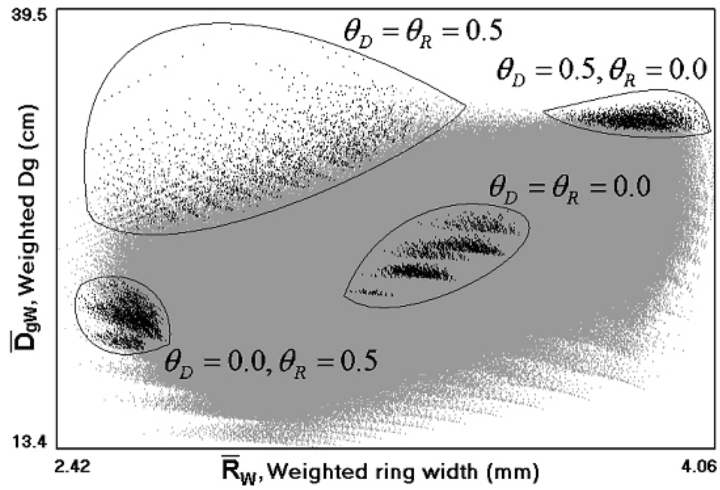

Figure 3. Plot of all 19,112,522 strategies (grey dots) in diameter/quality space. Frontier strategies (black dots) are overlaid for four different market scenarios (θ_D,θ_R).

Figure 3 may indicate that at least some of the frontiers include a wide range of markedly different silvicultural regimes. It emerges that this is indeed true in rather many cases. Figure 4 shows the distribution with respect to and for the particularly heterogeneous case where $\theta_D = \theta_R = 0.5$. It appears that in this case the frontier includes strategies with moderately light to very light thinning and strategies with thinning from below as well as strategies with thinning from above. Closer examination of the frontier in Fig. 4 reveals that the rotation age T only varies from 60 to 75 years (mean 72.6 years), whereas the initial number of plants N_0 varies from 2000 to 7000 ha^{-1} (mean 3024 ha^{-1}), high values coinciding with high values, and the weighted thinning age varies from 25 to 50 years (mean 40.8 years), high values coinciding with thinning from above.

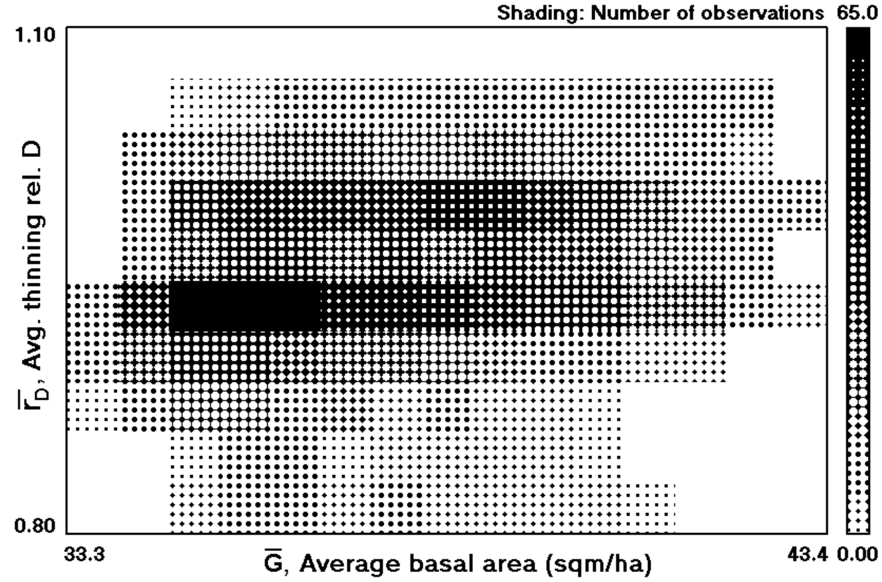

Figure 4. Distribution of frontier strategies for with respect to and .

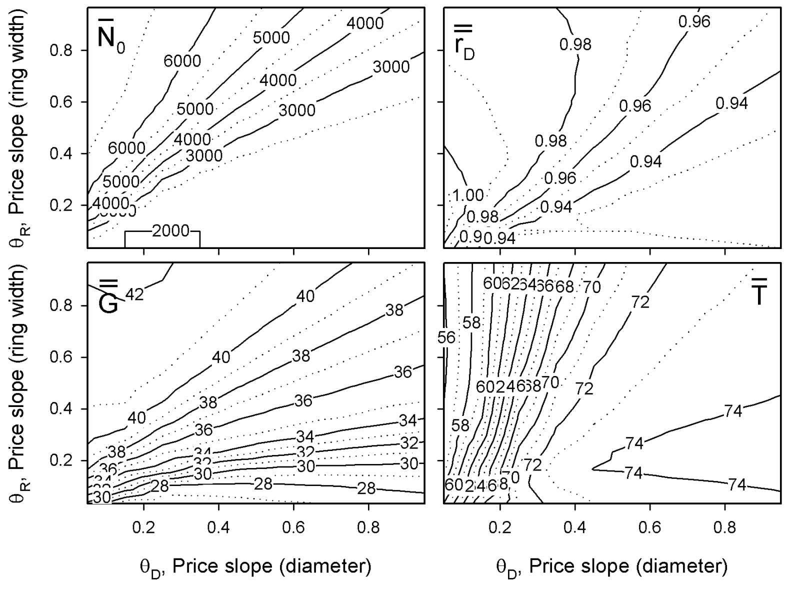

Figure 5. Contour plots showing mean values of strategy metrics for a range of market scenarios . Applied units: : ha^{-1}, : m^{2}ha^{-1}, : years and : no unit.

Depending on one's general attitude and state of mind, the wide range of strategies represented in the frontier in Figure 4 can either be considered comfortable or confusing. However, to obtain a notion of the effect of the expected future market situation it may be sufficient to examine the mean characteristics of the associated frontiers. An example of this is shown in Figure 5. As will appear from the Figure, the variations are pretty much in agreement with common sense, i.e. with increasing weight on quality the mean plant number increases and the thinning intensity decreases. Similarly, with increasing weight on diameter the mean number of plants decreases and the mean rotation age increases. On the other hand, it may be less obvious that increasing weight on diameter has no particular effect on mean basal area if there is no price premium on quality (θ_R HH 0). Similarly, the mean relative thinning diameter is not influenced much by a slope parameter (θ_D,θ_R) if the other slope parameter is close to zero.

5. Conclusion

Application of the production cost measure presented here does not maximise the welfare of the forest owner and, as such, it is not generally an ideal tool for choosing between silvicultural alternatives. However, for an owner who expects the future market to behave in a manner that differs markedly from previous experience and has a firm conviction with respect to the character of this future market, the described procedure is likely to yield robust and presumably quite efficient results without making use of assumptions regarding future price levels or price variations. Moreover, it provides a simple and pedagogic measure of cost, measured on the same scale as prices. Unfortunately, as described by Abildtrup (1999), price structures can be observed to vary considerably over time so the robustness and efficiency of silvicultural strategies chosen on the basis of production cost are clearly conditional on the owner's sincere faith in the applied price structure.

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Sustainability and Long-term Dynamics of Forests: Methods and Metrics for Detection of Convergence and Stationarity

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Abstract

Sustainability has several definitions within natural resource economics. Sustainable states may be economically or biologically determined. Age and age classes add complexity to any definition of forest sustainability. Here we focus on selected metrics that might be used to define forest sustainability, convergence to a sustainable state, and methods that allow convergence detection and classification of forest dynamics. In a deterministic world sustainable states of forests may be cyclic or fixed. If random perturbations are included, sustainability is associated with convergence of distribution parameters. Pattern recognition procedures are presented that detect whether a forest converges to a cyclic, a fixed or a stationary state and whether convergence is fast, slow or cannot be observed within the time horizon considered.

Keywords: Faustmann normal forest, forest cycles, convergence criteria, convergence detection

1. Introduction

An inherent characteristic of forest management is the need to make decisions regarding harvesting, regeneration, thinning and other silvicultural activities. These human interventions influence the current state and long-term development of the forest and its productivity, which determine economically feasible options. Some types of interventions are crucial to the state and long-term dynamics of the forest whereas other interventions have more limited impacts. Forest economics has widely focused on determining the optimal rotation age or harvest time for a stand of trees. However, long-term forest dynamics including the evolution of forest age class structure over many rotations has not received much scrutiny (Newman 2002).

Since the 1950's, standard answers regarding optimal harvesting provided by forest economists have been based on the Faustmann Model of forest management (see Newman 1988 and Newman 2002 for comprehensive reviews). In the Faustmann Model the optimal harvest age that maximizes the net present value of bare land is determined. In most studies the age class structure of the forest is assumed to follow directly from the Faustmann harvest age, and take the form of a Normal Forest, i.e. if a^* is the Faustmann harvest age, then a forest can be divided into a^* compartments, each with $1/a^*$th of the forest area. All a^* age classes within the interval $[0; a^*[$, or $[1; a^*]$ depending on the season, occupy one compartment and every year one compartment is harvested.

There are several reasons why a normal forest may be desirable, including such advantages as sustainable harvest levels and the absence of adjustment costs from changing harvest levels. However, the idea of a normal forest and particularly the Faustmann normal forest has acquired almost mythical, unquestioned status as an inherently desirable goal. Only a limited number of studies have addressed the questions of under what circumstances is a Faustmann normal forest desirable, under what conditions will optimal harvesting generate a Faustmann normal forest, and what types of dynamic/static age class structures will otherwise arise (Mitra & Wan 1985, 1986, Salo & Tahvonen 2002a,b, 2003, Wan 1985, Wan & Anderson 1983, Wan 1994).

A re-examination of the desirability and a more extensive analysis of the conditions that generate Faustmann normal forests are timely due to the emergence of sustainability as an increasingly important natural resource management goal, and the simultaneous proliferation of optimal harvesting rules that either extend the Faustmann rule or offer alternative rules, e.g. the 'reservation price approach' (Brazee & Mendelsohn 1988, Brazee & Newman 1999, Lohmander 1987) and the 'real-options approach' (Thorsen & Malchow-Moller 2003). The development of such alternative harvest rules, incorporating risk and uncertainty or in other ways extending the Faustmann Model, have dominated the forest economics literature since the late 1980's (Newman 2002). The focus of these alternative rules has been to incorporate omitted factors into optimal harvest rules. Thus, for example the analyses have focused on optimal response to changing prices, but have not analyzed changes of age class structures over time and the associated effects on managerial flexibility and sustainability.

Although much has been written on sustainability, little has been done to quantify the impacts of sustainability and its implications for forest management. The popularity of sustainability as a goal of forest and natural resource management suggests a concern with future harvests, future forests, and managerial flexibility. How the age class structure of a forest changes over time and how this influences the availability of mature stands for possible harvest are essential components of both determining forest sustainability and managerial flexibility.

The aim of this paper is to provide some of the tools needed to analyze age class structure and long-term forest dynamics. Metrics are a primary tool to describe forest dynamics and to distinguish between desirable and less desirable dynamics. The metrics are intended to serve as a basis for future studies that attempt to combine theoretical and applied approaches by focusing on the development and simulation of very simple systems with some standard features of standing forests. These studies are intended to supplement theoretical works with more detailed results providing a broader and clearer picture of the implications of various decision rules and management strategies.

The outline of the paper is as follows. In Section 2 general metrics are presented. In Section 3 relevant forest state variables are defined and identified. In Section 4 we present methods for convergence detection for different types of systems. In Section 5 we illustrate the characteristics of selected metrics when applied to a simple, deterministic example. Section 6 is a brief conclusion.

2. General metrics

By 'general metrics' we refer to parameters or statistics that are applicable to and could measure the distributional properties of almost any variable. These general metrics are intended to characterize dynamics after the time when the forest appears to have converged to some sort of dynamically stable state, or after the time when it has been decided that such a state cannot be identified within the time frame considered.

The graph in Figure 1 shows a single cycle of a forest state variable in deterministic systems or a forest state distribution parameter in stochastic systems. Figure 1 illustrates some standard metrics within a forest state cycle. The variations of the state variable influence the level and stability of the owner's utility as well as the risk implied by unexpected external events. The forest value is above the cycle mean most of the time but has a large negative spike. Within the context of risk aversion a large negative spike may have a greater impact than indicated by the standard deviation or the amplitude. Similarly, a large positive spike may have a smaller impact than indicated by the standard deviation or the amplitude.

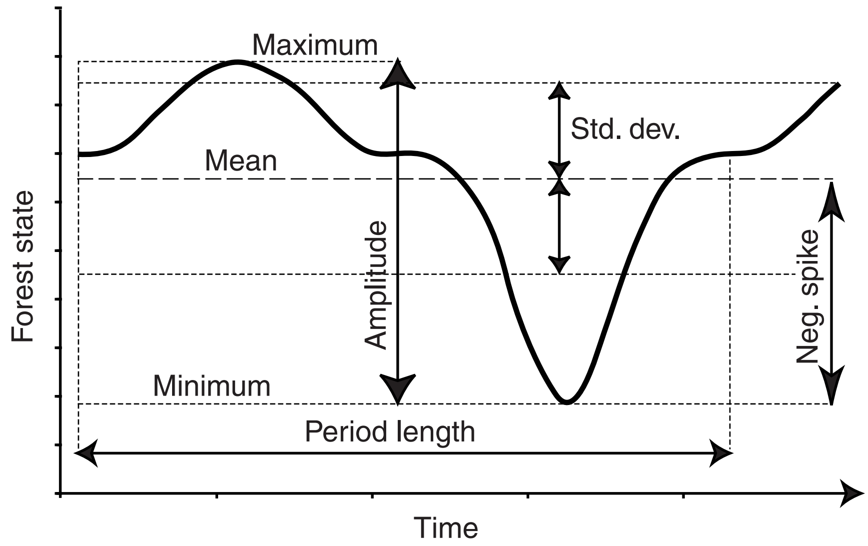

Figure 1. Characterization of the dynamics of a cycling forest state variable or distribution parameter.

When the forest has reached a static or dynamic equilibrium it will be characterized by constancy or cycles. To characterize cycles by periodicity let the *period length*, $p \geq 1$ be the time between identical forest states or identical distributions of forest states.

Dynamics type is a basic classification metric. We distinguish three different types: *convergent*, *cyclic* and *unresolved* dynamics. For *asymptotically convergent* dynamics the period length is $p = 1$, for *cyclic* dynamics $p > 1$, and for *unresolved* dynamics, p is not identified within T years. Formal definitions are presented in Section 4. Unresolved dynamics may indicate a chaotic process but – more likely – it means that the system has not been monitored for a sufficiently long period of time (T). To identify truly chaotic dynamics is demanding, both in terms of required number of iterations and required numerical precision. Stochastic state variables are considerably more difficult to characterize than are deterministic state variables. However, deterministic state variables are often difficult enough to type. For example, in one of the cases in Meilby (2002) a forest was observed to enter a 3,500-year cycle after roughly 12,000 years. Given the large, unknown number of iterations that maybe required to identify chaotic dynamics we prefer using the term '*unresolved*'.

A variable that is strongly related to the identification of the dynamics type and the associated period p is the *time to convergence*. The time to convergence, t_c, is defined as the time from the start of the process to the time of the first occurrence of a repeated forest state or forest state distribution and, therefore, for unresolved dynamics the value of t_c is not defined.

Consider a forest state variable, $X(t)$ at time t, $t \in [0;T]$. As all cycles of a fully converged deterministic forest are identical within some numerical tolerance, for a forest that has converged we only need to consider the period $t_0 = t_c$ to $t_1 = t_c + p - 1$ i.e. it is only necessary to define the metrics for one single period of duration p. However, in situations where the dynamics remain unresolved, and situations where state variables are stochastic, we may need to consider the period $t_0 = T - p$ to $t_1 = T$. Since examining an entire time horizon is effort consuming, it may be desirable to examine a subperiod. For unresolved deterministic dynamics one may choose to examine a given percentage of the latest simulated states. For many series, we found examining the last 10-20% of the series to work well. For a single convergent stochastic variable a reasonable choice seems to be to evaluate all states observed after the time when convergence was detected. For a single stochastic variable that does not appear to converge autocorrelation is likely to occur, and it may be appropriate to evaluate a systematic or random sample of, e.g., 10-20% of the forest states observed within the last 50% of the simulation.

Standard descriptive statics may be used to characterize both the trajectory of *X(t)* in the interval $t \in [0;T]$, or within a cycle of duration $p \geq 1$. For unresolved cases and for stochastic forests we operate on a sample. For deterministic cases with a fixed cycle, population formulas are used. Useful descriptive statistics include the *mean*, the *standard deviation*, the *minimum*, the *maximum* and the *amplitude*.

Compared to small and frequent negative deviations, rare but large negative deviations are often highly influential, when evaluating the utility of NPV or cash flow. Hence, it may be relevant to consider the *skewness* of the distribution of *X(t)*. Again we need to distinguish between situations where we operate on a sample or on a population. A simple skewness measure is:

When we consider a sample: $$.\ (X) = \frac{\sum_{t=t_0}^{t=t_1} \left(X(t) - \overline{X} \right)^3}{(S-1)\ V(X)^3}\ .$$

When the complete cycle is known: $$.\ (X) = \frac{\sum_{t=t_0}^{t=t_1} \left(X(t) - \overline{X} \right)^3}{S\ V(X)^3}\ .$$

An alternative way to measure the asymmetry of the distribution is to calculate the proportion of the sum of squared deviations caused by negative deviations from the mean:

$$G(X) = \frac{\sum_{t=t_0}^{t=t_1} + (t)^2}{\sum_{t=t_0}^{t=t_1} \left(X(t) - \overline{X} \right)^2} \quad \text{where} \quad H(t) = \begin{cases} 0 & if \quad X(t) \geq \overline{X} \\ X(t) - \overline{X} & if \quad X(t) < \overline{X} \end{cases}$$

By applying the above metrics to the relevant forest state variables a description of the long-term dynamics should be obtained for almost any forest system. However, as mentioned above the exact use of general metrics depends on the specific characteristics of the system under study.

3. State variables

The state of the forest may be described by a set of variables, which express the factors that have the greatest influence on economic sustainability, i.e. variables that describe the owner's current choices, long-term flexibility and the potential for dynamic stability. No single variable can describe all factors but by combining a few variables it may be possible to construct a useful description.

An obvious measure to partially describe an owner's current choices is the *disposal* or *liquidation* value of the forest (not including the sales value of bare land). Suppose that *a* is age, a_{max} is the maximum biological age of the forest or the maximum age that would ever occur in the forest, *P*(*a*) is the stumpage value at age *a* on a per hectare basis, and *A*(*a*,*t*) is the area in age class *a* at time *t*. The liquidation value at time *t* is:

$$L(t) = \sum_{a=1}^{a_{max}} P(a)\, A(a,t) \quad .$$

The liquidation value provides an indication of immediate flexibility but does not characterize the range of options available to the owner in the long term. Therefore, we include the *net present value* of the forest at time *t*:

$$W(t) = \lim_{T \to \infty} \sum_{\tau=t}^{T} \sum_{a=1}^{a_{max}} A_H(a,\tau) \big(P(a) - C\big) \left[1 + r\right]^{-(\tau - t)} \; ,$$

where A_H(*a*,*ô*) is the area harvested in age class *a* at time *ô*, *r* is discount rate and *C* is regeneration costs. In practice *W*(*t*) will be estimated on the basis of revenues from a finite period of time. However, with a positive discount rate net values in the distant future will be close to zero, and the approximation of *W(t)* will be close to the actual value. With the inclusion of state probabilities the extension to an expected net present value is immediate.

In the calculation of net present value future revenues and costs are weighted according to the owner's own time preference, and thus the net present value yields an exact description of the forest value perceived by a particular owner. However, with a positive discount rate the net present value puts the most weight on revenues of the near future. NPV does not provide a good description of the long-term stability of income from the forest. To adequately describe long-term stability we introduce a metric describing the age structure's *current deviation from a normal forest*. The goal of this metric is to determine the degree of disagreement between the actual land area distribution at time *t* and the normal forest rectangle (width a^* years; height $1/a^*$):

$$N(t) = \sum_{a=1}^{a^*} \left| A(a,t)/A_{tot}(t) - 1/a^* \right| + \sum_{a=a^*+1}^{a_{max}} A(a,t)/A_{tot}(t) \; ,$$

where $A_{tot}(t)$ is the total current area of the forest.

In a sense each deviation is counted twice, i.e. where it is "missing" and where it ends up. The highest value of this metric, $N = 2$, would only arise in a forest that is all older than a^*. When a forest is all younger than a^* and all land is in a single class, *N* converges towards 2 as a^* approaches infinity.

4. Convergence

To develop methods for pattern identification and classification of dynamic state variables, we need to distinguish between strictly deterministic systems, and processes that are known to be influenced by stochastic disturbances or are likely to endogenously generate perturbations. Truly deterministic systems are unlikely to exist in reality, but serve as useful benchmarks because results for deterministic systems are usually more detailed and complete than results for systems that include random effects. In addition, the dynamics of simple deterministic systems can be evaluated using only a single simulation, while it will usually be necessary to undertake Monte-Carlo simulations to evaluate stochastic systems.

In deterministic cases dynamics can be classified by examining whether a parameter converges towards an asymptotic value, a fixed cycle or remains unresolved at the end of the time period considered. In stochastic cases classification implies recognizing if and when a distribution parameter converges in probability to a limit. Here we will both consider situations where distribution parameters converge asymptotically (p = 1) and situations where they converge towards a cycle ($p > 1$). In all cases we will use the term ‘stationarity’ (*sensu lato*) to indicate a situation where convergence has been detected, no matter the particular type of pattern identified.

4.1 Convergence of deterministic systems

At time t the state of the forest system is given by $X(t)$. The system is monitored for T years/iterations, and the sequence is examined for occurrence of periodic/cyclic behavior. For any (small) tolerance *å* we may generally state that a cycle with period $p \geq 1$ occurs for X from time t_c and onwards if:

$$\forall k \in N^{+}, \forall \tau \in [0...p-1]: \left|X_i(t_c+\tau+k\,p) - X_i(t_c+\tau)\right| < \varepsilon \ .$$

As we only monitor the development of the system for T years a cycle with period p is in practice observed if

$$\forall k \in \left[1...\mathrm{int}\left((T-t_c)/p\right)\right], \forall \tau \in \left[0...p-1\right]: \left|X_i(t_c+\tau+k\,p) - X_i(t_c+\tau)\right| < \varepsilon \, .$$

If the observed period is p = 1, we will describe the convergence of the trajectory as asymptotical, otherwise it converges to a cycle. If t_c and p are not identified within T years the dynamics of the system is considered unresolved.

4.2 Convergence detection for replicated stochastic series

To detect dynamics types for stochastic series, it is necessary to define convergence of a stochastic series. There are several definitions of stochastic convergence. We adopt a simple definition based on Billingsley (1995, p. 70): lim$_{t®¥}$ P[|*Y*(*t*)-*ì*| ³ *e*] = 0, where *ì* is the convergence level of the parameter *Y* and *e* is an arbitrary tolerance.

Similar to deterministic systems the first task is to examine whether a process stabilizes over time or not. If the process converges key questions are: (1) how are the dynamics characterized, (2) at what level does the process stabilize and (3) how does the process vary over time. Here we attempt to categorize the stationary state by the first two moments of the distribution of outcomes. To do this it must first be determined whether the first two moments converge asymptotically or exhibit periodic behavior (cycles). In case that neither of these apply, we will consider the dynamics unresolved.

As above the system is monitored for T years. The simulation is repeated M times.

Accordingly, for $X(t)$ we have M different outcomes, $X_1(t)\ldots X_M(t)$. We define a level á at which we test the value of the mean and variance of X at one point in time, t_1, against the mean and variance of X at another point in time, t_2. We then propose a time of convergence $t_c \geq >0;T>$ and a period p ³ 1, and repeat the test $\forall N\geq \left[1 \ldots \text{IQW}((T - t_c)/S)\right]$ and $\forall \tau \in \left[0 \ldots p-1\right]$ with $t_1 = t_c + \tau$ and $t_2 = t_c + \tau + NS$. Based on the null hypothesis H_0: $s^2(X(t_1)) = s^2(X(t_2))$, we test the equality of the variances using the F statistic:

$$F = \frac{\max\left\{s^2(X(t_c+\tau)), s^2(X(t_c+\tau+kp))\right\}}{\min\left\{s^2(X(t_c+\tau)), s^2(X(t_c+\tau+kp))\right\}},$$

which is F-distributed with (M-1,M-1) degrees of freedom under H_0.

For all combinations of t_c and p the number of times that H_0 is rejected is tallied, and if the proportion of rejections does not exceed á or some other chosen threshold, we conclude that the variance of X is likely to exhibit periodic dynamics with period p from time t_c and onwards.

If it is established that periodicity with period p cannot be rejected from time t_c and onwards, we may proceed testing whether the apparent periodicity applies to the mean values too. The null hypothesis is H_0: $\mu(X(t_1)) = \mu(X(t_2))$. For all combinations of k and τ the following t statistic is used to test the null hypothesis:

$$t = \frac{\overline{X}(t_c+\tau) - \overline{X}(t_c+\tau+kp)}{\sqrt{\left(s^2(X(t_c+\tau)) + s^2(X(t_c+\tau+kp))\right)/M}}.$$

The number of degrees of freedom in each individual test can be estimated using Satterthwaite's approximation. When the number of replications is equal in the two samples Satterthwaite's approximation can be expressed as:

$$df = (M-1)\left(1 + \frac{2s^2(X(t_c+\tau))s^2(X(t_c+\tau+kp))}{s^4(X(t_c+\tau)) + s^4(X(t_c+\tau+kp))}\right),$$

i.e. df approximately equals 2 (M-1).

Again the number of times that H_0 is rejected is tallied. If the proportion of rejections does not exceed the chosen threshold, we conclude that the mean of X is likely to exhibit periodic dynamics with period p from time t_c and onwards.

Since the null hypothesis for mean values is only tested if the variance appears to be periodic, then it is assumed that $\sigma^2(X(t_1)) = \sigma^2(X(t_2))$, and we may use the pooled-variance version of the t statistic:

$$t = \frac{\overline{X}(t_c+\tau) - \overline{X}(t_c+\tau+kp)}{\sqrt{2s^2/M}},$$

where s^2 is the pooled variance:

$s^2 = (M-1)\times\left(s^2(X(t_c+\tau)) + s^2(X(t_c+\tau+kp))\right)/(2M-2)$ and the number of degrees of freedom in each individual test is $2M$-2.

It should be noted that the outcomes of the tests described inevitably depend on the number of replications (M) and the chosen significance level (a). Moreover, it may happen that ambiguous results are obtained, i.e. that periodicity is accepted for a number of different values of p (that are not multiples of each other). To choose the most likely set of t_c and p the value of a may be increased, leading to more frequent rejections of the null hypotheses, until only one candidate remains.

4.3 Convergence detection for a single stochastic trajectory

Although convergence of the mean and the variance indicate the existence of a comparatively stable region, they do not describe, neither address the convergence path. Paths may converge at different levels or exhibit fluctuations with different amplitudes, and some paths may become stationary before others. Therefore the distribution of times to stationarity (t_c) of individual paths as well as the mean and variance of individual stationary paths with regard to a specific state variable, X may be of interest. Here we define a convergence criterion for an individual series in addition to the convergence criteria defined above for the two first moments of the distribution of outcomes.

A single simulation of the system is not sufficient to enable estimation of the moments of the distribution at a given point in time. On the other hand, it appears to be a sufficient basis of examining whether the individual X series converges towards a limiting distribution. Suppose that the system is monitored for T years, with T being so large that the system can be expected to converge within this time if it converges at all. Suppose also that the last u years of the simulation ($t = T\text{-}u+1\ldots T$) are used as a basis of estimating the first two moments of the distribution. Next, using appropriate assumptions regarding the type of limiting distribution, outliers can be detected by introducing a threshold probability of more extreme outcomes (P_{ext}) and by estimating the corresponding quantiles, $Q_{lo}(u)$ and $Q_{up}(u)$, of the distribution. Next, the number of outliers, i.e. values below $Q_{lo}(u)$ or above $Q_{up}(u)$, may be summed from $t = T$ to $t = 0$. The time of convergence t_c may then be defined as the time when the calculated proportion of outliers, $R_{outlier}$, first exceeds a threshold value, i.e., $R_{max} {}^{3} P_{ext}$. $R_{outlier}$ is defined as:

$$R_{outlier}(u,t) = \frac{\#t \geq \succ t;T]\,|\,X(t) < Q_{lo}(u) \vee X(t) > Q_{up}(u)}{T+1-t} \quad .$$

A key choice is the value of u, i.e. the period used to estimate the moments of the limiting distribution. Clearly, the greater the value of T the better, not only because it improves the chances of actually observing values representing the limiting distribution but also because it allows for greater values of u, improving the estimates of the moments of the limiting distribution. If autocorrelation of the series arise, it may be necessary to examine the first-order differences of state variables, $\Delta X(t' \rightarrow t\text{-}1) = X(t) - X(t\text{-}1)$, instead of the current state variables, $X(t)$.

A general concern with the analysis of single stochastic time series is that, not even a long relatively stable series can guarantee that the system will not at some point diverge. Not even a Monte Carlo simulation will be able to demonstrate that a given system can never exhibit divergent behavior. Of course, if divergent patterns occur with not too small probabilities, we would expect to observe them if we execute a reasonable number of simulations. However, the possibility remains for stochastic series that rare circumstances may cause divergent behavior.

5. Examples

To illustrate and compare the properties of the proposed metrics, we examine a simple deterministic forest system with four age classes. The forest is assumed to have converged, meaning that the age class structure is repeated every four periods, and that all state variables fluctuate with $p = 4$. The age classes may be thought of as 10-year classes. Using a discount rate of 0.2 therefore corresponds to roughly 0.02 on an annual basis.

The assumed harvest revenues and liquidation values are given in Table 1. The values are stated in hypothetical monetary units per ha (MU ha^{-1}) but to give the values some real meaning one may think of 1 MU as, e.g. 1000 € or 1000 $.

First, we apply the metrics. Figure 2 presents eight age class structures, four of which (A…D) are designed to illustrate extremes, and four of which (E…H) are 'random' age class structures. As the forest has reached a cyclic equilibrium, and all metrics are calculated for the 4-year cycle the mean of liquidation and present values do not vary between age class structures. The mean liquation value is 6.00 and mean present value is 25.50. Results for standard deviation, skewness and amplitude are presented in Table 2. The variation within a cycle obviously depends on the age class structure, the normal forest (A) yields no variation at all and the single age class forest (D) yields a standard deviation for liquidation value that is similar to its mean liquidation value, and a standard deviation of the present value, that is roughly 20% of the mean present value. With only a single age class (D) has a large amplitude.

Regarding the deviation from a normal forest, it should be noted that due to the fact that this metric attaches the same weight to all age classes, it does not vary between the four periods of the cycle. Consequently Table 2 only includes the 'mean'. The maximum value of 1.5 is reached for age class structure (D). Since age classes 5 and over are not allowed in this example, 1.5 is the maximum possible value.

The skewness metrics cannot be calculated for the normal forest (A) as the standard deviations of liquidation and present values are both zero. For the forest with three age classes (B) the skewness of the liquidation value is negative because it has a marked negative spike due to the missing age class. By contrast, for this age class structure the skewness of the present value is positive because an upward spike generated when age class 1 is empty dominates. Note that for the forest with one age class (D) the results are exactly the opposite, and for the forest with two age classes (C) the distributions of liquidation and present values are symmetric so both skewness metrics are zero.

Table1. Harvest revenues and liquidation values used in the example.

Age class	**1**	**2**	**3**	**4**
Time of payment	0	1	2	3
Harvest revenue (MU ha^{-1})†	-4	0	6	15
Liquidation value (MU ha^{-1})†	0	1	8	15

† MU ha^{-1}: Monetary Units per ha

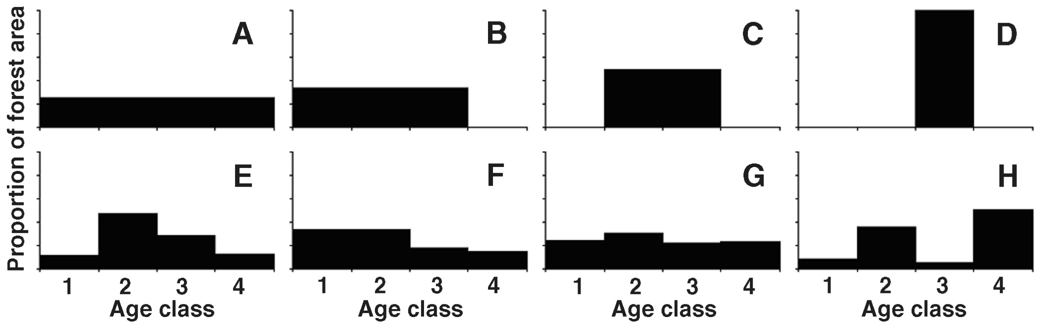

Figure 2. Age class structures applied in Table 2.

Table 2. Metrics for the eight age class stuctures A...H in Figure 2.

	Liquidation value, L (MU ha^{-1})†				Present value of forest, W (MU ha^{-1})†				Dev. from normal, N
	Mean	Std. Dev.	Skew-ness	Ampl.	Mean	Std. dev.	Skew-ness	Ampl.	(Mean)
A	6.00	0.00	-	0.00	25.50	0.00	-	0.00	0.00
B	6.00	2.01	-0.45	5.00	25.50	1.74	0.76	4.43	0.50
C	6.00	4.03	0.00	11.00	25.50	3.46	0.00	8.61	1.00
D	6.00	6.04	0.45	15.00	25.50	5.21	-0.76	13.28	1.50
E	6.00	2.19	-0.18	5.07	25.50	1.88	-0.54	5.17	0.50
F	6.00	1.44	-0.12	4.00	25.50	1.23	-0.05	2.91	0.35
G	6.00	0.49	0.77	1.30	25.50	0.42	-0.29	1.06	0.12
H	6.00	1.72	0.12	4.71	25.50	1.51	-0.63	3.80	0.74

† MU ha^{-1}: Monetary Units per ha

Apart from 'period length' and the 'time to convergence', we have suggested 4-7 different general metrics and 3 different variables that may be used to describe the state of the forest. This implies that there are a total of 12-21 metrics that need to be considered when describing the dynamics of a deterministic forest. However, some of the metrics are likely to be highly correlated. For example it is obvious that the standard deviation and amplitude of a variable are highly correlated. Therefore, in Table 3 we have calculated Pearson coefficients of correlation for seven metrics based on a sample of 2000 random forests, each with four age classes and a cycle with $p = 4$, similar to the examples (E…H) in Fig. 2. As expected, the table shows that one single metric describing the variation, be it a standard deviation or an amplitude, is sufficient. On the other hand, the skewness of liquidation value and present value are quite uncorrelated, and the correlation between the skewness metrics and any of the variation metrics are low. The deviation from a normal forest is, not surprisingly, highly correlated with the variation metrics but the correlation with the skewness metrics is low. Therefore it appears that to describe a deterministic forest one metric describing the mean of present value (or liquidation value), one metric describing the variation, either standard deviation or amplitude, and two skewness

Table 3. Estimated coefficients of correlation (Pearson) between pairs of metrics. The estimates are based on a sample of 2000 random initial age class structures with 4 age classes and a cycle with period 4.

			Liquidation value, *L*		**Present value of forest, *W***			**Dev. from normal, *N***
			Skewness	Amplitude	Std. dev.	Skewness	Amplitude	(Mean)
			2	3	4	5	6	7
Liquidation value, *L*	Std. dev.	1	0.16	*0.99*	*1.00*	-0.20	*0.99*	0.89
	Skewness	2		0.16	0.16	0.01	0.15	0.17
	Amplitude	3			*0.99*	-0.20	0.95	0.89
Present value, *W*	Std. dev.	4				-0.20	*0.99*	0.90
	Skewness	5					-0.20	-0.30
	Amplitude	6						0.88

metrics are needed. In addition it may be desirable to add the deviation from a normal forest.

6. Conclusion

In this paper we have outlined a number of general metrics and state variables that, in suitable combinations, may be used to describe the long-term dynamics and economic sustainability of forests in both deterministic and stochastic settings and regardless of whether convergence is detected or not. We note that if convergence is not detected it cannot be known whether the calculated metrics are representative of the long-term dynamics or simply describe part of the path towards a long-term equilibrium, provided such equilibrium exists. Obviously, detection of convergence is much easier for deterministic than for stochastic systems. In fact, for stochastic systems there is always a possibility, however small it may be, that random events may provoke the system to leave the equilibrium that it once converged towards. Nevertheless, provided that a sufficient number of iterations and replications are included in simulations the methods presented in Section 4 should enable identification of at least temporarily convergent dynamics.

Clearly, the metrics and principles described here are of limited value when examined in isolation. Thus, the *raison d'être* of this paper is to provide a foundation for simulation-based studies focusing on long-term forest dynamics that arise under a specific set of decision rules, initial conditions and externalities. Together the metrics and procedures in this paper form a partial toolbox. Although not likely to be complete we still expect the paper to introduce several of the tools that will be necessary for ongoing and planned studies on the role of constraints and taxation in the convergence of forests, dynamics resulting from the reservation price approach, and dynamics arising at the forest sector level as a consequence of owner's decision rules.

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IAS Fair Value and Forest Evaluation on Farm Forestry

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Summary

Forest evaluation causes the greatest problems in farm accounting because it requires exact, up-to date information concerning growing stock and bare forest-land. Moreover, the changes in forest property value caused by the fluctuation in stumpage prices affects both the balance sheet and even the profit and loss statement, and thus all forest profitability measures from annual net profit to various ROI measures. While the evaluation of merchantable stands can be based on market prices, the evaluation of unrealisable property, such as seedling stands, as well as young and middle aged stands, is imprecise.

In 2002, the European Union (EU) accepted the International Accounting Standards (IAS) –decree, which presumes that publicly quoted enterprises provide their concern financial statement according to the International Financial Reporting Standards (IFRS)[1] in 2005 at the latest. The forest industry corporations such as Stora Enso, UPM Kymmene and the M-real group are considerable forest owners, and have to apply IFRS decree and IAS regulations as well. The IAS 41 came into force at the beginning of 2003 (IAS 2002). This standard requires that the biological property of public enterprises on the stock exchange has to be evaluated by a 'fair value', which can be defined in terms of market prices at the time of felling and marketing expenses. However, evaluation by a 'fair value' must not be made if the value cannot be measured reliably. The value of seedling stands, as well as young and middle-aged stands can be based on yield value, such as net present value (NPV), which is calculated by discounting the incomes and costs. The interest rate used is defined in the IAS by the 'risk-free' rate. Although the IAS does not bind enterprises outside the stock exchange, there are reasons for other enterprises even on farms to adopt its practices.

The value of the whole growing stock has been divided into inventory and fixed asset in the balance sheet. The inventory value of the marketable stand is based on an allowable cut calculation that estimates the total number of felling opportunities when only forest law limitations have been included. The change in forest value also affects the profit and loss statement. The IAS therefore causes unrealistic fluctuations in net profit. The yearly fluctuations of property values are caused by fellings, as well as the change in the growing stock, but especially by the changes in stumpage prices. This profit and loss statement volatility suggests that it would be advisable to perform sensitivity analyses and to compare the evaluations obtained from different paradigms.

The forest management test material used in this research was collected from five bookkeeping farms. The farm profitability study is part of the EU's

[1] The Trustees of the IASC (International Accounting Standards Committee) has accepted in March 2001 a proposal to change the name of IAS-standards to IFRS-standards (IASC Foundation, Annual Report 2001).

Farm Accountancy Data Network (FADN). In Finland there are about 900 farms involved in this network. The economic data concerning forestry of the case farms comes from this bookkeeping. However, forest inventory data provided by the farms is based on their forest management plans (FMPs). Using up to date FMPs, the balance sheet can be calculated accurately enough, but over time the data will become obsolete. The value of the forest and its changes requires the growing stock to be updated. In addition to a FMP, knowledge of fellings and silvicultural activities is required. In this study, the applicability of a Finnish forest management planning software (MELA) is used for updating the forest inventory data.

Keywords: forest value, allowable cut, forest management plan, accounting, IAS (International Accounting Standards), farm accountancy data network (FADN)

1. Introduction

1.1 Agricultural bookkeeping farms and forestry

In Finland there were in 2001 roughly 72,500 farms with agricultural arable land exceeding one hectare, possessing altogether 4,490,000 hectares of forest. The average area of forest-land per farm was 48 hectares, an increase of some 6 hectares per farm from 1990. The agricultural profitability bookkeeping maintained by MTT Economic Research monitors the economic development of agriculture, horticulture, diversification business and forestry, based on the accounting data collected annually from the approximately 900 agricultural bookkeeping farms (Profitability bookkeeping 2004). Since 1995, profitability bookkeeping has been part of the farm accountancy data network (FADN) of the member states of the European union (EU). Profitability bookkeeping data and results is employed in research, agricultural administration, economic consulting, advising, interest supervision and agricultural education.

A bookkeeping farm can be disaggregated into different production lines (business areas): agriculture, horticulture, other diversification businesses and forestry. On farms income from timber sales can be used for production and investments in agriculture and other businesses. For each production line, closing the accounts, as well as ratios depicting profitability, liquidity and solvency, can be calculated using the data collected.

It has been difficult to calculate reliable accrual-based closing of accounts for forestry. The reason for this has been the lack of data as well as methodological deficiencies in estimating the values of the growing stock and the bare forest-land. The value of the growing stock fluctuates annually according to impact of the net increase and fellings. Moreover, changes in stumpage prices affect the value of the growing stock. The change in the value of the growing stock affects the profit and loss statement and, consequently, the profitability of forestry.

1.2 The international accounting standard (IAS) and forestry accounting

According to the Statement of Accounting Theory... (1977) research in accountancy can be divided into three approaches: (i) The **classic theory** attempts to create implicit accounting frameworks or to rationalise existing practices. (ii) **Decision-making and its benefits** emphasise investigating decision-making models and decision-makers. (iii) The **information economics** considers what information is needed in economic decision-making (Ikäheimo 1989). According to the **inductive approach** of the classic theory, profit is based on **realised** and **objective** values. The Finnish expenditure-revenue theory introduced by Saario (1968) is an **inductive approach of the classic theory**. The **normative-deductive** approach of the classic theory sees profit as the change in value of the enterprise (Lukka 1989). Finnish bookkeeping practice and legislation has applied the expenditure-revenue theory, but EU membership has caused a considerable change in accounting. After the 1992 and 1997 reforms of the Finnish accounting legislation, the 4th and 7th Company Law Directives of the European Union were adopted in the accounting statutes (for a comparison between Finnish and EU norms, see Teränne 1993).

Forestry accounting has been studied and changes in the valuation of forest analysed by Davy (1987) and Openshaw (1980), among others. Davy emphasises that profits should not be recognised as revenue until they are realised, which is actually against the IAS requirements. Forestry accounting has a long tradition in Central Europe, where data collection has also been developed for small-scale forestry (Sekot and Hellmeyr 2000, Vereinheitlichung … 1980). Eriksson (1996) compared accounting in Germany, France, Switzerland and EU, and recommended harmonisation within the EU. Accounting for non-industrial private forestry has been developed from the German tradition and coping with continuous changes by Hyder et al. (1994, 1996). Accounting for the practical extension has been studied for jointly owned forests (Penttinen 1992), for ratio analysis (Penttinen and Hakkarainen 1998) and for cost accounting (Penttinen et al. 2001).

The international bookkeeping standard called International Accounting Standard (IAS) 41, for the evaluation of biological property, came into force on January 1, 2003 (IAS 2002). This standard requires that *publicly quoted enterprises* evaluate their biological property based on the 'fair value' according to market prices, from which the cost of the sales momentum will be deducted (Argilés & Slof 2001). Evaluation of the property is by the 'fair value' if the value cannot be measured reliably. In forestry, a stand ready for final felling can use the felling value minus sales costs. The market prices of plantings, young or middle-aged stands do not conform to the present state of the biological property. The present value of the expected net cash flow from the asset can be used as their fair value (IFRIC 2003). The used interest rate is either (i) a 'risk-free rate' or (ii) a rate that incorporates a risk premium for the systematic risk inherent in the exptected cash flows (FASB 2003). Here the market interest rate before the impact of taxation is used as the discounting interest rate.

The IAS brings many improvements, such as more transparency and, especially, comparability (Liebfried 2002). The impact of market fluctuations on profit still remains a problem, however. Market value driven pricing of forests and more generally the fixed assets may cause considerable fluctuation in profit, volatility which is not based on real business transactions as recognised by the accounting principles. Moreover, it forces market values based on evaluation of property, which may mean "lazy" capital in the balance sheet. One example of the effect of these pressures is Stora Enso, which sold its forests to its own daughter company Tornator. Moreover, the M-real group has announced that they will sell their forest, in all some 100,000 hectares.

1.3 The objective of the study

The aim of this study is to define the IAS 'fair value' of forest property and the yearly changes in its value for accounting purposes. There are various ex-ante and ex-post methods for the valuation. Ex-ante methods are based in general on a forest management plan and forest inventory data that are used for calculating the expected values of the forest property. Ex-post methods are based on the mean values of realised transactions of forest estate purchases. The values are calculated using econometric methods such as the ordinary least square method (e.g., Airaksinen 1988, Hannelius 1988).

Since the ex-post valuation methods are too general for the IAS 'fair value' estimation, the valuation of the forest property is investigated using existing forest management plans (FMPs) in this paper. The value of the growing stock and the annual timber balance are estimated using the FMP's field measurements. The site information for each stand is also available for the evaluation of the forest-land. The evaluation of the growing stock for each fiscal year requires the updating of the FMP's stand data according to the situation at the end of the fiscal year. All the factors affecting the amount of the growing stock, such as net increment and fellings, have to be updated until the end of the fiscal year. The evaluation of forest land-can be based explicitly on the Faustmann formula or implicitly using the forest land values based on the auxiliary tables of the sum-value method (Vehkamäki 1998).

2. Material and methods

2.1 Evaluation methods

The approach of this study is that of the 'stand method' described by Beståndsmetoden för... (1988a, 1988b, 1988c), applied to determining the change in value the forest capital during the financial year by Hägg (1993) and developed by Bogghed & Jehander (1994). The IAS requires a market-based evaluation. In forest economics, stands have been grouped into three categories, in which the sapling stands such as plantations, seedling stands and natural regeneration have been evaluated using the cost value. In this study the cost value approach is replaced by the expected revenues approach.

The calculations were made using a Finnish forest management planning software package, MELA (Siitonen et al. 1996, Redsven et al. 2002). The MELA system consists of a stand simulator and a linear programming package. The stand simulator is based on individual tree models (see Hynynen et al. 2002, Nuutinen et al. 2000, Redsven et al. 2002). The simulator part automatically creates a finite number of feasible alternative management schedules for each stand. The linear programming package in MELA is the JLP (Lappi 1992).

The growing stock can be perceived both as means of production and product in the accounting framework (e.g. Keltikangas1969). The disaggregation of the value of the growing stock in the assets of the balance sheet requires a special calculation, which distinguishes the proportion of the immediately merchantable growing stock from the remaining growing stock. This split can be performed by the allowable cut calculation of MELA that maximises the immediate cutting opportunity (so-called cutting potential). The remaining share of the growing stock consists of the plantings, young and middle-aged stands, which contain no merchantable wood. In the balance sheet, the growing stock, which can immediately be cut according to the forestry law, the so-called allowable cut belongs to the current assets. The remaining portion of the value of the growing stock belongs to the fixed assets, i.e., tangible assets as an item called 'growing stock of forest'.

The allowable cut calculation yields the volume of the merchantable growing stock as well as the allowable output by roundwood assortment divided into logs and pulpwood. The allowable cut calculation is based on a ten-year calculation period, and the simulated felling is placed in the middle of the period. When the NPV's of the first planning period are maximised, the net incomes of the future periods are also taken into consideration. The allowable cut can also be calculated by maximising the net income of the first period and ignoring the impact of the net income of the future periods.

The annual entrepreneurs profit of a forest enterprise consists of three different parts. (i) The realised net income - the difference between felling incomes and expenditures - required to produce them, (ii) timber balance change, i.e., the change in the growing stock volume, and (iii) the change in the growing stock value caused by changes in stumpage prices. One can therefore talk about a dualistic value change that consists of a dynamic portion, i.e., the property value change based on the volumes, and an economic cycle portion, i.e., the property value change based on stumpage prices (Niskanen ym. 2002). The bare values have been estimated stand-wise using the Faustmann formulae and a long term forecasting horizon.

The annual change in the value of the growing stock will be included even in the profit and loss statement. The annual turnover of forestry can fluctuate dramatically between fiscal years because of the timber sales. However, the change in the value of the growing stock due to the stumpage price fluctuations may be the dominant part of the total income if timber sales income has been small or no wood has been sold during the year in question. This price volatility can cause significant changes in the value of the growing stock between fiscal years. All these annual changes affect the profitability of forestry from entrepreneurs profit to different ROI figures.

2.2 Material and calculations

Information supplied by bookkeeping farms consists of cash-based revenues and expenditures obtained from taxation bookkeeping as well as data of crops and animals, production amounts, changes in property and working hours. In order to be able to calculate accrual-based total operating income and costs, both cash revenues and cash expenditures have to be corrected in FADN-bookkeeping. In order to get turnover and expenditures belonging to that particular accounting year, accounts receivables and advances received have to be taken into account when correction of turnover is done. In correction of expenditure the trade payables and advance payments have to be taken into account. In order to obtain accrual-based items changes in product and purchase inventories must also be taken into account. After these corrections, the accrual-based profit and loss statement and balance sheet can be calculated.

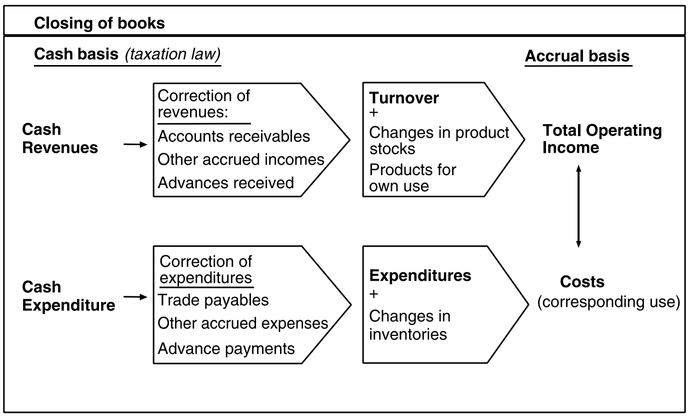

Figure 1. Transformation from cash based transactions to an accrual based one in profitability bookkeeping

In calculating changes of inventories of bookkeeping farms, the value of growing stock in the balance sheet and the changes in forest growing stock also have to be taken into account in the profit and loss statement. The forest management plans (FMPs) of bookkeeping farms for the years 2001 and 2002 formed the research data for studying those changes. In addition, inquiries concerning fellings and other silvicultural activities after the FMPs were sent to farms. The volumes of harvested wood were also sought by timber assortment and tree species for each stand. Moreover, the basal area of the remaining growing stock after the felling was sought, if possible.

The sales income figures of the bookkeeping material are based on realised accounting transactions. The stumpage prices used in the evaluation of the growing stock are average prices for 2001 and 2002 obtained from local forest centres.

The oldest FMPs of the five farms were from the year 2000 and so the values of growing stock do not include growth and fellings, which have taken place during recent years. Thus the growing stock information on the FMPs were updated until the end of 2001 and 2002 using the MELA system. Two different methods were used to simulate the felling information. Fellings were simulated both (i) based on the new updated field measurements and (ii) by using the activity control of MELA, which is based on simulation of silvicultural activities. The value of the growing stock was calculated manually in some cases. Then in both methods the sum value method was used and the forest stand information updated. The total value of the growing stock was then reduced by 30% according to the principle of the sum value method (see. Hannelius 1988, Vehkamäki 1998).

3. Results

3.1 The forest value and the allowable cut

The growing stock of farms were disaggregated in the balance sheet into current assets and fixed assets using the allowable cut calculation of the MELA system. The immediately merchantable growing stock belongs to inventories of the current assets. The value of the remaining growing stock is obtained by subtracting the allowable cut from the NPV of the net incomes of the whole growing stock.

The allowable cut was defined here using two alternative methods: (i) The calculation was based on the maximisation of the net present value (NPV) using a notional interest rate, say, 5%. This NPV calculation also takes into consideration the net income of the following periods. (ii) The calculation was based on the maximisation of net income of the first ten-year period without any consideration of the income from the following periods.

The MELA calculations have been classified as follows:

0) no cuttings = the calculation of the value of the growing stock was performed and based only on the forestry data of the FMP

1) MELA RSU = the calculation was based on the original FMP updated by the field measurements concerning harvested amounts and estimated basal areas of harvested stands

2) MELA SMU = the MELA has an implied activity control that automatically simulates the given harvesting and other silvicultural activities for the years determined, and these simulated activities, removals and stand figures (e.g., basal area), are used as such in the calculations

3) Sum-value = The value of the growing stock has been defined using the sum-value method, in which no cuttings have been taken into consideration

The calculation methods have been grouped according to different allowable cut calculations so that method 'A' maximises the PV of the net incomes and 'B' maximises the net income of the first 10 year planning period only.

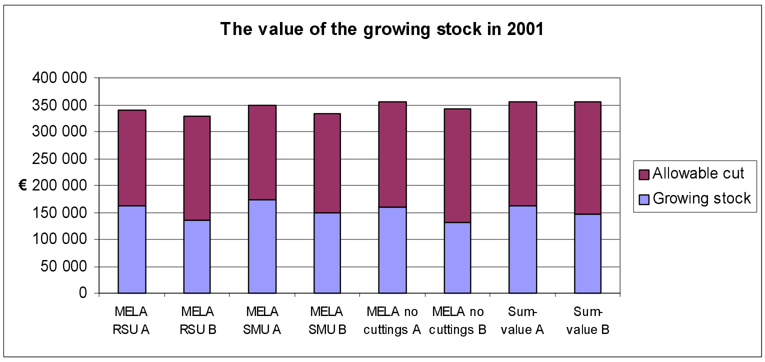

Figure 2. The value of the growing stock in 2001 divided into the allowable cut for the first 10 year period and the remaining growing stock by different methods in 2001

In 2002, the total value of the growing stock increased; on average, by 30,600 €, using method A and 29,700 € using method B. Both alternatives A and B are liquidation options. However, alternative A also takes into account the incomes of the future periods.

The RSU methods are the best in the sense that they have the actual basal area measurements available. However, the difference and the error when using SMU methods are reasonable, and the MELA SMU method would be the best choice or the only choice because of the measurement requirements of the MELA RSU.

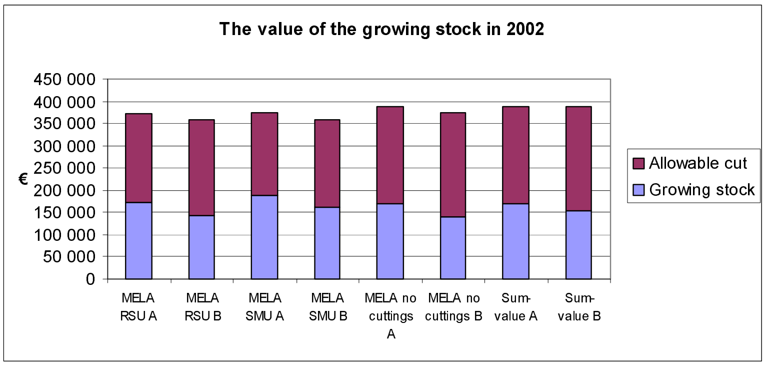

Figure 3. The value of the growing stock in 2002 divided into the allowable cut for the first 10 year period and the remaining growing stock in 2002

With both methods A and B, the allowable cut increased compared to the previous year on average by 10.5%.

3.2 The change in the growing stock value

The change in the growing stock value in 2001-2002 can be divided into the change in stumpage prices and the change in growing stock volumes. The change in volume means the difference between the net increment and fellings. The impact of the changes in stumpage prices has been defined by calculating the value of the growing stock at the end of 2002 using the stumpage prices of 2001 and 2002. The remaining portion of the value change has been caused by the change in net increment and fellings.

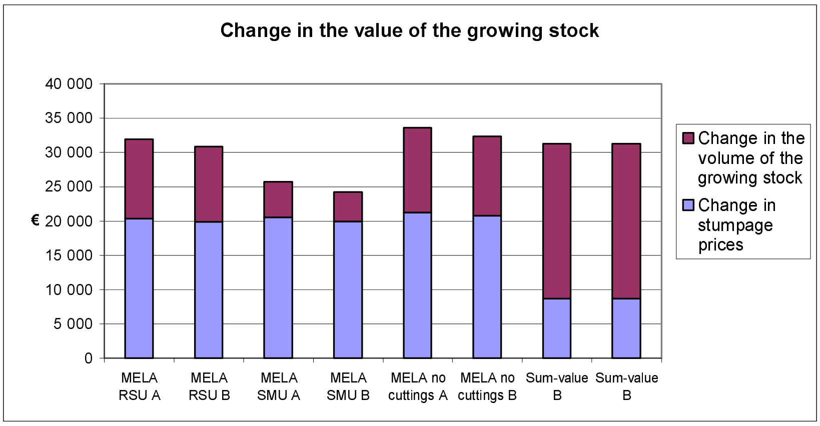

Figure 4. The change in growing stock value divided into stumpage price change and volume change impacts

The incomes of timber sales amounted to 17,500€ in 2002. The MELA RSU A and B methods, and MELA SMU A and B recognised the fellings and reduced the value of the growing stock. When Comparing these methods with methods MELA no cuttings A and B, it appears that the impact of the fellings on the change in the growing stock value is smaller than the sales income.

In this research five farms were used to test the accounting system. The average profit and loss statement and balance sheet of those farms are presented for the simulated felling option, which maximises the PV of the net incomes (SMU A) in frames of the Accounting Ordinance (2002) and the Committee for Corporate Analysis (2000) (see Appendices I and II). The allowable cut calculation is based here on a ten-year calculation period, and the simulated felling is placed in the middle of the period. These results and financial ratios were calculated from five cases (cf. Profitability bookkeeping 2004).

The net result, 39,000 € divided by the equity yielded the return on equity, of about 10 per cent. The profitability of forestry of these test farms was better than the average profitability of other businesses (agriculture, horticulture) in all of the bookkeeping farms. These financial statements and results of the forestry should not be generalised, because of the limited number of observations.

4. Summary

The amendment of the accounting of biological assets, IAS 41, inspired the development of the agricultural accounting network in order to implement an accrual-based accounting system to include forestry assets. The IAS 41 is based on the 'fair value' concept. The most recent interpretation of fair value focuses on the present value (PV) of the expected net cash flow from the asset. This PV requirement means that the forest stand data of the forest management plans (FMPs) and some FMP software are needed to evaluate these present values of future activities.

An inquiry among the circa 1000 bookkeeping farms revealed some 150 farmers who were interested in providing their FMPs for research purposes. Five forest holdings have been used in the analysis in this study. The rigorous input data requirements of the FMP software was very demanding, the estimation of the basal areas of stands after fellings constituting a particular challenge.

The change of the growing stock value and the felling income contribute the majority of the total operating income of the profit and loss statement. The value of the growing stock at the end of 2002 was nearly the same after the fellings performed by the 'measurement' based (RSU-) and by the pure 'simulation' based (SMU) methods. Recall that the basal areas after fellings were based on the actual measurements in the RSU-method and on software calculated fellings in the SMU-method. The measurement-based RSU method resulted in smaller and probably more realistic changes in the value of the growing stocks. The SMU method simulated the final fellings better than thinnings. The changes in stumpage prices were significantly smaller using the sum-value method than the forest management planning (FMP) software (MELA). The expectation values of the sum-value method are based on coefficients for each stand and a 30% reduction in the total calculated value that reduces the impact of the changes in stumpage price.

The evaluations were performed using a 4% interest rate. The critical point of the evaluation, the 'expected net cash flows' of seedling-, young- or middle-aged stands was performed using different methods, which also imposed allowable cut and forest value estimates. The maximisation of the net income of the first period, alternative B, represents a radical solution compared with the maximisation of the present values, alternative A, in the allowable cutting calculations. The A solutions, especially with the RSU and SMU methods were not close to each other, the first of these being considered the best estimate. Empirical measurements (of. the basal areas (RSU method) after felling by stand suggested that the measurements cannot be required in a larger production system. The present small number of test farms does not allow statistical tests. Further research requires more test farms and longer observation periods, so that even ex-post methods such as the capital asset pricing model (CAPM) (Capozza & Sick 1994 and Chavas & Thomas 1999) or option theory (Hughes 2000 and Duku-Kaakyire & Nanang 2004) can be applied.

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ADJUSTED PROFIT AND LOSS STATEMENT OF FORESTRY	2002	
	€	€/ha
Sales	17 547	122
Subsidies	201	1
Net turnover	17 748	124
Change in stocks of finished goods (+/-)	-42	0
Change in growing stocks	25 726	179
Production for own use	362	3
Other operating income	0	0
Total operating income	43 794	305
Raw materials and consumables purchases	-100	-1
Change in inventories (+/-)	0	0
External services	-1 042	-7
Wages and salaries	0	0
Other operating expenses	-28	0
Forest owners' own labour input	-1 620	-11
Rents	0	0
Other expenses	-1 072	-7
Depreciation, amoratisation and reduction in value		
Buildings	0	0
Machinery and equipment	-482	-3
Other depreciations	-261	-2
Operating profit (loss)	39 190	273
Financial income and expenses		
Interest and other financial income	326	2
Interest and other financial expenses	-167	-1
Profit (loss) before extraordinary items (=Net result)	39 349	274
Alternative interest cost of equity (5 % from below)	-19 192	-134
(Equity of the forest owner)	383 846	2 677
Entrepreneurs profit (economic value added)	20 156	141
Return on equity (ROE) (taxes not deducted)	10,25	
Return on total assets (ROA)	9,88	
Equity ratio, %	96,23	

ADJUSTED BALANCE SHEET OF FORESTRY	2001		2002	
	€	€/ha	€	€/ha
FIXED AND OTHER NON-CURRENT ASSETS				
Intangible assets				
Intangible rights	0	0	0	0
Other capitalised expenses	0	0	0	0
Tangible assets				
Land and waters	27 676	193	27 676	193
Buildings	0	0	0	0
Machinery and equipment	2 774	19	2 202	15
Non-merchantable growing stock of forest	174 145	1 215	189 694	1 323
Other tangible assets	2 084	15	2 347	16
Advanced payments and construction in progress	0	0	0	0
Investments				
Bonds and shares	5 843	41	5 835	41
Loan receivables	0	0	0	0
Other shares and similar rights of ownership	0	0	0	0
CURRENT ASSETS				
Stocks				
Raw materials and consumables	0	0	0	0
Work in progress (allowable cut)	173 984	1 213	184 162	1 284
Finished goods	587	4	5 447	38
Advance payments	0	0	0	0
Debtors				
Trade debtors	40	0	0	0
Loans receivable	0	0	31	0
Investments				
Own shares or similar rights of ownership	0	0	0	0
Other shares and similar rights of ownership	0	0	0	0
Cash in hand and at banks				
Cash in hand and at banks	0	0	0	0
TOTAL ASSETS	387 134	2 700	412 491	2 877

EQUITY AND LIABILITIES				
Capital and reserves				
Subscribed capital	0	0	0	0
Other	372 236	2 596	395 457	2 758
Provisions				
Voluntary provisions	1 464	10	1 464	10
Creditors				
Long term liabilities				
Bonds	285	2	251	2
Convertible bonds	0	0	0	0
Loans from financial institutions	9 906	69	8 814	61
Loans from pension institutions	0	0	0	0
Other loans and liabilities	379	3	294	2
Short term liabilities				
Loans from financial institutions	0	0	0	0
Advances received	706	5	2 960	21
Trade payables	0	0	0	0
Bills of exchange payable	0	0	0	0
Other loans and liabilities	24	0	0	0
Deferred income and accrued expenses	2 134	15	3 251	23
TOTAL EQUITY AND LIABILITIES	387 134	2 700	412 491	2 877

Costs of Carbon Sequestration in Scots Pine Stands in Finland

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Abstract

We use a joint production model of timber production and carbon sequestration to analyse the financially optimum silvicultural strategies and the costs of carbon sequestration for Scots pine at the stand level in Finland based on individual-tree growth models. This study expands the earlier analyses by taking into account thinnings as measures to increase carbon stocks in forests, in addition to lengthening the rotation age. The results indicated that, in joint production, both the growing stock level and rotation length are increased. Postponing thinnings and reducing their intensity was more cost-effective in sequestering carbon than increasing the rotation length. The costs for moderate increases of carbon sequestration were rather low, with present values of 1 – 6 € /ton CO_2, and they depended on the amount of carbon sequestered, initial stand age, site, and growing stock characteristics. For mature stands, the present value of costs to sequester a given amount of carbon was considerably higher, exceeding 20 € /ton CO_2. This was due to the higher annual rate of carbon sequestration and the fact that all the additional sequestration had to be obtained by increasing the rotation length.

Keywords: carbon sink, climate change, forest management, mitigation, optimal silviculture

1. Introduction

Forests can be used to mitigate the climate change by increasing the amount of carbon in forests. Carbon sequestration may become one of the major services that forests provide. If carbon sequestration is an additional product of the forest, then the forest manager faces the task of optimizing the joint production of timber and carbon sequestration, and possibly other non-timber benefits.

In environmental policy, carbon services can be organized in different ways. Project based approaches that identify carbon flows in a restricted area for a given time period are seen as viable instruments. Because the Kyoto Protocol addresses nation-wide emissions, governments may employ tax and subsidy based instruments to reduce the total costs of meeting emission targets. One possibility is that participating forest owners are paid for the carbon they sequester into their forests, to help a nation to meet its emission targets. Thus it might be profitable for forest owners to give up some timber returns in exchange for CO_2 returns. Another alternative is to use regulative approaches, e.g. to modify the silviculture recommendations in order to increase carbon sequestration.

The amount of carbon sequestration depends on the level of growing stock, which in turn is mainly influenced by intermediate as well as final cuttings and the initial regeneration investment. The rotation length approach has been commonly used to assess interactions between forestry and carbon sequestration. A usual approach to the question has been to solve the problem of production of timber and carbon sequestration analytically and then provide numerical examples based on a univariate or stand-level growth model for timber and tree carbon (see e.g. van Kooten et al 1995, Hoen and Solberg 1997, Gong and Kriström 1999, Stainback and Alavalapati 2002). A general impact reported in several studies and summarized in Watson et al. (2000) is the lengthening of the rotation. An early study that covers a wide range of management practices is by Hoen and Solberg (1994). However, their forest-level analysis is not targeted towards detailed study of trade-offs between stand management options such as thinning rate vs. final harvest age.

More detailed models of stand development have been used in a simulation setting to analyse rotation length effects on carbon flows and timber returns (Pussinen et al 2002, Liski et al. 2001, Masera et al. 2003). An economic analysis with optimization has not been available for these kinds of models.

In this study we expand the earlier economic analysis by including thinnings and thereby controlling the growing stock to increase the amount of carbon sequestered. We determine the optimal combination of thinnings and final harvest age for increasing carbon sequestration to various levels. Also, we highlight that the costs of carbon sequestration depend on initial stand age, site and growing stock characteristics, and the amount of carbon sequestered.

2. Joint production model

The forest owner faces two objectives, namely production of timber and carbon sequestration. To simultaneously investigate carbon sequestration and timber management questions we need an optimization model that contains intermediate cuttings and rotation as decision variables, and accounts for carbon flows. The objective function (1) for the forest owner maximizes the discounted net returns over an infinite time horizon and includes (at time *t*) stumpage returns from harvests, h_t, logging costs, l_t and regeneration costs, *w*, all discounted at rate *r* for a rotation of T years, subtracted by the penalty function *P* (2) where V_t is stand volume at time *t*, V_s is the required average volume, and *a* and *b* are parameters of the penalty function

$$\max \pi = \left[\sum_{t=0}^{T} (h_t - l_t)(1+r)^{-t} - w \right] \frac{1}{1-(1+r)^{-T}} - P \tag{1}$$

$$P = \begin{cases} a\left(V_s - \sum_{t=0}^{T} \frac{V_t}{T} \right)^b \; if\, V_s > \sum_{t=0}^{T} \frac{V_t}{T} \\ 0 \; otherwise \end{cases} \tag{2}$$

The decision variables in our optimization are the timings and intensities of precommercial and commercial thinnings, and rotation length. Because the optimization model uses several dozens of state variables, we do not write out the state equations but refer to the description of the stand projection system later in this chapter.

To compute the economic effects of increased stocking levels and thus carbon sequestration, we added a penalty function which required that the stand management regime results in a given level of average growing stock over rotation. This permits the analysis of how to optimally achieve increased carbon stocks in the forest by adjusting thinnings and the final harvest.

An augmented version of the SMA software (Valsta and Linkosalo 1995) is used to perform these analyses. Nonlinear, nondifferential optimization (Hooke and Jeeves 1961) is utilized to find the optimum solutions. The algorithm is augmented by random search phases as described in Valsta (1992).

The stand projection system in SMA is based on individual-tree, distance-independent growth and mortality models (Hynynen 1993, 1995a, 1995b, 1995c), also used in the Finnish MELA system (Siitonen et al. 1996) for national timber resource projections. Timber returns are computed based on road-side values and logging costs as in Valsta and Linkosalo (1995). Amounts of wood assortments are predicted with models that use tree characteristics (species, diameter, height) (Laasasenaho and Snellman 1983).

The parameter values to be identified include biological and economic parameters. The road side prices of pine sawlogs and pulpwood were 51 and 25 €/m^3, respectively. The minimum size of a tree for sawlogs was 17 cm dbh and 12 m height. The sawlog price premium based on tree breast-height diameter was chosen to be representative to present Finnish conditions. Regeneration costs were based on planting small seedlings with a base case cost of 600-1150 €/ha, depending on site conditions. Each stand projection is based on an initial tree size distribution, obtained from a measured plot.

3. Data

odel computations starting from bare land have been performed for 13 Scots pine stands from Southern and Central Finland. The characteristics of these stands are represented in Table 1. Computations starting from various ages have been performed for four Scots pine stands of 24-36 (initial age of the plot), 50 and 70 years. The initial states of the stands for later ages were obtained by simulating the development of stand according to silvicultural recommendations of Forestry Development Centre Tapio.

Table 1. Main characteristics of the stands.

Stand	H_{100}	Age	N	BA
501	19	40	2730	19.75
533	20	41	1970	24.09
53	21	40	1525	22.76
801	22	24	2000	10.00
115	22	27	1600	26.18
24	23	33	1400	17.48
27	24	29	1450	17.66
34	24	25	2375	24.11
4	24	36	1750	24.12
38	25	33	2150	26.56
219	28	27	2096	23.62
60	28	28	1875	26.63
20	29	29	2325	26.91

4. Results

The cost estimates are based on model optimizations in which the amount of carbon sequestered has been increased exogenously by increasing the required average stem volume during the rotation period by 20 m^3/ha (corresponding the amount of 23 ton of CO_2/ha in whole tree biomass) or 40 m^3/ha (45 ton of CO_2/ha). Costs follow from the loss in present value of net revenue due to the additional constraint. We used a 3 % real discount rate.

4.1 Optimal silviculture

The increased carbon sequestration can be obtained in the model by postponing the final cut and thinnings and by changing the intensity of thinnings. Delaying the harvests reduces the present value of timber income due to the discounting. Postponing the income from thinnings affects the net present value of income more than postponing the final harvest. On the other hand, postponing the thinnings is likely to increase the average volume more effectively.

As an example, the optimum cutting schedule for plot 4 is given for the unconstrained case and the one with an increase of 40 m^3/ha (45 t CO_2/ha) in the average volume (Fig. 1). The rotation length was increased by 12 years. Also, all the thinnings were postponed by approximately 10 years, thus the intervals for thinnings remain the same. The intensity of thinnings was only slightly reduced, except in the case of the last thinning. Two third of the increase in the average volume was obtained with thinnings and only one third by changing the rotation length.

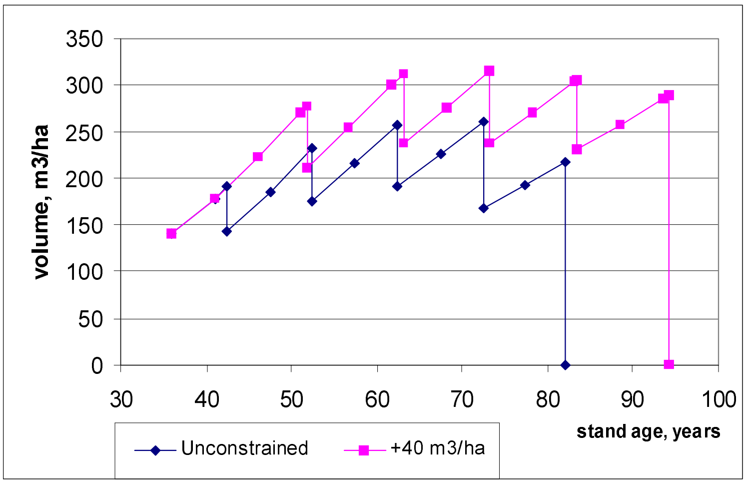

Figure 1. The impact of increasing the average stem volume by 40 m^3/ha (45 t CO_2/ha) on optimal silviculture.

4.2 Costs of carbon sequestration for stands starting from bare land

We show the average and marginal costs of carbon sequestration for plot 34 in Figure 2. As expected, the marginal costs increased when more carbon was sequestered as the least costly options to increase carbon sequestration are utilised first. Eventually, ecological factors set the limits to possibilities for increasing the average stem volume and thus the carbon sequestered.

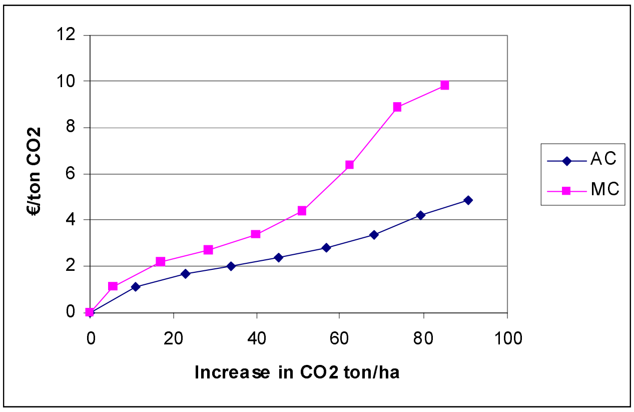

Figure 2. Present value average and marginal costs of carbon sequestration for plot 34.

Rotation age was increased from 70 years to 101 years for plot 34 when carbon sequestration was increased up to 90 ton CO_2/ha (Fig. 3). With small amounts of carbon sequestered, the larger share of carbon sequestered was obtained by postponing thinnings and reducing their intensity. However, with thinnings it is possible to increase the carbon sequestration only to some extent, and the more carbon is sequestered per hectare, the higher share of sequestration has to be obtained by lengthening the rotation period.

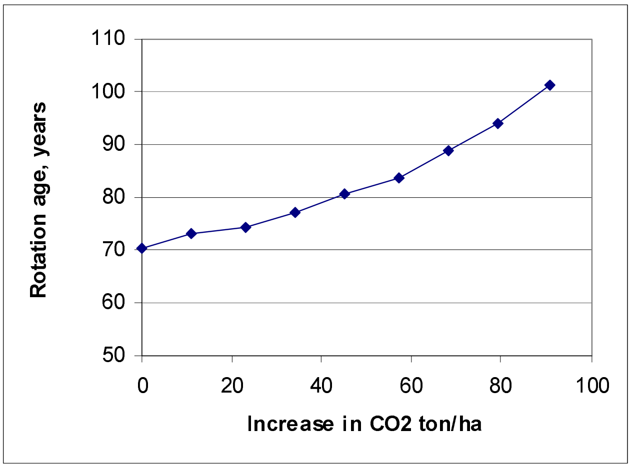

Figure 3. Impact of increasing carbon sequestration on rotation age for plot 34.

The tradeoff between the two objectives, namely timber production and carbon sequestration, can be described through production possibilities frontier analysis. The production possibility frontier of net present value of timber production and carbon sequestration for plot 34 is represented in Figure 4. Increasing carbon sequestration through the additional constraint reduces NPV. The shape of the production possibility frontier implies that it is optimal to use forests both for timber production and for carbon sequestration instead of using some stands for timber production and others for carbon sequestration. Convex combinations of points of the frontier are inferior.

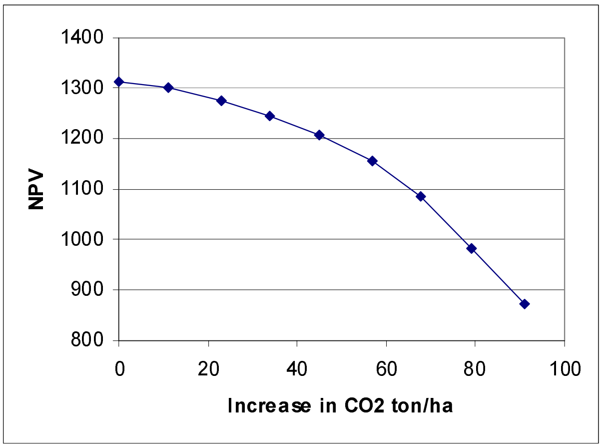

Figure 4. Production possibilities frontier of net present value of timber production and carbon sequestration for plot 34.

Costs differences between stands are illustrated in Figure 5 with results from a set of 13 individual plots and the average of these plots. The cost curves are obtained by increasing the average stem volume by 20 m³/ha (23 ton of CO_2/ha) and 40 m³/ha (45 ton of CO_2/ha).

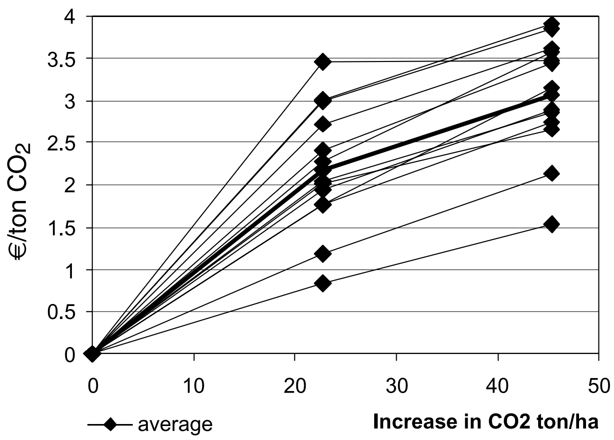

Figure 5. Present value average costs for a set of 13 individual plots and the average of these plots, €/ton of CO_2.

The costs differed notably between stands. For increase of 23 ton of CO_2/ha, the present value average cost varied from 0.8 €/ton of CO_2 to 3.5 €/ton of CO_2, with average of 2.2 €/ton of CO_2, and for increase of 45 ton of CO_2/ha from 1.5 €/ton of CO_2 to 3.9 €/ton of CO_2, with average of 3.1 €/ton of CO_2. However, about a half of the cost estimates were in a quite small range. No single factor explaining the cost differences between stands could been found. In order to analyse in which kind of forests it is less costly to increase sequestration more plots with more diverse properties are needed. Also, in order to make the stands more comparable, the initial age should be same.

4.3. Costs of carbon sequestration for stands of different ages

In addition of computations starting from bare land, we have performed computations for stands of various ages (24-36, 50 and 70 years). We increased the average volume by the same amount during the remaining rotation period for all of the plots of various ages. This implies that time period available for carbon sequestration (Table 2, second column) and thus the annual rate of increase in carbon sequestration (Table 2, third column) varies. The same average volume is required to fulfill during both the current and future rotation periods.

Table 2. The present value costs, sequestration periods and annual rates of carbon sequestration for stands of various ages, when increasing the average stem volume by 40 m^3/ha. All the figures represent average values of 4 stands.

Age class	Discounted cost €/ton CO_2 /ha	Sequestration period, years	Increase of CO_2, ton y^{-1} ha^{-1}	Rotation years
Bare land	3.1	92	0.5	92
Stands of 24-36 years	5.1	57	0.8	87
Stands of 50 years	5.6	35	1.3	85
Mature stands (70 years)	17.7	20	2.3	90

For stands starting from bare land the time period available for increased sequestration of 45 ton of CO_2/ha was on average 92 years while for 70 year old stands the time period was only 20 years. Correspondingly, the average annual increase varied from 0.5 ton of CO_2 per ha per year for bare land stands to 2.3 ton of CO_2 ha^{-1-yr} for stands of 70 years. The impact of annual rate of carbon sequestration on unit cost is illustrated in Figure 6 and can be seen also in Figure 7.

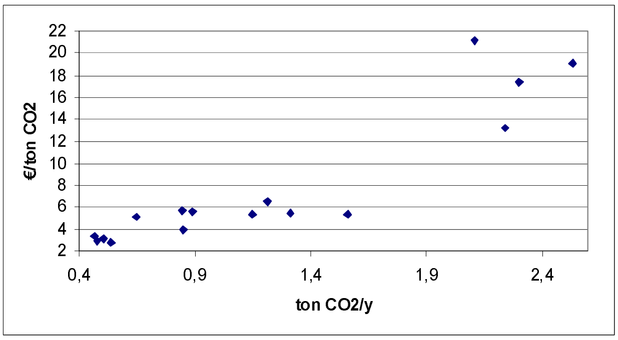

Figure 6. Present value costs of carbon sequestration in relation to increased sequestration per year.

As expected, the costs are the highest for 70 year old stands as the amount of carbon that have to be sequestered per year is largest. In addition of higher annual sequestration, higher costs are explained by the fact that regulating thinnings is no more an economically viable way to affect carbon sequestration. Thus sequestration can be increased only by lengthening the rotation that is more expensive measure than postponing thinnings. For younger stands, carbon sequestration takes mainly place between the years 40-70 by delaying and reducing thinnings. Also, for older stands the NPV’s are higher as the discounting period is shorter.

Thus, the loss calculated in absolute terms is higher.

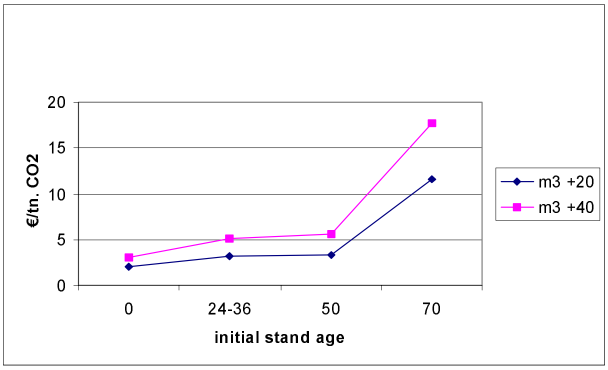

Figure 7. Average present value costs of carbon sequestration for different initial stand ages.

Even though carbon sequestration starts before 50 years of age, the costs are approximately the same for young stands and for 50 year old stands. As mentioned, the state of the stands at later ages were obtained by simulating them according to silvicultural recommendations of Tapio, to illustrate the state of the Finnish scot pine stands in a reality. This implied that the 50 year old stands were thinned right before starting to increase the carbon sequestration. The stands of 50 years and mature stands might provide higher costs for carbon sequestration if earlier thinnings were simulated at lower intensity. Correspondingly, the younger stands might provide different unit costs if an initial volume were lower. As illustrated in Figure 8, if the initial basal area differs from the one resulting from silvicultural recommendations (BA 19), higher unit costs of carbon sequestration are obtained. Higher initial basal area may diminish the biological potential and thus marginal revenue. Correspondingly, for the stands of lower basal area it may be difficult to increase the volume and thus carbon sequestration in absolute terms, due to lower growth potential of the initial stand. As the costs depend on whether thinnings have already been practiced or are still to be done, age of the stand for starting the carbon sequestration policy is an essential factor.

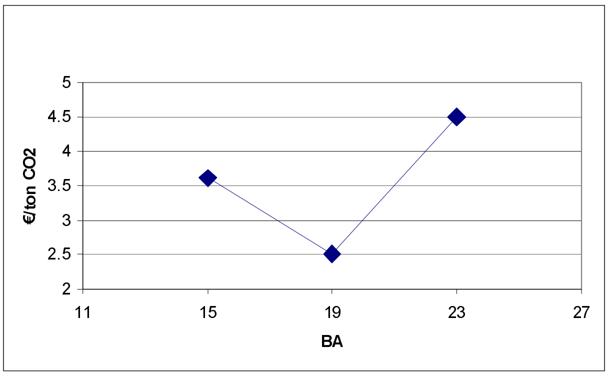

Figure 8. Present value unit costs of carbon sequestration for a 50-year old stand of various simulated initial basal area levels (15, 19 and 23), increase in average stem volume 20 m^3/ha.

5. Conclusions

This paper provides a preliminary analysis of costs of carbon sequestration for Scots pine stands in Finland. In addition of lengthening the rotation age, modifying the timing and intensity of thinnings were allowed as measures to increase carbon sequestration. Preliminary results suggest that postponing thinnings and reducing their intensity would be even more cost-effective measure to sequester carbon than increasing the rotation length. However, the more carbon is sequestered per hectare, the higher share of sequestration has to be obtained by lengthening the rotation period.

The results demonstrated that the cost of carbon sequestration is rather low with moderate amount of carbon sequestered, with a present value of 1 – 6 € /ton CO_2 depending on amount of carbon sequestered, initial stand age, site, and growing stock characteristics. As expected, marginal costs were an increasing function of the amount of carbon sequestered.

In this study we illustrated how the costs depend on the annual rate of additional carbon sequestration. For mature stands, the present value of costs to sequester a given amount of carbon were considerably higher than for younger stands, exceeding 20 € /ton CO_2. In addition of higher annual rate of sequestration, the higher costs were explained by the fact that the only measure available for increasing sequestration was lengthening the rotation period. Also, for older stands the NPV's are higher as the discounting period is shorter and thus the loss calculated in absolute terms is higher. In further analysis we plan to fix the amount of carbon sequestered in a given time period in order to better analyse the impact of stand age and initial state of stand on costs.

Acknowledgements

This study was partially funded by the Ministry of Agriculture and Forestry, and Environmental Cluster Programme of Ministry of Environment.

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Risk Aversion and Optimal Rotation: a Stochastic Efficiency Approach

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Abstract

A new stochastic efficiency analysis approach, called stochastic efficiency with respect to a function (SERF), that partitions a set of risky alternatives in terms of certainty equivalents (CEs) for a specified range of attitudes to risk, is applied to analyse average optimal rotation strategies at different levels of forest owner's risk aversion. Using Norwegian forest data with stochastic timber price and volume growth, the empirical results show that the optimal rotation length increases with increasing degree of risk aversion. It is also found that the effect of risk aversion is lower with higher interest rates, while the size of the investment cost affects only the level of the CE, with the forest owner's risk aversion being relatively unimportant.

Keywords: Dynamic risk analysis, stochastic budgeting, stochastic dominance with respect to a function.

1. Introduction

Risk management has received increased attention in the forest economics literature (Brazee and Newman 1999). However, with some exceptions (e.g., Caulfield 1988, Gong and Löfgren 2003), the relationship between risks involved and the forest owner's degree of risk aversion has not been subject to attention in the analyses. This is despite the fact that forest owners have to make investment decisions in the face of increased price uncertainty as well as uncertainty about future growth and quality of retained stands. Under assumed certainty, guidelines are available for the optimal forest rotation length for different investment costs, interest rates and growth conditions (Johansson and Löfgren 1985, for a rigorous treatment. In addition there exist also in most countries handbooks for practical forest management). But, as far as we know, no general guidelines about optimal rotation length exist when both the entailed risk and the forest owner's risk aversion are taken into account. Guidelines that cover these cases would be useful to investors who are deciding whether investing is worthwhile, as well as for policy makers.

Forest investment and management decisions have a long time horizon with significant risk. The variations in consequences can be large relative to the decision maker's (DM's) wealth and hence the cost of ignoring risk aversion might be too high to be ignored (Anderson and Hardaker 2003).

The returns from investing in a forest naturally depend on how that forest is managed. In particular, the choice of the rotation length must be resolved in advance since it determines the flows of costs and benefits over time. Most analyses of optimal rotation in a stochastic setting are formulated as a multistage decision process, and solved using dynamic programming.

In this paper we use an alternative approach using conventional budgeting methods. In particular, we apply a stochastic budgeting model within a stochastic dominance framework. The forest owners' temporary income for which risk aversion is likely to be slight is implicitly ignored in our model, and the focus is on the risk in permanent income, i.e., the general level of income over a long-time horizon. Using stochastic budgeting, we investigate the optimal rotation length under various assumptions and so determine the profitability to the DM of investing in a forest.

Caulfield (1988) and Gong (1998) used stochastic dominance analysis to explore the economic rotation of a forest with given assumptions about risk aversion. Caulfield investigated effects of stochastic volume growth, and especially changes in optimal rotation age followed by risk of fire. By using second-degree stochastic dominance (SSD) he found that the risk-efficient rotations might be shorter than would be the case in the absence of risk aversion. Gong investigated the effects of price risk using SSD analysis to show that risk-averse forest owners typically will harvest earlier than risk-neutral forest owners. Caulfield and Newman (1999) stated that the impact on rotation ages of incorporating price risk is uncertain.

In this paper we analyse how risk aversion affects the choice of an optimal forest rotation strategy and hence the initial investment decision using stochastic efficiency with respect to a function (SERF) (Hardaker et al. in press). SERF is a relatively new variant of the widely used stochastic dominance with respect to a function (SDRF) (Meyer 1977). SDRF has stronger discriminatory power (with respect to partially ranked risky alternatives) than first- and second-degree stochastic dominance. The greater discrimination is achieved through the introduction of bounds on the absolute risk-aversion coefficient within a SSD analysis.
SERF, which partitions a set of risky alternatives in terms of certainty equivalents (CEs) for a specified range of attitudes to risk, is more transparent, easier to implement, and has even stronger discriminating power than conventional SDRF. The method is illustrated with a simple example comparing the merits of different average rotation lengths for a hypothetical forest investment in Norway. The empirical results show that, in cases with stochastic timber prices and volume growth, optimal rotation length on average increases with increasing degree of risk aversion.

2. Modelling framework and methods

Resolving the investment decision requires the optimal rotation strategy of the forest to be decided, given stochastic timber price and volume growth and a risk-averse decision maker. However the effects of risk aversion on the optimal rotation length are ambiguous and are therefore an empirical question, as also deduced by Caulfield and Newman (1999).

In our computed model, we do not know the forest owner's utility function and some efficiency criteria that allow some ranking of risky alternatives when the exact degree of risk aversion is not known must be used. A much used efficiency criterion given risk aversion is SSD. SSD assumes that the DM prefers more income to less and is not risk preferring, i.e., that absolute risk aversion bounds are $0 \le r_a(w) < +\infty$. In empirical work it is often found that SSD are not discriminating enough to yield useful results.

An alternative to SSD is SDRF, which was introduced by Meyer (1977). In SDRF absolute risk aversion bounds are reduced to $r_L(w) \le r_a(w) \le r_U(w)$, and ranking of risky scenarios is defined for all DMs whose absolute risk aversion coefficients lie anywhere between lower and upper bounds $r_L(w)$ and $r_U(w)$, respectively.

In this paper we apply a more straightforward and potentially more discriminating method called stochastic efficiency with respect to a function (SERF) (Hardaker et al. in press). SERF partitions alternatives in terms of CEs as a selected measure of risk aversion is varied over a defined range. Conventional SDRF picks only the pairwise dominated alternatives, thus one can expect that pairwise SDRF may not isolate the smallest possible efficient set. By contrast, SERF will potentially identify a smaller efficient set than SDRF because it picks only the utility efficient alternatives, comparing each with all the other alternatives simultaneously.

The maximand used to determine the optimal rotation length is the equivalent annuity of the whole forest. It is necessary to work in annuity terms because we are comparing investments of different lengths. The equivalent annuity can be interpreted as the forest owner's permanent income, meaning the average income over several years. Risk aversion is likely to be important in assessing stochastic permanent income levels. Given stochastic timber price and volume growth and assuming risk aversion, we base the choice of the optimal rotation (and hence the assessment of the profitability of the investment decision) on the expected utility of permanent income.

Under an assumption of stationarity, the distribution of permanent income (i.e. distribution of equivalent annuity) is measured by the distribution of the NPV of one stand of area A/T where A is total forest area and T is rotation length. In other words, the distribution of the NPV to an infinite horizon of one stand in our model is also the distribution of the equivalent annuity to an infinite horizon for the whole forest area.

If we return to our decision problem of the forest owner, we ignore any probability of natural disaster problems and exclude the possibility of partial harvesting before clearcutting each stand. Costs of silviculture, thinnings etc. are taken into account in the cost for the replanting year. Thus, the cash flow in the NPV formula for each stand consists only of the year with planting and the year with clearcut.

Given stochastic timber prices and volume growth, the one stand expected NPV of an infinite series of rotations of length T is calculated as

$$E[NPV] = \frac{\tilde{p}(T)\cdot \tilde{f}(T)\cdot e^{-iT} - I_0}{1 - e^{-iT}} \qquad (1)$$

where I_0 are investment costs in the start of each rotation, $\tilde{p}(T)$ is the stochastic stationary timber price less harvesting costs in year T, $\tilde{f}(T)$ is the stochastic stationary timber volume in year T, and i is the discount rate.

For each risky alternative and for a chosen form of the utility function, the subjective expected utility hypothesis means that utility of permanent income (equivalent annuity) can be calculated depending on the degree of risk aversion, r, and the distribution of the NPV from one stand as:

$$E[U(NPV,r)] = U(NPV,r) = \int U(NPV,r) f(NPV) dNPV \quad (2)$$

Then U is calculated for selected values of r in the range r_1 to r_2. The *CE*s for each of these values of U are found by:

$$CE(NPV,r) = U^{-1}(NPV,r) \quad (3)$$

The general rule for SERF analysis for the given assumptions is that the efficient set contains only those alternatives that have the highest (or equal highest) CE for some value of r in the relevant range.

The CDF distribution of one stand NPV in our model depends on many risky input variables, so we constructed a Monte Carlo stochastic simulation model to represent the forest owner's risky decision environment. We implemented the stochastic Monte Carlo simulation model within the SERF approach for our forest decision problem through the following steps:

1. Select a rotation length, T;
2. Run one iteration and record the cash flows;
3. Select a coefficient of absolute risk aversion, r_a, within the range r_1 to r_2;
4. Convert cash flows to utilities, by using a negative exponential utility function, and find utility of the one stand net present value, $U(NPV)$ (as a measure for utility of permanent income and equivalent annuity);
5. Loop back to 3;
6. Loop back to 2;
7. When enough iterations, expected utility of NPV is computed for each r, and the inverse function is used to get CEs for each r;
8. Loop back to 1 and do it all again for a different rotation length;
9. For each value of r_a, select as optimal the rotation length with the highest CE; investment is worth-while only if the optimal CEs are positive.

3. Application

In this section, the approach outlined above is applied for a hypothetical forest property in Norway. For simplicity, we assume that the forest will be the forest owner's sole source of wealth.

The size of the chosen forest property is 3000 ha which is planted with Norway spruce with an even site quality index (H40) of G14. The uncertainty concerning future growth and quality has several different sources. Forestry is exposed to physical, climatic, and biological risks (e.g. insect attacks and rot). And from time to time extreme weather (for example gales) can cause natural disasters such as windthrows. In addition, the forest owner regards the price and market risk as important. We assume that the forest owner is risk-averse, but that we have not quantified exactly how risk-averse he is.

The presence of risk and risk aversion aspects makes it difficult to decide the optimal rotational strategy, but some general guidelines are needed. In this illustration we construct an optimal rotation model taking volume and price risk into account. The results from such a model can give general guidelines about optimal rotation cycles for forest owners or prospective forest investors.

3.1. Variable Specification

The net stumpage value is a function of price, timber quality and volume, and harvesting costs. The timber quality and expected volume changes with the age of the stand. The volume function is estimated from a database of forest production and development of stand plots (site index G14) in Eastern Norway collected by the Norwegian Institute of Land Inventory for the years 1994 to 2002. Since we observed heteroskedasticity in the data, we estimated a cubic function with multiplicative heteroskedasticity (Harvey 1976):

$$f(t) = 0.7053 * t + 0.0787 * t^2 - 0.000528 * t^3 + e_t \qquad (5)$$
$$Var(e_t) = 21.39^2 \exp(0.0488 * t - 0.000172 * t^2)$$

where $f(t)$ is volume per ha at forest age t.

The correlation of stand volume levels between years was calculated to be 0.95, implying that the expected volume curve from any stage onwards is conditional to the volume in the current year. This stochastic dependency is included in the analysis by defining the conditional expected yield in any year, given the volume in the previous year (where we assume that volume is normal distributed and the change in volume per ha between years is bivariate normal).

During a rotation there are changes in the portion of various log grades that can be produced from the harvested stems. Generally, increased age means a higher portion of high valued product (sawlogs) and lower portion of low valued grades (pulpwood). Thus, the expected timber price increases with age of stand. Moreover, timber quality becomes less even with age so that the price variation becomes greater. In order to capture these effects we estimated a price function where mean price and price variation depend on stand age. We first applied the relative price function for Norway spruce, which has height, diameter and the relative price difference between sawlogs and pulpwood ((sawlog price-pulpwood price)/ pulpwood price) as input parameters. Given volume and increment functions for Norway spruce, and the actual relative timber prices in Eastern Norway for 2001, we got figures for relative prices for various stand ages. Normalising to a stand age of 79 years (i.e. we assumed that this age yielded the mean price), we got the following expressions for expected gross value per m^3, $p(t)$ and the variance at a given time, t:

$$p(t) = E[p(t)] = 113.02 + 2.709t + e_t \qquad (6)$$
$$Var(e_t) = (28.24 + 06769t)^2$$

We further assumed that the expected price is constant after a stand reaches 100 years of age, because this logs at this age is supposed to give the maximum sawlog share.

Investment costs were set to NOK (Norwegian kroner) 7000 ha^{-1}. This figure was chosen to represent the investment of the average forest owner. The real interest rate was assumed to be 2 per cent per annum.

3.2. Results

Stochastic simulation means that we can evaluate a given rotation strategy with any required degree of precision simply by setting the appropriate simulation sample size. We used a sample size of 5000 to get good estimates of the distribution of the chosen objective variable for any specified strategy.

We ran the simulation for rotation lengths from 60 to 110 years, with 10-years intervals and for four different degrees of risk aversion. A rough and ready classification of degrees of risk aversion, based on the relative risk aversion with respect of wealth, $r_r(w)$, is in the range 0.5 (hardly risk-averse at all) to about 4 (very risk-averse). In this paper we are not considering utility and risk aversion in terms of wealth, but in terms of permanent income (where the uncertainty relates to the long-run level of income). The relation between absolute risk aversion with respect of permanent income and relative risk aversion with respect to wealth is $r_a(x) \approx r_r(w)/x$ where x is permanent income [5]. We assume that the typical level of a forest owner's permanent income is NOK 150 000 per annum. Then a value of $r_a(x)$ in the range 0.00000667 to 0.00002667 corresponds to $r_r(w)$ in the range 0.5 to 4. This range was used as the risk aversion bounds in this analysis.

The SERF approach using a negative exponential utility function resulted in the CE-graph shown in Fig. 1.

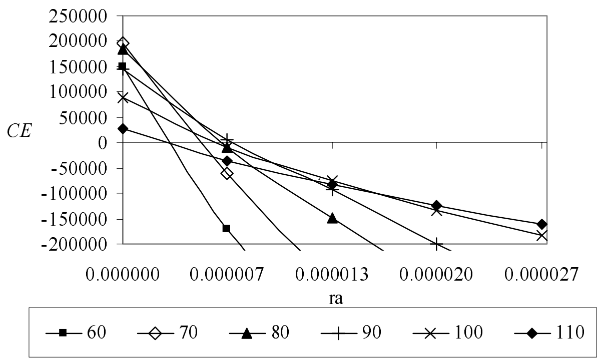

Figure 1. CE-graph of optimal forest strategies (60 – 110 years) for different degree of risk aversion. CE is excepted equivalent annuity in NOK per year.

From the CE-graph we can observe:

· The forest owner's degree of risk aversion has a strong influence on the optimal rotation strategy. For a rotation strategy of, e.g., 80 years the CE annuity per year is reduced by 296% from risk neutrality to the most risk-averse case;

· A rotation length 70 or 80 years gives the highest CE for a risk indifferent forest owner $(r_a(x) = 0)$;

· A moderately risk-averse forest owner (i.e. where $r_a(x) = 0.000013$ and $r_r(w) \approx 2$) should be almost indifferent between rotation lengths of 90, 100 and 110 years;

· A very risk-averse forest owner $(r_a(x) = 0.0000267)$, $(r_r(w) \approx 4)$ should prefer a rotation length of 110 years;

· At absolute risk aversion levels less than about 0.000008, there exists at least one rotation length that yields a positive CE, i.e. investment is worthwhile (subject to comparison with other non-forest alternatives);

· For very risk averse forest owners (with coefficient of absolute risk aversion higher than 0.000008) the investment is unprofitable, since all rotation strategies yields a negative CE.

3.3. Sensitivity Analysis

The results might be sensitive to variable specification. We therefore conducted sensitivity analyses by changing the interest rate from 2 to 3 per cent per annum; the investment cost from NOK 7000 to NOK 3500 ha^{-1}; and a combination of these two. The results from this analysis are shown in Fig. 2.

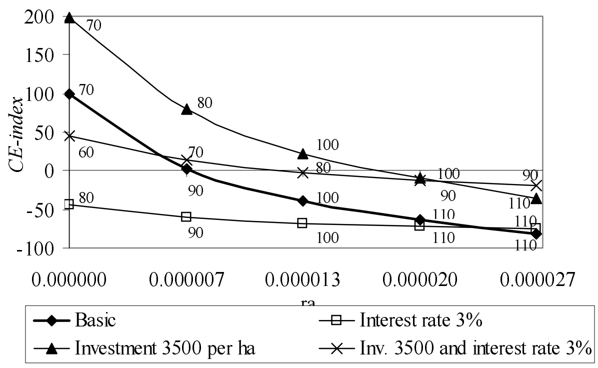

Figure 2. Sensitivity analysis of choice of interest rate, investment cost and the combination of both. For further details see the explanation in the text.

The frontiers (optimal choices) for each case are drawn in Fig. 2. The frontier curves are represented by index values, where the CE for a risk-neutral forest owner in the "basic" alternative is indexed to 100. In the basic alternative the interest rate is 2 per cent per annum and the investment cost is NOK 7000 ha^{-1}. The numbers inside the figure show the optimal rotation age for each case at the plotted degree of risk aversion.

Our empirical results show that a risk-neutral forest owner would be best advised to choose a longer rotation length (70 to 80 years) when the interest rates increase and approximately the same (though slightly shorter) rotation length when the investment cost decreases, as is expected from theory (Johansson and Löfgren 1985). From these results we thus also conclude that:

· the degree of risk aversion becomes less important in the choice of the optimal rotation strategy with the increase in the interest rate;

· the size of the investment cost affects only the level of the CE, and only slightly the importance of the degree of risk aversion.

4. Conclusions

Earlier studies, which have focused on either price risk or volume growth risk, have found that risk-averse forest owners typically will harvest earlier than risk-neutral forest owners. Our empirical results, that include both price and volume growth risk, show that the optimal length of the rotation strategy increases with increasing degree of risk aversion. Some reasons for this somewhat result that is contrary to earlier findings can be suggested. First, mathematically there is no a priori reason to expect that risk aversion lead to shorter rotations. Second, our model is an infinite horizon stationary model, which implies that the same uncertainty applies for a rotation length of, e.g., 80 years today as for a rotation length of 80 years that starts, e.g., 500 years in the future. The limitation of the stationarity property is that the uncertainty is likely to increase over time (from rotation to rotation) for a real forest owner, yet this aspect is not accounted for in the stationary model. This limitation may disfavour shorter rotations.

We have assumed the same investment strategy for all degrees of risk aversion. The results show that, for very risk-averse forest owners, the CEs are negative. The policy implication of this is that such types of forest owners will choose to invest less in forestry, or not to invest at all.

In the literature an often-used way to analyse optimal rotation decisions for a forest is to use of stochastic dynamic programming. It may be argued that stochastic simulation is more flexible and easier to implement and understand than stochastic dynamic programming. Our SERF-approach does not account for non-stationarity (as is also normally the case for infinite horizon dynamic programming). We have used our model to illustrate how general guidelines can be determined for investment based on a rotational strategy that matches each case, including the DM's degree of aversion to permanent income risk. Of course, in practice each forest owners does not have to decide at the start what rotation length to adopt. He can look at each section and decide when to harvest. This aspect is probably better analysed using dynamic programming.

We have assumed that it is sufficient to use a utility function defined in terms of the average annual income (equivalent annuity). At best this is an approximation of an intertemporal utility function. In the real risky world with a less than perfect capital market, the discounted cash flow method has several limitations. For future research, alternative utility functions should be considered, especially if the analysis accounts for the reality that income flows through time may be irregular.

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Matrix Modelling in Uneven-aged forest Management Planning

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Abstract

A matrix growth model suitable for analysis of uneven-aged forest management is developed based on recursive equations represented on matrix form. The equations consist of transition probabilities forming part of application of Markov chain theory, which describe growth between diameter classes, ingrowth to the smallest diameter class, and mortality in the larger classes. The model is exemplified with use of growth and yield data for beech (Fagus silvatica L.). The growth model is based on a diameter class structure where the width is equal to 5 cm. The time interval between interventions is equal to 5 years. Diameter growth according to a treatment regime for even-aged stands is assumed. The system of recursive equations is solved by use of linear programming allowing analysis of economic optimal treatment. Possible stand structures are analysed using constraints in linear programming of the maximum harvest by diameter classes. Formulation of harvesting constraints is based on analysis of the production in a normal forest structure. The economic characteristics in the steady-state are analysed and the model structure is suitable for economic analysis of conversion from even-aged to uneven-aged forest management characterising near-natural forest management. It is concluded that the model is suitable for analyses of stand structure, growth and yield, including economic yield, and analyses of different harvesting regimes applied in uneven-aged forest management.

Keywords: Economic optimisation, linear programming, matrix modelling, near-natural forest management planning

Introduction

Near-natural forest management gains increasing interest in practice at present due to increased priority on environmental outputs from forestry that are in accordance with natural ecological functions. This development creates a need for new forest planning models that are able to handle uneven-aged forest structures with multiple species.

From an economic point of view near-natural forest management is motivated by reduction of regeneration costs through natural regeneration and by target diameter harvesting increasing the harvest revenue through an increase of the selling price of logs of larger dimension. However, the harvesting and transport costs using a target diameter regime may be higher than those experienced in even-aged forest management because the harvest volume per ha is lower and thus distributed over a larger area requiring more man and machine time. Logging and transport operations often need to be performed with caution not to damage the remaining stand, which may also tend to increase the costs (Buongiorno and Gilless (2003).

Beech (Fagus silvatica L.) is the dominant broadleaved species in Danish forestry and is viewed as the major species in future near-natural forest management because it is indigenous and adapted genetically to the climatic and soil conditions. Natural regeneration has been used in even-aged natural silvicultural systems over many decades (Holten-Andersen 1987), and it is therefore likely that it will be an important element in future uneven-aged forest management.

Modelling uneven-aged forest structures may be performed by use of size classes represented by diameter classes even though other options exist such as for example age classes. Diameter strata are viewed as appropriate modelling components through representation in a matrix model as described below.

Uneven-aged forest management in a steady state is often represented by a stem number distribution to diameter classes that has the classical inverse J shape with a high stem number per ha in small diameter classes and a low stem number in the larger. Estimation of the economic optimal conversion from an even-aged stand to an uneven-aged steady-state distribution is dependent on the structure of the initial stand. The steady-state distribution may be determined by fulfilling constraints on future harvests by diameter classes as illustrated in the following section.

Materials and methods

Stand growth is represented by recursive equations as shown below:

$$\mathbf{y}_{t+1} = \mathbf{G}(\mathbf{y}_t - \mathbf{h}_t) + \mathbf{c} \qquad (1)$$

where
G is a matrix of constant parameters depicting the growth from one state to other state(s)
$\mathbf{y}_t$ is a column vector that designates the state of an uneven-aged stand at time t
$\mathbf{h}_t$ is a column vector that designates the harvest of an uneven-aged stand at time t
c is vector of constant parameters

Each vector element of $\mathbf{y}_t$ is the average number of trees per ha in each of n diameter classes, $\mathbf{h}_t$ is the number of harvested trees per ha in each of n diameter classes, **c** represents the constant part of ingrowth to the smallest diameter class. The time interval t to t+1 is u years.

The recursive equation (1) allows prediction of the stand state at any point in the future, starting from a particular initial state $\mathbf{y}_0$ and subject to a specific sequence of harvests $\mathbf{h}_0$, $\mathbf{h}_1,\ldots,\mathbf{h}_T$:

$$\begin{aligned} \mathbf{y}_1 &= \mathbf{G}(\mathbf{y}_0 - \mathbf{h}_0) + \mathbf{c} \\ \mathbf{y}_2 &= \mathbf{G}(\mathbf{y}_1 - \mathbf{h}_1) + \mathbf{c} \\ &\ldots \\ \mathbf{y}_T &= \mathbf{G}(\mathbf{y}_{T-1} - \mathbf{h}_{T-1}) + \mathbf{c} \end{aligned} \qquad (2)$$

The combination of growth, ingrowth, harvest and mortality will cause a stand to converge to a steady state as t increases. The steady state is independent of the initial conditions and depends only on the parameters of the recursive equations. The system has a unique solution, which can be found by use of linear programming (LP).

The maximum periodic production may be computed by use of the following objective function

$$\max_{\mathbf{h}_l, \mathbf{y}_l} Z_Q = \mathbf{v}\mathbf{h}_l \qquad (3)$$

where

v is a row vector of dimension n of the volumes per tree in each of the n size classes

The maximum value of the production may be computed by use of equation (3) by substituting **v** with the value per tree and the net present value (NPV) or expectation value (EV) may consequently be computed by proper discounting of “**v** (Buongiorno & Gilless 2003).

The classical inverse J shape of uneven-aged stands is determined by fulfilment of harvest constraints where the harvest per diameter class is equal to the harvest that is obtained from a forest structure, which is almost a normal forest with an area of equal size in each diameter class. The forest structure is based on application of Markov chains as described below.

It is assumed that the diameter class growth is equal to that of an even-aged stand treated according to the thinning regime of Moeller (1933). The diameter growth rate is identified as approximately constant over time with an annual diameter growth of 0.54 cm per year. The use of the recursive equations in formula 1 may be modelled as a Markov chain using the following equation

$$\mathbf{p}_t = \mathbf{p}_{t-1}\mathbf{P}\text{ , for t=1,…, T} \qquad (4)$$

where

$\mathbf{p}_t$ is the state vector defined by the diameter distribution in terms of the number of trees per unit area in different size classes at time t

P is the transition probability matrix of trees between states of trees

T is the number of periods in a projection

P provides a means to predict the probability that a tree in a diameter class would be in another diameter class after a certain amount of time. The probability distribution of the stand state in period t, $\mathbf{p}_{t,}$ is obtained by postmultiplying the probability distribution of the diameter classes in the previous period, $\mathbf{p}_{t-1}$, by the transition probability matrix **P**.

As T increases to infinity, the vector $\mathbf{p}_T$ converges to a vector of steady-state probabilities, $\mathbf{p}_*$, which is independent of the initial state $\mathbf{p}_0$ (Buongiorno and Gilless 2003).

The steady-state in the form of the stem number per diameter class is found by use of LP maximizing the expectation value of the stand using formula 3 and fulfilling the following set of constraints:

$$y_{i,t+1} = y_{it} = y_i$$
$$y_{it} \geq 0 \qquad (5)$$

for i = 1…n and for all t
where n is the number of diameter classes

The yield table for beech (Fagus silvatica L.), site index 1, attaining a stand height of 31.8 metres at age 100 years, of Moeller (1933) is applied according to the extension of the yield table prepared by Dansk Skovforening et al. (2000). The diameter growth function by age, which is a consequence of the applied thinning regime, can be described with an acceptable precision by use of a linear function. This finding is applied when estimating the transition probability matrix shown in Table 1, which is based on the assumption of a period length of five years. Estimation of harvest volume is based on use of the volume equations developed by Madsen (1987). It is assumed that regeneration occurs naturally at no costs.

Results

The steady-state area distribution following from application of the Markov chain model based on the transition probability matrix shown in Table 1 with 14 diameter classes with a width of 5 cm ranging from 7.5 to 72.5 cm consists of 7.4% of the area by diameter class except the largest diameter class, which covers an area of 4.0%. The diameter class distribution in terms of area is not completely even because it is assumed that all trees in the largest diameter class are harvested every five-year period. The subsequent harvest volumes and harvest stem numbers by diameter classes are shown in Table 2 applying a period length of five years.

The mean annual harvest assuming a target diameter of 70 cm amounts to 14.2 m^3 ha^{-1}. The corresponding results for lower target diameters are: 65 cm: 14.4, 60 cm: 14.7, 55 cm: 15.1 m^3 ha^{-1}.

	End state j													
Begin state i	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	62.5	67.5	72.5
7.5	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.5	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.5	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27.5	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.5	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37.5	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00
42.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00	0.00
47.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00	0.00
52.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00	0.00
57.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00	0.00
62.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54	0.00
67.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54
72.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 1. 5-year transition probability matrix assuming diameter classes from 7.5-72.5 cm.

Figure 1 shows the stem number distribution to diameter classes in the steady-state and figure 2 shows the corresponding basal area distribution. The stem number per ha varies between 593 assuming a target diameter of 70 cm and 741 with a target diameter of 55 cm. The basal area varies between 22.4 and 21.6 m^2 ha^{-1} applying a target diameter of 70 and 55 cm, respectively. The minimum/maximum basal area per diameter class is 1.0/1.9 m^2 ha^{-1} for target diameter 70 cm and 1.3/2.4 using a target diameter of 55 cm. The average basal area per diameter class varies between 1.6 and 2.0 applying target diameters of 70 and 55 cm, respectively.

Table 2. Harvest volume and harvest stem number per ha per period of five years.

Diameter class (cm)	Harvest volume per ha (m3 ha-1)	Harvest stem number per ha
7,5	0,3	10,2
12,5	7,0	69,7
17,5	5,1	20,4
22,5	4,8	9,7
27,5	3,7	4,4
32,5	3,4	2,7
37,5	3,1	1,7
42,5	3,0	1,2
47,5	3,1	0,9
52,5	3,4	0,8
57,5	3,5	0,6
62,5	3,3	0,5
67,5	2,7	0,3
72,5	24,6	2,6
Total	71,0	125,6

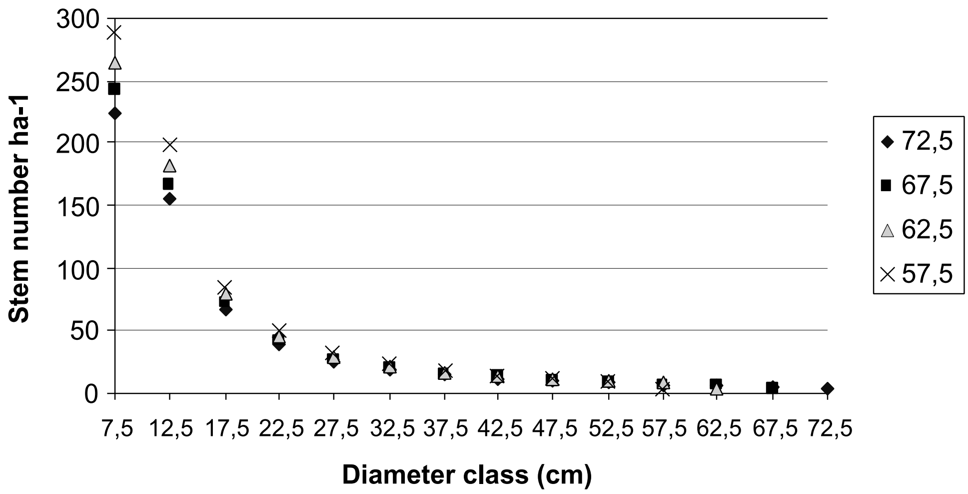

Figure 1. Stem number distribution by diameter classes in steady-state.

Ingrowth to the smallest diameter class (7.5 cm), which is required to sustain the steady state, varies between 126 stems every 5 years applying a target diameter of 70 cm to 162 stems applying a target diameter of 55 cm.

The thinning intensity varies between 5 and 45% of the stem number/standing volume

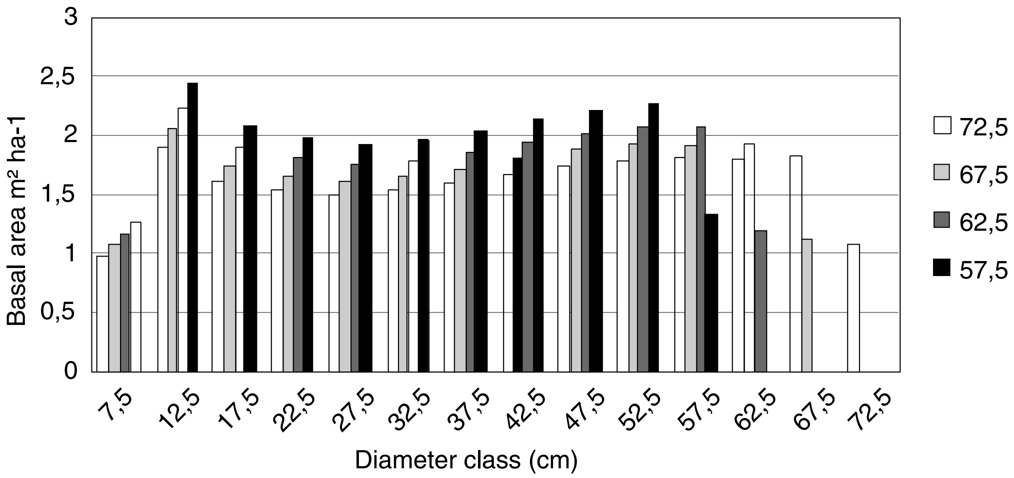

Figure 2. Basal area distribution by diameter classes in steady-state.

per diameter class every 5 years independent of target diameter. The relative thinning intensity measured in terms of thinning stem number or thinning volume is highest for the lower diameter classes, thus decreasing by dimension. The average thinning intensity per diameter class increases from 15% to 18% when the target diameter decreases from 70 to 55 cm. It is found that the relative thinning volume per diameter class is independent of target diameter. Thus, the difference between the thinning regimes applying different target diameters is determined by the number of diameter classes, the stem number per diameter class, and the target diameter harvest volume. The stem number per diameter class increases with decreasing target diameter. As a consequence of these results the annual target diameter harvest volume increases from 4.9 to 5.6 m^3 ha^{-1} and the thinning volume increases from 9.3 to 9.5 m^3 ha^{-1} when the target diameter is reduced from 70 to 55 cm, reaching a total harvest volume between 14.2 and 15.1 m^3 ha^{-1} depending on target diameter.

The mean annual cash flow, expectation value, stock value, and land expectation value per ha depending on target diameter and discount rate are shown in Table 3, where the land expectation value is defined as the expectation value minus the stock value in steady-state.

Table 3 shows that the expectation value in steady-state is positively correlated with a large target diameter. The expectation value assuming a target diameter of 55 cm amounts to 96% of the expectation value assuming a target diameter of 70 cm. It is seen that the relative expectation values for different target diameters are independent of the discount rate.

The maximum deviation between the expectation value in steady-state assuming a target diameter of 70 cm and that following from use of a target diameter of 55 cm does, however, not exceed 5%. Thus, the expectation value of a stand in steady-state is not significantly affected by the size of the target diameter. This observation is also reflected by the small variation of the mean annual cash flow following from a change of the target diameter. Estimation of the expectation value does, however, not include the value of the initial growing stock that is required for implementation of the observed target diameter regime.

The land expectation value, defined as the expectation value minus the stock value, is naturally more sensitive to variation of the discount rate than the expectation value itself.

Target diameter	Mean annual cash flow € ha-1	Expectation value € ha-1	Stock value € ha-1	Land expectation value € ha-1	Relative expectation value (%)	Relative land expectation value (%)
r=0.5%						
55	592	120279	11843	108436	96,3	100,0
60	606	123043	13336	109706	98,5	101,2
65	614	124555	14849	109706	99,7	101,2
70	615	124920	16340	108580	100,0	100,1
r=1%						
55	592	61037	11843	49194	96,3	100,0
60	606	62440	13336	49103	98,5	99,8
65	614	63207	14849	48358	99,7	98,3
70	615	63392	16340	47052	100,0	95,6
r=2%						
55	592	31425	11843	19581	96,3	100,0
60	606	32147	13336	18811	98,5	96,1
65	614	32542	14849	17693	99,7	90,4
70	615	32637	16340	16297	100,0	83,2
r=3%						
55	592	21562	11843	9718	96,3	100,0
60	606	22057	13336	8721	98,5	89,7
65	614	22328	14849	7479	99,7	77,0
70	615	22394	16340	6054	100,0	62,3
r=4%						
55	592	16636	11843	4792	96,3	100,0
60	606	17018	13336	3682	98,5	76,8
65	614	17227	14849	2378	99,7	49,6
70	615	17278	16340	938	100,0	19,6
r=5%						
55	592	13685	11843	1841	96,3	100,0
60	606	13999	13336	663	98,5	36,0
65	614	14171	14849	-678	99,7	-36,8
70	615	14213	16340	-2127	100,0	-115,5

Table 3. Mean annual cash flow, expectation value, stock value, and land expectation value depending on target diameter and discount rate.

Table 3 shows that the highest land expectation value is obtained by use of a small target diameter when the discount rate is larger than or equal to 1%. The land expectation value is strongly reduced assuming large target diameters when the discount rate is increased above this level. The stock value exceeds the expectation value when the discount rate is 5% and the target diameter exceeds 60 cm, resulting in a negative land expectation value. So, it is indicated that the maximum land expectation value is obtained when using the smallest possible target diameter. The results indicate, however, that the economic optimal target diameter increases when the discount rate is very low as shown in Table 3 assuming a discount rate of 0.5%. In this situation the deviation of the land expectation value as a consequence of changing the target diameter is however not significant – reaching a relative deviation of 1.2% when comparing the land expectation value using a target diameter of 55 cm and 60 cm, respectively.

Discussion

The usefulness of Markov chain theory in modelling in general is documented by numerous authors applying models for analysis of a large variety of investigations.

The concept of singulary stationary Markov processes was applied for assessment of the future wood supply in the Netherlands by Hinssen (1994).

Forest sector modeling by use of Markov chain models was described by Sallnas (1990).

The model generated reasonable growth levels and growth patterns. It was concluded that the model is suitable for implementation in integrated forest sector modeling.

Specific applications of Markov chain theory for modelling of mixed species uneven-aged forest management include Kouba (1989) where a normal forest structure is constructed on the basis of a Markov chain model. The optimal conversion to the stationary state is investigated by use of LP where the objective function is the sum of final cutting volume over the conversion period. Kouba (1991) described how estimation of transition probabilities was performed, including the effect of calamities, forming a basis for analysis of the optimal conversion to a normal forest structure.

Lee et al. (2000) employed sample plot data from natural deciduous forests and describe successional trends so that the future overstorey species composition could be predicted in different topographic positions. The succession time to reach the steady-state was 200-250 years depending on topography and forest type. They noted that the forest community is serial rather than of a climax type. A similar study in a mixed broadleaved-Abies forest was described by Kim (1992), where the succession length to reach the steady-state was 700 years. The study forest was still in its serial stages. Quercus mongilica was identified as a mid-successional dominant. The dynamics of the forest structure were dependent on human intervention in the present serial stages. It is noted that the Markov chain model applied in the analysis here also include human intervention through modeling of thinning and final harvesting.

Cho & Boerner (1991) used Markov chain models to predict the future composition of a mixed broadleaved old-growth forest in Ohio. The model was based on most probable replacers of current canopy trees documented by data for replacement in 23 recent treefall gaps in the complex. It was found that Acer and Fagus species were likely to replace Quercus and Fraxinus species in the future due to a change of the regional drainage regime.

A Markov chain application with the purpose to predict the natural course of succession in mixed boreal forests by Logofet and Korotkov (2002) included the use of expert data for transition probability estimation. However, this approach created a high degree of uncertainty. The model was calibrated using a geographical information system for multidimensional non-linear optimization. The best likelihood ratios were used as a basis for adjustment of the transition probabilities obtained from the expert evaluations.

The combined use of Markovian models and optimization was described by Lin & Buongiorno (1998) and Buongiorno and Gilless (2003). The first analysed income possibilities from Wisconsin´s maple-birch forests. The Markov decision process method allowed for the design of compromise policies that would maximize income while keeping diversity above specified limits. Advantages of the method reside in the ability to model complex ecosystem processes with simple probability matrices, and in the rich Markov decision process theory and algorithms. Limitations included the difficulty of defining a space set large enough for accurate discretization, but small enough for practical application. The opportunity cost of increasing tree size diversity was found to be much higher than for species diversity. Comparing the maximum timber income owners could have got with what they actually cut suggested that the amenity value of forests is four times that of timber. Aside from this interesting result the presentation confirmed the wide applicability of Markov chain theory for modelling of uneven-aged forest management.

It has not been possible to locate publications about Markov chain theory applied for economic analysis of uneven-aged beech forests in Northern Europe but a comparison of uneven-aged beech forest management in Northern Germany with for example a cyclical even-aged regime was presented by Nord-Larsen et al. (2003). The average site index corresponded to a height of 30 metres of the mean basal area tree at a stand age of 100 years. The uneven-aged regime is serial in nature and the maximum expectation value is estimated at about €30,000 per ha (r=2%) compared with €31-33,000 per ha in steady-state as shown in Table 3. The results are however not immediately comparable due to difference in site index and variation of the stand structure of the serial regime over time. The mean annual net revenue is estimated at €479 ha^{-1} compared with €592-615 ha^{-1} in the analysis results presented in Table 3. Nord-Larsen et al. 2003 found that the average harvesting costs were reduced when using a target diameter regime compared with traditional even-aged regimes, mainly due to an increased proportion of large size stem wood. On the other hand, it is noted that red heart formation is associated with production of large dimension logs and may therefore reduce the economic optimal target diameter.

Conclusion

The matrix model structure consisting of recursive equations with application of Markov chains represented by transition probability data is suitable for modelling of near-natural forest management requiring application of models representing uneven-aged stand structures.

The recursive equations are suitable for economic analysis of conversion from an even-aged to an uneven-aged stand structure, even though economic analysis of conversion is not subject to specific evaluation here. LP is useful for estimation of steady-state characteristics. It is demonstrated how the steady-state diameter distribution is derived by use of constraints on harvest volume by diameter class determined from the production capability of a normal forest structure.

It is found that the expectation value of a stand in steady-state is neither significantly affected by the size of the target diameter, nor by the size of the discount rate. However, when the value of the growing stock in steady-state is taken into account by estimation of the land expectation value it is found that the economic optimal target diameter should be as low as possible especially when the discount rate is large. When the discount rate is lower than about 1% it is found that the economic optimal target diameter is increasing but the variation of the land expectation value as a consequence of changing the target diameter is not significant when assuming a discount rate at this level.

Future research could include sensitivity analysis of the target diameter dependent on the extent of declassification of logs due to red heart formation. In addition, future development of models for mixed species uneven-aged forest management comprises a challenging research goal.

Acknowledgements

The research leading to this paper was supported by the Ministry of Science, Technology and Innovation, Danish Research Agency, Danish Agricultural and Veterinary Research Council (23-02-0190).

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FOREST POLICY
(INCL. MULTIPLE USE)

Avoided Greenhouse Gas Emissions when Forest Products substitute Competing Materials – Effect on Carbon Account and Optimal Forest Management
A Case Study of Hedmark County in Norway

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Terje Gobakken
Hans Fredrik Hoen
Birger Solberg

Abstract

In the discussion of how forests can contribute to reducing the content of greenhouse gases in the atmosphere, most focus has been given to sequestration of carbon dioxide in forests. Few studies have analysed the additional impact wood-based products has as a substitute for other materials. This effect comes in addition to fixation and release of carbon and can contribute to a long-term solution. The aim of this article is to provide an empirical study on how wood products contribute to reduction of greenhouse gas emissions on a regional level. The case study is of Hedmark county in Norway, and is done with the dynamic forest management optimisation model GAYA-J/C. This model includes costs, revenues, and all the main carbon flows related to forests (living trees, dead trees, litter, soil, materials substitution, and energy substitution).

The paper has three main objectives. The first is to find the effect of including substitution in a carbon account of Hedmark county. The second objective is to find how optimal forest management will change with various prices on CO_2, and also study how the optimal forest management changes when substitution is included. The third objective is to find the frontier between net present value in monetary terms and net present value of carbon benefit, and see how it will change when substitution is included.

Key words: dynamic forest management optimisation model, GAYA-J/C, greenhouse gases, living trees, dead trees, litter, soil, harvest residues, materials substitution, energy substitution.

Incentives for Local Authorities to Supply Environmental Benefits through Afforestation

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Abstract

In 1989 the Danish Parliament announced it an official goal of the forest policy to double the Danish forest area in 60-100 years. One of the goals of this policy was to improve the recreational possibilities for the urban population. Therefore focus has been on furthering public afforestation projects close to cities with little forest nearby. We know from previous research that mature urban forests possess significant amenity values for urban areas; the question is whether the same holds for afforestation projects? Thus, the aim of this analysis is to examine the inhabitants' willingness to pay for proximity to urban afforestation projects. We use a hedonic pricing approach to estimate the willingness to pay for the environmental benefits related to the proximity for two afforestation projects Bakkely Forest and True Forest. The model used enables us to calculate the WTP for each house depending on the distance from the forest and the total WTP for the two areas. The study also examines the impact of the observed raise in house prices on the property taxes that the inhabitants pay. As the property tax depends on the value of the house, higher prices. This increase in the tax burden has to be included in the total WTP measure to avoid a serious under-estimation of the total WTP. We show that the present value of the extra property tax may lie between 20 and 100 % of the increase in property value.

Keywords: Afforestation, amenities, recreation, hedonic pricing, property tax, WTP.

Introduction

In urbanized Europe, the welfare-economic importance of forests consists to an increasing extent of their ability to produce positive externalities. In Denmark, urban afforestation programs are established and financed partly by the Government and partly by the EU to ensure the provision of such externalities, especially recreational opportunities for local population. However, increased budget restrictions in the state agency administering the program have raised the question whether other actors could take over part of the financial burden. In particular those who stand to gain the most from the program.

In this paper, we use a valuation study to examine the link between the new recreational benefits and tax revenues for the local authorities, which could be a possible financing mechanism for nature projects close to urban centers. In 2002 a hedonic pricing study was made to evaluate the willingness to pay (WTP) for proximity to new forests (Anthon 2003, Anthon & Thorsen 2002). Other hedonic studies (Tyrväinen and Miettinen 2000, Præstholm et al. 2002) have shown that proximity to existing forests increases the market value of houses. This increase represents a windfall gain to the house owners, but for many reasons they are not likely to formulate the demand for and secure the supply of the benefits related to urban-fringe afforestation projects. These reasons include the absence of organization and in particular the incentive to free-riding on possible investments. However, other actors benefit from the increased hedonic values. The increase in house prices can lead to higher tax revenues, both property taxes and in the long run higher income taxes too. We assess the quantitative effect of these increased taxes and discuss the extent to which this can be used as an incentive to finance afforestation projects. Two forests are used as case areas.

The hedonic pricing study

The hedonic pricing theory and estimation techniques will not be described in detail here. The core idea is that a property like a house is a composite good and that the price of given house *i* (P_i) is determined by its structural (S), neighborhood (N) and environmental (Q) characteristics (Freeman 1993):

$$P_i = P(S_i, 1_i, Q_i)$$

When a new forest is planted near the house, the environmental characteristics change while all other characteristics remain constant. If proximity to forest is considered a benefit, one would expect the house price to change marginally as a reflection of the willingness to pay (WTP) for living near the new forest.

The hedonic pricing study estimates these changes in two areas, where new forests were in the mid-1990s planted close to the town border. True Forest was planted close to a large suburb (Skjoldhøjparken) of Århus, the second largest town in Denmark, and Bakkely Forest is located close to a small town called Vemmelev. The two afforestation projects are very much alike as to area, species, etc. The data consist of prices of houses sold in the period 1984-2001 and a number of house characteristics, e.g. floorage, age, and proximity to motorways or railways. The effect of the new forest on the price of a given house is modeled using a formulation that allows for an effect of distance to the forest.

The econometric results are presented and discussed thoroughly in Anthon (2003) and Anthon and Thorsen (2002). They showed a significant, positive value of the new forest reflected in house prices. They also showed that the willingness to pay was three times higher at True Forest compared to Bakkely Forest. Figure 2 shows the percentage price increase as a function of distance to the forest. It is seen that the inhabitants were willing to pay for proximity to the forest, and that the effect was highest for the houses situated close to the forest border. The houses closest to True Forest were situated at a distance of 150 meters and experienced an estimated price increase of 9%. At Bakkely Forest, the highest price increase was 10% for a house situated only 50 meters from the forest border. The WTP decreased rather fast - houses located 500 meters from True Forest and Bakkely Forest experienced an estimated increase of only 3 and 1%, respectively.

From the hedonic pricing model it was possible to calculate the aggregate WTP in the two areas (Table 1). It was estimated to be 3.7 times higher for True Forest than for Bakkely Forest. The higher aggregate WTP for True Forest is due to a higher WTP for each house, combined with a higher number of houses in the nearby area and higher average house prices.

Table 1. Aggregate willingness to pay for the two new forests as reflected in house price changes

	True Forest	Bakkely Forest
Total number of houses	977	500
Average house price	185,000 USD	139,000 USD
Aggregate willingness to pay	5.3 mio. USD	1.4 mio. USD

The result from the hedonic pricing study can also be interpreted in a different but equivalent way: as the total rise in house prices if the houses were sold today. This means that the expected value of the houses has increased by 5.3 mio. USD in Skjoldhøjparken and 1.4 mio. USD in Vemmelev.

The impact on tax revenues for local authorities

The increase in house prices from the hedonic pricing study can be used to calculate the expected impact on tax revenues for local authorities. Higher house prices have a direct effect on property tax and we suspect an indirect effect on income tax.

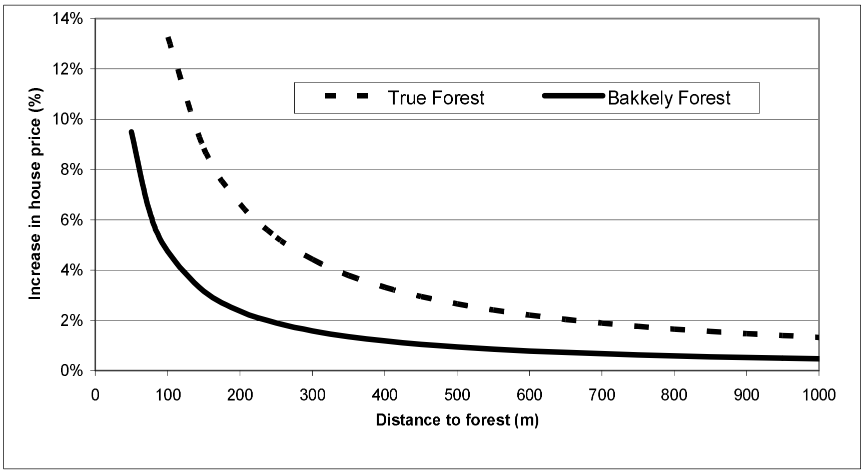

Figure 1. The WTP for the two afforestation projects as a function of distance to the forest

Property tax

In Denmark, house owners pay annual property taxes, which are calculated as a percentage of the assessed market value of their house. Thus, as the proximity to the new forest increases, house prices property taxes increase when the market value assessment has been adjusted. As argued by Anthon et al. (2003) this should be taken into account when assessing the WTP for the proximity to forests. However, in this paper, the interesting aspect is that the property taxes represent a redistribution of wealth – a windfall gain re-allocated to the local authorities, in Denmark counties and municipalities.

The revenue function R_p for property tax can be formulated as:

$$R_P = \frac{p \cdot \Delta h}{r \cdot (1+r)^j}$$

Here p is the property tax percentage levied; Äh is the absolute change in the value of the affected houses. The discount rate used by the community is denoted r and the formulation allows for a possible delay of j years in the administrative adjustment of the market value assessment of the houses in the area.

The calculated R_p is reported in Table 2, showing the increase in annual property taxes caused by the two case afforestations and how it is shared between the two tax levying authorities in each area. The calculations are made using the estimated distance dependent price change of the houses. We have used a discount rate of 3% and assumed a delay of five years, i.e. $j = 5$, for the adjustment of market value assessment to have effect. Since market values are, in fact, regulated every year, this assumption implies a conservative bias of the property tax effect.

Table 2 The property tax effect for the two afforestations and the two local authorities levying the tax. Here $j = 5$ and $r = 0.03$.

Tax authority	Annual increase (1000 USD)	NPV 3% (1000 USD)
True Forest, total	87	2632
Municipality	59	1684
County	33	948
Bakkely Forest, total	24	697
Municipality	16	463
County	8	234

It is seen from Table 2 that the annual increase in property taxes is 87,000 USD for True Forest and 24,000 USD for Bakkely Forest. In total, the local authorities can expect an increase of 2,632,000 USD after the establishment of True Forest and 697,000 USD for Bakkely Forest.

Income tax

Another aspect to consider is the potential long-run effect on income levels in the areas near the forests. If the individual is assumed to be willing to spend only a certain share of the income on housing expenses, then increases in house prices will tend to result in current owners moving out and new owners with higher income levels will move in. At least if the implied costs of higher prices exceed transaction costs. However, since the price changes here have rather marginal cost effects compared to transaction costs of moving, we assume that the rate of turn-over in the group of owners will not change. Thus, only slowly will new owners with higher income move into the area. To the extent that such movements occur across local community boarders they become interesting because they imply that high-income households are attracted and hence, for given tax rates, more tax income will accrue to the local community as such.

In Denmark, counties and municipalities both levy income taxes on their community members. However, as we shall see below, only municipalities are small enough as to make likely a significant amount of cross-community boarder movements. Thus, not only the affected house owners, but also the local communities and authorities stand to benefit from the hedonic effects of afforestation projects – in a very direct way.

Assuming that the marginal propensity to pay for housing is constant across the income ranges considered, it is quite easy to show that a proportional change, Ä*h*/*h*, in house prices must in the long run lead to a similar proportional change in taxable income levels, *Y*, of the households occupying the houses. The revenue function R_I – in present values - for the community can be formulated as:

$$R_I = \gamma \cdot s \cdot Y \cdot \Delta h/h \sum_{t=0}^{\infty} \frac{\min\{1, mt\}}{(1+r)^t} . \qquad (1)$$

R_I captures the increased revenue from levying the income tax percentage s on taxable income Y. The taxable income is suspected to increase only slowly over time with the moving rate m towards a total change of Äh/h percent, obtained when all houses in the area have been traded, i.e. mt=1. Not all new households in the area come from outside the community, but ã measures the proportion of new households entering from outside. Again, the discount rate r is used to calculate the present value of these revenue changes.

Assuming the propensity to spend income on housing expenditures to be constant across income levels, we have argued above that proportional change in house prices must in the long run lead to higher income households living in the area. This assumption is not completely unqualified - figures from Danish Statistics show that households with quite low income use a higher percentage of it for housing than do households with rather high income. However, average pre-tax household income per year is in Vemmelev (Korsør Municipality) 61,000 USD and in Århus 74,000 USD, and since the change in house prices are after all limited, the average household will – before and after houses have been traded - in both municipalities lie in the same official income bracket (50,000- 83,000 USD/yr.). Thus, because house price changes are marginal we find the assumption of constant propensity justified.

Another key factor pointed out above is whether the household moving into the neighborhood did not already live in the municipality or county. If they did, no higher net tax revenue will result. Since the counties are rather large entities – in household numbers as well as geographically - most moves are found to be within-counties. Thus, in general the effect is probably higher for the municipalities.

Data from Danish Statistics show that in Korsør Municipality 28% of households moving takes place from another municipality, in Århus 22%.This difference most likely reflects the fact that Århus is a rather large municipality with approximately 300,000 inhabitants, whereas Vemmelev has only 3,000 inhabitants and is a part of Korsør Municipality with only 20,000 inhabitants. Thus, for Århus we find ã = 0.22 and for Korsør ã = 0.28.

As argued above the full effect on income tax revenues will not show immediately, since the price change is sufficiently marginal not to exceed transaction costs of moving. Only gradually will the houses be sold to people with higher incomes. Data from Skjoldhøjparken and Vemmelev show that 3-4 % of the houses are sold every year. Therefore, the tax revenues will increase over a period of 25-33 years – within approximately one generation all houses will have been traded. After that the income tax revenue increase will be constant at full effect. Thus, we have m = 0.04 for Vemmelev in Korsør municipality and m = 0.03 for Århus.

Using the estimated hedonic price function, a discount rate of 3%, and the reported values of m and ã, we find the income tax effects shown in Table 3. Even with the large effect of the slow moving rate, combined with discounting and the low proportion of newcomers, the total effect is still rather large and in fact is seen to be of the same order of magnitude as the property tax effect. Also, the combined tax effects are seen to reach the same magnitude as the estimated aggregate windfall gain to the house owners. Thus, house owners and local communities both stand to gain from afforestation projects.

It is seen that the NPV of the increase in income tax is of the same magnitude as the increase in property tax. But it is only the municipalities that experience a rise in tax revenues. Århus Municipality can expect a total of 2,073,000 USD and Korsør Municipality 891,000

USD.

Discussion on incentives to supply environmental benefits

This paper has documented that the environmental benefits of urban fringe afforestation do not only imply a windfall gain to nearby house owners, but may also imply rather large gains for the community as such through increased property taxes (in fact reflecting part of the welfare gain) and increased income taxes.

Municipalities in Denmark supply a number of (public) goods to their inhabitants, e.g. childcare, schools, certain health programs, and sport facilities. Supplying these goods in high quality and at low (tax) costs are important goals for the municipalities. It will enable them to attract high income households, which in turn increases tax revenues and allow for either quality and quantity improvements or reductions in the relative tax burden. Thus, municipalities in many ways compete to attract high income citizens.

Providing nice, quiet and beautiful living surroundings is just another way to increase local wealth and in the long run income too. Thus, municipalities and counties may stand to benefit from, e.g. urban fringe afforestation projects, and hence they may have an incentive to

Table 3. Assessing the income tax effect for the municipalities benefiting from the increased attractiveness of the involved residential areas. For parameter assumptions, see text.

	Newcomers	House sales per year	NPV 3% (1000 USD)
True Forest (Århus Municipality)	22%	3 %	2073
Bakkely Forest (Korsør Municipality)	28%	4 %	891

secure this kind of benefits to their inhabitants. Furthermore - unlike the individual household - they have the organizational and financial capacity to handle projects of this size, and they have no incentive to free-riding.

In Table 4 we provide a rough and conservative calculation (based on Anthon and Thorsen 2002) of the net gain for the local authorities, if they themselves had financed the two case afforestation projects. Note that the highest cost burden of public afforestation projects is the acquisition of agricultural land and establishment of the new forest. Forest production does not contribute much to the overall economic value of the project. Note that in this calculation, the community ends up owning the forestland. Once the forest is in place, it is in fact possible to sell the forestland as such because it becomes forest reserve. This will substantially improve the balance.

When we compare the estimated costs of the project with the estimated future tax revenue, it is evident that the possibility of financing afforestation projects through increased tax revenues is not unambiguous, at least not for these two cases. The large differences between the two areas are among other things due to:

· The households in Skjoldhøjparken have a higher average income than those in Vemmelev
· There are more houses close to True Forest compared to Bakkely Forest
· There is a higher increase in house prices in Skjoldhøjparken compared to Vemmelev

However, even without taking this option into account we find that for True Skov, the local authorities stand to benefit substantially and could easily have financed the afforestation projects. For Bakkely Skov at Vemmelev, the balance is more ambiguous. But again, the 60

Table 4. A rough calculation of the net gain for the local authorities in the to case areas, had they themselves invested in establishing the afforestation areas.

	True Forest 1,000 USD	Bakkely Forest, 1,000 USD
Agricultural land	-1.667	-1.000
Establishment	-1.100	-700
Forest management	0	33
Total costs	-2.767	-1.667
Property tax revenue delayed 5 years	2.632	697
Income tax revenue delayed response	2.073	890
Total tax revenue	4.706	1.587
Balance	2061	-80

hectares of forest in Bakkely Skov represent a value of some 300,000 USD, which has not been included here.

Thus, we find that due to the tax revenue changes following hedonic effects of the environmental benefits caused by urban fringe afforestation, local communities may have a clear incentive to actively secure the supply of these benefits to their inhabitants.

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The EU Forest Policy after the Enlargement: A Method for Assessing the New Member States' Potential Impact[1]

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Abstract

The enlargement of the EU in 1995 with Austria, Finland and Sweden had a considerable effect on the Union's policy on forests, and there is reason to believe that further impact will arise from the enlargement in 2004 with ten Central and Eastern European countries. The present study aims at assessing the potential short-medium term change – its extent and direction – of the Forest Strategy 1998 resulting from the enlargement. However, as the assessment is somewhat subjective and based on a small part of the relevant information, emphasis is on the method developed for policy analysis, its merits being that qualitative information is quantified in a simple and transparent way, making the results easily interpreted and reproducible to a reasonable extent.

Keywords: policy analysis, EU Forest Strategy 1998

1. Introduction

The enlargement of the EU in 1995 with Austria, Finland and Sweden had a considerable effect on the Union's policy on forests, and there is reason to believe that further impact will arise from the enlargement with ten Central and Eastern European countries (Eisma 1998). As illustrated by the key figures in Table 1, the forest resource and its potentials of the EU-25 are much larger than those of the EU-15.

No common forest policy proper exists in the EU-15. However, the Forest Strategy 1998 (COUN 1999) is an important statement on common forest policy principles, to which EU forestry initiatives and measures should adhere. The Strategy may be considered a compromise, i.e. the solution on which the fifteen Member States with rather different forest policies could agree. It will to a great extent be implemented through Agenda 2000 (COMM

Table 1. Key figures on development of the EU forest resource (Based on ECE/FAO 2000).

	Forest area	Forest Available for Wood Supply (FAWS)			
		Area	Growing stock	Net annual increment	Annual removals
	1,000 ha	1,000 ha	1,000 m^3 o.b.	1,000 m^3 o.b.	1,000 m^3 o.b.
EU-15	113,567	95,525	13,420,123	458,839	265,679
10 New Members	23,493	21,373	4,506,413	114,920	61,187
EU-25	137,060	116,901	17,926,536	573,759	326,866
% of EU-15	121	122	134	125	123

[1] The paper is based on Nielsen & Poulstrup (2001).

1999) and is therefore immediately relevant to the new Member States (COMM 1998, p. 9). The Forest Strategy is a dynamic process (COUN 1999, Paragraph 2) and will change as a result of the Member States' forest policies, even though they have all reformed their forest legislation within the last decade, more or less as part of the endeavours to qualify for EU membership – they are "expected to respect the same international commitments and processes to forests and the environment as the European Union" (ESC 2002, Paragraph 5.1).

The present study aims at assessing the potential short-medium term change – its extent and direction – of the Forest Strategy resulting from the EU enlargement. However, as the assessment is somewhat subjective and based on a small part of the relevant information, emphasis is on the method developed for policy analysis.

2. Method

The overall idea of this paper is that the Forest Strategy represents a certain balance of three sustainability concepts: ecological, economic and social functions, and that the enlargement of the EU will lead to a new balance. The Strategy's present position in relation to the sustainability concept is used as the point of reference, to be compared with the aggregate position of the new Member States' present forest policy. The difference gives a first indication of the new balance position. However, the forest policy of a new Member State may not tally with the potentials of its forest resources and therefore a dynamic aspect is included, illustrating, as it were, a difference between theory and practice.

The analysis follows two lines (see Figure 1): (i) Forest policy analysis (Section 2.1): The components of the Forest Strategy and of the new Member States' present forest policies are weighed according to the three sustainability functions and visualised as in Figure 2. (ii) Forest resource assessment (Section 2.2): The forest resource of each new Member State is analysed with respect to its potential prioritisation of the sustainability functions (arrows in Figure 2).

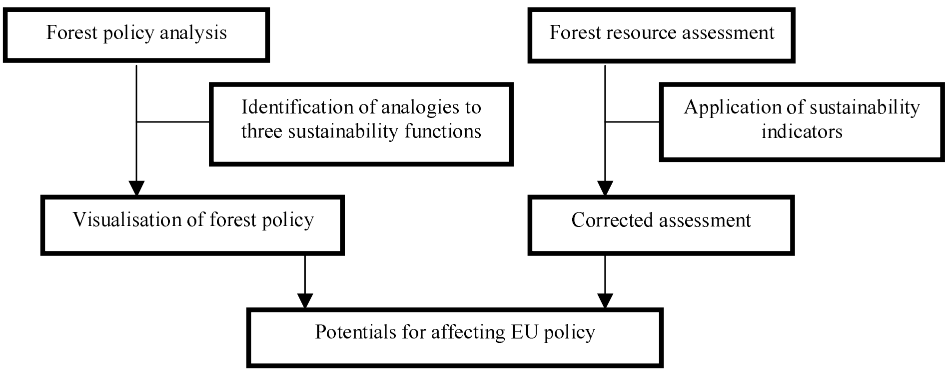

Figure 1. Overview of the analysis method

2.1 Forest policy analysis

The Forest Strategy and each new Member State's forest policy are related to the three sustainability functions through identification of *analogies*. Examples: (i) An aim of increasing forestry's productivity indicates economic functions, (ii) efforts to establish national parks may indicate ecological functions, and (iii) emphasis on recreation indicates social functions. For some policy aims the characterisation may depend on the context, e.g. fire protection and afforestation, and they are therefore not included. The 'strength' of each policy aim is assessed through the assignment of 1, 2 or 3 points. For illustration of analogies to ecological functions:

· *Strong* (3 points): "conservation and enhancement of ecological stability of forest ecosystems, and their sustainable and close-to-nature treatment" (Slovenia: Forestry Policy and Strategy 1996, Objective 1.1 (EFC 2000b)).

· *Moderate* (2 points): "conservation and improvement of the quality of air, whose content of impurities must not be detrimental to the existence and development of natural forests" (Objective 2.1)

· *Weak* (1 point): "conservation, establishment and forming of forest edges and groups of trees, solitary trees, riparian forest vegetation, windbreaks and hedgerows outside the forest" (Objective 2.3).

Such identification and weighing of analogies is subjective but this may to some extent be counterbalanced by the systematic approach. The chosen policy statements and their analogies are shown in Table 2.

For each of the three sustainability functions the weights are summed and the relative scoring calculated. The relative scoring defines the country's position in Figure 2. Coordinates (0.33; 0.33; 0.33) imply equal weights, whereas e.g. coordinates (0.50; 0.25; 0.25) imply emphasis on ecological functions and lower but equal weight on economic and social functions.

For a given country, the most recent and comprehensive forest policy document(s) available is consulted: Forest Law, national forest programme, strategy, etc.

Table 2. Selected policy statements and their classification

Policy statements	**Analogies and priorities**		
	1st priority	2nd priority	3rd priority
Public access	Social	-	-
Land amalgamation	Economic	-	-
Protection of flora and fauna	Ecological	-	-
Employment	Social	Economic	-
Biodiversity/multiplicity	Ecological	-	-
Certification	Social	Ecological	-
CO_2 sequestration	Social	Ecological	-
Democratic processes/participation	Social	-	-
Research	Social	Ecological	-
Information	Social	-	-
Hunting	Economic	Social	-
Capacity building	Social	Economic	-
Climate functions	Ecologic	Social	-
Cultural functions	Social	-	-
Selected seed material	Ecological	Economic	-
Possibility to convert into farmland	Economic	-	-
Non-timber forest products	Economic	Ecological	Social
Plantations	Economic	-	-
Production/commercial activities	Economic	-	-
Recreation	Social	-	-
Restitution	Social	Economic	-
Tax benefits	Economic	-	-
Forest health	Ecological	Economic	-
Grants/subsidies	Economic	Social	-
Incentives for owners' associations	Economic	Social	-
Technology development	Economic	Ecological	-

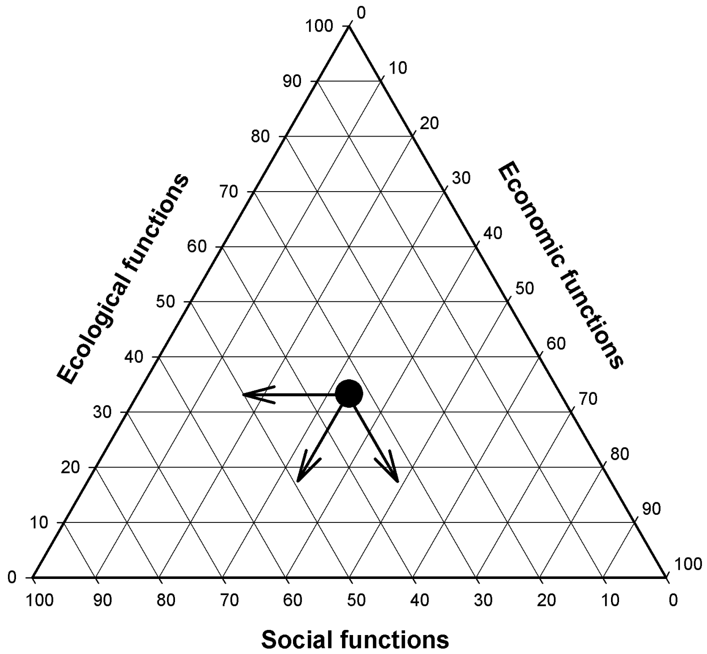

Figure 2. Illustration of the assessment correction ● new Member State

2.2 Forest resource assessment

In order to decide whether the forest policy statements tally with the forest resource potential the resource is assessed by applying the same sustainability functions that were used in Section 2.1. Three *sustainability indicators* are defined, for each of which is made a weighing by twos of the sustainability functions, and in the case of transitivity an overall weigh is derived. However, no numerical value is aimed at, i.e. no exact position in the sustainability triangle. What is obtained is an indication of the direction in which the forest resource 'pulls' the forest policy through relative prioritisation of the sustainability functions. For instance, there is a pull towards economic functions if analysis of the indicators reveals more weight on such functions than on ecological and/or social functions.

The indicators are listed in Table 3 together with the associated hypotheses (these also show limits to the use of the indicators). In Figure 2 the arrows show the prioritisations by twos – in this hypothetical example, social functions are given priority to economic (horizontal arrow), economic functions priority to ecological (arrow sloping downward to the right), and social functions priority to ecological functions (arrow sloping downward to the left).

3. Results

The results of the analysis are shown for the Forest Strategy and for the ten new Member States as a whole. Two of these have been selected for further illustration: a North and a Central European country, namely Lithuania and Slovenia.

3.1 EU-15

The Council Resolution on the EU Forestry Strategy (COUN 1999) considers, in particular, the UNCED 1992 and the Pan-European Ministerial Conferences on the Protection of Forests, when emphasising "the importance of the multifunctional role of forests and sustainable forest management based on their social, economic, environmental, ecological and cultural functions for the development of society and, in particular, rural areas and emphasises the contribution forests and forestry make to existing Community policies" (Section 1).

Among the substantial elements of the Forestry Strategy identified by the Council are: (i) Sustainable forest management and the multifunctional role of forests as overall principles for action, (ii) the importance of sustainable forest management for the conservation and enhancement of biological diversity, and for the living conditions for animals and plants, (iii) the contribution of forestry and forest-based industries to income, employment and other elements affecting the quality of life, (iv) the need for specific approaches and action for the different types of forests, recognising the wide range of natural, social, economic and cultural conditions of the forests in the Community. (Section 2).

The result of classifying the Forest Strategy to sustainability analogies is shown in Table 4. According to the analysis, ecological functions dominate the Strategy whereas economic functions carry relatively little weight. The weights define the Strategy's position in Figures 3-4.

Table 3. The three sustainability indicators applied.

Indicators	Functions	Description	Hypotheses
1	Economic/Social	Ratio of felling to increment	The closer the level of felling to that of net increment, the more the weight on forestry's profitability. Conversely, the more the non-utilised net increment, the more the standing volume accumulation, resource and social benefits in different environmental and recreational contexts
2	Economic/Ecological	Ratio of mixed forest area to total area of Forest Available for Wood Supply (FAWS)	Mono-species forest has higher business economic value than mixed forest, which has higher ecological value in the form of biodiversity. Comparison with the EU-15 average reveals whether the resource complies more/less with economic or ecological functions
3	Ecological/Social	Ratio of IUCN* classes 1 and 2 forest area to total area of protected forests	IUCN forest classes 1 and 2 have high ecological value but are more or less inaccessible to the public. This means that a trade-off is made between ecological and social functions through increasing/reducing the share of forests protected to such extent that they are little open to public use

* International Union for Conservation of Nature

3.2 Lithuania

Lithuanian forest policy is based on the UNCED 1992 sustainability principles and the primary aims are: (i) Implementation of the Pan-European resolutions 1990, 1993 and 1998, (ii) development of sustainable and multiple-use forest management, (iii) protection of biodiversity, (iv) afforestation of abandoned agricultural land, and (v) development of forestry research, education, and extension (EFC 2000a).

The Forestry Law 1994, latest amendment 1999, aims to "establish rights and duties of all forest managers, owners and users…to utilise, reproduce, grow and protect forests, strike a balance between the interests of forest owners and society, establish the main principles of forest management" (Article 2). Among the "main trends of forest policy" are: "Forests shall be managed properly without violating economic and ecological interests of the State. The environment, diversity of plants and animals, landscape, nature and culture values must be preserved and harmonised in the forests." (Article 1).

In Lithuanian forest policy, ecological functions are slightly more important than economic functions, whereas comparatively little weight is given to social functions (see Table 5). Lithuania's position in the sustainability triangle is shown in Figure 3.

The total forest area is 19,780,000 ha (32% of land area, 0.5 ha/cap), 85% of which is Forest Available for Wood Supply (FAWS). Like in the other Baltic States (and Poland and the Czech Republic) the growing stock is predominantly coniferous. Conifers cover 45% of the area, broadleaves 35% and 20% is mixed forest. The average growing stock per ha is 186 m3 and increasing: net annual increment 5.0 m3/ha, annual removals 2.3 m3/ha. (Based on ECE/FAO 2000). By year 2000 77% of the area was still in public ownership, the restitution target being 55-60% (INDUFOR-ECO 2000).

Application of the sustainability indicators to the forest resource is illustrated in Figure 5. As is seen from Table 7, no dynamic aspect is identified, cf. Figure 3.

Table 4. Policy analysis of the EU Forest Strategy 1998
(based on COUN 1999)

Section	Ecological functions	Economic functions	Social functions	
1	1	1	2	
2a			1	
2c	3	1	1	
2g	2			
2h	2	1		
2i		2	2	
2k			2	
3			1	
4	2			
5	3			
6	2	1	1	
7			1	
11	3			
12	2			
13		1	1	
14		1		
15			2	
16			1	
Total	20	8	15	43
Share	0.47	0.19	0.35	1.01

3.3 Slovenia

The Law on Forests 1993 stipulates that the "programme of forest development in Slovenia [FDPS] shall set out a national forest policy of close-to-nature forest management, guidelines for the conservation and development of forests, and conditions for their exploitation and multiple use" (EFC 2000b).

The FDPS 1996 takes into account the UNCED 1992 sustainability principles 1992 and the Pan-European resolutions 1990 and 1993, and based on the Law on Forests, it develops the "fundamental long-term objectives of forest management": (i) Conservation and sustainable development of forests with regard to their biodiversity and all their ecological, social and production functions, (ii) conservation of the natural environment and an ecological balance in the landscape, (iii) conservation of landscape settlement, and cultivation and improvement of the quality of life in the countryside.

In Slovenian forest policy, the three sustainability functions carry almost equal weight (Table 5). Slovenia's position in the sustainability triangle is shown in Figure 3.

The total forest area is 1,099,000 ha, the smallest among the new Member States (apart from Cyprus and Malta with very small forest areas): 54% of the land area and 0.6 ha/cap, 94% of which is FAWS. The area distribution is conifers 30%, broadleaves 38% and mixed forest 32%. The average growing stock per ha is 283 m3/ha and increasing: net annual increment 5.9 m3/ha, annual removals 1.9 m3/ha. Seventy per cent of the area is in private ownership. (Based on ECE/FAO 2000).

Application of the sustainability indicators to the forest resource is illustrated in Figure 5. As is seen from Table 7, a dynamic aspect is identified, cf. Figure 3.

Table 5. Policy analysis for Lithuania and Slovenia

Lithuania, Forestry Law 1994				
Article	Ecological Functions	Economic functions	Social functions	
1.1	3	3	1	
1.2	3		3	
1.3	2		1	
2.1		1	1	
4.1	3			
4.2	2		2	
4.3	2	1		
4.4	1	3		
5	1	1		
7			1	
8.1		3		
8.2		2		
8.3			2	
8.4		3		
8.5		1	1	
9			3	
10	3	1	1	
11		2		
16.1			2	
16.2		1		
17	1	2		
18	3			
19	2	1		
20	2			
Total	28	25	18	71
share	0.39	0.35	0.25	0.99

Slovenian FDPS 1996 (EFC 2000b)				
Objec-tives	Ecological functions	Economic functions	Social functions	
1.1	3			
1.2	3			
1.3	2		2	
1.4			3	
1.5			1	
1.6		3		
1.7	1	2		
1.8	1	2	2	
1.9			2	
2.1	2			
2.2		2	1	
2.3	1	1	1	
2.4	2			
2.5	2			
3.1		2		
3.2		2		
3.3		1	2	
3.4		2	2	
Total	17	17	16	50
share	0.34	0.34	0.32	1.00

3.4 All new Member States

In Table 6 are shown the results of the policy analysis for all new Member States. Apart from Cyprus and Malta, the sustainability concept (UNCED 1992 and Pan-European resolutions) is explicitly recognised as the basis of forest policy in all States. However, as shown in Figure 4 the positions in the sustainability triangle differ considerably, but the only 'outlier' is Malta. The aggregate position is also shown in Figure 4, indicating some difference from the EU-15 Forest Strategy with regard to the weighting of ecological and economic functions, cf. Table 7 showing the result of the forest resource analysis for all new Member States. The method does not warrant the estimation of a correction of the aggregate position. The numerical results with regard to the three sustainability indicators are shown in Figure 5.

Table 6. Policy analysis for the new Member States, EU-25 and EU-15.

	Ecological functions	Economic functions	Social functions
Cyprus	0.29	0.19	0.52
Czech R.	0.26	0.40	0.34
Estonia	0.38	0.27	0.36
Hungary	0.31	0.29	0.40
Latvia	0.44	0.29	0.27
Lithuania	0.39	0.35	0.25
Malta[†]	0.76	0.00	0.24
Poland	0.42	0.20	0.37
Slovak R.	0.29	0.14	0.57
Slovenia	0.34	0.34	0.32
EU-25[‡]	0.35	0.27	0.38
EU-15	0.47	0.19	0.35

[†] Based on environmental legislation
[‡] Excluding Malta

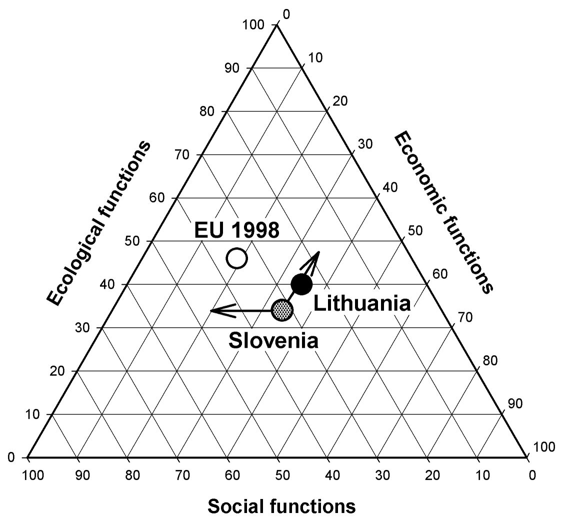

Figure 3. Illustration of forest policy analysis
o Forest Strategy • Lithuania, • Slovenia

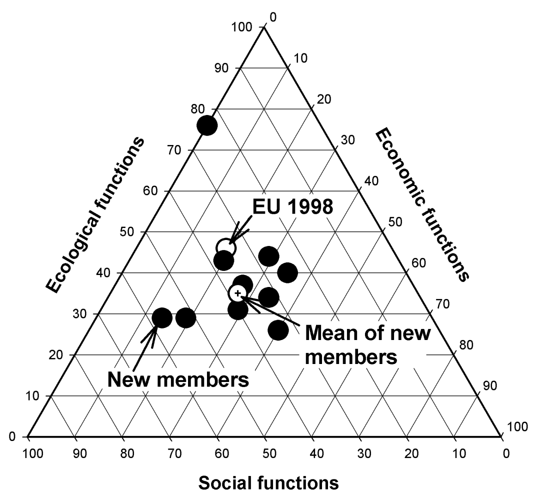

Figure 4. Forest Strategy and the average of all new Member States except Malta
○ Forest Strategy, ● new Member State, ⊕ mean of new Member States

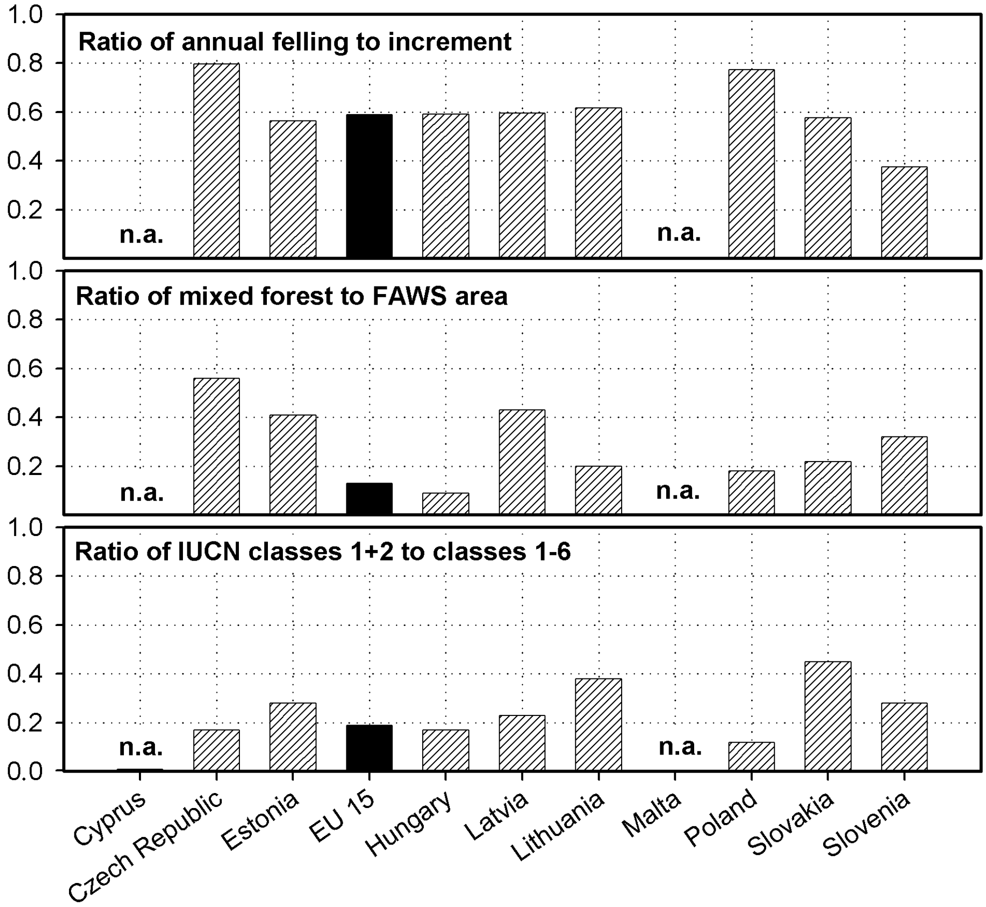

Figure 5. Analysis of the three sustainability indicators.

4. Discussion

The Forest Strategy 1998 reflects a forest policy compromise between the fifteen EU Member States. The enlargement of the EU implies that a new compromise must be arranged, reflecting the intersection of twenty-five Member States. This study has analysed the forest policy difference between the Strategy and each of the new Member States' forest policy and its dynamic aspects. Two assumptions are made: (i) All new Member States have equal interest in forest policy, and (ii) they exert equal influence on the new common balance in the sustainability triangle, an influence even equal to that of the present Member States. The first assumption is not correct but is also not easily qualified. The second assumption holds true, at least in principle.

Some difference is found between the EU-15 and EU-25 weighting of ecological and economic functions. In other words, the EU enlargement may imply a pressure on EU forest policy towards more weight on economy and less on ecology. (The important result of the analysis is not the numerical assessment of differences but its revealing that they exist). Among the possible reasons for the trade-off between ecology and economy are:

· Apart from Cyprus and Malta, forestry in the ten new Member States has a long tradition of emphasising ecological functions.

· With the same exceptions, these States are much behind the EU-15 with respect to economic standard of living and have the possibility to increase the financial benefits from forestry.

Table 7. Results of forest resource assessment for new member states

Country	Indicators	Comparisons	Overall results
Cyprus	1	Economy > Society	Economy > Society > Ecology
	2	Economy > Ecology	
	3	Society > Ecology	
Czech R.	1	Ecology > Economy	None
	2	Ecology > Economy	
	3	Society > Ecology	
Estonia	1	Society > Economy	Ecology > Society > Economy
	2	Ecology > Economy	
	3	Ecology > Society	
Hungary	1	Economy > Society	Economy > Society > Ecology
	2	Economy > Ecology	
	3	Society > Ecology	
Latvia	1	Economy > Society	Ecology > Economy > Society
	2	Ecology > Economy	
	3	Ecology > Society	
Lithuania	1	Economy > Society	Ecology > Economy > Society
	2	Ecology > Economy	
	3	Ecology > Society	
Malta	1	n.a.	Society > Economy > Ecology
	2	Economy > Ecology	
	3	Society > Ecology	
Poland	1	Economy > Society	None
	2	Ecology > Economy	
	3	Society > Ecology	
Slovak R.	1	Society > Economy	Ecology > Society > Economy
	2	Ecology > Economy	
	3	Ecology > Society	
Slovenia	1	Society > Economy	Ecology > Society > Economy
	2	Ecology > Economy	
	3	Ecology > Society	

The equal weighting of social functions in the EU-15 and EU-25 may be explained as follows:

· In EU-15 the emphasis on social functions is mainly attributable to the high economic standard of living.

· In EU-25 social functions are to a varying degree conditioned by, e.g. a restitution process, protection of cultural heritage, usufruct (berries, fungi).

The uncertainties of the analysis method and its results are mainly:

· The aim has been to base the analysis on the most recent and comprehensive national forest policy statements in the ten countries. Apart from the problem of whether the policy statement available is in fact the most recent, much policy is provisional and incomplete, reflecting the effort to comply with *l'aquis communautaire*.

· The evident element of subjectivity is reduced through making more than one person analyse a given text according to a clear procedure.

· When applying the sustainability concept it has sometimes been problematic to identify analogies, in particular to social functions. It might have been advantageous to use a more detailed scaling, e.g. 1-10 instead of 1-3.

· It is difficult to select a limited number of sustainability indicators that are logical, unambiguous and adequate. Applying more indicators might have facilitated the analysis and led to more telling characterisation of forest resource potentials.

5. Conclusion

The method developed seems suited for policy analysis, its merit being that qualitative information is quantified in a simple and transparent way, making the results easily interpreted and reproducible to a reasonable extent.

The study leads to the conclusion that the enlargement by ten new Member States may in the short-medium term tend to make the EU policy on forests put more emphasis on economic functions at the expense of ecological functions, whereas the relative importance of social functions may remain unchanged.

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Welfare Incidence of Subsidized Recreation Services in Finland

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Abstract

The paper addresses the question who benefits from public funding of recreation areas. Employing a survey data set that includes both users and nonusers of state-owned recreation and conservation areas in Finland, we derive measures of the income elasticity of willingness to pay for recreation services. Our elasticity estimates indicate that public provision of these services seems to benefit more those with lower incomes. We also estimate potential welfare effects for two separate income groups (lower-/higher-than-median income) in alternative cases in which a fee acceptable to a median voter would be implemented for the use of recreation areas. The efficiency and welfare losses have ambiguous impacts on the high- and low-income groups, with the impacts depending on the actual level of the fee implemented. Finally, we discuss whether public funding of recreation services can be justified and what the optimal policies might be for implementing user fees.

Keywords: user fees, benefits, environment, income

Introduction

The positive impact of outdoor recreation on health and well-being is considered a major motivation for governments to subsidize recreation services. Nature conservation areas promote environmental education, and recreation services further conservation aims by preventing overuse and degradation of valuable sites. On the other hand, implementing user fees for state-owned recreation areas would reduce congestion and open up a new source of income for the government. Here the fundamental question becomes whether distribution considerations in the provision of subsidized recreation services should play a role in instituting user charges.

Our paper examines equity in and public funding of recreation services. We study the relationship between income and willingness to pay (WTP) for collectively provided state-owned recreation and conservation areas in Finland and discuss distributional impacts of subsidized recreation services. Economists have long been concerned about whether government provision of public goods benefits other than high-income groups despite perhaps the initial political intention of serving the needs of all citizens (Besley and Coate 1991). In this context, nature protection or other programs to improve the quality of the environment are often classified as luxury demand (see, e.g., Baumol and Oates 1989). Accordingly, even though recreation services cannot be considered rationed, pure public goods, studies on the income elasticity of the demand for outdoor recreation facilities have categorized recreation as a luxury good (Boercherding and Deaton, 1972; Bergstrom and Goodman, 1973). However, there are few indicators that this is necessarily the case in general, although there is considerable evidence that recreation services are more often used by relatively wealthy people (e.g., Vaux 1975, Cordell et al. 2002). An intuitive explanation is that when there are costs involved in the use of recreation services (travel, equipment, etc.), higher-income households can better afford to enjoy public recreation services. Countering this is the argument that as recreation is a time-consuming activity, the opportunity cost of time is lower for households with lower incomes; for example, evidence from travel cost studies indicates that income elasticity for changes in recreational consumer surplus is less than one (Morey et al. 1993). In their study on Maine state park campers, Reiling et al. (1992) also found evidence that higher fees would have a discriminatory impact on low-income users.

A special feature of recreation services that complicates demand analysis is that they have the nature of both a private and a public good. Considered as a private good and in terms of their complementarity with or substitutability for other goods, recreation services clearly need not be viewed as luxury goods. In fact, how they are classified depends on institutional context, knowledge, etc. (Daily et al. 2000). There are strong reasons to assume that other than user values, such as conservation of nature and cultural values associated with state parks, are as important as opportunities to use state parks free of charge. In contingent valuation studies, it is typically found that the income elasticity of WTP for ecosystem services provided by the environment (clean air, water purification, pollination) is less than one (Kriström and Riera 1996, Hökby and Söderqvist 2003). An essential point of departure for our analysis is that recreation services provided by the government have not only a private good component – captured by the use of the services – but also a public good component – determined, for example, by users' preferences with regard to nature conservation.

Our study makes two main contributions. First, we derive the income elasticity of willingness to pay for recreation services for alternative sub-groups of the whole population. Second, by estimating welfare measures for two income groups (lower-/higher-than-median income) we address questions such as who benefits from the recreation services most, whether fees would be welfare enhancing, and what the optimal fee level would be.

We investigate a representative sample of the Finnish population including both users and nonusers of the recreational services provided by all of the state-owned outdoor recreation parks. The data used are a sub-sample of the extensive Finnish Outdoor Recreation Survey, which was obtained along with the weekly Labor Force Survey, a continuous panel survey based on census data. The survey included questions eliciting people's willingness to pay for state-owned recreation and conservation areas. The statistical model we employ for analyzing WTP responses is a variant of the Tobit model in which the data are completely censored. This estimation method, initially suggested by Cameron and Huppert (1989), takes into account the interval nature of payment card WTP responses. In addition, a nonparametric Ayer estimator is used for comparison of welfare measures in the alternative user and income groups.

Our results show that users' overall preferences and funding alternatives for services influence how recreation services are perceived. The estimates of the income elasticity of WTP indicate that current policy favors those with lower incomes. However, a closer look at the welfare measures estimated demonstrates that the incidence of benefits is ambiguous.

The paper is organized as follows. The section to follow discusses the theoretical considerations of the analysis and briefly describes the statistical methods used. The next two sections present the data and the results of the demand analysis, respectively. The concluding section discusses policy implications with a special emphasis on whether public funding of recreation services is justified, and, if so, to which extent and on which grounds.

Theoretical considerations and statistical methods for hypothesis testing

Our hypothesis is that the incidence of benefits from subsidized recreation services depends on income. Obvious indicators for verifying benefit incidence are estimates of income elasticity and consumer surplus measures. Two measures can be derived from our survey data: an estimate of the income elasticity of WTP and a welfare measure consisting of a money measure of utility change based on the hypothetical contingent valuation scenario. Let us discuss these measures in more detail.

The income elasticity of willingness to pay

In the theoretical literature, it has been emphasized that a clear distinction should be made between the income elasticity of demand and the income elasticity of WTP (Hanemann 1991, Flores and Carson 1997, Ebert 2003). The income elasticity of WTP is an elasticity derived for a "virtual price" for environmental quality elicited in contingent valuation studies. The income elasticity of willingness to pay is of the form å$_w$=d(*ln t TP*)/d(*lnM*), where *M* is income.

We derive the income elasticity of WTP from demand functions estimated using a grouped data Tobit model, given that a payment card was used for eliciting WTP responses. The method is a standard procedure, included, for example, as part of the LIMDEP computer package (Greene, 1998). The essence of the estimation procedure is to take into account the fact that the WTP responses cannot be considered as deterministic point estimates but are known only for the intervals used in the bid vector. Formally, the model is

$$(1) \qquad y^* = \beta \mathbf{x} + \varepsilon, \ \varepsilon \sim N[0,\sigma^2],$$
$$y = j \text{ if } A(j-1) \leq y^* \leq A(j), j = 1,...,J, A(0) = -\infty, A(J) = +\infty$$

Let L_i and U_i denote the lower and upper limits of the payment card interval. If y_i equals 1, L_i is A(0)=-∞ and U_i is A(1), the first limit value given. The log-likelihood function for this model is

$$(2) \qquad \ln L = \Sigma_{(i=1,N)}\{\ln[\Phi(\eta U - \gamma \mathbf{x}_i) - \Phi(\eta L - \gamma \mathbf{x}_i)]\},$$

where $\gamma = \beta/\sigma$ and $\eta = 1/\sigma$ and Φ is the standard normal cumulative density function.

Once the optimized β and σ have been attained, the conditional mean of y* for any given vector of variables will be $\beta\mathbf{x}$. Cameron and Huppert (1989) use a lognormal conditional distribution for valuations, or $y_i=\ln(WTP_i) \sim N[0,\sigma^2]$, whereby the mean of the untransformed WTP variable is $\exp(\beta\mathbf{x}+\sigma^2/2)$ and the median is $\exp(\beta\mathbf{x})$. This indicates that the mean as a welfare measure is more sensitive to the disturbance standard deviation, σ, as will be seen below. Following Kriström and Riera (1996), we use income, *M*, as the only explanatory variable such that $\beta\mathbf{x} = \alpha + \beta_M M$. The income elasticity of mean WTP can then be calculated from the model as follows:

$$\varepsilon_w = \frac{\partial E[WTP]}{\partial M} = \frac{\sigma^2}{2}\beta_M \ .$$

The income elasticity of WTP, ε_w, indicates whether the share of WTP allocated to the recreation services decreases or increases with income. The distribution of environmental benefits is "pro poor" if $\varepsilon_w<1$, proportional if $\varepsilon_w=1$, and "pro rich" if $\varepsilon_w>1$. (See, e.g., Hökby and Söderqvist 2003).

Consumer surplus measures

As for our second indicator of distributional impacts, i.e., the welfare measure, the wording of the WTP question determines which surplus measure is actually employed (see, e.g., Johansson 1987). Since the respondents were asked about their willingness to contribute to financing the same range of recreation services in state-owned parks as is currently provided by the government free of charge, WTP is a measure of equivalent variation. In other words, the ex post level of utility will potentially be lower if a payment is charged for recreation services. The welfare measure, equivalent variation, expresses the maximum sum of money that must be charged individuals to make them as well off as they would be with a reduction in recreational services.

To illustrate the distributional impacts of fees on the consumer surplus, we adopt nonparametric estimation techniques, which are increasingly common in contingent valuation analyses. The purpose is to estimate the survival function directly from the survey responses, taking the empirical distribution as the "true" distribution instead of imposing a parametric distribution on the data. We will use the algorithm developed in Ayer et al (1955), which was first applied in environmental valuation analyses by Kriström (1990). The method has been shown to yield a consistent maximum likelihood estimator (Cosslett 1983) that is particularly easy to compute when there are no covariates. The WTP observations are grouped in the WTP space into intervals according to the responses obtained. The nonparametric iterative procedure generates a survival function such as that shown in Figure 1. The nonparametric WTP distribution is actually a step function, but this cannot be seen from the figure as scaling has rendered the distances between observations nondetectable.

In sum, the point estimates for mean and median WTP will be estimated parametrically, which also makes possible the derivation of the income elasticity of WTP. Nonparametrically derived survival distributions are used for estimating the changes in welfare that would result from the implementation of fees. The welfare changes are calculated for different fee levels and sub-groups of the population to illustrate the distribution of the burden of fees, or the incidence of benefits from currently subsidized recreation services.

Data

We use data from an extensive national outdoor recreation survey carried out in Finland in the years 1997-2000 (Sievänen 2001). The sub-survey on the importance of outdoor recreation services ultimately yielded 1,871 questionnaires, constituting a response rate of 64%. The sample is representative for the Finnish population, and includes both users and nonusers of state-owned recreation and conservation areas. Sampling, data collection, pretesting and details of the mixed-mode survey (piloting, telephone and mail) are described in more detail in Virtanen et al (2001).

The sub-survey data used here included answers to contingent valuation questions which were intended to reflect the respondent's total annual WTP for recreation services in state-owned parks. The respondents were asked about their willingness to contribute to financing the same range of services as is currently provided by the government free of charge. Willingness to pay for a recreation pass and willingness to pay a general tax earmarked for the provision of outdoor recreation services were used as payment vehicles in two separate sub-samples. The respondents were asked to choose the sum that came closest to their valuation on a payment card (see, e.g., Mitchell and Carson, 1989). The following amounts of money were listed on the card: FIM 0, 50, 100, 200, 300, 500, 1000, 1500, 2000, over 2000 (1 €=FIM 5.94[1]).

Table 1 gives summary statistics for the raw WTP distribution in the data set and captures the basis for our analysis of distributional impacts by comparing the mean WTP measures between lower- and higher-income groups within both payment vehicles. Although respondents with higher incomes had a higher WTP, the difference did not prove to be statistically significant. Interestingly, the proportion of respondents indicating zero WTP was highest (lowest) in the lower-than-median (higher-than-median) income group when tax (a recreation pass) was used as the payment vehicle.

Table 1. Mean WTP per year (FIM) by income group and payment vehicle (N=1582).

Total sampleMean WTP(FIM)/Proportion WTP=0 (%)		Income Lower than median	Higher than median
Payment vehicle	Tax	FIM 90 / 40.2%	FIM 105 / 33.7%
	Recreation pass	FIM 94 / 31.2%	FIM 97 / 23.9%

To gain more insight into the mean WTP in income groups, the same comparisons were conducted among nonusers and users (Table 2). When only nonusers were studied, WTP wassignificantly higher among respondents with higher-than-median incomes where the payment vehicle was a tax increase. Mean WTP was also compared between nonusers and users. The difference was significant, as the users of the state recreation and conservation areas were willing to pay FIM 25 more on average than nonusers. The difference between nonusers and users was especially high (FIM 52) among respondents whose income was below median when tax was used as the payment vehicle. This is consistent with a stylized fact whereby fees are considered regressive while at least some forms of taxes are viewed as progressive (More 1999).

Table 2. Mean WTP per year (FIM) among nonusers and users by income group and payment vehicle.

Mean WTP(FIM) per year		Nonuser/Income		User/Income	
		Lower than median	Higher than median	Lower than median	Higher than median
Payment vehicle	Tax	FIM 78[1)2)]	FIM 102[1)]	FIM 130[2)]	FIM 110
	Recreation pass	FIM 83	FIM 95	FIM 116	FIM 103
	Both	FIM 87[3)]		FIM 112[3)]	

Notes: Superscripts indicate statistically significant differences: 1) among nonusers: between income groups; 2) among the lower-than-median income group: between users and nonusers; and 3) between nonusers and users.

According to these comparisons, income is an important variable when WTP is also affected by interactions with personal use of recreation services and payment vehicle. Both of these variables are in part related to whether recreation services are perceived as private and/ or public goods.

Results

To calculate the income elasticity of WTP, we need to evaluate the function relating WTP to income. The estimations with grouped data Tobit specifications were carried out separately for three sub-samples: a sample including all respondents, a sample including only nonuser respondents, and a sample including respondents who had received a questionnaire presenting a general tax increase as a payment vehicle. Table 3 summarizes the estimation results.

Table 3. Grouped data Tobit regression results for WTP.

Sample	All N=1582		Nonusers N=1272		Payment vehicle: Tax N=753	
Variable	Estimate	p-value	Estimate	p-value	Estimate	p-value
α	3.60	.0000	3.46	.0000	3.19	.0000
β_M	.99	.0378	.12	.0343	.20	.0137
σ	1.32	.0000	1.36	.0000	1.49	.0000
WTP FIM per year: Mean	113		107		119	
Median	47		42		39	
ε_w	0.09		0.11		0.21	

Notes: α = constant, β_M = coefficient for log of income (FIM 1000), and σ = disturbance standard deviation

In every sub-group, the estimate of the income elasticity of WTP, ε_w, receives a value below one indicating that policies providing recreation areas favor "the poor". Comparison of the elasticity values between sub-groups suggests that nonusers benefit less in relative terms than users from current policy and that, as perceived by the respondents, a tax would have a similar impact. These findings are consistent with the estimates of median WTP, which is

[1] On January 1, 2002 Finland switched to the Euro (€); the Finnish mark was the official currency of Finland at the time of the survey.

highest (largest benefit) when the total sample is included in the estimation. The same effect cannot be seen in the mean estimate, because it is sensitive to the tails of the WTP distribution.

If one were to draw conclusions from the point estimates presented in Table 3, the most conservative overall assessment would be that current policy does not discriminate against those with lower incomes. To get a more comprehensive picture of the distributional impacts between income groups, we have to examine the entire empirical WTP distribution, and this is done in what follows.

Using the WTP data, we derive estimates of loss of consumer surplus by income group for alternative median voter scenarios. We assume that the median voter determines the level of the user fee, should a fee be implemented. As both users and nonusers participate in a referendum, we use the following median willingness-to-pay measures:

1. An annual fee of FIM 84 per person accepted by a median voter
2. An annual fee of FIM 63 per person accepted by a median voter and adjusted for the average number of visits per year for the population, including nonusers (average number of visits: 1.35)
3. An annual fee of FIM 12 per person accepted by a median voter and adjusted for the average number of visits per year for the population, including users only (average number of visits: 7.08).

Table 4 summarizes the results for the welfare changes using the Ayer estimator; both upper and lower bounds are reported (see Boman et al. 1999).

Table 4. Ayer estimates of welfare changes.

	Scenario I: WTP based[1)] Median WTP FIM 84		Scenario II: Use based[2)] Median WTP FIM 63		Scenario III: Use based[3)] Median WTP FIM 12	
	Low income[4)] FIM	High income[5)]	Low income FIM	High income	Low income FIM	High income
Efficiency loss						
-lower estimate	17 889 250	14 158 790	30 714 242	45 272 746	8 376 527	6 897 020
-upper estimate	69 391 244	50 152 382	34 504 554	50 825 178	9 477 245	8 091 208
Welfare change						
-lower estimate	101 495 769	95 115 764	44 675 313	56 104 604	21 707 099	25 023 803
-upper estimate	152 997 763	131 109 355	48 465 635	61 657 036	22 807 817	26 217 991

Notes: [1)] Annual WTP, no adjustments for actual use of the services [2)] WTP adjusted for average number of visits per year: 1.35 [3)] WTP adjusted for average number of visits per year: 7.08 [4)] Lower-than-median income [5)] Higher-than-median income

The results of Scenario I suggest that current policy favors "the poor". In other words, a policy reform implementing a fee of FIM 84 per year would generate a larger welfare loss for those with lower rather than higher income. This result is in line with the results of our elasticity estimates. However, a comparison between users and nonusers in two income groups (not reported in Table 4) reveals that "rich" users currently benefit more than "poor" users. This suggests that a policy reform implementing a fee of FIM 84 per year would be more beneficial for low-income nonusers than for low-income users.

Interestingly, the results of benefit incidence become even more ambiguous when we look at the impact of the size of the fee on those who actually use the recreation services. In the case of a small increase in recreation fee (from zero to FIM 12= €2 in Scenario III), the low-income group would suffer a larger efficiency loss in vis-á-vis the high-income group than they would in the case of a large increase in fee (from zero to FIM 63= €10 in Scenario II). The size of the efficiency loss is important since it gives an estimate of how large a proportion of previous users will be excluded from the use of services due to a fee.

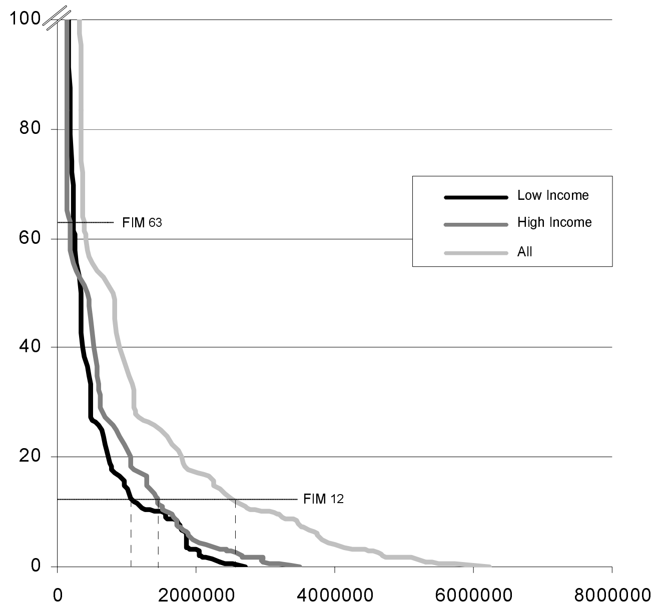

Figure 1. WTP distribution per visit by income group (lower-/higher-than median income, all).

This effect is illustrated in Figure 1, which depicts the welfare losses at a fee level of FIM 12 for two income groups. That the efficiency loss of the lower-income group would be larger in relative terms with a lower fee than that of the higher-income group reflects a phenomenon commonly observed when estimating the demand elasticity of consumption goods. Demand for recreation seems to be more elastic for low-income groups.

Conclusions

We have investigated what can be said about the patterns of distribution of benefits associated with recreation services. One of the most interesting results of our analysis is that when nonuse values are included, the loss in consumer surplus indicates that those with lower-than- median incomes would lose more than those with higher-than-median incomes. In other words, nonuse values seem to be at least equally important to both the poor and the rich. This finding contradicts a common assumption about the nature of environmental, public goods as luxury goods.

The paper also yields an interesting policy implication regarding the use values, i.e., that current policy may in fact benefit those with higher incomes.

Finally, to make policy design an even more challenging task, we found that if a fee is to be imposed, an optimal fee should be “high enough” for distributional reasons; however, this would necessitate a policy that recycles revenues from fees back to low-income users. If the decision on a fee were made by the users only, they would vote for a fee too low from a social point of view. Actually, our results indicate that a majority voting in a referendum might yield the data necessary to establish the required fee level.

Acknowledgements

This study is based on the data set of the National Inventory of Outdoor Recreation Demand. Paula Horne, Ville Ovaskainen and Tuija Sievänen from the Finnish Forest Research Institute participated in planning the survey and Statistics Finland collected the data. We would also like to thank Enni Rönkä for her editorial help and Richard Foley for correcting our English. The usual caveat applies.

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Management of State Forests in Estonia with Comparison to Finland

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Abstract

The main goal of the study is to compare the management of Estonian public forests and the factors influencing the management with the Finnish public forests. The concept public forests refers here only to the forests managed by the state forest organisations – *'RMK'* in Estonia and *'Metsähallitus'* in Finland.

When analysing the management of state forests, all the goals set for the organisations have to be considered. In Finland, the goal setting has been more precise and complex than in Estonia, where the mission of *RMK* is formulated as the efficient and sustainable forest management. In both countries the public owner's interests are reflected in the State Budget – financial provision to the Budget is very important driving force of the activity in both organisations.

The indicators discussed in the study are supply of roundwood and financial performance of the forest management.

Keywords: state forestry, roundwood supply, profit target, nature conservation, organisational reform

Introduction

The main aim of the study is to analyse the purposes of management of public forests in Estonia and Finland; the procedure of goal setting, the dynamics of cutting volumes and factors influencing it. In the study, only state forests are considered and forests owned by local public authorities are not included in the analysis.

In Finland, public forests are managed by Forest and Park Service, *Metsähallitus*, which operated as a National Board of Forestry until 1991, also fulfilling the tasks of public administration. Since 1994, Metsähallitus has operated as a state enterprise, having functions only on state-owned lands.

RMK (State Forest Management Centre) was established in 1998 in order to manage state forests in Estonia. *RMK* is the state-owned profit-making organisation which was established in reorganising the previous system of public forest management. Only the management functions of state forests remained the same, but controlling and supervising are carried out by other public institutions. While establishing *RMK*, an example was taken from *Metsähallitus*, hence one can find similar features between these two organisations.

The main difference of public forest ownership compared to private forest ownership is based on the structure of ownership and decision-making. An owner is a person or a company having rights to make decisions concerning forest management and benefits gained from the forest. Hence, all citizens should be considered as the owners of public forests and it is essential to take into consideration all needs and requests of forest owners. As public forests by this definition have large variety of owners, there are more requests and confrontations between public forest owners compared to private ones. Actual decisions about the management of public forests are political.

Profit maximizing cannot theoretically be the only most important goal in public forestry, because forest owners are both producers and consumers of benefits gained from forests. From the standpoint of society the aim of forest management is the surplus maximizing for producers and consumers (Nautiyal 1988). In decision-making process concerning public forests, the negative or positive external impacts have to be considered. For instance, in both Estonia and Finland, special forest areas have been marked off having special rules of management.

State forestry is relatively less studied in Estonia and Finland. In Finland more surveys have been carried out of private forests. There have been comparatively less studies on forest ownership and decision-making in Estonia than in Finland, but on the other hand, studies dealing with silviculture and biological productivity of forests are quite numerous. Studies on economic behaviour of public forest ownership in Finland are based on empirical data concentrating on factors influencing timber supply (see Tervo 1978, 1986).

Goal setting in state forestry

According to public business theory the goals set for public forest management organisations are divided into socio-political and financial ones (Rees 1984). Still, goal-setting and implementation of goals may not coincide. Public business theory states that public enterprise does not act relying only on established goals, but referring to *main agent theory* it considers also the interests of organisation (Rees 1987, Aharoni 1986, Millward et al. 1983).

Public forests fulfil occasionally also special goals set by society. Examples in the history of the past century in both Estonia and Finland can be found, when after gaining independence forest plots were allocated for private ownership in order to support living of landless people and promote settlement in rural areas. In Estonia, as an example, forest stands were used in 1992 as a warranty of national currency – Estonian *kroon*.

Finnish *Metsähallitus* operated until 1993 as a state business organisation and it was in short-term directed by using Government financing scheme based on gross-budgeting, having no relation between profits and revenues. As a consequence, the operating volume/capacity and quality depended on certain State Budget. Generally, it is reckoned that gross-budgeting is not the suitable operating strategy in forest management (Metsähallintokomitean mietintö 1959, Metsähallituksen kehittämistyöryhmän muistio 1993).

In the course of organisational reform, net budgeting was adopted for *Metsähallitus* since 1993, meaning that only annual net revenues, investments and financing of certain public interests like nature conservation tasks have been considered in the State Budget. Since then, *Metsähallitus* has used sales revenues in covering all operating costs.

While in Finland public officials have since 1993 affected forest management by setting profit requirements, in Estonia the decision-makers are directing bodies of public forest management. Although, it should be mentioned that in Estonia, the representatives of ministries and members of Parliament also belong to the Council of State Forest Management Centre.

In Estonia, during the period the country was incorporated to Soviet Union, the goals were mainly set as quantity means, usually accompanied with financing plans. Nevertheless, costs in forestry exceeded the revenues. The situation in forestry at the end of the 1980's is expressed referring to F. Nõmmsalu: "…It seems to be the most important to pay attention to the state of forest instead of hectares and cubic metres in financing plans and statistical records. Our main goal is to get the maximum amount of timber from a hectare. The purpose of forest management is to expand forest usage and accelerate silviculture, to use entirely the potential of land as means of production and guarantee the maximum gross productivity of forests." (Nõmmsalu 1989).

The definition of forest policy can be well illustrated with the situation in 1970's and 1980's, when the operating funds and capital investments from public assignments per hectare of forest area increased one and a half times and doubled according to one harvested cubic metre. For example, in 1987 income from stumpage and other incomes were 11.15 roubles per hectare. Costs in forest management, capital investments and also assignments for research and maintaining infrastructure formed 36.16 roubles per hectare, i.e. 3.2 times more than direct revenues from forestry (Nõmmsalu 1989).

Today, the profit targets of *RMK* and *Metsähallitus* are both connected with State Budget, i.e. certain amount of money has to be paid to state budget as a dividend. In case the net income is bigger than the dividend requirement to Budget, it can be used in fulfilling certain goals connected with forestry. However, setting only profit target is considered to be problematic, because then socio-political tasks are not emphasised (Valtion liikelaitoskomitean mietintö 1983).

In Finland, the main goals set for *Metsähallitus* are presented in legislation, which is currently (2004) being reformed. According to *Act on Metsähallitus* (1993), *Metsähallitus* has to manage, use and protect sustainably and productively the property under its administration. For instance, timber production has to be sustainable (but not increasing as was enacted until 1991). In Estonia, annual allowed cutting volume is set by Estonian Government, based on forest inventory and forest management plans.

The regulation of annual cutting volume of *Metsähallitus* has been used in stabilising Finnish timber market (Saastamoinen 1997, Metsähallituksen kehittämistyöryhmän muistio 1993). This objective has not been legislated, but it seems that net income (profit) and employment requirements have been major reasons for this behaviour (Piiparinen 2001). The timber market stabilisation as an state forestry objective has also been discussed in Estonia in recent years, but in reality the annual cutting volume has not been changing with market fluctuations. Principally, it has been tried to maintain cutting volume as stable as possible, and in case of storm damages even reduce it in areas remaining intact by storms.

Traditionally, *Metsähallitus* has been obliged to support rural employment by maintaining certain amount of working places. Today however, this is reflected more due to remote locations of state-owned lands than specific employment requirements. In Estonia, employment maintaining rules are not compulsory for *RMK*. Therefore, the influence of compulsory employment is not analysed in the present study.

The efficient forest management is emphasised in Estonian Forest Policy approved in Estonian parliament *Riigikogu* in 1997. In order to fulfil policy requirements, *RMK* had to reduce remarkably the number of employees. At the beginning of 1990's 4,500 employees were engaged in public forestry sector, but in 2003 the number of workers was reduced to ca. 1,300.

Table 1. Forest management goals in Finland and Estonia.

Goal	Finland	Estonia
Profit target	+	+
Timber production	+	+
Forest conservation	+	+
Employment	+	-

Forest management in state forests

In order to provide forest management time series in comparable way both for Finland and Estonia, following list of time series was adopted (table 2). In this article, only Estonian time series are presented. Respective time-series on Finnish state forests have been presented by Piiparinen (2001) and Leppänen & Piiparinen (2002) and will be employed in further comparative analyses.

Table 2. The availability of time series describing the activity of state forests.

Time series	Finland	Estonia
Net income	+	1998-2003
Share of protected forests	+	+
Timber production	+	+
Employment	+	-
Growing stock	+	+
Value of harvesting and silvicultural equipment	+	-
Prices for timber	+	1996-2003
(Interest rate, state bonds)	+	-

The time frame from 1970 to 2003 can be divided into three parts also according to the organization responsible for the management of state forests. In total, there have been three organizational changes during this period (Figure 1). During the Soviet time, the responsible authority for public forests was Ministry of Forestry and Nature Protection. With the reindependence of Estonia in 1991, state forests were first organised in form of National Forestry Board. Since 1998, the organisational form has been the State Forest Management Centre *RMK*.

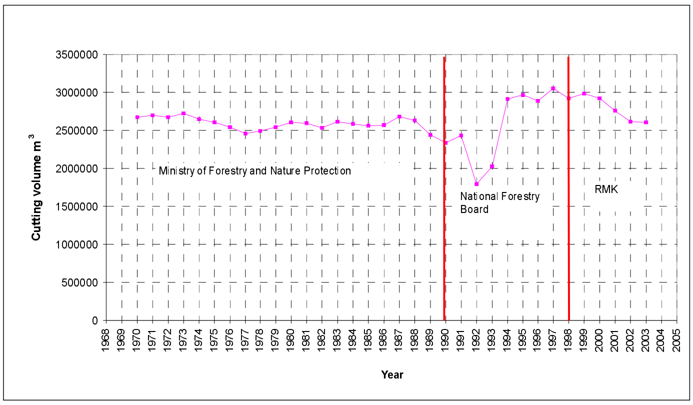

Figure 1. Volume of felling volume in Estonian state forests 1970–2002.

From 1970 to 1990, the harvesting volume was quite stable and even a little bit decreasing, varying between 2,7 million m^3 in 1973 and 2,4 million m^3 in 1990 (Figure 1). Due to forest policy objectives, also the forest area was increasing continuously. In total, the forest area expansion was 18 per cents during 1970-1990 (Figure 2). The reason is the handover of unpropitious lands of agriculture to forest sector, draining of swamps and afforestation of pit heaps. Increase of forest area increased also the growing stock volume (Figure 2).

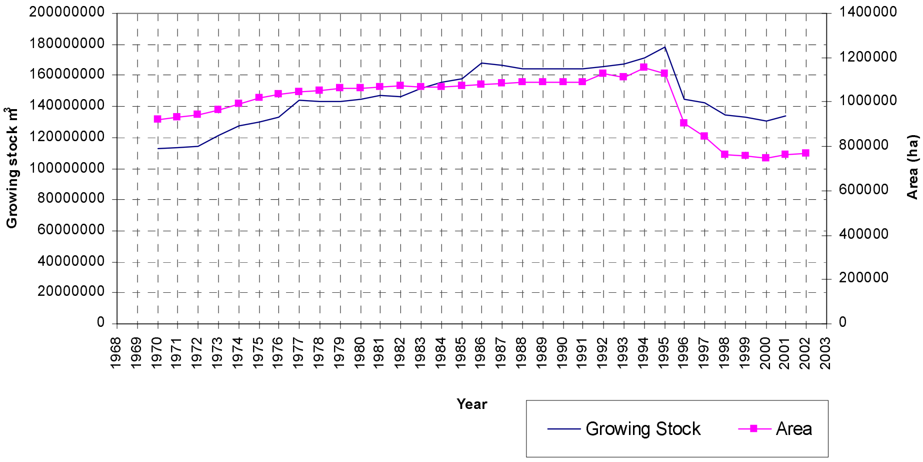

Figure 2. Volume of growing stock and forest area in Estonian state forests 1970 – 2003

From 1991 to 1998 there were many changes in public administration after restoring Estonian independence. During this period forestry was mostly influenced by the inception of private forest ownership and by remarkable development of forest industries.

Characteristic for this period is the considerable decrease of annual harvesting volume in the early of 1990's. For example, in 1992 the annual harvesting volume was 1.8 million m^3, while the average annual harvesting volume in previous years 1986–1990 was ca. 2.5 million m^3 (Figure 1). The reason for decreased harvesting was the land reform, which was started in 1992. Felling constraints were set because of the large amount of forests under the re-privatisation. The land reform is reverberated also in Figure 2, which shows the area of forests and growing stock being decreased by almost 20% in 1996 (Figure 2).

The fact that a considerable decrease of growing stock and forests area is not caused by excessive cuttings appears also in Figure 3, indicating that in 1996 the harvesting was about 2% of the total growing stock (Figure 3).

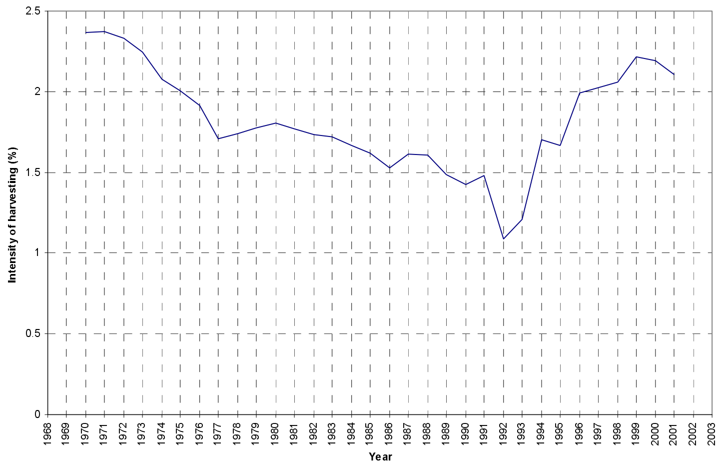

Figure 3. Harvesting percentage of the growing stock in Estonian state forests 1970-2001.

In the beginning of the period starting from 1999, second major reorganisation of public forest management took place. In December 1998 the State Forest Management Centre *(RMK)* was established and started to serve in 1999. Characteristic for this period is a slightly decreasing harvesting volume.

With *RMK*, the net income of forestry as a goal has been considered since 1999. Therefore, providing income for State Budget became an important goal of the state forest organisation. Despite the decrease in felling volume, the net income of *RMK* has increased consistently year by year (Figure 4). The increase of net income is caused by the increase of the timber prices (Figure 5), and increasing efficiency due to decreasing employment in state forestry.

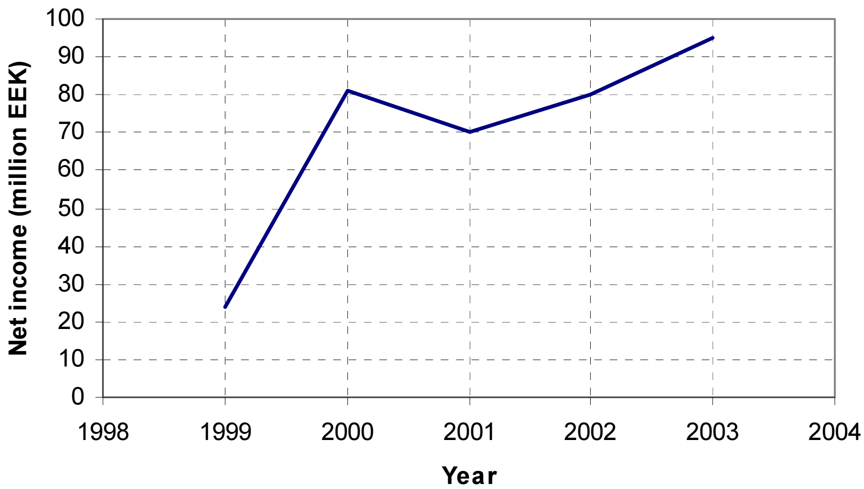

Figure 4. Net income of RMK 1999-2003.

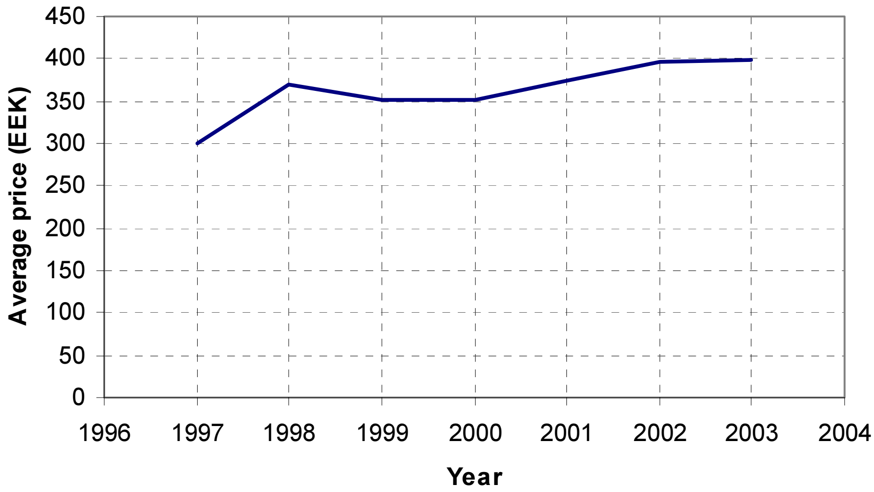

Figure 5. Average delivery price of roundwood of Estonian state forests 1997-2003.

Forming of relevant time-series on forest conservation was difficult for both countries. In Finland, the areas of protected forests are enforced in legislation, but in reality the management restrictions have already been implemented already long before the legislation is enacted. With national parks and nature reserves this advance approval of forthcoming conservation has been in average 4 years. In Estonia, formal statistics on different forest land use categories have been for decades published every 4 years and therefore the implementing of restrictions of forest management may not coincide with the recorded data. The share of strictly protected and protection forests in Estonian public forests is shown in Figure 6.

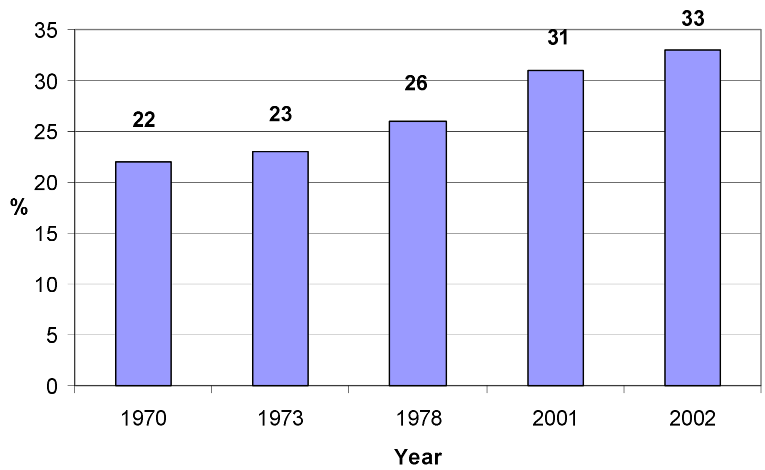

Figure 6. Share of strictly protected and protection forests in Estonian public forests 1970-2002.

Time series describing timber production in Finland are compiled separately for logs and pulpwood. In Estonia, time series are compiled considering regeneration and intermediate felling. The volume of regeneration and intermediate felling is presented in Figure 7 (see also Figure 1).

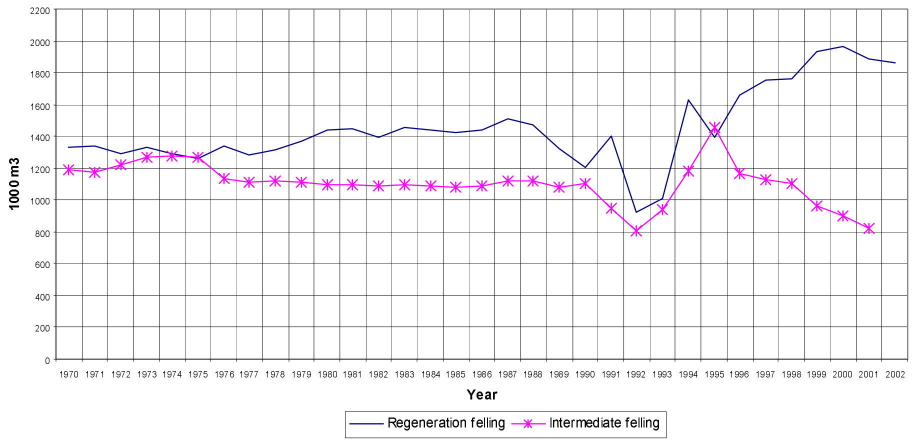

Figure 7. Volume of regeneration and intermediate fellings in Estonian state forests 1970-2002.

The increase of share and volume of intermediate felling has been remarkable in 1974-1975 and in 1995. It constitutes in 1974-1975 almost 50 percents of the total harvesting volume and in 1995 even more.

The reasons of increased felling volume from thinning in 1974-1975 are more political than silvicultural. One characteristic of the Soviet planning system was its extraordinarily high degree of centralisation. For example, orders regarding regeneration felling were issued directly from Moscow, based on the reasoning that the output was part of the Union-wide harvesting plan (Kallas, A. 2002).

The reason of big share of intermediate felling in 1995 is the faltering at re-privatisation and as a consequence, also at the respective regeneration felling constraints in the forests under the land reform.

Conclusions and further research aims

In the Finnish state forest management the goal setting has been more precise and complex than in Estonia, where the mission of *RMK* is formulated as the efficient and sustainable forest management. However, in both countries the public owner's interests are reflected in the State Budget. Financial provision to the Budget is very important driving force of the activity in both organisations.

State forests have to fulfil special tasks set by society. Examples of those in both countries are nature conservation tasks and in earlier also the promotion of permanent settlement of landless people in rural areas in both countries. However, many special tasks of state forests are unexpected as experienced only a decade ago, when state forests were employed as guarantees for money reform in Estonia after restoration of the independence.

Next step in our analysis is to test for comparative econometric models for Estonian and Finnish state forest functioning in order to study impacts of different factors on the roundwood supply, financial performance and other targets of state forest management.

Acknowledgements

This article has been prepared within the Evaluating Financing of Forestry in Europe (EFFE) project, carried out with the financial support from the Commission of the European Communities, DG Research - Quality of Life and Management of Living Resources Programme under the contract number QLK5-CT-2000-01228.

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Landowner Attitudes and Typologies in Relation to Forestry

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Abstract

The article reviews typologies of non-industrial private forest (NIPF) owners' values, attitudes and ownership objectives. Private forest management is primarily a voluntary action with few legal constraints. Forest owners are largely free to decide which management activities they pursue in their forests. The characteristics of the forest holding, owners' values and attitudes towards forestry, and objectives concerning their own forest property are each important factors that affect management decisions.

Theoretically well-founded attitude or value typologies have been rare in the NIPF literature. The adoption of universal socio-psychological value theories is restricted by their generality and inability to adequately depict forest values. They can be employed as the basic theory of human requirements that are present also in the relationship between humans and nature. However, more specific theoretical value typologies towards nature or forests have been presented and also empirically tested. Empirical typologies concerning the objectives of forest ownership or motivations for forest management have been more commonly created and adopted, and from the practical point of view they have been more useful.

Forest management behavior is basically volitional. Knowledge of forest owners' values, attitudes and landowner objectives and their impact on actual behavior is therefore important when planning and implementing public forest policies concerning non-industrial private forestry. Such knowledge is essential, for instance, when matching the supply and contents of forestry extension services to the varying motivations of forest owners. The identification of owner groups with different values, attitudes and objectives by readily observable owner and holding characteristics is crucial in this respect, but, unfortunately, too often ignore**1.**

Introduction

Private forest management is primarily a voluntary action with few legal constraints. Typically, there may be an obligation to reforestation after final fellings. Forest owners can largely decide which management activities they pursue in their forests. The characteristics of the forest holding and the financial position of the owner are important in this decision-making. However, forest owners' attitudes towards forestry " or basically their values " and their objectives concerning their forest property are the most important factors affecting the management decisions. This is an underlying assumption in many empirical studies on non-industrial private forest owners' (NIPF) forest management behavior.

This assumption has often been implicit, rather than being explicitly based on direct measurements of motivational factors. Demographic characteristcs, such as income or occupation, are often interpreted to reflect owners' attitudes or preferences. Even when attitudes or "reasons for owning forest land" have been explicitely measured, the analysis of their effects on actual behavior has often been descriptive.

Theoretically well-founded attitude or value typologies have been rare in the NIPF literature. For instance, the adaption of universal socio-psychological value theories, such as those of Rokeach (1973) and Schwartz (1992), is restricted by their generality and inability to adequately depict forest values. However, they can be employed as the basic theory of human requirements that are present also in the relationship between humans and nature.

Pietarinen (1987, 1991) has presented a specific typology of value orientations towards nature and forests in general. Pietarinen's typology considers the commonly used distinction between anthropocentric v. biocentric orientations (e.g., Rolston and Coufal 1991, Steel *et al.* 1994). Materialism and humanism in Pietarinen's typology can be regarded as mainly anthropocentric, and primitivism as biocentric in orientation. The typology also identifies a mystic value orientation which is not common in the literature. The theory has also been tested empirically (Karppinen 1998, 2000). Other, more empirically than theoretically grounded attitude typologies have been presented in the NIPF literature (e.g. Kurtz and Lewis 1981, Bliss and Martin 1989, Kline *et al*. 2000).

Private forest management behavior is basically volitional. Knowledge of forest owners' values, attitudes and ownership objectives is therefore of crucial importance in understanding and predicting forestry behavior in private woodlots. This kind of knowledge should be available for policy-makers in the sphere of environmental and forest policy, especially if NIPF owners form a considerable landowner group.

This article is a review of studies concerning private forest owners' values, attitudes and ownership objectives. The article describes both theoretical typologies and empirically grounded classifications.

2. Theoretical typologies

2.1 Socio-psychological value theories

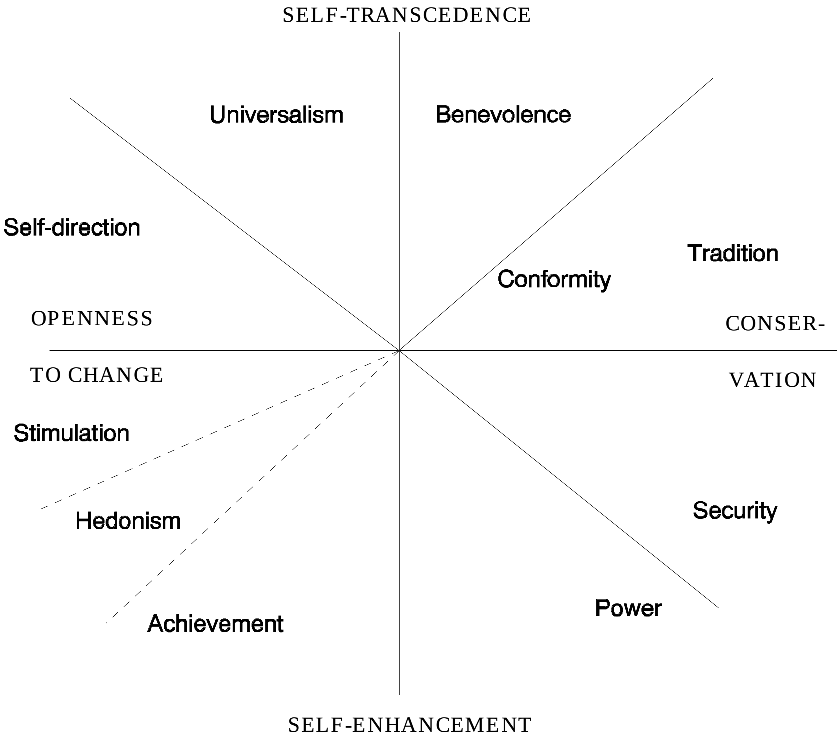
There is a limited number of basic human problems for which all cultures must find a solution. The relationship between humans and nature is included in the five most important problems of mankind (Kluckhohn 1957). The relationship can be exploitative, harmonious or subjugated. Universal value theories should cover all the basic requirements of human existence (Schwartz 1992, Helkama 1999), including the relationship between humans and nature.

Two universal socio-psychological value theories, those of Rokeach (1973) and Schwartz (1992), are briefly discussed below in order to assess their applicability for describing forest values. A basic distinction in Rokeach's theory is the division between instrumental and terminal values, the former referring to modes of conduct and the latter end-states of existence (Rokeach 1973). Terminal values can be divided into personal (e.g., peace of mind) and social (e.g., world peace). Instrumental values are means to achieve the sought end and can be either moral or competence values (e.g., honest v. logical). Rokeach's theory has been measured empirically by using eighteen terminal and eighteen instrumental values that are regarded to describe basic requirements for human existence (Rokeach 1973).

Values explicitly associated with the relationship between humans and nature are almost entirely lacking in Rokeach's list of values. The only directly relevant terminal value concerns aesthetics: a world of beauty, considering beauty of nature and the arts. Obviously, this kind of general value theory is not useful, at least without further modifications, to depict values related to forests.

A more recent endeavor to develop a universally applicable value theory has been carried out by Schwartz (1992). The theory is a successor of Rokeach's theory and assumes that values have a universal content and structure (Fig. 1) (Helkama 1999). It is therefore a more solid theory than Rokeach's theory, which is merely a list of two sets of values with loose interconnections. Besides the content and structure of values, comprehensiveness and equivalence of meaning are also considered. Value structure is described by consistent conflicts and compatibilities between values (Schwartz 1992)

Fig. 1. The structure of value types in Schwartz's model. Sources: Schwartz 1992, p. 45, Helkama 1999, p. 64.



According to the theory, eleven motivational or value types can be identified and measured by 56 specific values. The motivational types can be summarized as follows (Schwartz 1992, p. 5-12, Puohiniemi 1995, p. 16):

SELF-DIRECTION	Independence of thought and action – choosing own goals, creating, exploring
STIMULATION	Excitement, novelty, challenge in life
HEDONISM	Pleasure or sensuous gratification for oneself
ACHIEVEMENT	Personal success through demonstrating competence according to prevailing cultural standards
POWER	Social status and prestige, control or dominance over people and resources

SECURITY	Safety, harmony and stability of society, of relationships and of self
CONFORMITY	Restraint of actions, inclinations and impulses likely to upset or harm others, and violate social expectations or norms
TRADITION	Respect, commitment and acceptance of the customs and ideas that one's culture or religion impose on the individual
BENEVOLENCE	Preservation and enhancement of the welfare of people with whom one is in frequent personal contact
UNIVERSALISM	Understanding, appreciation, tolerance and protection of the welfare of all people and nature
SPRITUALITY	Endowing life with meaning and coherence in the face of the seeming meaninglessness of everyday existence

The specific values attached to universalism are interesting with regards to the relationship between humans and nature. Unity with nature, a world of beauty and protecting the environment can be found among the eight indicators in this motivational type. Consequently, Schwartz's theory considers the mystic, aesthetic and pro-environmental aspects of the relationship between humans and nature. Schwartz's value theory is, however, too general to be directly useful when analyzing values related to forests.

2.2. Pietarinen's typology

Pietarinen (1987, 1991) has presented a specific typology of value orientations towards nature and forests in general. The basically philosophical typology includes the three types of relationships between humans and nature presented by Kluckhohn (1957): exploitative, harmonious or subjugated-to-nature. According to Pietarinen, mankind's relations to nature can be described by four value orientations: materialism (utilism), humanism, mysticism and primitivism.

In *materialism*, forests are regarded merely as a means to increase the material standard of living. Natural resources are considered to be the storage of raw material for industrial and energy production. Materialism expresses a strong faith in technology, which is seen to be able to solve all mankind's problems. The main problem of this orientation is contrafinality: the outcome is opposite to original goals. For instance, increased production may lead to increased material standard of living, but at the expense of the quality of environment.

Humanism stresses that forests should be used to promote many cultural pursuits, not only material benefits. These pursuits, of course, presuppose material well-being. Nature should provide mankind with aesthetic satisfaction, advance moral character, promote mental health and positive relations between persons. The ideal is a "socratic" human being who aims at ethical, aesthetic and intellectual perfection. As Passmore (1980, p. 33) puts it: "to perfect nature is to humanize it, to make it more useful for men's purposes, more intelligible to their reason, more beautiful to their eyes." The main problem in humanism is how to strike a balance between culture and nature. The idea of self-control, included in the Socratic virtues, aims at rejecting unnecessary production and consumption, which is certainly not easy. Though humanists optimistically believe in the possibility of harmony with nature, they also face the problem of contrafinality.

Mysticism addresses the immediate experience of the unity of man and nature, it seeks something beyond objective reason. The sacredness of nature can especially be experienced in natural forests. Mysticism argues for the preservation of nature in as pristine state as possible. The problem is achieving a balance between material well-being and the sanctity of nature. Mysticists, nevertheless, optimistically consider that the sacredness of nature cannot be totally destroyed. The American transcendentalists, such as Ralph Emerson and Henry Thoreau, are typical representatives of mysticism.

Primitivism denies all human privileges in nature. Man has no right to endanger other forms of life: nature has intrinsic value. Each species should be considered equally important and therefore have the same right to exist. All ideals of civilization and material well-being must be rejected and human beings must "return to nature" to live in primitive circumstances. Primitivistic ideals may be brought about, for example, by an ecological catastrophe or via events leading to the violent reduction of the population and the destruction of industrial society.

Pietarinen's typology addresses the commonly used distinction between anthropocentric v. biocentric orientations (e.g., Rolston and Coufal 1991, Steel *et al.* 1994). Materialism and humanism in Pietarinen's typology can be regarded as mainly anthropocentric and primitivism as biocentric in orientation, although it does not satifactorily represent the full spectrum of biocentric values. The typology also distinguishes a mystic value orientation, which is not common in the literature.

Pietarinen's theoretical typology has also been tested empirically (Karppinen 1998, 2000). The study indicated that NIPF owners supported different kinds of forest values. Three kinds of value orientations were found by principal component analysis: materialism, humanism and primitivism-mysticism. However, no grouping of forest owners could be established based on these value dimensions.

2.3. Rolston-Coufal model

Rolston and Coufal (1991) took five statutory multiple uses of forests (1960 Multiple Use -Sustained Yield Act) as a starting point for developing a typology of forest related values in the spirit of Leopold's Land Ethic. These uses were recreation, timber, range, watershed and wildlife and fish. Ten categories were established integrating human and biotic values: life support values, economic values, scientific values, recreational values, aesthetic values, wildlife values, biotic diversity values, natural history values, spiritual values and intrisinc values.

A thirteen-item modified version of the Rolston"Coufal typlogy was empirically tested by Brown and Reed (2000) among Alaskan residents, i.e. not by a sample of forest owners. Additional values such as cultural, therapeutic, subsistence and future (bequest and option) values were included while wildlife values were excluded. A sum of $ 100 was to be allocated between these thirteen items. Principal component analysis found no latent structures suggesting that the selected items were distinct dimensions of forest related values.

2.4. McKinsey's matrix

The concepts and theories of strategic marketing have also been used as a theoretical framework to classify forest owners according to their forestry attitudes. Kurttila *et al*. (2001) used forest owners' attitudes towards internal and external environments of forestry when they identified business units according to McKinsey's matrix describing the strategic position of forestry. According to the theory, there are four kinds of business units: stars, cash cows, wildcats and dogs (Fig. 2).

Fig. 2. Strategic groups of forest owners (business units) according to their attitudes towards internal and external factors (SWOT analysis). Source: Kurttila *et al*. 2001.

EXTERNAL FACTORS \ INTERNAL FACTORS	Strengths dominant	Weaknesses dominant
Opportunities dominant	Stars	Wildcats
Threats dominant	Cash cows	Dogs

Stars have a promising future concerning external factors while internal strengths are also emphasized. This group can be interpreted to represent "the profitability strategy" in forestry, which is reflected in economic effectiveness in forest treatment, obedience of optimal rotations, maximum sustained yield cutting policy and use of natural reforestation.

Cash cows have a weaker position in the markets than stars. The best forestry strategy for cash cows may be "liquidity": forest owners cutting decisions are guided by financial needs. Cutting levels vary according to the financial position of the owner's economy. The level of silvicultural activity is relatively low.

Wildcats operate in promising and high growth markets, but their position is not very strong. Wildcats may emphasize "progressive forestry", investments for the future. This strategy implies forest improvements, long rotations and artificial reforestation indicating a low time preference. Cutting levels are below the sustainable yield in order to increase future cutting potentials.

Dogs have a poor position in unattractive markets. In forestry, a worthwhile solution could be the selling of the forest property. Another solution would be intensive cuttings on the short-term and the avoidance of investments. Kurttila *et al*. (2001) also tested the theory and established a link between the strategic attitude groups, owner and holding characteristics and owners' forest management behavior.

3. Empirical attitude typologies

3.1. Decision-making framework

Kurtz and Lewis (1981) developed a decision-making framework for NIPF owners. Owners' motivations and objectives on the one hand, and constraints on the other, guide and restrict the selection of forest management strategies. Motivations were seen as guiding forces and five distinct motivations were identified:

1) financial return (regular income)
2) investment (maintaining ownership for its increased value)
3) satisfaction or aesthetics (intangible qualities)
4) residence
5) social responsibility (preserving forests for future generations)

Whereas motivations are regarded as guiding forces, objectives represent the end state to be sought. Four primary objectives were distinguished:

1) timber production (selling timber)
2) recreation and wildlife (enhancing recreational potential and proliferation of wildlife)
3) grazing (providing wooded pasture for domestic livestock)
4) preservation (maintaining forests undisturbed)

According to Kurtz and Lewis (1981), management constraints can be caused by market conditions (e.g., anticipated timber prices and costs of growing timber), personal characteristics of the owners (management and marketing experience, socio-demographic characteristics), forest resources and societal and institutional factors (legislation, forestry regulations, public incentive programs).

Forest owners were classified by their motivations and objectives using a psychological testing technique (Q-sort). Four owner types were identified: timber agriculturist, range pragmatist, timber conservationist, and forest environmentalist (c.f. Marty *et al.* 1988).

Timber agriculturalists grow and harvest timber in a sustained manner. They keep the land in the most effective use, in timber production. However, timber production is not considered to exclude other benefits, such as aesthetic amenities. This group is business-oriented, attempting to maximize the financial return from timber. Land property is regarded as an asset and a hedge against inflation. Clearing of forest land for agricultural production (pasture) is not favored.

Timber conservationists manage their forest land for timber production. Forest management is considered to be beneficial to wildlife and aesthetics, as well as other amenities. Timber conservationists are less business-oriented than timber agriculturalists and represent a combined production"consumption orientation. Forests are preserved for future generations for their enjoyment and utilization. Clearing of forest land for grazing is strongly opposed.

Forest environmentalists emphasize non-timber benefits, such as aesthetic values, wildlife and privacy. The impetus for forest management is to preserve non-timber values of forest. The group expresses clear consumption orientation. Forest environmentalists are not profit-oriented but do recognize the investment value of forests. Clearing of forest land for pasture is opposed on ecological grounds.

Range pragmatists represent a business and production orientation. Grazing is the main source of income, but the investment value of forest land is also recognized. Timber production is not very important in the farm economy, but timber is harvested when it is economically feasible. Forest improvements to enhance timber growth are not regarded to be important, but clearing of land for pasture is common practice. Forests are also seen as a haven for wildlife.

Kurtz and Lewis (1981) described the timber management behavior of these owner types. However, they did not attempt to identify the background characteristics of these forest owner groups, which would have been essential if the results were to be used for extension activities.

3.2 Typologies of ownership objectives

Values are often understood as fundamental, basic conceptions of the desirable guiding selective behavior (e.g. Williams 1968). Karppinen (1998, 2000) took the following definition of a value as a starting point in his analysis: "Value is a common and permanent conception of a desire or the desirable, learned from the environment, influencing the selection of goals" (Allardt 1983, p.51, Karppinen 2000, p.15). He considered that ownership objectives are more concrete than forest values and that they are based on owners' interests concerning their forest property, such as provision of monetary, recreational, emotional, and aesthetic benefits. Objectives can therefore be considered to be subordinate to values in personal decision hierarchies. The objective of forest ownership was defined as a "rather permanent conception of a desire concerning one's own forest property and influencing forestry behavior" (Karppinen 2000. p.25)

Landowner objectives were measured by twenty-one statements in a mail inquiry. Original variables were condensed into three principal components, which were used as grouping variables in clustering the owners. Grouping permitted different combinations of the main dimensions of objectives and enabled measuring the representation of these combinations among forest owners. On this basis, the forest owners could be classified into four groups: recreationists, self-employed owners, investors and multiobjective owners (Karppinen 1998, 2000). *Recreationists* emphasize non-timber and amenity aspects of their forest ownership, such as outdoor recreation, aesthetic considerations and berry-picking. *Self-employed* owners value regular sales and labor income from delivery sales (the seller does the logging and hauling), as well as employment provided by their forests. The importance of household timber is also emphasized. *Investors* regard their forest property as an asset and a source of economic security, such as security against inflation and for old age. Bequest motives are also emphasized. *Multiobjective owners* value equally both the short-term and long-term monetary benefits as well as amenity benefits of their forests.

A link was established between landowner objectives, owner and holding characteristics, as well as harvesting and silvicultural behavior. The forest owner groups based on their objectives were identified by owner and holding characteristics using logit-models. Silvicultural and harvesting behavior was also analyzed in these groups (Karppinen 1998). Besides descriptive analyses, dummy variables indicating assignments to these groups were included in the econometric timber supply function along with other explaining factors to investigate the effects of ownership objectives on timber sales (Kuuluvainen *et al*. 1996). The timber sales of NIPF owners were connected to their objectives: multiobjective owners harvested significantly more than the other three groups. Knowledge of forest owners' assignment to the groups based on ownership objectives was similarly incorporated in the models when analyzing forest owners' reforestation behavior. The results suggested that ownership objectives explained both seeding and planting, and seedling stand improvement activities (Hänninen *et al.* 2001).

Kurtz and Lewis (1981) divided their owner types into consumption- and production-oriented groups (see also Ferretti 1984). Using this classification, it appears that recreationists are mainly consumption-oriented, whereas investors and self-employed owners are production-oriented. Nevertheless, self-employed owners also emphasize the importance of the consumption of household timber. Multiobjective owners, the most active group with respect to silvicultural and cutting behavior, represent a mixture of the two orientations.

Kline *et al*. (2000) used similar approach in their study concerning forest owners' willingness to accept incentive payments to forego harvesting in order to improve wildlife habitat. Principal component analysis and cluster analysis were used to classify forest owners by their ownership objectives, and these cluster memberships and owners' socio-economic characteristics were used in an empirical model explaining willingness to accept incentives (c.f. Kuuluvainen *et al*. 1996).

Four groups were identified: timber producers, recreationists, passive owners and multiobjective owners. *Timber producers* emphasize timber production and land investment considerations. *Recreationists* value non-timber objectives of forest ownership, such as recreation and enjoyment of green space, and they, to some extent, emphasize bequest motives. *Passive owners* tend to underline owner gratification " simple enjoyment of owning forest land, which was described by the appreciation of forest as a part of farm or residence and enjoyment of green space. *Multiobjective owners* emphasize economic, non-timber and gratification objectives equally.

Wiersum *et al.* (2002) also presented a similar classification of forest owners based on owners' forest management objectives in their pan-European study. Four groups were identified: indifferent owners, environmentalists, multifunctional owners and self-interested owners.

3.3 Forest management motivations

Bliss and Martin (1989) identified factors that motivate active NIPF owners to practice forest management. The classification of the motivations was based on qualitative interviews. *Ethnic identity* was used to refer to shared and permanent cultural values and lifestyles of American immigrant groups. Forest ownership also has a role in creating *family identity* by increasing family cohesiveness and as a source of intergenerational continuity.

Personal identity can be shaped by childhood experiences related to forests. Forest management can be regarded either as recreational, therapeutic experience, or as a challenge. Forest management may be intellectual, innovational, entrepreneurial or physical challenge to the forest owner. One important part of personal identity is the need to control nature. Forest management may act as an agent of this control. Finally, forest management can contribute to the owner's identity through bequest motives: the forest property is seen as a legacy.

Bliss and Martin (1989) also identified *forest related values* in their classification of motivations. These moral considerations included resource protection, utilization, improvement and production ethics as well as integrated resource management.

3.4 A typology of objectives and motivations: forestry experts' views

Ingemarson and Hugosson (2001) took a novel approach to the study of forest owners' objectives. They asked forestry professionals to assess NIPF owners' motivations and objectives by means of qualitative interviews. An anthropological theory by Kroeber and Kluckhohn (1952) was used for the development of a three-trait hierarchical model concerning values, motivations and objectives. The more concrete driving forces in particular fields of actions, i.e. motivations and objectives, were investigated empirically. Motivations were considered to be general traits concerning desirable states or types of actions, and objectives were regarded to concern particular actions, concrete forest management activities.

Ingemarson and Hugosson (2001) concluded that forest owners have four basic motivations: conservation, production, amenities, and economic efficiency. *Conservation* includes objectives concerning protective and preserving forest management. Nature conservation comprises of both biodiversity and forest landscape preservation and can be enhanced, for instance, by preserving key habitats, valuable broadleaved species and the management of game trails. Cultural conservation presupposes, for instance, preservation of traces of cultural activities such as old roads, stone walls, meadows etc. Water conservation aims to high quality of water and soil conservation deals with protection of soil from leaching and erosion.

The *production* motivation comprises of wood production and harvesting for sale and for domestic consumption including fuelwood production. Game management through improving habitats and forage, and posessing and selling hunting rights also belong to this category. Mushroom and berry production can also be influeneced by forest management. For instance, clearcuttings favor light demanding species. Finally, forest grazing can also be included in this category of motivations.

Amenities concern intangible aspects of forest ownership. Emotional ties to forest estate and social contacts with realatives, friends and foresters and other forest owners can be of importance for forest owners. Forestry tradition may demand forest ower to take care of the legacy in a traditional manner and pass over the forest holding to future generations. Aesthetic considerations and forest management as a source of intellectual, innovational and physical challenge can also be included in this motivational category.

Economic efficiency concerns economic objectives of managing forests. Yield of capital refers to financial returns from forestry and liquidity reserve concerns, e.g., hedging effects of forest property against years of crop failure in agriculture. The emphasis of immediate income for consumption is often connected to self-employment in forest management. Tax planning is also included in this category of motivations. Based on literature study, Hörnfeldt and Ingemarson (2002) used this typology of motivations and objectives in analyzing the association of silvicultural practices with ownership objectives.

3.5. Landowners' perspectives on the future of Rural Europe

Wiersum *et al*. (2002) studied forest landowners' opinions on the role of forestry in rural development in Europe. Empirical data using the same questionnaire were collected from eight countries. A typology based on the perceived role of forests to local quality of life was established. Forest owners could be divided into five opinion groups.

Enthusiasts embrace forest in their locality and are unable to see that forests possess any negative aspects. *Moderate enthusiasts* are mostly positive about forests but are aware of the low profitability in forestry. They also have doubts about the contribution of forests to recreation and biodiversity. *Positive realists* consider that forests have only minor economic benefits to offer. They take a neutral stand on the landscape benefits of forests, but they disagree that forests have nothing to offer. *Skeptics* are aware of the benefits of forests, and even economic benefits are considered to be important. However, they regard forests to be a threat to other forms of land use and claim that forest causes feelings of isolation among inhabitants. Skeptics also think that (new) forests spoil the landscape and believe that local inhabitants have been against the establishment of plantations. *Adversaries* dislike local forests in almost every aspect, the only positive benefit of forests is the provision of places for outdoor recreation.

3.6 Commitment, situational difficulties and Mixed Rasch model

A psychometric model, called the Mixed Rasch model, was used as an analytical tool in studying private forest owners' current and potential commitment to forestry (Mutz *et al.* 2002). The model was used to distinguish between situational difficulties and general commitments. Basically two similar classifications were identified based on either behavior or motives.

Economically oriented owners use their forests as a source of immediate income for consumption and a source of economic security. *Leisure oriented* owners consider their forest mainly as a place for outdoor recreation or hunting, or as an object of nature conservation. *Selective users* utilize their forests mainly by harvesting for sale or household use, and they also emphasize the provision of amenities (e.g. landscape). The commitment potential, defined as proportion of owners who would do more for their forests if the situational conditions would allow, was high among economically oriented and low in the other groups. The commitment to the forest increased by the size of forest holding.

3.7 Forest conservation or forest utilization

Forest owners' attitudes towards forest conservation and utilization have also been used as criterion of creating attitude typology (Karppinen and Hänninen 2000). The procedure including the use of multivariate methods is similar to the one described above (Karppinen 1998, 2000). Four groups were established by discerning between those owners with strong attitudes towards forest conservation and economic utilization of forests, and those persons with more flexible attitudes towards these attributes.

In the first group, the forest owners emphasize forest conservation and do not support economic utilization. Consequently, such persons can be characterized as *supporters of forest conservation*. In the second group, the situation is the opposite: economic utilization of forests is emphasized at the expense of nature conservation. Thus the group can be labeled *supporters of forest utilization.* The owners belonging to third group consider that both forest conservation and economic utilization could be increased at the same time. The group can therefore be labeled *multifunctionalists*. The respondents of the fourth group take a negative attitude towards both forest conservation and economic utilization. They do not want to either increase forest conservation or economic utilization. The group can be labeled *the indifferent*. The analysis revealed that Finnish forest owners support the utilization of forests clearly more often than other Finns, but many forest owners also consider forest conservation important.

4. Conclusions

Theoretically well-founded attitude or value typologies have been rare in the NIPF literature. The adoption of universal socio-psychological value theories is restricted by their generality and inability to depict forest values. They can only be utilized as a basic theory of human requirements in general, which are present also in the relationship between humans and nature. However, more specific theoretical value typologies towards nature or forests have been presented and also empirically tested. Empirical typologies concerning the objectives of forest ownership or motivations for forest management have been more commonly established, and from the practical point of view they have been, perhaps, more useful.

Forest management behavior is basically volitional. Therefore a knowledge of forest values, attitudes and landowner objectives is important for the planning and implementation of public forest policies concerning non-industrial private forestry. But what kind of motivational typologies of forest owners do the decision makers need? Certainly, the stand on a single attitude statement is not very useful. Attitudes are often contradictory; many respondents have favorable attitudes towards almost opposite alternatives, especially when they represent something “good”. Grouping forest owners by their response sets for a series of attitude statements can potentially lead to more useful typologies. The identification of these owner groups by rather easily observable demographic information, i.e. owner and holding characteristics, is crucial from the practical point of view. However, this description is too often ignored.

The groupings of forest owners become more meaningful and useful if motivational and demographic characteristics can be connected to certain types of behavioral patterns.There are few examples in the literature where all types of relevant factors, including motivational typologies, have been successfully incorporated in models explaining intended or actual behavior (e.g. Kuuluvainen *et al.* 1996, Kline *et al.* 2000). This kind of information can be utilized, for instance, when matching the supply and contents of private forestry extension services to the varying motivations and behavioral patterns of forest owners.

Acknowledgement: I thank Dr. Ashley Selby for his comments and checking the language.

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Predicting Forest Owners' Timber-selling Satisfaction

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Abstract

The forest owners' timber-selling satisfaction has been researched only a little even though it can be considered as an essential feature in the timber-sales transactions. The satisfaction survey was conducted for the Finnish non-industrial private forest owners. Forest owners sent back 796 completed questionnaire forms. The levels of the elements of timber-selling satisfaction – i.e. perceived performance, satisfaction, word-of-mouth communication, and behavioural intentions – were depicted and modelled. The forest owners' satisfaction elements were predicted by applying a canonical discriminant analysis in which the different background and performance variables were independent ones. Forest owners were mostly satisfied with the performance of the procurement companies in their most recent timber-sales transactions. There were several service performance variables in the canonical discriminant models.

Keywords: forest owners, timber trade, satisfaction, modelling, discriminant analysis

1. Introduction

In Finland a lot of studies in the field of the objectives of non-industrial private forest (NIPF) owners and of the structural changes among the forest owners have been conducted (e.g. Ovaskainen and Kuuluvainen 1994, Kuuluvainen et al. 1996, Ripatti and Järveläinen 1997, Karppinen 1998a, 1998b, Karppinen et al. 2002). Instead, there are only a few surveys concerning the timber-selling satisfaction of forest owners (Kärhä and Oinas 1998, Kärhä 1999, Kärhä and Tammiruusu 2003, Pammo and Ripatti 2003).

In 2003, 55 million m^3 of roundwood was purchased from Finnish forests (Sevola and Siuhkonen 2004). The NIPF owners play a crucial role in Finnish roundwood market. The proportion of commercial cuttings from the forests of NIPF owners was more than 80 per cent in 2003.

Satisfaction with the performance of timber procurement companies can be regarded as an essential component of the timber trade since timber sellers' satisfaction can be assumed to considerably influence their willingness to sell timber to the same company again. In addition, timber sellers' unsatisfactory experiences associated with their most recent timber-sales transaction may lead them to refuse to participate in future timber-sales transactions. This being the case, good satisfaction and loyalty levels among timber sellers towards timber procurement companies can be considered a significant competitive advantage for procurement companies to be successful in the future timber procurement environment.

More information about the satisfaction of NIPF owners in their timber-sales transactions is needed. The main aims of the research undertaking were i) to clarify the satisfaction levels of NIPF owners in their most recent timber-sales transactions and ii) to predict the satisfaction elements.

2. Material and Methods

The study undertaken was conducted in the form of a mail question-naire. Finnish NIPF owners involved in the survey were asked to report on matters connected to their timber-selling beha-viour, especially regarding the background to their most recent timber-sales transaction carried out during the past three years (1997-1999), as well as some commonly-used, indicative variables on themselves and the woodlots they own – i.e. age, gender, socio-economic group, size of woodlot area, distance from home to woodlot, importance of forms of utilizing woodlot, share of forestry income, and so forth.

Their expectations were determined using the importance attached by the subject to the various aspects of the timber trade (cf. Teas 1993). There were, in all, 41 different characteristics of the timber procurement process in the questionnaire. The levels of forest owners' expectations (exp) and perceived performance (perf) were employed using a graduated scale of 4...10 (exp: 4=Not at all important ... 10=Extremely important; and perf: 4=Terrible ... 10=Excellent). Forest owners evaluated also the overall performance of timber procurement company using a graduated scale (4=Terrible ... 10=Excellent). The measurement scale (4...10) used may be considered valid in Finland where it is the scale used to grade pupils in the school system.

The overall satisfaction of forest owners was determined using a Likert scale (Very satisfied … Very dissatisfied). The consequences of satisfaction of fo-rest ow-ners were clarified using the following indicators:

i) How willingly- forest owner recommended the company he/she had most recently engaged with in a timber-sales transaction?

ii) To how many people has forest owner told about his/her latest timber-sales transaction?

iii) What kind of message has forest owner told to other people?

iv) How willingly forest owner was prepared to sell again to the same company?

There were four sample areas (Häme-Uusimaa, Keski-Suomi, Pohjois-Karjala, and Pohjois-Savo) – comprising twelve local forest management associations (Häme-Uusimaa: Hauho-Lammi, Janakkala and Padasjoki; Keski-Suomi: Hankasalmi-Laukaa, Jyväskylä and Leivonmäki; Pohjois-Karjala: Kesälahti, Kitee and Tohmajärvi-Värtsilä, and Pohjois-Savo: Iisalmi, Kiuruvesi and Pielavesi). Characteristically, the procurement actions were carried out by all major timber procurement companies prior to mergers (in 1995) in all the selected areas. The questionnaire forms were sent out to a total of 1,400 NIPF owners in late March – early May of 1999. The number of acceptable responses was 796, giving a response per-centage of 57 %.

The antecedents and consequences of satisfaction were analysed using percentage shares, mean values, standard deviations (sd), and Spearman's correlations (r_s). Following basic analyses, the forest owners' satisfaction elements were estimated by applying a canonical discriminant analysis in which the different background and performance variables were independent ones. The F-ratio of the variable was used as a selection criterion of variables for models in the discriminant analysis (when $F>3.84$ the variable to model, and when $F<2.71$ the variable out model).

Eighty-two per cent of the respondents were male and 18 % female. The subjects' average age was 55 years (sd=13.0). More than one third of subjects (38 %) were farmers, 28 % were wage-earners, 26 % were pensioners, and 6 % were none of the above (others). The subjects lived at an average distance of 44 kilometres (sd=103) from their woodlots, whose average size was 75 hectares (sd=140). The size of median woodlot was 42 ha. The subjects stated that wood pro-duction is the most important form of utilizing their woodlot (index=8.73 [4=Not at all important ... 10=Extremely important]); second place went to economic security (8.31) recreational use (i.e. outdoor recreation, hunting) (7.56), and conservation of forest nature and landscape (7.49).

During the past ten years, each respondent had, on average, made 5.2 timber-sales transactions. The most recent timber-sales transaction's average size was 651 m^3 (sd=696) (median=414 m^3). The subjects reckoned that the share of income obtained from forestry was circa 25 % (sd=22).

Twenty per cent of the most recent timber-sales transactions -had been delivered sales, and 80 % standing sales. The respondents further reckoned that the foremost motives for their most recent timber-sales transactions had been the silvicultural reasons (index=8.70 [4=Not at all important ... 10=Extremely important]), good price paid for timber (7.95), extensive, unused harvesting possibilities (7.95), the need for income from selling timber (7.85), and good quality of the company (7.18).

3. Results

3.1 Antecedents of customer satisfaction

The expectations of forest owners were highest in regard to the following attributes: timber buyer is solvent (mean value 9.60), timber measurement is true (9.54), logging causes slight root and stem damage to remaining trees (9.35), company personnel are reliable (9.35), and competitive price level (9.33).

The overall grade of perceived performance of the forest owners was 8.54 (sd=1.02). From the forest owners' point of view, company characteristics connected to great success as timber buyers include solvency (mean value 9.67), border and shape of stand marked for harvesting complying with contract (9.18), timber measurement is true (9.11), company personnel are reliable (9.02), and possibility for conducting business with familiar company person (9.01).

Similarly, timber sellers were of the opinion that the most negative aspects slight possibility to choose harvesting contractor (7.44), in dealing with companies was having to be infrequently in touch with them (7.81), slight possibility to choose harvesting method (mechanized/motor-manual) (8.12), much stemwood is left as logging residues (8.25), and less information about changes in timber trade (8.30).

There were statistically significant correlations between the overall grade for procurement company and the other satisfaction variables (Table 1). In particular, the higher overall grade for company was, the higher the level of satisfaction (r_s=0.46; $p<0.001$), and the better message quality (r_s=0.48; $p<0.001$) were.

Table 1. Spearman's correlations of satisfaction elements.

	I	II	III	IV	V	VI
I Grade for company	1					
II Satisfaction [Dissatisfaction … Satisfaction]	0,457***	1				
III Willingness to recommend [No … Yes]	0,289***	0,430***	1			
IV Told to the others [persons]	0,091*			1		
V Message quality [Negative … Positive]	0,478***	0,522***	0,398***		1	
VI Willingness to re-sell [Decreasing … Increasing]	0,441***	0,394***	0,301***	0,401***		1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.2 Customer satisfaction

The customer satisfaction index for each timber-sales factor was calculated by the disparity of perceived performance (perf) and expectation (exp) levels. The biggest negative satisfaction indices among the timber sellers were obtained in connection with the following: only a little stemwood being left as logging residues, cross-cutting of stems to maximize the sawlog portion, slight damage to retention stands, short stumps, and competitive price level (Figure 1). That is to say, timber sellers were deeply dissatisfied with these factors. On the other hand, timber sellers were clearly satisfied with the following points: retention of corresponding numbers of living and dead trees, possibility to enter into a timber-sales transaction with a familiar company person, retention of buffer zones around lakes and rivers, no logging in biodiversity areas, and courtesy of company personnel.

Figure 1. Five procurement points with which forest owners were most satisfied, and five points with which they were most dissatisfied.

Eighty-seven per cent of timber sellers estimated that they were satisfied with the performance of procurement company in their most recent timber-sales transactions (Figure 2). Only two per cent of timber sellers told that they were dissatisfied with their most recent timber-sales transactions. The higher the level of satisfaction was, the higher the willingness to recommend (r_s=0.43; p<0.001) was, and the better the message quality (r_s=0.52; p<0.001) and also the higher the re-selling intentions (r_s=0.39; p<0.001) were (Table 1).

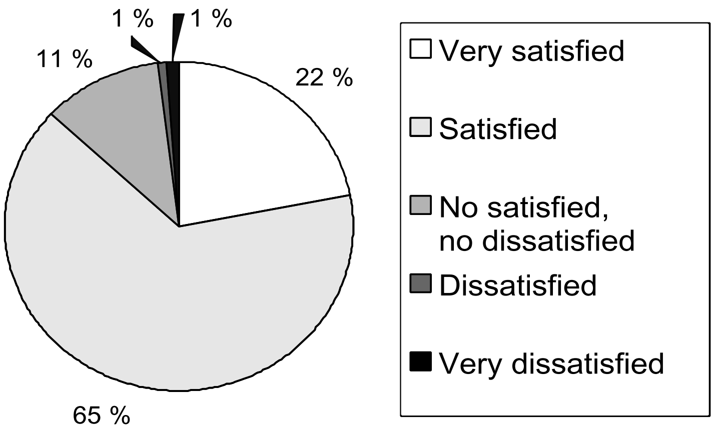

Figure 2. Overall satisfaction levels of forest owners with their most recent timber-sales transaction.

Using canonical discriminant analysis, "satisfied" [1], "neutral" [2], and "dissatisfied" [3] sellers could be separated from each other with an accuracy of 61-84 % by canonical discriminant functions (unstandardized coefficients of $CDF_{\text{Satisfaction I and II}}$) in which the evaluated group centroids were: $CDF_{\text{Satisfaction I}}$: [1]: -1.81, [2]: -1.53, [3]: 0,24; and $CDF_{\text{Satisfaction II}}$: [1]: 2.15, [2]: -0.45, [3]: 0.01 (Table 2). The satisfaction with the performance of company seemed to be greater, the better experiences of earlier timber trade he/she had met with, and the better performance (Flexibility of company personnel, Reliability of personnel, Business-like attitude of personnel concerning complaints, and Good quality of company as timber buyer) he/she had met with in his/her last timber trade.

Table 2. Canonical discriminant functions of satisfaction.

Variable	F-ratio	Standardized coefficient		Correlation		Unstandardized coefficient	
		I	II	I	II	I	II
Background variable							
- Perceived performance in earlier trade, 4…10	$19,65^{***}$	0,380	0,609	0,580	0,518	0,478	0,767
Performance variables, 4…10							
- Flexibility of company personnel	$17,51^{***}$	-0,005	0,665	0,575	0,373	-0,040	0,586
- Reliability of personnel	$29,14^{***}$	0,417	-0,228	0,782	-0,178	0,380	-0,208
- Business-like attitude of personnel concerning complaints	$29,99^{***}$	0,446	0,010	0,797	-0,112	0,384	0,008
- Good quality of company as timber buyer	$23,34^{***}$	0,153	-0,860	0,658	-0,461	0,158	-0,886
(Constant)						-11,982	-1,672

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3 Consequences of customer satisfaction

Recommending

Six per cent of the respondents felt that they could not recommend to the others the company with which they had made their most recent timber-sales transaction. All the same, most forest owners (94 %) reported that they could recommend their company to other forest owners.

Using canonical discriminant analysis, the “non-inclined to recommend” [1] and “inclined to recommend” [2] sellers could be separated from each other with an accuracy of 81-90 % by a canonical discriminant function (unstandardized coefficients of $CDF_{Recommend}$) in which the evaluated group centroids were: [1]: -2.35; and [2]: 0.13 (Table 3). The willingness to give favorable reports of the company to which they had most recently sold timber to the others seemed to be the greater, the better performance (Understanding needs of timber seller, and Feedback easy to give to the company) he/she had met with.

Table 3. Canonical discriminant function of the willingness to recommend.

Variable	F-ratio	Standardized coefficient	Correlation	Unstandardized coefficient
Performance variables, 4…10				
- Understanding needs of timber seller	79,04***	0,531	0,876	0,516
- Feedback easy to give the company	93,56***	0,653	0,806	0,618
(Constant)				-9,954

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

On an average, the forest owners reported that they had told five people about their most recent timber-sales transaction. Sixty-two per cent of the forest owners said that they had told mainly positive information about timber trade. Only two per cent of the forest owners had given mainly negative information. One fifth of the forest owners had given both positive and negative information. Sixteen per cent of the forest owners had not told anyone about their most recent timber-sales transaction.

When processing a discriminant analysis with four message quality groups (“no discussions” [1], “negative message” [2], “negative and positive message” [3], and “positive message” [4]), these segments could not be separated very well (accuracy of 29-71 %). Especially, the success of analysis was weak concerning the “no discussions” and “positive and negative message” groups. The estimated group centroids were: $CDF_{Message\ I}$: [1]: -0.31, [2]: -2.08, [3]: -0.92, [4]: 0.40; and $CDF_{Message\ II}$: [1]: -0.01, [2]: -2.97, [3]: 0.31, [4]: 0.05. The $CDF_{Message}$ functions suggested that those timber sellers, who had had some good experiences (i.e. Flexibility of company personnel, Good quality of company as timber buyer, and Feedback easy to give the company), had told positive message to other people (Table 4).

Table 4. Canonical discriminant functions of message quality.

Variable	F-ratio	Standardized coefficient		Correlation		Unstandardized coefficient	
		I	II	I	II	I	II
Performance variables, 4…10							
- Flexibility of company personnel	20,94***	0,483	-0,980	0,771	-0,582	0,454	-0,922
- Good quality of company as timber buyer	15,72***	0,174	0,671	0,670	0,462	0,166	0,640
- Feedback easy to give the company	22,89***	0,594	0,356	0,861	0,337	0,649	0,389
(Constant)						-11,129	-1,283

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Re-selling willingness

Almost half of the respondents pointed out that their last timber trade did not affect their selling intentions (Figure 3). Only five per cent of the timber sellers recognized that their willingness to sell timber again to the same timber buyer as last had been reduced. In contrast, almost half of the timber sellers were of the opinion that their last timber-sales transaction increased their willingness to resell to the same company in the future.

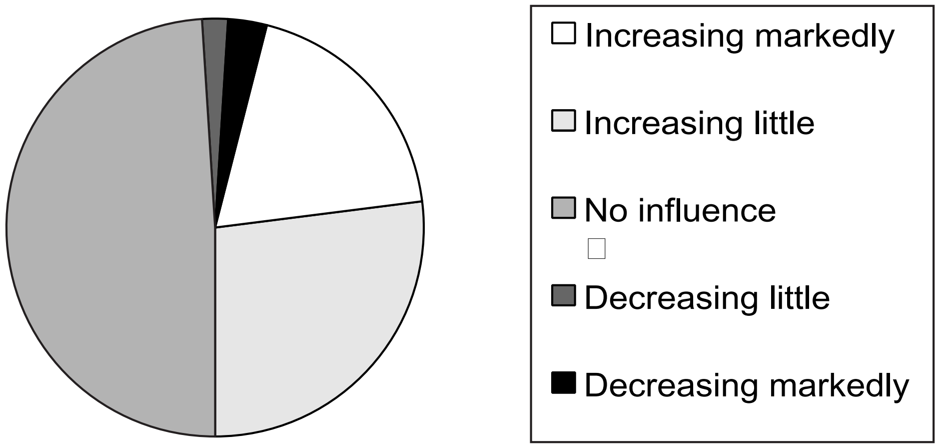

Figure 3. Influence of the last timber-sales transactions on the re-selling willingness of forest owners.

When processing a discriminant analysis with three re-selling groups, these segments could be separated from each other with the accuracy of 67 % "willingness-decreased" [1], of 48 % "no-change-in-willingness" [2], and of 74 % "willingness-increased" [3]. The evaluated group centroids were: $CDF_{Re\text{-}Selling\ I}$: [1]: -1.95, [2]: -0.27, [3]: 0.45; and $CDF_{Re\text{-}Selling\ II}$: [1]: 0.56, [2]: -0.21, [3]: 0.13 (Table 5). The $CDF_{Re\text{-}Selling}$ functions suggested that those timber sellers, who had good quality of the company as a motive to sell timber and had suffered – in their view – some bad experiences, are not willing to sell to the same company in the future.

Table 5. Canonical discriminant functions of the willingness to re-sell.

Variable	F-ratio	Standardized coefficient		Correlation		Unstandardized coefficient	
		I	II	I	II	I	II
Background variable							
- Good quality of the company as a motive to sell timber, 4…10	26,97***	0,453	0,917	0,622	0,779	0,248	0,503
Performance variables, 4…10							
- Understanding needs of timber seller	26,84***	0,300	-0,318	0,673	-0,332	0,282	-0,299
- Reliability of personnel	25,34***	0,182	-0,010	0,657	-0,276	0,163	-0,009
- Good quality of company as timber buyer	37,08***	0,503	-0,442	0,790	-0,401	0,535	-0,470
(Constant)						-10,474	3,292

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4 Conclusions

The results argued that NIPF owners were mainly satisfied with the performance of procurement companies in their most recent timber-sales transactions. However, half of the respondents did stress that their last timber trade did not affect their timber-selling intentions. In addition, forest owners were particularly dissatisfied with the poor degree of utilization of stems in the course of logging (i.e. stems are not cross-cut to maximize the sawlog portion, and a lot of stemwood is left as logging residues). This kind of argument may be obtained with respect to the prevailing customer-orientation in timber procurement – i.e. timber procurement companies purchase for their customers (sawmills and pulp mills) timber meeting the dimension requirements of the mills.

Timber sellers were also dissatisfied with the damage to standing trees caused by logging. However, a recent extensive survey focusing on the silcultural result revealed that the percentage of damaged trees has decreased from previous years' level, and is nowadays mostly deemed to be of good level (Ranta 2003).

Respectively, forest owners appeared to be pleased with the fact that companies attach importance to environmental values (i.e. living and dead trees are retained on harvesting sites, and no logging is carried out in areas with significant biodiversity values). These observations are supported by the results obtained by Kotiharju and Niemelä (2000). It must be noted, nonetheless, that the subjects interviewed in this survey did not place marked stress on the function of conversation of forest nature, whose mean index was 7.49, whereas wood production, for example, received the index value of 8.73.

There were several service performance variables in the canonical discriminant models (Tables 2-5), price level not included. Because almost all forest owners were dissatisfied with the price level, therefore it did not separate the groups from each other.

What comes to the continuing measuring of satisfaction by procurement companies, the research presented some background variables and the most indicative performance features (Tables 2-5). Accordingly, procurement companies should ask timber sellers about the level of these performance attributes (i.e. Flexibility of company personnel, Reliability of personnel, Understanding needs of timber seller, Business-like attitude of personnel concerning complaints, Feedback easy to give the company, and Good quality of the company as timber buyer).

Procurement companies can also ask directly, for instance, how satisfied the timber seller is generally with the performance of their company, or how willing the timber seller is to sell again to their company. The weakness in such direct inquiry is that companies cannot discover possible unsuccessful operations in the timber trade process. Therefore, indirect measurement of the satisfaction and loyalty of timber seller can be considered to be a better survey method. As a result of these inquiries, and of course of using the presented models and functions, companies can then find the dissatisfied sellers and further contact them by way of an after-service process, for example, and finally have less-dissatisfied sellers, who would otherwise tell negative things about their company or switch to dealing with other companies (cf. Gengler and Popkowski Leszczyc 1997).

The response rate to this survey was 57 per cent. This is a quite good percentage in comparison to previous postal questionnaire surveys focusing on customer satisfaction (e.g. Kärhä and Oinas 1998). Farmers and forest owners who have big woodlots were more active timber seller segments to take part in the research due to their larger timber-selling activity (cf. Karppinen et al. 2002).

Acknowledgements

I wish to extend my thanks to the Foundation for Research of Natural Resources in Finland for funding the research project and to Vesa Tammiruusu for aiding to collect the research material.

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Comparison of Forest Owner Typologies Based on Latent Class Analysis and Cluster Analysis

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Abstract

Survey data on forest owner attitudes can be used to divide forest owners into types, each type forming a group of similar owners with attitudes differing markedly from those observed for other types. Such an empirical typology can be developed using a range of different statistical methods, including cluster analyses and latent class analysis. In this paper we examine the sensitivity of a forest owner typology to the choice of statistical model. Based on a latent class analysis of data from a survey among private forest owners in Denmark, we identify different types of owners. The resulting typology is compared with previous results based on k-means clustering of the same data. It emerges that the two statistical methods lead to almost identical forest owner types, but also that the final typology is influenced by various choices made on the way through the analysis. The most significant of these choices is the number of owner types.

Keywords: private forest owner, typology, latent class analysis, cluster analysis

1. Introduction

Using cluster analysis, Boon et al. (2004) identify three distinct types of forest owners in Denmark, (1) 'the classic forest owner' to whom forest has significant, economic importance, (2) 'the hobby owner' who enjoys to work and recreate in his/her forest, and (3) 'the indifferent farmer' to whom all the values provided by the forest are equally (un)important. This typology compares well with studies conducted elsewhere. 'The classic forest owner' is similar to 'the economically motivated owners' identified by, e.g., Becker et al. (2000) and Bieling (2004), but also 'the multi-objective owners' (Kuuluvainen et al. 1996; Karppinen 1998; Kline et al. 2000). 'The hobby owner' shares many characteristics with the 'recreationist' type as well as the 'self-employed' type (Kuuluvainen et al. 1996; Karppinen 1998; Kline et al. 2000). And 'the indifferent farmer' is similar to 'the passive owner', but also 'the disinterested owner' and 'the resigning owner' (Volz & Bieling 1998; Kline et al. 2000; Bieling 2004).

However, it may be questioned whether it is justifiable to compare the owner types identified in such studies. Obviously, the socio-demographic and bio-geographic context varies from country to country. But the studies also vary with respect to the types of survey questions used and the statistical methods applied. Here we investigate how sensitive the results obtained for a particular data set may be towards the choice of statistical model used to develop a forest owner typology.

Thus, the basic question addressed in this paper is: What is the effect of choosing a particular statistical model when clustering forest owners to identify a set of forest owner types? We will try to provide a partial answer to this question by comparing typologies obtained using latent class analysis with the typology presented in Boon et al. (2004).

2. Materials

This paper is based on results from a mail questionnaire survey that was carried out in February – March 2002 among private forest owners in Denmark, in collaboration with Statistics Denmark. The population consisted of all private, personally owned forest properties with an area of 2 hectares or more. Questionnaires were distributed to 1,986 forest owners of whom 63 were omitted from the sample as 'non-relevant', as the recipients stated that they did not own any forest. Of the remaining 1,923 forest owners 1,553 responded and, hence, the response rate was 80.8%. Further information about the survey and the sample is found in Boon (2003), Boon & Meilby (2004), and Boon et al. (2002,2004).

The questionnaire included 27 questions concerning:
- The forest (area, location, tree species composition).
- The owner (age, sex, income level, type and duration of ownership, etc.).
- Perception of the importance of forest benefits (economics, hunting, recreation, etc.).
- Forest management attitudes and practices.

Similar to Boon et al. (2004) we will emphasise one of these questions, namely Question 12 regarding the forest owner's perception of the importance of various benefits associated with the forest. Question 12 includes 17 sub-questions, 16 of which are used here and in Boon et al. (2004). The questions are listed in Table 1 and all questions were answered using the same five-level ordinal scale: 1 = very important, 2 = important, 3 = neither nor, 4 = not important, 5 = absolutely not important.

Table 1 Survey questions used as a basis of the typology.

12	"A forest provides a range of benefits to the owner. How important are each of the following benefits to your forest ownership?"		
12a	The forest as an investment object	12i	My identity as 'forest owner'
12b	Earnings from wood production	12j	The forest is used as entertainment for business relations
12c	Earnings from renting out hunting rights	12k	It is my hobby to tend the forest (forest work)
12d	Earnings from Christmas trees and greenery	12l	It is a place for me to go hunting as a hobby
12e	Regulating annual household income through delay/realisation of forest earnings	12m	To hike, pick berries, watch birds a.o. recreation
12f	Side employment for employees/myself	12n	The landscape value and aesthetics of the forest
12g	(Fuel) wood/timber for household consumption	12o	Diversity of flora and fauna
12h	The forest is the family's legacy	12p	Public access to outdoor life and recreation

3. Methods and models

The basic idea of latent class analysis is that, apart from dependent variables (indicators, y) and independent variables (covariates, x) observed when sampling a population, there may exist a number of latent, unobserved variables (z) indicating that the population is, in reality, a conglomerate of subpopulations, each of which have their own distribution with respect to the indicators (y).

In latent class cluster analysis a statistical model is developed and used to examine how many different classes the population appears to include and what the characteristics of the subpopulations are. A latent class cluster model for categorical data not including covariates can be expressed as (Vermunt & Magidson 2003b):

$$\pi(y_1 y_2 ... y_K) = \sum_z \pi(z) \prod_{k=1}^{K} \pi(y_k \mid z) \qquad (1)$$

where K is the number of categorical indicator variables y_k, z is a single latent class variable which is assumed to have a certain number of levels corresponding to the number of classes/clusters, $\pi(y_1 y_2 ... y_K)$ is the probability of observing a particular combination of indicator values, $\pi(z)$ is the probability of a certain value of the latent class variable, and $\pi(y_k \mid z)$ is the conditional probability of y_k for a given latent class z.

In model (1) the conditional probabilities $\pi(y_k \mid z)$ are parameterised as:

$$\pi(y_k \mid z) = \frac{\exp(\eta_{y_k|z})}{\sum_{y_k} \exp(\eta_{y_k|z})}, \qquad (2)$$

where $\eta_{y_k|z} = \beta^0_{y_k} + \beta^1_{zy_k}$. The indicator variables applied in this paper are ordinal and, therefore, the two-variable interaction term $\beta^1_{zy_k}$ is restricted by introducing K fixed category scores υ_{y_k} : $\beta^1_{zy_k} = \beta^1_{zk} \cdot \upsilon_{y_k}$.

In the above model the basic assumption is that the indicators are locally independent. However, this certainly is not guaranteed; in fact it is highly likely that some of the applied indicators are associated. To account for this, the local independence assumption can be relaxed for selected pairs of indicators. The basic model (1) can be written as:

$$\pi(y_1 y_2 ... y_K) = \sum_z \pi(z)\pi(y_1 \mid z)\pi(y_2 \mid z)\pi(y_3 \mid z)\ldots\pi(y_K \mid z) \qquad (3)$$

Similarly a model where the variables y_1 and y_2 are assumed to be associated, and therefore may be combined, can be written as:

$$\pi(y_1 y_2 ... y_K) = \sum_z \pi(z)\pi(y_1 y_2 \mid z)\pi(y_3 \mid z)\ldots\pi(y_K \mid z) \qquad (4)$$

For $\pi(y_1 y_2 \mid z)$ the linear term in the model (2) is now:

$$\eta_{y_1 y_2|z} = \beta^0_{y_1} + \beta^0_{y_2} + \beta^0_{y_1 y_2} + \beta^1_{zy_1} + \beta^1_{zy_2} \qquad (5)$$

Models are compared using the Bayesian Information Criterion (*BIC*) for the logarithm of the likelihood function (log–!), which includes a penalty for the numbers of parameters j and observations N: $BIC_{\log \ell} = -2\log \ell + j \log N$. The lower the value of $BIC_{\text{log–!}}$ the better the fit of the model. The analysis was carried out using Latent Gold 3.0 (Vermunt & Magidson 2003a,b).

4. Results

To examine possible associations between responses to the 16 questions in Table 1 we calculated Kendall ô-b coefficients of correlation for all pairs of indicator variables. The results are shown in Table 2. As will appear from the table almost all pairs appear to be related and very few coefficients are not significantly different from zero at the 1% level. On the other hand, the Kendall ô-b coefficient is only greater than 0.5 in one single case, namely for Questions 12n and 12o regarding the importance of landscape aesthetics (12n) and diversity of flora and fauna (12o).

Table 2. Testing the association between responses to the 16 survey questions. Kendall ô-b coefficients of correlation. Coefficients that are not significantly different from zero at the 1% level are italicised. Values greater than 0.4 are boldfaced.

	12b	12c	12d	12e	12f	12g	12h	12i	12j	12k	12l	12m	12n	12o	12p
12a	.33	.25	.32	.34	.25	.09	.15	.25	.23	.16	.13	.08	.14	.07	*.03*
12b		**.49**	.39	**.45**	.32	.23	.31	.29	.21	.08	.06	*.02*	.17	.08	.12
12c			.34	.37	.20	.11	.25	.21	.25	-.06	-.06	*-.03*	.10	*.03*	.16
12d				**.43**	.29	.07	.17	.22	.18	.10	*.05*	*-.01*	.08	*.02*	.09
12e					**.42**	.18	.22	.28	.34	.08	.10	*.01*	.09	*.03*	.13
12f						.32	.15	.29	.21	.26	.17	.10	.18	.13	.07
12g							.12	.20	.14	.23	.12	.14	.15	.13	.07
12h								**.43**	.20	.12	.07	.14	.25	.17	.14
12i									.35	.26	.18	.20	.25	.18	.13
12j										.09	.19	.07	.08	*.06*	.13
12k											.32	.35	.30	.28	*.04*
12l												.26	.18	.28	*-.01*
12m													**.46**	**.46**	.14
12n														**.67**	.15
12o															.12

4.1 Choice of model

The usual way to proceed with cluster analysis is either to reduce the number of clusters until the loss of information becomes unacceptable or to increase the number of clusters until a model has been obtained that yields an acceptable description of the material. The latter method can also be used with latent class modelling. With the current set of data it emerges that the number of clusters that minimises $BIC_{log-!}$ is 10, which is far more than we would like to consider. Clearly, our objectives are conflicting, on the one hand we want a model that yields the best possible description of our observations and on the other hand we want it not to distinguish too many classes. Therefore, a more convenient alternative is to decide roughly how many clusters we would like to consider and then relax those local independence assumptions that are most likely to be violated. According to Table 2, the independence assumption is particularly inappropriate for the pairs: 12n-12o, 12b-12c, 12n-12m, 12o-12m, 12b-12e, 12d-12e, 12h-12i, and 12e-12f.

In Figure 1 $BIC_{log-!}$ is shown for models including 1-6 clusters and 0-8 direct associations between variable pairs (relaxed independence assumptions). For any number of clusters the independence assumptions were relaxed for one pair of variables at a time, always prioritising that pair for which the bivariate residuals indicated the greatest potential improvement of the model. Using $BIC_{log-!}$ as the performance criterion it appears from Figure 1 that, e.g., a two-cluster model with six dependent pairs of indicators ($BIC_{log-!}$ = 51881) yields a better fit than a five-cluster model with no dependent pairs ($BIC_{log-!}$ = 52026). Moreover, it turns out that for a three-cluster model one only needs to include four direct relationships ($BIC_{log-!}$ = 51701) to obtain a better fit than the one obtained by a crude six-cluster model ($BIC_{log-!}$ = 51829). For four- and five-cluster models it is still necessary to include two direct associations to compete with the crude six-cluster model. If we consider just one single class it appears that, even if we include eight direct associations, the model performs poorer than two- or three-cluster models including only one single direct association; so the material generally supports distinguishing a number of clusters.

Below we will consider three different models and compare them with the results obtained in Boon et al. (2004) using k-means clustering. The three models are: a three-cluster model with no direct associations between indicators (Model A, $BIC_{log-!}$ = 52842), a three-cluster model with eight direct associations (Model B, $BIC_{log-!}$ = 51367), and the best-performing model (Model C, $BIC_{log-!}$ = 51205), a six-cluster model with five direct associations. Six-cluster models with higher numbers of direct associations between pairs of variables perform slightly poorer than model C.

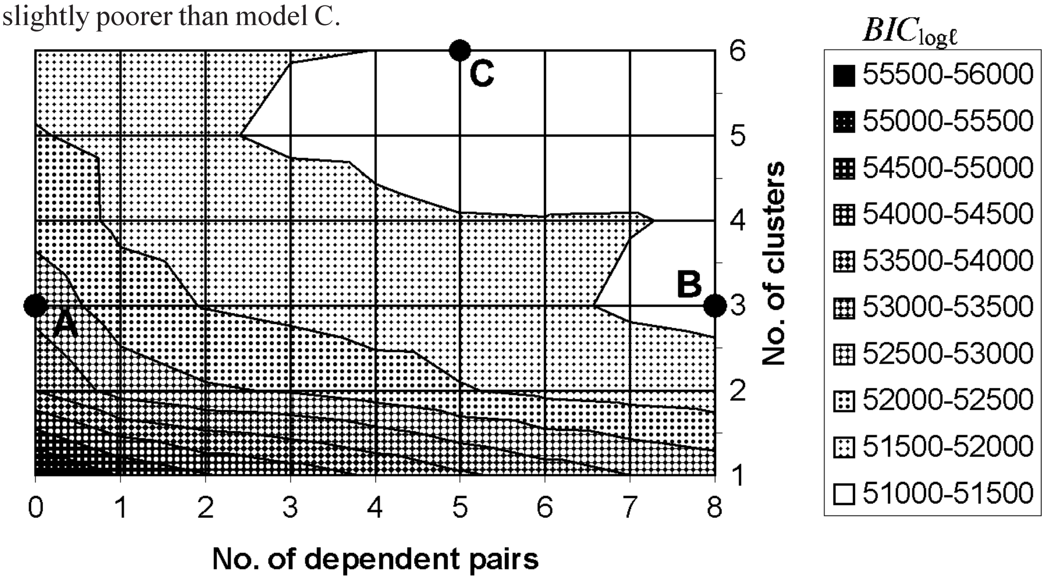

Figure 1. Contour plot illustrating the Bayesian Information Criterion ($BIC_{log-!}$) for a range of latent class cluster models. The selected models (A, B, C) are marked.

4.2 Distribution of respondents

In Table 3 we compare the clusters of the three selected latent class models with the clusters identified by Boon et al. (2004). For each pair of models compared Table 3 shows the percentage of respondents falling within a given pair of clusters. For three-cluster models the clusters have been numbered in such a manner that if the models compared yield identical typologies, all respondents will end up in the diagonal.

From the table it appears that, in terms of classification of the respondents, the k-means clustering and Model B yield similar results. More than 4/5 of the respondents in K1 are also found in B1, 5/6 of the respondents in K2 are within B2, whereas the responses in K3 are about equally divided between B2 and B3.

The six-cluster model, Model C, also seems to yield results that are in agreement with the k-means clustering. The respondents within C1 and C4 are almost exclusively found within K1, those in C2 and C5 are found in K2, and those in C3 and C6 end up in K3. Similarly, Model C is in almost perfect agreement with Model B: 9/10 of the respondents in C1 and C4 are found in B1; almost all respondents in C2 and C3 fall within B2, and respondents in C5 and C6 fall within B3.

On the other hand, although the clusters of Model B and the k-means model *could* be subdivided, it appears that this should be done in slightly different ways. Apparently, the two models capture different aspects of the variation between forest owners. For example, most of the respondents in C5 are found in K2, which is the class resembling B2 the most; nevertheless most of the respondents in C5 end up in B3. Similarly, most of the respondents in C3 are found in K3 and B2, rather than B3. Moreover, the respondents in K3 are divided between C1, C3, C5 and C6, whereas the respondents in B3 are divided between C3, C5 and C6.

Finally, the comparison shows that Models A and B differ considerably and, more importantly, that the original k-means clusters are comparatively stable when compared with Model B, cluster K3 being the least stable.

Table 3. Comparison of the k-means clustering results and three different latent class cluster models: Model A: 3 clusters and no direct associations; B: 3 clusters and eight direct associations (12c-12b, 12d-12b, 12i-12h, 12j-12i, 12m-12k, 12m-12l, 12n-12m, 12o-12n); C: 6 clusters and five direct associations (12c-12b, 12d-12b, 12i-12h, 12j-12i, 12o-12n). Per cent of respondents.

%		K-means			Model A			Model B		
	Cl.	K1	K2	K3	A1	A2	A3	B1	B2	B3
Model B	B1	41.4	1.6	2.1	31.8	13.2	0.0	45.0	-	-
	B2	10.5	24.2	9.1	21.9	12.2	9.7	-	43.8	-
	B3	0.0	4.0	7.2	0.0	0.7	10.6	-	-	11.2
Model C	C1	32.8	2.4	2.2	32.5	4.8	0.1	34.6	2.8	0.0
	C2	7.6	18.9	0.3	13.3	11.2	2.3	1.3	25.4	0.1
	C3	2.2	3.8	10.9	7.0	0.5	9.4	0.3	14.3	2.4
	C4	9.3	0.4	0.0	0.9	8.7	0.0	8.9	0.8	0.0
	C5	0.0	4.3	1.6	0.0	0.8	5.1	0.0	0.5	5.4
	C6	0.0	0.0	3.4	0.0	0.0	3.4	0.0	0.0	3.4

4.3 Comparison of ower characteristics

In Table 4 we compare the best of the three-cluster models, Model B, with the k-means model in terms of owner and property characteristics within the clusters. The clusters are numbered as above. The table confirms the impression that the clusters of the two models are very similar, only the clusters of Model B more clearly show the profile of the three owner types already identified in Boon et al. (2004): 'the classic owner' (K1), 'the hobby owner' (K2) and 'the indifferent farmer' (K3). The main differences between the two models are:

-Compared to the 'classic owner' (K1), B1 encompasses fewer owners who on average spend less recreation days in their forest and are more likely to have a strategic plan for the forest.

-Compared to 'the hobby owner' (K2), B2 encompasses more owners, the average forest area is larger and the owners more often have strategic plans for their forest and spend more days working in the forest.

- Compared to the 'indifferent farmer' (K3), B3 encompasses fewer owners, the average forest area is smaller, fewer of the owners have a strategic plan for their forest, they spend fewer days working in the forest and the share of female owners is higher.

Table 4. Comparison of average characteristics of owners and properties between k-means clusters and the clusters of Model B. Applied exchange rate: 7.5832 DKK = 1 €.

		Cluster 1		**Cluster 2**		**Cluster 3**	
	Unit	K-means K1	Model B B1	K-means K2	Model B B2	K-means K3	Model B B3
Number of owners		633	549	363	534	224	137
Men	%	87.2	88.2	85.7	85.4	84.4	81.8
Women	%	12.8	11.8	14.3	14.6	15.6	18.3
East (Islands)	%	26.9	28.0	15.7	16.3	12.5	10.2
West (Jutland+Funen)	%	73.1	72.0	84.3	83.7	87.5	89.8
Forest map exists	%	36.2	37.3	17.9	20.0	13.4	8.8
Strategic plan exists	%	18.2	19.5	8.3	9.0	7.1	4.4
Mean age of owners	years	52.3	51.8	51.6	52.8	53.6	52.3
Avg. duration of ownership	years	19.5	19.6	17.2	18.7	19.8	17.0
Mean forested area	ha	91.2	90.0	26.9	41.9	32.9	22.7
Deciduous species	%	38.5	37.9	31.6	33.5	32.2	31.9
Mean household income	€/yr	70400	70466	70067	70070	66404	64260
Avg. days in the forest		141.9	140.4	124.7	121.6	80.2	82.6
- Hunting		9.1	9.7	10.2	7.2	2.5	6.5
- Recreation		63.6	57.8	63.3	64.2	36.8	40.3
- Working		51.4	52.4	29.2	34.7	28.0	15.9
Mean activity index†		7.6	7.6	5.8	6.0	4.1	3.5

† From 0 = no activity within the past 5 years, to 14 = on average 14 different activity types within the past 5 years (e.g. cutting firewood, clear-cutting, harvesting greenery and Christmas trees, doing soil preparation).

Table 5 reports the characteristics of owners and their properties for the six clusters in Model C. If we compare the clusters of Model C with the k-means clusters according to the distribution of responses, we observe the following characteristics.

C1 and C4 both fall within 'the classic owner' (K1). Compared to C1, C4 comprises slightly older owners with a higher average household income, on average owning a larger forest area that is more frequently located in the West of Denmark and has a higher share of deciduous species than those in C1. The share of female owners is slightly higher and the owners more often have a map and a strategic plan for the forest. Moreover, on average they spend more days in the forest, and their mean activity index is higher too.

C2 and C5 both fall within 'the hobby owner' (K2). Compared to C2, C5 is characterised by owners with a lower average household income, owning a significantly smaller average forest area, which is more frequently located in the West of Denmark. C5 has a significantly higher share of female owners and a shorter average duration of ownership, on average the owners spend fewer days in the forest, they are less active and less frequently have a map or a strategic plan for the forest.

C3 and C6 both fall within 'the indifferent farmer' cluster (K3). Compared to C3, C6 deviates by having a lower average household income, a slightly higher share of female owners, who on average own a significantly smaller forest area (less than 10 ha) that is more often located in the West of Denmark and has a lower share of deciduous species. Significantly less owners (almost none) have a map or a strategic plan for the forest, the activity index is lower too, and they visit the forest significantly fewer days annually.

Table 5. Average characteristics of owners and properties for the six clusters of latent class Model C. Applied exchange rate: 7.5832 DKK = 1 €.

	Unit	Cluster					
		1	2	3	4	5	6
Number of owners		456	327	206	118	72	41
Men	%	88.2	86.5	84.5	86.4	79.2	82.9
Women	%	11.8	13.5	15.5	13.6	20.8	17.1
East (Islands)	%	27.9	15.9	18.0	25.4	5.6	12.2
West (Jutland+Funen)	%	72.2	84.1	82.0	74.6	94.4	87.8
Forest map exists	%	36.0	19.3	19.4	41.5	9.7	2.4
Strategic plan exists	%	18.4	8.0	8.7	24.6	4.2	2.4
Mean age of owners	years	51.9	51.4	54.4	52.5	51.9	52.9
Avg. duration of ownership	years	19.3	17.3	21.2	20.3	15.9	17.7
Mean forested area	ha	87.8	31.7	59.4	91.1	15.2	9.9
Deciduous species	%	37.2	31.9	34.7	42.5	35.5	23.7
Mean household income	€/yr	69090	71487	68091	73905	65910	59245
Avg. days in the forest		123.0	142.9	84.0	196.7	105.5	48.3
- Hunting		8.2	10.4	2.5	12.9	10.4	2.1
- Recreation		51.3	75.9	39.0	82.6	63.8	14.1
- Working		46.6	37.6	25.2	75.1	18.2	9.2
Mean activity index†		7.1	6.5	4.9	8.7	4.1	2.5

† From 0 = no activity within the past 5 years, to 14 = on average 14 different activity types within the past 5 years (e.g. cutting firewood, clear-cutting, harvesting greenery and Christmas trees, doing soil preparation).

4.4 Comparison of ownership objectives

The average responses to the 16 questions in Table 1 are reported in Table 6 for Model B and the k-means clusters. When comparing the results it appears that, in spite of the concordance observed in Table 3, there *are* differences between the two models.

Among the k-means clusters, the 'classic owner' is the owner type most strongly motivated by all objectives except for the hobby objectives and flora and fauna where 'the hobby owner' type is the most strongly motivated. By contrast 'the indifferent farmer' is the owner type that is least motivated by all ownership objectives except income from hunting and greenery production for which 'the hobby owner' is least motivated. In Model B, on the other hand, the B1 cluster (similar to 'the classic owner' K1), is most strongly motivated by all ownership objectives, the B3 cluster is the least motivated by all ownership objectives, and cluster B2 is intermediate. So apparently the hobby dimension that was found to be more profound for 'the hobby owner' (K2) than 'the classic owner' and 'the indifferent farmer', has been reduced slightly. Instead, the owners in cluster B2 appear to be more strongly financially motivated than the K2 'hobby owner', whereas the cluster B3 is even less financially motivated than the K3 'indifferent farmer' type.

Table 6. Mean values of responses in questions 12a...12p for the three clusters. Perceived importance of an objective decreases with increasing response value.

Ownership objective (no. of obs.)		Cluster 1 K-means (633)	Cluster 1 Model B (549)	Cluster 2 K-means (363)	Cluster 2 Model B (534)	Cluster 3 K-means (224)	Cluster 3 Model B (137)
Financial importance							
- Investment	12a	2.76	2.68	3.52	3.40	3.80	4.35
- Wood earnings	12b	2.69	2.69	4.03	3.62	4.09	4.93
- Hunting rent	12c	3.01	2.98	4.25	3.88	4.04	4.73
- Greenery earnings	12d	2.56	2.45	4.09	3.72	3.80	4.55
- Income regulation	12e	3.20	2.89	4.34	4.32	4.37	5.00
- Sideline	12f	2.78	2.70	3.77	3.61	4.17	4.77
- Household use	12g	2.75	2.79	3.21	3.12	3.87	4.23
Legacy	12h	2.43	2.55	3.28	3.13	4.04	4.13
Identity	12i	2.81	2.87	3.52	3.44	4.30	4.45
Representation	12j	3.68	3.57	4.15	4.25	4.65	4.77
Hobby work	12k	2.30	2.36	2.20	2.47	3.75	3.47
Hobby hunting	12l	2.71	2.64	2.21	2.83	4.23	3.67
Recreation a.o.	12m	2.13	2.25	1.85	2.19	3.47	2.91
Landscape aesthetics	12n	1.70	1.78	1.75	1.87	2.74	2.57
Flora and fauna	12o	1.69	1.76	1.60	1.75	2.56	2.37
Public recreation access	12p	3.03	3.14	3.50	3.34	3.85	3.95

5. Discussion

In this paper we have studied the effect of choosing different statistical models when clustering forest owners to develop a forest owner typology.

The latent class analysis showed that the fit of latent class models is significantly improved by taking the associations between the variables that form the basis of clustering into account. For example it emerged that a three-cluster model only needs to include four direct associations to perform better than a crude six-cluster model.

We compared the best six-cluster model, Model C, with the best three-cluster model, Model B, and found that Model C widely represents a differentiation of each of the three B-clusters into two sub-clusters.

Comparative analysis showed that, in this case, latent class modelling and k-means cluster analysis lead to quite similar forest typologies. The owner and forestland characteristics of the best latent class model with three clusters, Model B, were very similar to those of the k-means clusters, whereas the attitudes differed slightly. The 'classic owner' (K1) and B1 both represent owners of larger forests who feel strongly about most ownership objectives, including the financial objectives. The specific 'hobby dimension' characterising the 'hobby owner type' (K2) became less profound for B2, and instead, the average number of working days increased. The 'indifferent farmer' (K3) and B3 both represent owners of smaller forest properties who are least motivated by all ownership objectives and who have the lowest activity index and forest visit frequency. The lower average forest area of B3 compared to 'the indifferent farmer' (K3) may explain the slightly lower appreciation of financial ownership objectives. Also, the fact that B2 includes some of the 'indifferent farmers' (K3) and 'classic owners' (K1), cf. Table 3, may explain why the hobby dimension of K2 is not as pronounced in B2.

As to the methods applied to create the typology, it is an obvious advantage of latent class analysis that, in contrast to traditional clustering procedures including k-means clustering, it provides statistical inference that may be used to identify the most suitable model. In addition it allows the potential association between indicators to be taken into account. However, with the current set of data it appeared that a considerably higher number of latent classes was supported by the data than we would be prepared to consider under most circumstances. So the full potential of the method was not utilised.

The analysis indicates that the typology developed in Boon et al. (2004) is quite stable. The next question to be investigated is whether and how the differences in attitudes between owner types are reflected in differences in management and administrative practices. Tracing such differences will give valuable insight regarding how to accommodate policy instruments and extension advice to the observed owner type profiles.

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National Forest Programmes in Scandinavian Political Culture

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Abstract

National forest programme (NFP) as a new forest policy tool, was launched in the Rio Summit in 1992. It emphasizes participation, delegation and inter-sectoral coordination. The adaptation of these principles in the forest policy in Finland, Norway and Sweden are discussed in this paper. The stage of the NFP process in each of them is very different in spite of the common structural features in the political culture. Separate policy actions related to the identification of sustainable forest management were arranged in Finland (forest specific environmental program in 1994) and in Norway (Living Forests program in 1998) whereas in Sweden a specific process has not been identifiable prior to Environmental Code 1999 and Quality Criteria. The compulsory processes towards regional forest programs in Finland promoted delegation and regional participation. No NFP- specific revisions in delegation has been named in Norway or Sweden. The Finnish government had an incentive to start a participatory political process towards NFP in order to maintain and even increase public subsidies to timber management investments, whereas Norway and Sweden had already abandoned such subsidies.

Keywords: corporatism, forest policy programmes, political culture.

1. Introduction

A new forest policy tool, National Forest Programme (NFP), has been developed through the international forest policy dialogue started in 1992 at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro. Since then, a concept of NFP is frequently referred to in the consecutive UN forums: the Intergovernmental Panel on Forests (IPF), the Intergovernmental Forum on Forests (IFF) and United Nations Forum on Forests (UNFF). In 1997 IPF encouraged countries to develop, implement, monitor and evaluate national forest programmes. In the European level, Ministerial Conference on Protecting Forest Environment has worked towards common approach for NFPs since 1999.

National sovereignty is appreciated, and customary and traditional rights are recognized in NFP process (eg. land tenure arrangements, rights of indigenous people and local communities). Consistency with each country's sustainable development strategies is also required (Egestad 1999). The transparency and comparability between national solutions is arranged through criteria and indicators (C&I). The European C&I target was included into the resolution of the 2nd Ministerial Conference in Helsinki, Finland and the operational level guidelines accepted in the 3rd conference in Lisbon in 1998.

Finland, Norway and Sweden, discussed in this study, have long multiparty parliamentary traditions accompanied with open participation in political processes. The countries share common features related to political culture and its implementation in forest policy context (Berge & Saastamoinen 2002, Lönnstedt 1999, Svensson 2004).

All the three Scandinavian countries have participated both UN and European processes but the path towards formal NFP has been different. Finland has implemented NFP since 1999, Norway is starting the process towards formal NFP program and Sweden is in the way of initiating the program preparation (see national reports to the UN process: Finland 2002, 2003, Norway 2002, 2003, Sweden 2002, 2003 and Nilsson 2001). The purpose of this paper is to discuss on the differences between Finland, Norway and Sweden in the implementation of IPF and IFF targets in general and those implemented through NFPs.

2. Forest tenure structures and political culture in Scandinavian countries

Scandinavian countries share many common features in the characteristics of forest land tenure and timber related economic interests as well as in political culture:

1) *stable multi-party parliamentary democracy*. The political power on legislate level is concentrated to the Parliament in all three countries. Many political parties are represented in parliaments. The political power on executive level has been characterised by a long series of coalition governments. Coalition governments have been more common in Finland and Norway than in Sweden (eg. Tiihonen 2000). Frequent government changes due to political controversies and shifts in the power structures of Parliament have been typical in Finland and Norway and the majority governments of the Social Democratic Party in Sweden have not meant much difference. The steps towards a modern industrialized welfare society have been the major political target in all of these countries. The role of the Royal Family is symbolic both in Norway and Sweden whereas the President of Finland has some political power in Foreign Affairs.

2) *economic structures and institutions based on free competitive market transactions and private entrepreneurship*. Non-industrial private forest (NIPF) land tenure is preferred and consequent supportive structures are maintained in the countries. Forest land tenure is dominated by fragmented private ownership. Tenure share of NIPF-owners is 54 % in Finland (440 000 holding units), 76 % in Norway (125 000 holding units), and 51 % in Sweden (125 000 holding units) (Hyttinen & Tikkanen 1999, Lönnstedt 1999, Nyrud 1999). Commercial timber production has been the major source of utilities from forests implying a strong advocacy among timber related NGOs in the forest policy arena. All three countries are highly industrialized with strong export oriented forest industries. The current value share of timber related industries in export is 26 % in Finland, 14 % in Sweden, and 6 % in Norway. Political power structures among interested parties in forest sector policy have deteriorated in time due to the diminished employment and export income share of forest industries.

3) *well- organized advocacies and functional coalitions among the major functional NGOs*. The power structures in the three countries have been characterised by power sharing among the major political parties and divergent minority parties. Power structures have provided for neo-corporatist arrangements (Lijphart 1999). The core of the neo-corporatist agenda follows from the principle that functional interests tend to act towards consensus procedures (Pregernig 1999). The functionally organised interests of NGO's are arranged in the neo-corporatist concentrations through the recognised, representational participants (cf. Kalnes 2001). Corporatism is identifiable through the arrangements of political power by monopoly representation, internal hierarchies and an authority of leadership that commits members (Knutsen 1997). Diversified political structures accompanied with weak political power of Parliament tend to promote the strong presence of NGOs on political arenas.

The structural features of political cultures can be traced by analysing the power distributions between the public bureaucrats and the representatives of the relevant NGO's in the political arena (Rommetvedt 2002). The taxonomy of political cultures can be based on the identification of power concentrations among public and private actors at the legislative (Parliament) and executive (Government) levels of the political arena respectively (cf. Heinz et.al. 1993). The lobbyist political actions of NGOs on the legislate level are excluded here and the survey concentrates relations on the executive level. Representation of the major timber related NGOs through advocacies and the formation of coalitions at the executive level have been especially strong in wage and price contracting. These activities also developed in timber trade in the 1970's when macroeconomic income policy was an essential part of the financial policy and macroeconomic policy in general (Pekkarinen 1990).

4) *Diversified NIPF-owners dominate forest land tenure.* The average size of individual NIPF forest holdings is small in all three Nordic countries, implying irregular cuttings and a variable market supply of timber. The dominance of domestic roundwood trade has promoted collective bargaining among the market parties. Well-functioning NIPF-owner associations and their coalitions have been typical in each country paralleled by collective interests among forest industry firms.

3. Forest policy institutions

Governmental decision making

The political power of the executive level in forestry issues in the Nordic countries is vested in the corresponding Ministry (Ministry of Agriculture and Forestry in Finland, Ministry of Agriculture in Norway and Ministry of Industry Employment and Communication in Sweden). None of the countries have a separate ministry for forestry issues, but Finland and Norway have ministerial departments for forest- related. In Sweden, the Ministry of Industry, Employment and Communication accommodates a small forest policy section for managing forestry issues in the political arena.

Forestry- specific national public agencies are responsible for policy implementation in Norway and in Sweden, whereas this kind central agency is missing in Finland. State-owned commercial forests are managed by a separate company and commercial interests are separated from the non- commercial in all countries. Non- commercial interests are controlled by forest authorities in Sweden and Norway but by environmental authorities in Finland (Forest and Park Service).

Central forestry administration

A strong central public office, national board of forestry with regional district organisations, had executive tasks in forest policy in all three countries up to the 1990's. In Finland, a sectoral ministry department replaced the Forest and Park Service in 1991 which simplified the delegation of policy implementation. Regional forestry boards (13 in Finland, 9 in Norway and 10 in Sweden) command policy implementation and supervision at regional level.

Strong structures among timber related NGOs

The implementation of forest policy at the local level is in the duty of self-governed associations under the supervision of district forestry boards in Finland and Norway. The Forestry Districts in Sweden do not have separate local organisations to assist forest owners.

The administrative structures permit large internal self government rather than public regulation (regulated self regulation) in all three countries. The principal timber related actors in forest policy arena have similar patterns in the three countries. There is single advocacy for non-industrial private forest owners in Finland and *Sweden,* but *two separate advocacies are identifiable in Norway (the co-operative and independent respectively).* Organisations represent forest owners both at the legislative and executive levels. They also have direct commercial interests in Norway and Sweden, but in Finland, commercial activities are carried out by a separate co-operative corporation.

The Norwegian Pulp and Paper Association and Norwegian Sawmill Industries are separate, but in Finland and in Sweden forest industries federations represent both the mechanical as well as pulp and paper industries. These associations represent and monitor the interests of their members, while advancing a broader public understanding of their entrepreneurial activities.

The non-profit forestry associations in Finland, Norway and Sweden are mainly responsible on the promotion of the social understanding of forestry. As a central NGO representing the major forest related interest actors, they organize forestry conferences and excursions, and provide information about the forest sector as.

4. What is an NFP?

Substantive inter- sectoral policy preparation, extensive participation, and the decentralization and empowerment of regional and local authorities are among the explicit targets in the NFP policy process. The major innovations in the NFP policy agenda are partnership and participatory mechanisms that involve all interested parties. The NFP also introduces explicit conflict management (Glück et.al. 2003b). The policy agenda based on open access, participatory, interactive processes has been gradually developed as a tool towards sustainable forest management. The new policy arena, predicated upon the NFP process, will broaden the social base of participants and extend the sphere of public authorities that are involved (Berge & Aasen 2000).

In the previous policy process, only relevant public authorities and coalitions of the most influential NGO's concerned were invited to participate in policy formation: a process characterized by top-down procedures with symbolic inter-sectoral co-ordination, consensus orientation and persuasion agendas. The excludable policy institutions gradually developed into permanent policy formation networks with relatively permanent relationships and interactions between public and private actors that strived to realize common aims (Pregernig 1999, Ollonqvist 2002 a,b).

Adaptive and iterative learning are intended to be employed in the NFP process. The need for substantial inter- sectoral coordination makes it necessary among the ministries concerned to put more effort and resources into policy formulation when conflicting interests are concerned. Intra-bureaucratic intermediation processes and capacity building among the new entrants have become important procedural issues. The principles to be applied in the implementation, links to other policy means, as well as legal regulation and financial incentives are still to be decided (Glück et.al.2003a).

5. Adaptation to post Rio era in national forest policy

The international commitments established during the early 1990's, the UN and European ministerial resolutions among the major ones, pushed the process towards sustainable forest management in the three countries (see an international comparison Yudego 2002). The key interested parties in forest policy were poorly prepared for the bottom-up policy formulation process. The traditional forest policy network even had difficulties to identify the relevant new interested parties and institutions to be included in the policy process (in Finland see Palo 1993,Viitala 2003).

Introducing new inter- sectoral coordination

The preparatory actions, preceding the formal new policy, transformed inter-sectoral coordination and extended participation. In Finland, the environmental forest program process was a joint effort of the forestry and environmental ministries with major related NGO's intensifying the inter- sectoral participation (Environmental Program ... 1994). The extended participation of governmental and non-governmental environmental organizations promoted the adoption of new communicative rationality into the policy agenda. The environmental program, accepted in 1994, initiated the comprehensive revision of legal background in forestry and became the basic statement on Finnish forest policy during the 1990s. In Norway, the participatory approach in the preparation of the Living Forest- program had parallel structure what concerns the distribution of the stakeholders. They achieved consensus over 23 Standards included into 6 Criteria and 95 Indicators of sustainable forest management (Sanness 2002) and Living Forest- resolution achieved official status in Norway when accepted in 1998 (Lindstad 2002a). Living Forest program implemented the general issues on ecological sustainability, accepted by the Norwegian parliament in 1996, into forestry. The comprehensive policy revision related to sustainable forest management has thereafter passed Norwegian Parliament in 1999. In Sweden, ecological sustainability and ecosystem management were included in the forestry legislation in 1994. The new coordinated forest environmental code and environmental quality objectives have been accepted by the parliament. The relevant indicators are under preparation (Nilsson 2001). The intensification of inter-sectoral coordination among forestry and environmental authorities and relevant NGO's was promoted by "a richer forest campaign" during 1987–1994, preceding the legislation reform (Svensson 2004).

Criteria and Indicators to measure SFM implementation

The criteria and indicators, the tools for gathering and assessing information on the success in implementing the general guidelines of sustainable forest management, were described in the resolutions of 2nd European Ministerial conference and agreed in the follow-up Expert Meeting in 1994. The six European criteria were accompanied by indicators measuring the fulfillment of the criteria. Finland was among the pioneers to formulate national criteria and indicators in 1995 (Eeronheimo et.al. 1997). The Living Forest- process had the same objective in Norway during 1995-1998. The consensus in Norway was not achieved before the international consensus over the operational guidelines was achieved. in the 3th Ministerial conference in 1998. Sweden has actively participated to forest policy activities towards national criteria and indicators. The follow up- measurements on the 15 officially accepted objectives are currently under preparation in Sweden.

International consensus over national criteria and indicators laid the basis for development of a Pan-European Forest certification scheme (Mäntyranta 2002). Forest certification provided a convenient way to pass the slow national criteria and indicator- process and achieve a rapid response to the commercial interests related to sustainable forest management in forest product market. Finland, Norway and Sweden were among the 11 European countries to launch the Pan-European Forest Certification system in 1999.

Timber related financial policy targets and NFP process

Public subsidies were provided for timber production investments in Finland, Norway and Sweden up to the late 1980's to support intensive timber production. Parallel dimensions of sustainability (economic, ecological and social) in the sustainable forest management objective challenged the patterns of these investments and timber related commercial interests in countries like Finland, Norway and Sweden with strong forest sector. The structure of the public subsidies on forestry was thoroughly changed in Norway and Sweden when implementing the new enlarged policy objective. Direct subsidies for timber production investments were totally abolished in Sweden in1993 and in Norway ten years later.

The Norwegian internal self- financing, based on the a mandatory reinvestment of revenues from the timber trade to a forest trust fund was preserved as the major source of funds on timber production investments in 2003 reform (Norway 2003). The indirect subsidies through federal income tax deductions were preserved (Øistad 2001). In Finland, public subsidies for timber management investments were preserved by the Act on the Financing of Sustainable Forestry in 1997. These subsidies were involved into the major forest policy instrument of NFP in Finland contrary to Norway and Sweden. In Sweden, the abolition of public subsidies for timber production was a part in the restructuring the public administration of timber management in private forestry in the early 1990's (Sandström 2002). Capital income taxation substituted prior forest taxation, and tax reductions became the major source of public incentives in timber management. Direct public subsidies were available for environmental, recreational and cultural heritage activities.

6. New participation charge challenges forest policy arena

The formation of partnerships in the forest policy arena is among the necessary conditions for a substantial NFP process, i.e. open access participation and an interactive, iterative program process (Glück et al 2003b). However, the management of the policy preparation on climate change, biodiversity conservation and rights of indigenous people have proved to be challenging in the Scandinavian political culture. Cultural traditions, together with country's political culture and patterns, have turned out to be significant supporting or impeding factors in the NFP process. These issues were evaluated in COST E19 action[1] (Glûck et.al. 2003).

The major propositions of COST E19 action concerning political culture, presented below, do not explain the differences in NFP process between the three Scandinavian countries.

Proposition 1. Social and political culture supporting the NFP process of the country secure rights of participation, provide adequate conflict resolution and adaptiveness, as well as the government's anticipatory and active approach to problem solving and its tendency to make decisions through achieving agreement between interested parties.

The public forestry authorities have been active initiators and monitors of the forest

[1] The COST E19 Action "National Forest Programmes in a European Context" was organised during 2000-2003 to get together forest policy researchers 20 participating countries to evaluate "conceptual essentials" of NFP process. Action based on EFI Seminar in Freiburg (1998), MCPFE Workshop in Tulln (1999) concentrated to four issues related to the policy arena and agenda: Participatory mechanisms (including conflict management), Collaborative approaches (partnership for implementation), Holistic and inter sectoral approaches and Iterative process with long-term commitment. The country reports from 20 participating countries indicate variety of interpretations and solutions to the NFP initial (Humpreys D. 2004).

policy actions in all three countries. The environmental issues in forestry have been administered by the corresponding public authorities. Inter-sectoral co-ordination in environmental forestry issues has been initiated in all three countries but with unequal time schedule.

Proposition 2. Close co-operation between government and a selected number of employers' and employees' interest groups is an impeding factor of participation, co-ordination and conflict resolution capacities in NFP processes with regard to involving actors outside such a narrow policy network. If, as it is most frequently found, the leadership for steering the NFP process is the forest administration and participation is focused on the traditional clientele (forestry and forest industry), then this impedes inter- sectoral co-ordination in an NFP process.

Neo- corporatist features have been dominant in the forest policy arena in all the three countries up to the early 1990's. The strong and extensive influence of neo- corporatist policy mode is still clearly visible in, for instance, the low interests to establish adequate conflict management planning.

Proposition 3. If the political culture of a country is able to deliver government driven forest programmes, then this likely leads to moderate or low participation, low inter-sectoral co-ordination and low conflict resolution capacities, as well as "command and control" policy instruments. The more rigid the distribution of power among formal authorities (e.g. ministries, departments), the less likely it is that inter-sectoral co-ordination will occur.

Sector- oriented public administration and corresponding policy actions support the preparation of segmented policies, and the Scandinavian style of participation has been sector segmented. The attempts advance substantial, inter- sectoral co-operation among forestry and environmental authorities has been clearly visible in all three countries.

The governance pattern in the Scandinavian countries has had features identified in political science as regulated self regulation (see Rayner & Howlett 2003). The outcome of NFP process in Finland was different from that in Norway and Sweden. Classical NFP achieved in Finland, implies strong public capacity with respect to that of NGO's. Equivalent to NFP outcome, achieved in Norway and Sweden, implies strong NGO's with respect to public capacity. The latter outcome means that countries have joined to UNFF process without the accepted formal policy agenda of NFP process. Strong public capacity to policy processes, overcoming the structural weaknesses due to the fragmented ownership and regional specialities, has been a necessary condition to make substantial participation to UNFF process. The major differences between the countries can be identified with the type of NFP achieved. The strong position of closed neo-corporatist policy networks in the forest policy arena is visible in the Scandinavian countries (Hilden et al.1999). The consensus over national criteria and indicators, among the fundamental issues when identifying the ecological dimension of the sustainable forest management objective, opened up new partnership elements into forest policy when environmental programs were prepared (Environmental Forestry Program in Finland in 1994 and Living Forests in Norway in 1998). Partnership elements were introduced in the preparation of NFP in Finland (public hearings, interactive web pages etc). However, the Ministry of Agriculture and Forestry invited a closed expert policy community to participate in the preparation of NFP, and the program process turned out to be a convenient vehicle to broaden and deepen the neo-corporatist policy network by inviting new relevant interested parties into the process (see discussion in Rayner & Howlett 2003).

The political decision concerning a formal NFP process has already been made in the Parliaments of Norway and Sweden, and the relevant agenda and arena have been evaluated. Finland's National Forest Programme 2010 (1999) was clearly different from its predecessors.

Unlike the previous program processes, it was the first stemming from a government initiative and having governmental commitment. The formal acceptance of the key ministries and political parties in the Government has been achieved, as the three subsequent governments have continued the NFP process. Comprehensive political acceptance has been achieved without parliamentary authority because of the shifts in the party structure of the coalition government. The formal authorisation of the programme in Finland has made it a binding forest policy framework. The commitment of the key ministries, the Ministry of Finance in particular, and the parties in power, has provided better opportunities to incorporate expenses, e.g. indirect and direct public subsidies, into the State budget in order to enforce the programme.

7. Conclusions

It has been a challenging task for the governments of the three Scandinavian countries to adopt open access participatory processes and to include, ecological, social and cultural sustainability in parallel with the economic aims of forest policy. The new policy agenda and arena have been developed in several transparent international forums. Those arranged by United Nation (IPF, IFF, Forum on Forests) and Ministerial Conferences on the Protection of Forests and the Council of the European Union at the European level have challenged the old consensus oriented policy arrangements in Finland, Norway and Sweden. The co-operative activities among interested parties in forestry and the environment in the policy arena have witnessed the ability to adapt parallel internal incentives to substantial co-operation.

In Finland, the early joint effort of forest and environment authorities and major NGO's in the preparation of forest specific environmental program in 1994 proceeded substantial inter-sectoral policy coordination. Similar consensus in Norway in 1998 on the identification of sustainable forestry (Living Forests program) paved way to a formal NFP process. The policy activities in Sweden concerning an environmental policy for forestry related to the environmental code are on going and may be achieved during 2004. Sweden has still problems in achieving a fruitful dialogue between forestry and environmental authorities and corresponding NGOs concerning forest policy issues (Svensson 2004). The entrenched position of the National Board of Forestry with its regional district organizations, together with principle of including forest related environmental issues in the general environmental policy, may be an impeding factor in the creation of a formal NFP in Sweden.

Finland has alone preserved direct public timber production investment subsidies during the 1990's. The NIPF-owners lobby has had incentives to support the NFP process that has promoted the continuation of these subsidies. These economic interests are missing in Norway and Sweden with respect to NFP process. It has been possible to achieve the immediate commercial interests related to sustainable forest management targets in general as well as in particular through forest certification. The aim to preserve regulated self- regulation, that has been true among the private forest owners lobby in the three Scandinavian countries for decades, remains a primary issue in NFP process (specification of regulated self regulation see Rayner & Howlett 2003).

Acknowledgements

The comments of Lars Lönnstedt, Anders Nyrud and Anders Portin on a previous draft are gratefully acknowledged but authors remain responsible on all mistakes, and final arguments of the paper.

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Fund Substitution and the Public Cost sharing of Non-industrial Private Forest Investments in Finland 1983-2000

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Abstract

A model of public cost sharing of non-industrial private forestry investment is proposed to describe substitution between non-industrial private financing of investments and public investment assistance. Substitution depends on the curvature conditions of forest investment function on forest stock. When the second order investment effects are close to zero or when they do not exist, the funding substitution will not take place. Simultaneous econometric model for non-industrial private and public funding with forest incomes, forest income taxes, interest rates, investment scale, and market wood price expectations as exogenous variables is estimated. The model estimation with Finnish regional data in period 1983-2000 rejects the substitution alternative. A 10% increase in non-industrial private investment funding increases public funding demand with same rate but a 10% increase of public funds increases the private funds supply 2.4%. Significant income effects are found only for non-industrial private funding. In northern Finland scale effects are large for public financial assistance. Interest rate and price expectation effects are negative.

Cost-Sharing and Private Timber Stand Improvements: A Two-Step Approach

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Abstract. The effects of cost-sharing and technical assistance on nonindustrial private forest owners' investment in timber stand improvements are analyzed using a two-step estimation method. We use survey data on Finnish NIPF owners' stand improvements, including precommercial thinnings and cleaning of seedling stands as well as restoration thinnings of overstocked juvenile stands in 1994–1998. The investment decision is theoretically considered in a two-period consumption–savings model with amenity values. To allow for the joint determination of participation in the cost-sharing program and the decision to invest, a two-step estimation method is used. The predicted probability of using public subsidy from the first-step model is included in the second-step model explaining the probability or relative extent of stand improvements. For robust inference, a quasi-maximum likelihood estimation technique and the Murphy–Topel correction are applied. Both public subsidy, personal assistance and forest planning expectedly increased the probability to invest. Especially public subsidy had substantial effects on the probability as well as extent of stand improvement. Besides overcoming the endogeneity of cost-sharing, the two-step approach showed that personal assistance also encourages stand improvements indirectly through its effect on the use of public subsidy.

Challenges for Research in Forest Economics

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Forest Economics: What it is

As a starting point, the formulation of the title allows one to consider the definition of Forest Economics. Two possible ways to define Forest Economics exist at the end points of a scale measuring the scope of the discipline. Accordingly, one can use a broad approach and consider Forest Economics as a field that studies a wide array of socio-economic topics related to forests and the forest sector. At the other end of the scale is a narrow definition in which Forest Economics is regarded as purely a field studying the economics of forestry. The broad definition is appealing since it does not appear to be overly rigid. It offers a certain closeness to the commonly held view according to which Forest Economics also includes research which cannot be classified as economics or even applied economics per se, but which may be closer to other behavioral and social fields, such as management sciences, marketing, or sociology. On the other hand, the broad definition is unappealing since it may be sometimes confusing to post the label of economics on research which is not economics.

In the following I adopt a middle ground in which Forest Economics is understood to be applied economics but whose scope is broader than just forestry.

Strengths and Weaknesses of Research in Forest Economics

To this speaker two obvious strengths of Forest Economics as a discipline are its strong empirical basis and its multidisciplinary character. These attributes should also be regarded as the opportunities for research in the Forest Economics field. Even when a Forest Economist is involved in theoretical work concerning the behavior of, say, forest industries or landowner behavior, the research must maintain close links to concrete real-life decision-making frameworks. In this sense Forest Economics offers to its practitioner an appealing way to study and apply economics meaningfully, and to get " ... your hands dirty in experiments, instead of strolling about discussing ideas purely in philosophical terms." (Gribbin 2003, p.102). Inherently, Forest Economics is a multidisciplinary discipline in which the restrictions set by natural environments are constantly present when one is analyzing the behavior of individuals or societies. Forest Economics thus provides a fertile academic ground conducive to multidisciplinary research and all the potential insights thereof.

While Forest Economics is a multidisciplinary field it also is a sectoral science. In the past this may have led Forest Economists to favor a somewhat narrow perspective in their general research approach. In these times when the world is growing more global, the interfaces between various industrial, scientific and political sectors have become more pronounced and visible. This gives a strong message to Forest Economists as well; forest sector issues should be placed and viewed within large, cross-sectoral setups. Ignoring extra-sectoral impacts easily leads to biased results in research. This is true as well in optimizing forestland management or in analyzing the causes of tropical deforestation, just to mention a couple of research examples.

An Institutional Aspect: Who Sets the Problems?

At a general level in science, it is interesting to look at how research problems are set and how general research topics are processed to specific study themes and objectives. Without going into too much details in this question - which would in fact warrant a study of its own - one can say that the process referred to and changes in it are likely to have profound effects also on the future research in Forest Economics. As a general tendency, at least in the applied fields of scientific research, there seems to be a push towards a more topdown approach where research questions or themes are 'given' from the funding institutes to researchers in a more refined or processed format. Evidently, this tendency must be connected to the overall calls for enhanced cost-effectiveness in the use of research funding. Funding agencies want to have more direct control over how their money is spent. With the ubiquitous nature of cost-effectiveness in the societies most of us live in today, it is only fair that researchers are expected to adapt to cost-cutting demands as well.

Ideally, it may be claimed that the process where very general issues - such as the role of forests in the carbon cycle or in biodiversity conservation - are transformed into more detailed study objectives or questions, should be based on interactions between researchers and the users of research. However, researchers should not be asked by policymakers or funding agencies to compromise on retaining the ultimate responsibility to formulate research questions. This is because the knowledge regarding to which extent a certain question is researchable and to which extent it is not, should be understood to lie within the expertise of qualified researchership. This understanding will help the society make full use of its investments in research, and it will, in the long run, benefit the society most.

How to Guarantee an Inflow of Competent People into the Field of Forest Economics?

To a large extent the future societal role of research in Forest Economics will also be shaped by the attributes of people engaged in it. To guarantee a sufficient inflow of quality people into the field will place natural demands on the curricula of university programs in Forest Economics. In meeting these demands there is no other viable solution than trying to work with the perceived strengths of Forest Economics, such as those outlined earlier.

Forest Economics as such is not an academic field that offers a quick route to personal satisfaction. A successful student in it needs to build a solid understanding in various theories in economics and, equally importantly, needs to learn to apply these theories in a meaningful way. The application part requires both methodological skills as well as an understanding of the multifaceted roles of forests and the forest sector in the society and in natural environments. These qualifications are obviously challenges on an individual level, but they also form a challenge when thinking of the future human resource basis of Forest Economics in general.

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FOREST INDUSTRY
&
FOREST PRODUCTS' MARKETS

Differences and Similarities in Logistic Servige Requirements

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Abstract

Offering accurate logistic services is essential for all suppliers. Identifying the requirements is becoming a matter of survival, particularly for companies delivering commodity products.

Softwood lumber has traditionally been considered a commodity product. The sawmills' business climate is characterized by factors such as; fluctuation in market price and continuous pressure on reducing costs. These factors together with issues such as heterogeneous products and immense changes in the customer base make the sawmills' business environment uncertain and difficult to predict. In order to become a preferred supplier, the sawmills have to deliver the products and services that their customers are asking for.

The sawmill industry delivers softwood lumber to the retail industry and the house building industry. Knowing and understanding the retail and house building industries' logistic service requirements will hence be the key to success for the sawmills.

This paper identifies and compares the retail and house building industries' logistic service requirements.

Keywords: Retail industry, house building industry and softwood lumber

1. Introduction

1.1. Background

During the last years, a general focus has been drawn to the service component of products and it has become almost impossible for individual companies to achieve and maintain a competitive advantage through the physical product. Hence offering services together with products is of essential importance for all suppliers. At the same time, companies are continuously working with reducing their supply base and work with just a few so-called "preferred suppliers". This puts supplying companies in a difficult situation. They have to offer the accurate services to each customer and if their total offer (products, service and price) does not exactly corresponding to the customer's needs, they will not be one of that specific customer's preferred suppliers.

The sawmills are under hard pressure. They have to deliver softwood lumber to their customers, which have become more professional and have started to place requirements on their suppliers. At the same time, they purchase raw material from small forest owners, which usually have no specific need for selling. For traditional sawmills, softwood lumber is a commodity product and hence they aim at maximizing their production process. As a consequence of producing and delivering commodity products, they are continuously exposed to fluctuation in market prices and pressure on reducing costs.

The sawmills have mainly two categories of customers; the retail industry and the house building industry. The retail industry is both selling its products to private consumers and traditional contractors, while the house building industry uses softwood lumber as an incoming material. House builders assemble the house (prefabrication of houses to different extents) more or less completely at the factory and transport the modules in order to finalize the assembling at the delivery site. Both customer categories are under continuous transformation and they have started to place stricter and in some cases new requirements on their suppliers of softwood lumber. New types of retailers, so-called "Do It Yourself multiple retailers", have entered the market place and changed the conditions for the incumbent retailers. The development in the house building industry has been towards reducing the building time (Kvist, 1995, page 7) and consequently the focus has been towards prefabricated buildings.

These two customer categories are similar in some ways at the same time as they differ with regards to a number of aspects. The two customer categories differ in for instance delivery pattern and requirements on their suppliers. Nevertheless, meeting the logistic service requirements from these two customer categories is of essential importance for the sawmills. However, in order for the sawmills to be able to deliver products to both customer categories they need to develop their logistic strategy and possibly integrate their logistic processes.

This work is one part of a wider study that aims at identifying structure and service requirements in the distribution channel for softwood lumber. It is focused on identification and comparisons between the retail industry's and house building industry's requirements on logistic service.

1.2. Purpose

Logistic service requirements could be difficult to identify and structure but never the less important. Hence, the purpose of this paper is;

,,, to identify, structure, and compare logistic service requirements of the retail industry and house building industry.

1.3. Limitation

The study is limited to the Swedish retail industry and house building industry.

2. Concept of logistic service requirements

The most critical events that influence a company proceed externally. Customers experience a result of using and interacting with the supplier's products, services, and actions (Lanning 1998). Combinations of these elements determine to what degree they are satisfied with the company and its offers (Sharma et al.1995). Service is becoming an important part in the development of long-term relationships between the different participants in a distribution channel (Donaldson. 1995). According to La Londe et al. 1988, service could be considered as;

"a process for providing significant value-added benefits to the supply chain in a cost effective way".

According to Mattsson (1998) service can be divided into three elements: delivery, information, and logistics. It is not possible to determine which service element is most important because it is determined by the situation. *Delivery service* is considered to be such services as delivery time, delivery precision, and delivery flexibility. *Information service* is the customers' possibility to obtain information during the business process concerning, for instance, order statuses and delivery notification. *Logistics service* is referred to be the other customer services that are complementary to the physical product. This service element constitutes among other things bar-coded products, special packages, and handling of customer's inventories (Vendor

Managed Inventories). Logistics services have increased in importance more than the other customer service elements over the recent years.

Mattsson divides service into three elements all related to logistics. However, as all elements stem from logistics and logistics related activities, the classification of the service elements, as done by Mattsson, is in one way confusing. In order not to cause any misunderstandings, the following interpretation of Mattsson's concept of "service" is suggested.

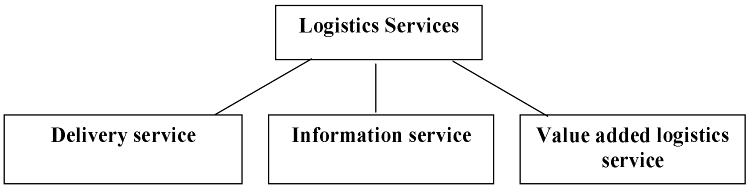

Figure 1. Logistics service elements

The element (named logistics services by Mattsson) is hereafter called "Value added logistics services" and the embracing term is logistics service.[1]

This model is generic and focuses on transaction related elements. However, by using this model it becomes possible to identify services within the process, service related to the process and services that are additional to the process. Delivery service is provided by the process, information service is facilitating and related to the process at the same time as it lays the foundation for value added logistics services. The exact logistic service requirements are dependent on each specific industry.

2.1. Previous studies on service requirements

Research on logistic services has been done since the 1960ies (Simon, 1965). Basically there are two ways; empirically or theoretically. Empirical studies started in the late 70ies and each study aims at identifying the specific logistic service requirements in different industries. The following empirical studies have been conducted with the aim of applying logistic service requirements from a retail perspective.

Table 1. Previous research on operationalisation of logistic service from a retail' perspective

Author	Year	Industries
Levy [2]	1978	Pharmaceutical
Gilmour	1982	Different
Sterling and Lambert	1987	Office systems and furniture industry
Lambert and Harrington	1989	Plastic

The following empirical studies have been conducted with the aim of applying logistic service requirements from a manufacturers perspective.

[1] There are other models of service, for instance the classical elements put forward by La Londe and Zinzer (1976). However they are less suitable for this study because of the elements existing in this industry. (Extremely long business relationships and pre-transaction and post-transaction elements do not exist and some transaction elements barely exist).

[2] Names it wholesaler, but the function described is a retail function

Table 2. Previous research on operationalisation of logistic service from a manufacturer perspective

Author	Year	Industry
Cunningham and Roberts	1974	Valve and Pump (purchase of steel)
Lambert and Sharma	1990	Chemical
Gilmour et al	1994	Chemical, apparatus and instruments
Donaldsson	1995	General manufacturing

This far no empirical study has focused on the sawmill industry.

2.2. General pattern of order process

Both retail and house building industry make use of contracts and orders in their relationship with their suppliers. In general contracts specify product and price (and in some cases volume). The lengths of the contracts vary depending on price situation.

In general orders are placed according to the following procedure.

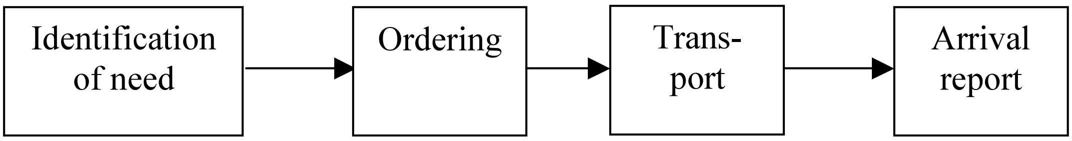

Figure 2. Order-cycle process

- *Identification of need*
  Notice (visually) when running short on products. In some cases, generation of orders is computerized.
- *Ordering - Place order*
  Orders are usually placed by telephone, mails or faxes to the sawmill and they specify;
  1) Product (specific measurements)
  2) Volume
  3) Quality
  4) Required delivery time
- *Transport*
  The sawmills arrange for the deliveries to the building house building industry. Regarding the retail industry, either the retailer arranges for the softwood lumber to be picked up at the sawmill' or the sawmill administers transport to the retailer's.
- *Arrival report*
  1) Makes a control of softwood lumber and quality control of the visible products (verify with delivery note)
  2) Registers the delivery of softwood lumber into the system (if such system

exist)

3) Places softwood lumber on the shelf

3. Empirical study

3.1. Gathering of data

Data is gathered by personal explorative interviews performed in order to identify the logistic service requirements. Purchasing managers for softwood lumber, in the retail industry, were interviewed in year 2001 and purchasing managers for softwood lumber, in the house building industry, were interviewed in year 2004.

In total nine interviews were conducted, five retailers and four house builders. Interviews were conduced until no additional aspects were revealed in the respondents' natural setting. The interviews were of explorative nature and touched upon three broad areas for discussion; the distribution channel, order cycle process and service requirements (both present and within a five year period). The nature of the interviews were unstructured and hence the respondents were asked to speak freely about the present situation and possible changes for the future, while the interviewer took a passive role posing areas and putting forward additional questions if and when needed. Validity was ensured by interviewing several purchasing managers and the answers and discussions were with regards to the same issues.2.2. Empirical data - The retail industry

The following logistic service requirements, for the retail industry, were identified in each interview.

Table 3. Logistic service requirements in the retail industry for softwood lumber Empirical data - The house building industry

Respondent	Present logistic service requirements	Future logistic service requirements
Interview 1	Deliveries according to a promised delivery time Short delivery times Possibility of fast deliveries Customization of specific products	Small delivery sizes Different assortments within each package Deviation reports.
Interview 2	Short delivery times Increased frequency and smaller delivery sizes Fixed delivery days Small package sizes	Deviation reports Bar-coded products
Interview 3	Deliveries according to a promised delivery time	Deviation reports Smaller delivery sizes
Interview 4	Short delivery times Deliveries according to a promised delivery time Customized products and packages	N.A.
Interview 5	Short delivery times Deliveries according to a promised delivery time Customized products Small package sizes	Specification of lengths and assortment to vary within a package.

The following logistic service requirements, for the house building industry, were identified in each interview.

Table 4. Logistic service requirements in the house building industry for softwood lumber

Respondent	Present logistic service requirements	Future logistic service requirements
Interview 1	Short delivery times Specified delivery date when ordering Order cycle time is reliable	Short delivery times
Interview 2	Short delivery times Specified delivery date when ordering Order cycle time is reliable	Bar-coded products
Interview 3	Short delivery times Order cycle time is reliable	Keeping supplier stock at production site Order cycle time is reliable
Interview 4	Short delivery times Specified delivery date when ordering Fixed delivery days Order cycle time is reliable	Possibility to order and receive all softwood lumber needed for one houses at the same time

4. Discussion and conclusion

In order for the sawmills to structure the logistic service requirements that their different customers are enforcing upon them, it is necessary to get a complete overview of the requirements. The following tables and paragraphs identify the requirements for each industry separately.

The identified logistic service requirements, together with its association to logistic service elements, in the retail industry, are shown in the following table.

Table 5. Logistic service requirements in the retail industry

Logistic service requirements - Retail industry	Logistic service elements
Bar-coded products	Value-added
Customization (of products and / or packages)	Value-added
Delivers according to promised delivery time	Delivery
Deviation reports	Information
Fixed delivery days	Delivery
Increased frequency and smaller delivery sizes	Delivery
Possibility of fast deliveries	Delivery
Several assortments within each package	Value-added
Short delivery times	Delivery
Small package sizes	Value-added

The retail industry has identified logistic service requirements that concern the direct distribution and delivery of products as well as some “less traditional” requirements (for instance bar-coding) as important. The retail industry appears to focus on the movement of softwood lumber and additional services to the flow. The products ought to be transported as quickly as possible to the retailers’. However, this implies that the retailers order softwood lumber in an unstructured way. If the retailer knew its stock situation and had an apprehension of customer demand, it should be possible for them to do long-term planning to a wider extent than today. In that situation the requirement of “fast deliveries” and “possibility of fast deliveries” would be diminishing and the focus might be drawn to activities that facilitate the physical and administrative flows. The additional services stem primarily from the retailers aim to reduce tied up capital in inventory and possibility to reduce administration costs.

The identified logistic service requirements, together with its association to logistic service elements, in the house building industry, are shown in the following table.

Table 6. Logistic service requirements in the house building industry

Logistic service requirements - house building industry	Logistic service elements
Bar-coded products	Value-added
Fixed delivery days	Deliveries
Keeping supplier stock at production site	Value-added
Order cycle time is reliable	Delivery
Possibility to order in "entities"*	Value-added
Short delivery times	Delivery
Specified delivery date when ordering	Information

In the same manner as the retail industry, the house building industry appears to put emphasis on the delivery of softwood lumber as well as on services regarded as Value added logistic services. However, the house building industry appears to require more customer specific services. These services imply for instance specific packages and keeping supplier stock at the production site. Keeping supplier stock at production site requires a rational handling, clearly defined products as well as it implies a trustworthy relationship between the members.

The following table illustrates the differences and similarities, regarding logistic service requirements, between the retail industry and the house building industry.

Table 7. Overview of the retail and house building industries' logistic service requirements with regards taken to the individual logistic service elements

Logistic service element	Retail industry	House building industry
Delivery	Fixed delivery days	Fixed delivery days
	Short delivery times	Short delivery times
	Delivers according to promised delivery time	Order cycle time is reliable
	Possibility of fast deliveries	
	Increased frequency and smaller delivery sizes	
Information	Deviation reports	Specified delivery date when ordering
Value-added	Bar-coded products	Bar-coded products
	Several assortments within each package	Possibility to order in "entities"*
	Customization (of products and / or packages)	
	Small package sizes	
		Keeping supplier stock at production site

* Possibility to order and receive all softwood lumber needed for one houses or apartment at the same time i.e. several assortments within each package or delivery

Some of the logistic service requirements are corresponding exactly, for instance; "Fixed delivery days", "Short delivery times" and "Bar-coded products". A majority of the corresponding logistic service requirements ought to be regarded as "Delivery service". This implies that the foundation of logistics is about the same for the retail and the house building industry and that the sawmills ought to emphasis the actual distribution of softwood lumber.

Some logistic service requirements have the same basic meaning, even though they have been expressed differently. "Delivers according to promised delivery time" and "Order cycle time is reliable" refers to the reliability of the deliveries, " Deviation reports" and "Specified delivery date when ordering" concerns planning of incoming material as well as their impact on the ordering procedure. However, deviation reports indicate a higher level of sophistication than obtaining a specified delivery date when ordering. "Several assortments within each package" and "Possibility to order in entities" concerns the supplies' adjustments to the customers' specific needs.

Some of the requirements are strictly different. The house building industry requires for instance "Keeping supplier stock at production site. "Keeping supplier stock at production site", is a VMI (Vendor Managed Inventories) solution and it requires a certain level of computerization and predetermined routines. VMI implies that the supplier keeps stock on behalf of the customer and it is thereby necessary, for the members, to understand each process and the counterpart fairly well. The retailers on the other hand require for instance "Small package sizes". This requirement concerns the retailers aim to reduce tied up capital as well as their possibilities to meet their customers' demand (i.e. end consumers) in a sufficient manner. The differences in logistic service requirements between the categories ought to stem from the underlying production process (i.e. the retail industry sells its softwood lumber while the house building industry uses it as an incoming material).

The sawmills view two customer industries that are more or less requiring basic logistic services from the sawmills. However, as "new requirements" are appearing, the distribution channel for softwood lumber is moving into a new phase. Fulfilling the basic requirements ought to be possible for all sawmills, but for sawmills aiming for success it is necessary to structure customer handling and integrate and develop their logistic processes and strategy.

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Forest Products Trade Flow Discrepancies – Unintentional and Intentional Errors

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Abstract

Forest products trade flow data consists of two observations for each trade flow. The first observation is made by an exporting country A (concerning exports to importing country B) and the second observation is made by the importing country B (concerning imports from the previously mentioned, exporting country, A). The existence of these two different observations regarding the same trade flow allows for some rather interesting investigations. Looking at trade flow statistics one often sees that reports on opposite ends of the same trade flow are contradictory. In this paper a number of possible explanations will be given. Furthermore, some suggestions will be given that might help to distinguish between unintentional and intentional data reporting faults, because the latter can be an indication for the occurrence of illegal activities.

Keywords: EU, Asia, import and export reports, reporting errors, illegal forest products trade.

Introduction

Wood products are one of the most important commodity groups traded internationally and they have a significant impact on the balance of trade in many countries. Forest products and forest resources are also at the centre of international debates on environmental protection (Peck, 2001). About one quarter of the industrial forest products produced each year enter into international trade and this trade is valued at some $150 billion per year (FAO, 2000). The "trade flow" represents a summary of the volume and the value of the effort in production and transport, of all shipments of good of a given category produced in one country and delivered to a second country in the course of one year. Information on trade flows helps to identify where the priority of those concerned with national forest products trade should be concentrated. Knowledge of international flows helps to indicate opportunities to develop markets and the supporting infrastructure to facilitate this. Information about the change in trade flows is essential for understanding the external factors influencing product trade and for assessing their impact. The power of comprehensive analysis in this area opens up completely new possibilities of understanding the existing information on trade in forest products and mobilizing it for decision-making on developing strategies to face the future (Michie and Wardle, 1998).

Trade Flow Data

To gather trade flow data is laborious, since one is dealing with many shipments of all sorts of goods by large numbers of different enterprises in one country to all sorts of enterprises in countries in the rest of the world. Official records of exports are compiled from the records of shipments collected at the point of departure, traditionally the customs post. These data are collected in relation to payment of duty or tariffs and to measure the economic activity associated with trade. The records are collected together, for all a country's customs posts, in national trade statistics. To make the assembly orderly and to make comparisons possible, the collection procedure is standardized. Value and quantity measurements, origin and destination are defined and the types of goods are classified and defined and coded. International agreements on the regulation of trade have required international standardization of these classifications and measurement standards.

The United Nations Statistics Division assembles national data on trade in UN trade statistics (UNSTAT/COMTRADE). The only comprehensive data on trade in a country is that collected by the National Trade Statistics Office. The only comprehensive statistics on international trade is that collected – from the national offices – by the United Nations. Within Europe UNSTAT is not the only one recording trade flow data into a database. The member countries of the EU are required by EU regulations, to provide their national trade statistics to EUROSTAT/COMEXT. So that is an official source for EU countries in slightly more detail than UNSTAT/COMTRADE and with slightly different standards. Figure 1 represents the main flows of trade data collection and processing within EU and EFTA (European Free Trade Association) countries. At high levels of aggregation EUROSTAT/COMEXT and UNSTAT/COMTRADE may be regarded as equal for purposes of forest products trade statistics – in aggregate the difference is less than 2% (Wardle et al., 2003). Concerning forest products FAO and the UNECE have also collected data on primary forest products and FAO publishes annual statistics of both production and total trade for all countries (oral communication Wardle, 2004). The database used for this paper – the EFI/WFSE database – is based on data from UNSTAT's COMTRADE database.

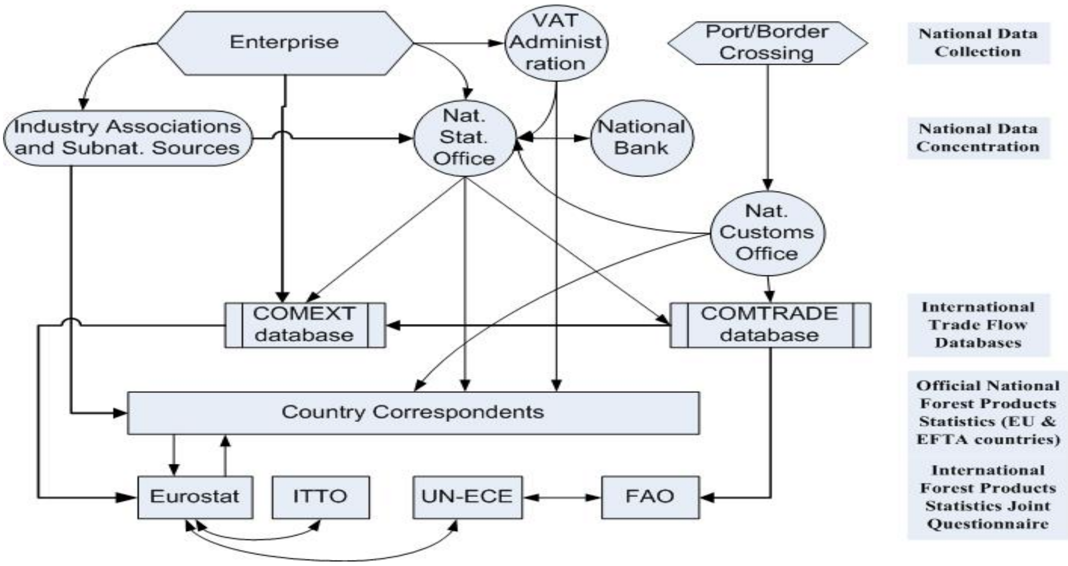


Figure 1. Flows of forest products trade and trade flow data between national and international organizations (Wardle et al., 2003).

Discrepancies

Trade flow data consists of two observations for each trade flow. The first observation is made by an exporting country A (concerning exports to importing country B) and the second observation is made by the importing country B (concerning imports from the previously mentioned exporting country A). The existence of these two different observations regarding the same trade flow allows for some rather interesting investigations. For instance, when looking at trade flow statistics one often sees that reports on opposite ends of the same trade flow are contradictory (Kornai, 1985; Michie and Wardle, 1998 & 2002; Michie et al., 2002, Johnson, 2003). That is, a user may find that what country A officially declares as imports from country B will not correspond to what country B officially, and reciprocally, declares as its exports to country A, for a given commodity in a given year (in terms of quantity and/or value). It is difficult, if possible at all, to explain the differences between two reporting countries. It is equally difficult to choose between the two given (differing) figures in order to estimate what has actually been traded from country A to country B. When a country reports to have exported a product to another country it only means that it was shipped, but does not have to mean that it was actually received by the other country. On the other hand, when a country reports to have imported a product it only means that the product was received, but it does not have to mean that it was really shipped by the country listed as country of origin. Furthermore, it is difficult to check reported trade between EU (European Union) countries, because of the lack of custom formalities that could confirm the shipment of exports or the receipt of imports – making EU trade flow statistics especially troublesome.

There are a number of possible reasons – due to unintentional mistakes – that can partly explain discrepancies:

- Time lag: an export reported in December of a given year could reach destination in January of the following year (and would only then be reported as an import by the country of destination).
- Misclassification of commodities between exporter and importer.
- Partner country mismatch – "Triangular Trade": the two reporting countries may report the place of origin or of final destination differently. Consider, for instance, an export that leaves country (A), is unloaded at the port of country (B), and is then transported by land to country (C). The exporter (A) could correctly state the country of final destination as (C), while the importer (C) could declare that the origin of the goods was country (B).
- Some countries provide data according to General Trade guidelines (all imports, exports and re-exports are reported), others according to Special Trade guidelines (only goods cleared through customs are reported. Goods in bonded warehouses and free zones are excluded).
- Data confidentiality. The exporting or importing company may choose to report a certain transaction under a secret code.
- Exported quantities could be destroyed or lost en route due to accidents, weather conditions, etc.
- Data-entry errors, such as simple typing/calculation errors when entering the data in customs database.
- Reporting periods. While most countries report on an annual January-December basis, some reporters have different periods (e.g. India is April-March; Pakistan is July-June) (FAO Statistics Division, 2004).
- Within the EU there is a problem of degree of coverage of traders particularly when they are small operators, since the EU does not try to measure 100% of products traded

as customs authorities normally would.

Illegal activities in timber trade

Illegal activities do not stop at illegal logging; rather, they include the entire market chain from illegal transport to industrial processing and trade operations, all the way down the line to markets (Contreras-Hermosilla, 2001). Although quantifying the illegal trade is by its nature very hard, the problem of illegal logging has reached proportions where in producer countries it has now in places started to undermine the rule of law. The volumes of illegal timber entering the global trade, and the current difficulties of distinguishing legal timber from illegal, make it impossible for consuming countries to verify that imported wood products are not made from illegally harvested timber, or that the trade in wood and wood products – tropical and temperate alike – is not contributing directly to deforestation and undermining good governance and the rule of law in producer countries (Scotland and Ludwig, 2002). The definitions of illegal logging vary between countries and time, and it is difficult to find a single explanation on what logging is illegal. From the legal perspective, illegal logging can be understood as logging done with the infringement of criminal law (timber robbery) or of administrative law (e.g. legally binding forest management and harvesting regulations) (Bouriaud and Niskanen, 2003).

Numerous types of illegal activities can be mentioned, but with regard to forest products trade flow discrepancies the avoidance of royalties and duties by under-grading, under-measuring, under-reporting and under-valuing of timber and mis-classification of species are most relevant (Callister, 1999; Contreras-Hermosilla, 2001).

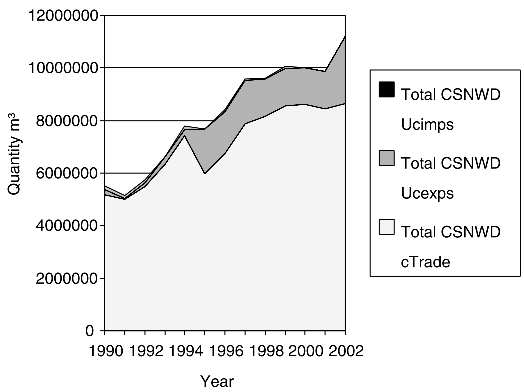
Johnson (2003) discusses the use of comparing trade data between trade partners for detecting potential instances of illegal or undocumented trade. He, however, recognizes that global analyses of all timber products using customs statistics contained in the UNSTAT/ COMTRADE database have shown that errors and other problems in statistical reporting together with legitimate reasons for discrepancies between trading partner reports may reduce the utility of such analyses for identifying potentially illegal trade flows. Nonetheless the International Tropical Timber Organization (ITTO) has found that trade flow statistics, in so far as they are reliable and when analyzed over a period of several years, and for several trading partners, can be useful first indicators for the existence and extent of illegal or otherwise undocumented trade. Johnson (2003) states that when discrepancies are consistent in direction across a range of trading partners and /or across a range of years for one or more trading partners, this can provide a strong indication of, and hence an argument for, the need for further investigation. The use of trade flow data discrepancies can also prove useful as an instrument in the frame of the recently issued EU proposal for an action plan on "Forest Law Enforcement, Governance and Trade (FLEGT)" (Commission of the European Communities, 2003). Furthermore, it is also imaginable that trade discrepancies can be used to raise awareness at the international level.

A closer look at the discrepancies

If one takes a closer look at trade flow discrepancies, several peculiar things can be seen. For one, there are numerous cases of *Unconfirmed Exports* and *Unconfirmed Imports* showing up in trade statistics. Unconfirmed exports are exports that are claimed by the exporting country, but do not get reported by the importing country. Unconfirmed imports are imports claimed by the importing country, but do not get reported as exports by the exporting country.

In the following Figures some examples are given [Source of the data: UNCOMTRADE database, standardized in European Forest Institute's WFSE database].

For figures 2 to 5 those European trade-flows (intra EU as well as from a non-EU country to an EU country) with the largest discrepancies have been selected. In Figure 2 the unconfirmed exports of coniferous sawnwood have been approximately 2 million m^3 per year over the last 7 years, which is a large proportion compared to the total confirmed trade. In Figure 3 the unconfirmed imports of coniferous roundwood have increased from approximately 500.000 m^3 to 1 million m^3 over the last 12 years, which is also a considerable proportion compared to the total trade. Apparently something goes wrong when recording trade, since the proportion of unconfirmed imports and exports is quite large for the selected trade flows. The graphs in Figures 2 and 3 are made up of several trade-flows (cf. Fig. 4 and 5, in which this trade is split up per bilateral trade-flow). Some of the selected trade-flows take place within EU boundaries; some of the other trade-flows are between EU and non-EU countries. Statistics on intra-EU trade differ from extra-EU trade with regard to reporting of trade. The European Union functions as a single market (since 1st of January 1993) and with its removal of customs formalities the traditional source of statistical data has disappeared. Beside national statistics or customs offices being a primary source of trade data, data may also be obtained from industry associations, a secondary source, which is usually used when national data are not available or considered unreliable. EUROSTAT and COMTRADE aim to collect as much trade data as possible, through a country's national statistics office. Sometimes national statistics offices may collect data only on the production of enterprises with more than 50 employees, or in case the data stems from an industry association, this association may only provide data on its member organizations (Wardle et al., 2003). This may account for some of the underreporting taking place.



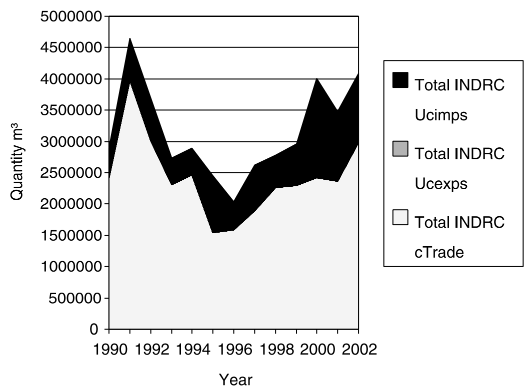
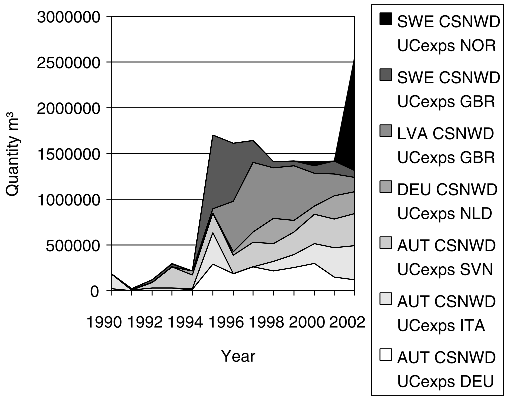


Figure 2. [left] Confirmed and Unconfirmed (Imports and Exports) Trade within Europe for Coniferous Sawnwood (selection of trade-flows within Europe with the largest discrepancies).
Figure 3. Confirmed and Unconfirmed (Imports and Exports) Trade within Europe for Coniferous Roundwood (selection of trade-flows within Europe with the largest discrepancies).

Figure 4 gives the unconfirmed exports of coniferous sawnwood of Figure 2 split up per trade-flow. Figure 5 gives the unconfirmed imports of coniferous roundwood of Figure 3 split up per trade-flow. The unconfirmed export trade-flows of coniferous sawnwood in Figure 4 are all more or less of the same magnitude. The unconfirmed imports of coniferous roundwood in Figure 5, on the other hand, reveal a single large discrepancy for the trade from Germany to Austria. Apparently a considerable proportion of Germany's exports of roundwood to Austria are not reported.



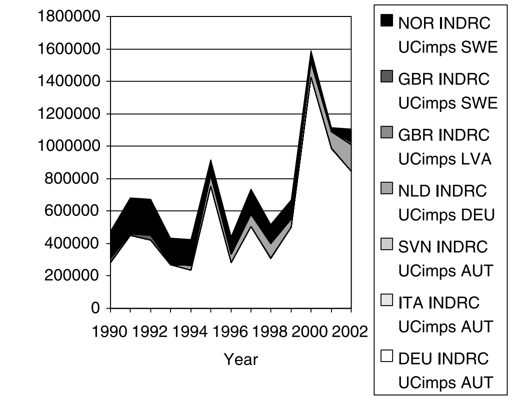
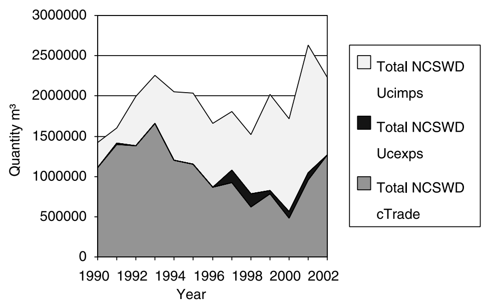


Figure 4. [left] Unconfirmed Exports of Coniferous Sawnwood for Several European Countries (split up per country pair for the unconfirmed exports of Figure 2)
Figure 5. Unconfirmed Imports of Coniferous Roundwood for Several European Countries (split up per country pair for the unconfirmed imports of Figure 3).

It is virtually impossible to pinpoint a reason for the discrepancies in a specific trade-flow. Many of the explanations given earlier could partly apply here. Companies exporting goods to another EU country could, for instance, be below the reporting limit set by national statistics offices (e.g. in the Germany-Austria trade-flow). The sum of all these unreported exports could make up a large part of the unconfirmed imports. In a sense, having a threshold for reporting is deliberate under reporting of trade. However, there are two players supplying trade data: companies and the statistical authority. A company might like to hide some transactions for its own reasons (taxation, etc.) so it under reports. The statistical authority might also like to miss some transactions for balance of trade reasons instance. This is, however, impossible to prove.



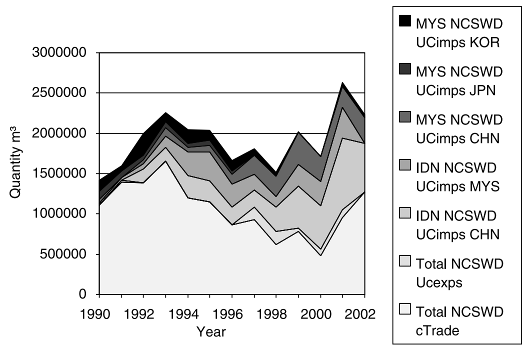
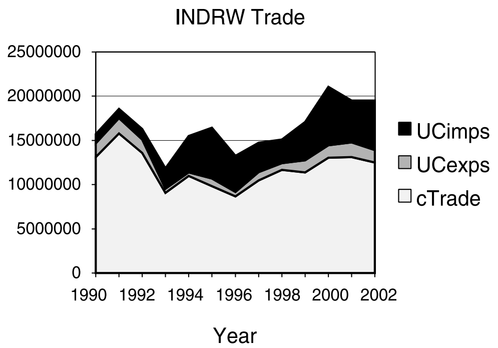


Figure 6. [left] Confirmed and Unconfirmed (Imports and Exports) Trade within Asia for Non-Coniferous Sawnwood (selected trade-flows with largest discrepancies)
Figure 7. Unconfirmed Imports of Non-Coniferous Sawnwood for several Asian Countries (split up per country pair for the unconfirmed imports of Figure 6; selected trade-flows with largest discrepancies)

Before discussing the Asian graphs it is important to note that in Asia, compared to EU trade, customs formalities exist, and hence all trade should be reported there.

In Figure 6 the confirmed and unconfirmed imports and exports for several trade-flows within Asia (those trade-flows with the largest discrepancies) are shown. As one can see the unconfirmed imports have grown larger over the years and in some years even outnumber the confirmed trade. In Figure 7 the unconfirmed imports of Figure 6 are split up per country pair trade flow. Especially the discrepancy between what China claims to have imported from Indonesia and what Indonesia claims to have exported to China is considerable. Johnson (2003) points to the same discrepancy, thereby noting that in Indonesia the problems of illegal logging and illegal trade forest products have been widely recognized. The unconfirmed imports in the Malaysia (exporter) to China (importer) trade-flow are lower, but still quite visible, something which is also mentioned by Johnson (2003). A possible explanation China's higher reported imports as compared to the Indonesian exports might be that Indonesia reports exports of non-coniferous roundwood to a "middle-man" country where the roundwood then is processed into sawnwood, which is then sent to China. Indonesia may claim exports of roundwood to China, or claim exports of roundwood to a middle-man country. China on the other hand may claim imports of sawnwood from Indonesia, since that is the origin of the timber. There is also the theoretical possibility of Indonesian companies not reporting exports, for whichever reason. But, as stated before, finding possible explanations for discrepancies is one thing, proving your hypotheses right is another. With regards to the Malaysia-China trade-flow, Johnson (2003) also mentions that part of the discrepancy could be due to different definitions of sawnwood.

According to ITTO (2003) discrepancies in the import and export data for tropical timber between China and the exporting countries of Malaysia, Indonesia, Thailand and Myanmar, for example, can arise from several sources, according to analyst Dai Guangcui. These include: the incorrect specification of origin or destination of shipment, particularly since a significant quantity of tropical timber imports to China are trans-shipped through Hong Kong; confusion in the classification of tropical and temperate non-coniferous timber; and differences in measurement standards and scaling methods. Illegal trade is likely to account for some of the discrepancies but it is difficult to assess the extent of this without a more detailed analysis of customs documents in both source and destination countries than was possible under this study. On the other hand, analysts S.Y. Chrystanto and Imam Santosa suggest that smuggling is the most significant contributor to the very large export-import data discrepancies observed between Indonesia and several importing countries (ITTO, 2003).



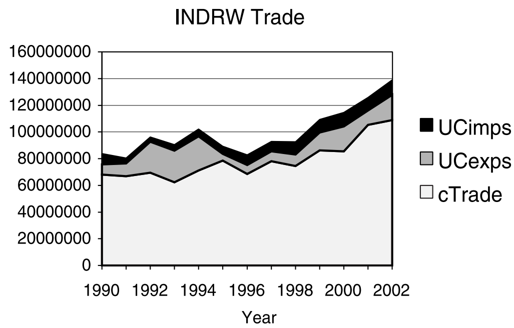
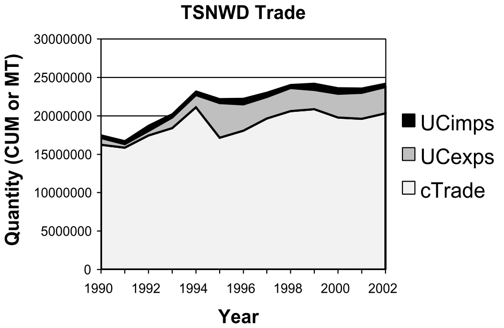


Figure 8. [left] EU Total Industrial Roundwood (coniferous and non-coniferous) Trade
Figure 9. World minus EU Total Industrial Roundwood (coniferous and non-coniferous) Trade

As can be seen in Figure 8 the EU Total Industrial Roundwood Trade has a relatively high unconfirmed import part in the graph, whereas for the world minus EU (Fig 9) the unconfirmed imports and exports are more or less of the same magnitude. A reason for the relatively high unconfirmed imports in the EU trade might be that there are many small-sized producers of roundwood that do not report their exports, because they are below the reporting limit – and since there are no customs formalities for intra EU trade these figures do not get recorded anywhere.



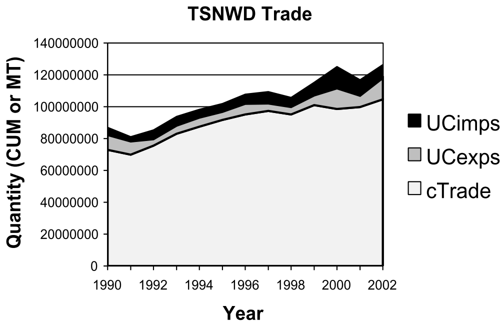


Figure 10. [left] EU Total Sawnwood (coniferous and non-coniferous) Trade
Figure 11. World minus EU Total Sawnwood (coniferous and non-coniferous) Trade

For Total Sawnwood the EU Trade (Fig 10) also behaves differently than the rest of the World (Fig 11). In the EU there is a relatively large amount of unconfirmed exports of sawnwood, whereas the World minus the EU has a more equal distribution of unconfirmed imports and exports. A possible explanation for the relatively high part of unconfirmed exports in EU trade could be that sawmills deliver the sawnwood they produce directly to construction sites or small enterprises abroad that are too small to be asked to report their imports.

Conclusions and recommendations

For policy decision-makers the numerous explanations for discrepant transactions might be interesting, but what is really important to them is that countries, which systematically misrepresent their reported bilateral trade, are identified. Identification of unreliable reporters, however, requires empirical evidence.

Gehlar (1996), for instance, proposes the use of an Index of Reliability, based on the sum of the total value of accurate partner matches as a share of total reported trade (see his paper for a detailed calculation methodology). With this index one is better to be able to assess the reliability of a country's reporting.

With regard to suggestions on how to deal with missing trade data some might argue that in the case of missing import (or exports) reports from one country regarding a bilateral trade, one might substitute this data with the export (or import) reports of the trading partner. Yeats (1995), however, concludes that partner country gap filling procedures have little or no potential for improving the general coverage or quality of international trade data, although they may be useful in cases where the trade data of a specific country are known to incorporate a large error component. The conclusion applies equally to attempts to substitute partner country directly into missing records, or where such information is allocated to missing records using some purely mechanistic procedure. Significant progress in upgrading the accuracy and coverage of trade statistics will require improved procedures for data collection and reporting at the country level.

Other suggestions on how to validate data and how to deal with missing data are given by Wardle et al. (2003). The main premise for their suggestions is that all countries check data and have procedures to follow up and revision; certain countries indicate the investigation of compatibility of data from alternative sources in deciding the best estimate; some countries utilize secondary sources when the primary source does not report or official data are suppressed for confidentiality reasons; and certain countries repeat previous period data as an estimate when current data are delayed.

It is important to keep in mind that the UNSTAT/COMTRADE and EUROSTAT/COMEXT depend on competent national authorities to submit correct data. For this reaso Wardle et al. (2003) make the following recommendations:

- Validation as much as possible at the national level
- Data from secondary sources should be provided by the national correspondent
- The use of a secondary source by the international collecting agency be acceptable to the national correspondent
- A secondary source should be used in preference to missing data in the case of non-response by the normal source

In general one should also consider establishing oversight by independent observers where there may be a conflict of interest by those required to report trade and those charged with collecting trade statistics. It might be worthwhile to study what impact these discrepancies might have on the measurement of EU production statistics as well as on total imports and exports within the EU.

Acknowledgements

The author wishes to thank Dr. Bruce Michie (EFI), for without his expertise on forest products trade flows and the EFI/WFSE database this paper would not have been possible.

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Managing the Sawmill with Product Costs – A Simulation Study

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Abstract:

This paper analyzes the effects of using product costs derived from an LP-model for managing the salesmen's efforts at a sawmill company. The salesmen are not controlled by sales quota, as is usual, but assessed by the accounting profit they generate. The analysis is realized by computer simulation experiments under various assumptions on sales response and the mill's flexibility in purchasing timber. The cost figures are recalculated in each period. The results indicate that the success of the approach decreases with the length of the recalculation period, and increases strongly with the mill's flexibility in purchasing timber.

Keywords: joint cost, product costing, linear programming, sawmilling, lumber costing, sales management.

1. Introduction

Several Swedish sawmill companies have recently developed product-costing systems for lumber products, possibly to meet the needs of new organizational set-ups and new market conditions. The market organizations have been changed from decentralized ones where a salesman was responsible for the sales of a single sawmill, to centralized organizations where the salesmen are responsible for specific markets or customers with products taken from several mills. An advantage of these new organizations may be better opportunities to coordinate marketing and production in the group. It may also facilitate specialization of salesmen in markets and customers, which may be of increased importance as markets change towards larger customers with increasingly specific needs.

The marginal cost of lumber is complicated due to the joint costs character of the production, where several products simultaneously are sawn from one log.

Several of the recently developed systems for cost calculation are founded on arbitrary allocation methods and may be expected to give deceptive product costs. Johansson and Rosling (2002) describe some of the methods and test them on a small sawmill case, which shows large discrepancy between calculated and theoretical defensible costs. Similarly, Balachandran and Ramakrishnan (1981) derived some cost allocation rules by game theory. Their rules are equitable, but not relevant for decision-making.

Manes and Cheng (1988, p. 123) discuss joint production in variable proportions, which is similar to sawmill production. The sawmill may typically obtain a desired mix of products by varying the amount of logs sawn according to a specific pattern. This flexibility may be limited, though, by insufficient flexibility in timber procurement and in the sawing process. The present paper derives the marginal costs of lumber products by an LP model of sawmill production that includes restricted flexibility in timber supply. The purpose of the paper is to analyze the economic effects of using the product costs to manage the salesmen's efforts.

Following Balachandran et al. (1997) the analysis relies on simulation.

Section 2 describes the long run planning problem. The characteristics of product costs in sawmills are discussed in section 3 and a theoretical defendable method for allocating the costs is outlined in section 4. Section 5 describes how demand is assumed to respond to sales efforts, and sales efforts to accounting profits. The simulations are described in section 6. Section 7 presents the results and section 8 concludes.

2. The Planning Problem

The objective of the company is to maximize long-run profit. Theoretically, the optimal production and sale may be found through maximizing a mathematical model that describes the long-run cost and revenue functions of the manufacturing and sales processes. When the optimal solution is found, all activities should be directed in a way that fulfils the plan. However, there is a considerable disadvantage of this approach.

One of the most obvious difficulties in practice is presumably to estimate the effects of the sales efforts, and thereby formulate accurate cost- and revenue functions of the sales (Cheng and Manes, 1992). This is possibly even more marked when the share of non-standardized business deals without known market prices increases, which tends to be the case for several sawmill companies.

An alternative approach would be to divide the planning problem into two parts: one production problem and one marketing problem. The production-planning problem should minimize the costs of production. The marketing problem should strive after maximizing the profit of the sales work. The salesmen have to estimate the revenues and costs of their sales efforts, and by that maximize the marketing profit. Decentralizing these decisions to the salesmen would be an important advantage compared to the non-divided optimization approach. However, to find the optimal solution for the whole company in this decentralized approach, the salesmen have to know the marginal costs of production. Given the current sales, D_k of product k, these cost are calculated through the dual of the following LP problem:

LP: $0\ \mathrm{IQ}_{\geq 0}\ \Sigma_i C_i X_i$ (1)

such that $\Sigma_i a_{ki} X_i\ {}^3\ D_k$, for each product, k. *(2)*

Here C_i is the variable costs of sawing pattern i, X_i the amount of sawing pattern i and a_{ki} the yield of product k in sawing pattern i.

The associated dual that calculates the product costs, Π_k for product k, is then

DLP: $\mathrm{Max}_{P^30} \Sigma_k \Pi_k D_k$ *(3)*

such that $\Sigma_k a_{ki} \Pi_k \leq C_i$ for each sawing pattern, i. *(4)*

The interaction between the production-planning problem and the marketing-planning problem is illustrated in figure 1. The salesmen communicate their sales results to the sawmill, which returns the current marginal costs.

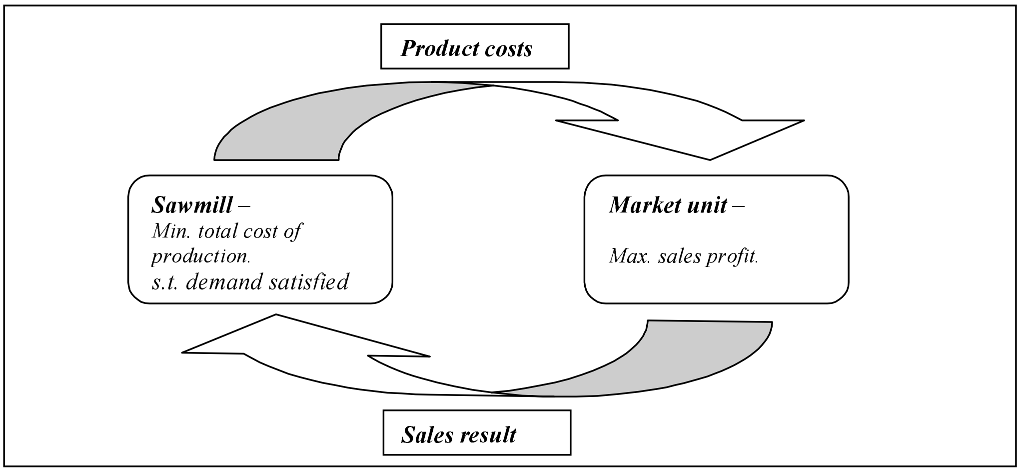

Figure 1. The optimization problem is divided in two parts - production and marketing. They are coupled with product costs and sales result.

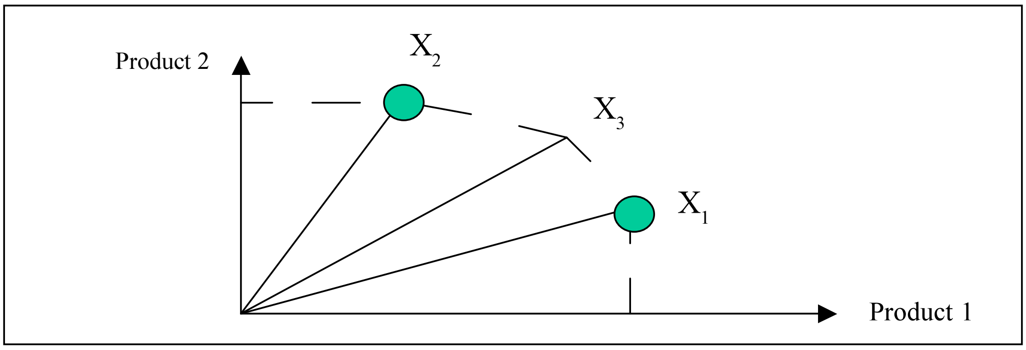

Figure 2. Iso-cost curve for lumber production. X_1, X_2 and X_3, respectively, correspond to a specific sawing pattern.

However, the joint cost character of the sawmilling process may raise doubts about using the product costs to manage the sales efforts. Even if the costs are calculated with a theoretical defensible method, the costs typically change with the sales.

3. The Product Costs

In contrast to the assembling industry, where product costs can be considered to be separable and constant in the long run, lumber cost are typically inseparable. This implies that the iso-cost lines are not linear but built up by linear segments, and consequently, the marginal costs are not constant. Since the marginal cost of a product may change as sales change, the planning had probably better be organized as an iterative process, with the marginal costs frequently recalculated.

4. Calculating the Cost of the Boards

The cost of a sawing pattern includes all costs accumulated up to the sawing, including the timber cost and minus net revenues from by-products, i.e., sideboards, cellulose chips, bark and saw dust. Costs after the sawing point, e.g. drying-, grading- and packaging costs reduce the market prices.

Some of the characteristics of the LP model are:

· Only the marginal costs of centre boards (main products) are calculated.

· The sales volumes of all centre boards are fixed to their present level.

· Market prices for all by-products are fixed.

· Restricted timber supply – saw classes are available in fixed or semi-fixed proportions.

Technically, this is realized by adding the following constraints to *LP,*

$$(1/r)\, q_t \Sigma_i X_i \leq \Sigma_i \varepsilon_{it} X_i \leq r\, q_t \Sigma_i X_i \quad \text{for each log type, t,} \qquad (5)$$

where e_{it} equals 1 or 0 depending on whether pattern *i* requires log type *t* or not, q_t denotes the proportion of log type *t* in today's timber supply, and r and 1/ r denote the max possible changes of q_t. The dual formulation, *DLP,* changes correspondingly.

· The marginal costs of centre boards are restricted by upper and lower bounds (max/ min prices).

Technically, this is realized by adding to *DLP* the constraints

$$P_k^{min} \leq \Pi_k \leq P_k^{max} \textit{ for each product k,} \qquad (6)$$

with corresponding changes in the primal formulation, *LP*.

The upper bound (max price) on the marginal cost may be interpreted as the marginal cost for the mill of buying the board externally. The lower bound (min price) may be interpreted as the net marginal revenue of selling surplus quantities (typically to non-regular customers). See Johansson (2002) for a detailed formulation of the LP model and interpretation of the product costs of the dual formulation.

5. Modelling the Sales Response

Through purposeful sales work, the demand of each product can be increased or decreased from one sales period to another. In each period, the salesmen are assumed to strive to change the sales volume of each product to maximize the accounting profit, i.e., the total revenues minus product costs minus selling costs. The market organization's problem may be stated as:

$$\text{Max}_{T^{3}0}\ \Delta\text{Profit(T)} = \Sigma_k((P_k - \Pi_k)\,\Delta D_k) - \Sigma_k\,(L\,T_k), \qquad (7)$$

Where P_k denotes the market price minus costs after sawing, DD_k the sales change, T_k the sales time (h) and *L* the sales cost (SEK/h). Subscript *k* denotes the product.

The Sales Response

Since the salesmen have to work with more demanding customers the more they sell, the sales increase effect is assumed to diminish when the sales volume increase. When the salesmen want to decrease sales, they are similarly required to work harder the greater the decrease. These assumptions implicitly mean that the salesmen in advance can estimate how difficult it will be to change the sales to a specific customer and so, allocate their sales time in an optimal way (cf. Beswick, 1977).

Additional notations:
a_k = sales increase of a sales hour when the current sales volume is 0 m^3, product , *k*
b_k = change in sales effect due to volume, b_k ³ 0 for all *k*,
h_k = sales decrease per sales hour when the current sales volume is 0 m^3, product *k*,
PROF = set of profitable products, i.e., *k* for which $\boldsymbol{P_k}$ ³ Π_k
UNPROF = set of unprofitable products, i.e., *k* for which $\boldsymbol{P_k} < \Pi_k$.

A schematic view of the sales response presents in fig. 3.

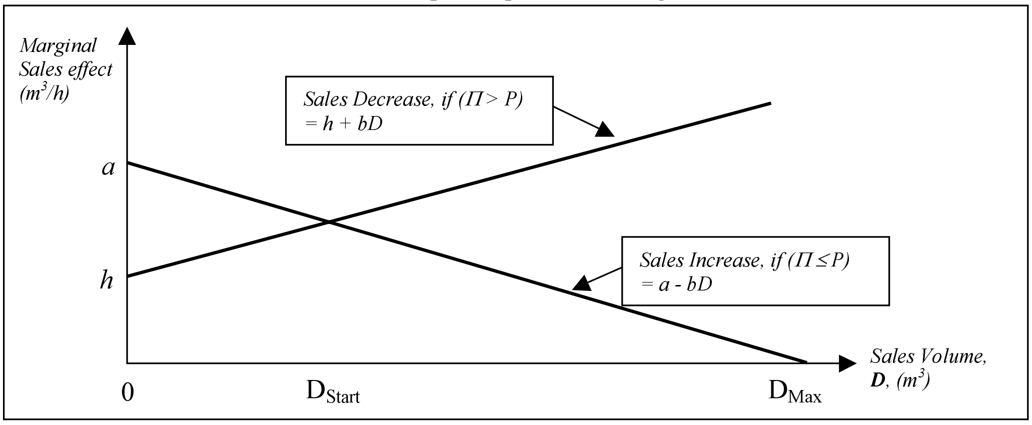

Figure 3. Schematic view of the sales model. In the tested cases, the marginal effect for sales increase and decrease are equal at today's sales volumes. D_{Start} denotes today's sales of the product. Note that sales volume cannot exceed D_{Max}

Volume change – increase (*k Î PROF*) is stated as:

$\Delta D_k = \{a_k - b_k\, [D_k + (D_k + \Delta D_k)]/2\}\, T_k$ or

$$\Delta D_k = (a_k - b_k\, D_k)/(1/T_k + b_k/2). \qquad (8)$$

Minimizing (8) now gives:

$$T_k^* = \{(2/b_k)[\{(P_k - \Pi_k)\, [a_k - b_k\, D]/L\}^{1/2} - 1]\} \qquad (9)$$

Substituting T_k^* into (8) gives:

$$\Delta D_k = (a_k - b_k\, D_k)/(b_k/\{2[\{(P_k - \Pi_k)\, [a_k - b_k D_k]/L\}^{1/2} - 1]\} + b_k/2), \qquad (10)$$

which expresses the expected sales increase from one period to the following.

Volume change – decrease (*k* $\in$ *UNPROF*)

Analogous to profitable products, the expected sales decrease for unprofitable products may be derived as:

$$\Delta D_k = (h_k + b_k D_k)/(b_k/\{2[\{\Pi_k P_k)[h_k + b_k D_k]/L\}^{½} - 1]\}+b_k/2) \quad (11)$$

6. The Simulation Model

The calculations are based on a Swedish pine sawmill, which belongs to a large sawmill group. The mill, which has a yearly sales budget of about 160 000 m^3 and 152 main products (combinations of width, thickness and quality), makes and sells products mainly to the furniture and joinery industries. Production capacities, costs and product prices were collected from the company's present costing system. These data were further processed in Microsoft Excel, Microsoft Access and in a program developed in Microsoft Visual Basic. LINGO from LINDO software Inc. was used to implement the LP model.

When the coefficients in the sales model were determined, the average sales changes per hour were compared with actual average change per sales hour in the company. However, the observable sales work concerns mainly preservation of the current sales budget and not sales work that actually change the budget, which is the aim to mimic in the present study. Therefore, the modelled sales changes were set considerably lower. It was assumed that the company could increase the sales of a product three times the volume of the present budget, i.e. D_{Max} in fig. 3 was set to $3D_{Start}$. Furthermore, the marginal sales effect (both increase and decrease) in today's budget was calculated as 0.5 % of the product's volume. These facts together with the linearity assumption determine the coefficients *a, b* and *h*. For each product, the coefficients *a* and *b* were solved with the two related equations:

$$\begin{cases} 0.005D_{Start} = a - bD_{Start} & (12) \\ 0 = a - 3bD_{Start}, & (13) \end{cases}$$

Equation (12) corresponds to the marginal sales increase at D_{Start} and (13) at D_{Max}.
Coefficient *h* was then solved by (14):

$$0.005D_{Start} = h + bD_{Start}, \quad (14)$$

which corresponds to the marginal sales decrease at D_{Start}.

Thus, $b = 0.0025$ for all products. Coefficients *a* and *h* differ among products dependent on their present sales. The variable sales cost, *L*, was set to 1000 SEK/h.
To imitate the tardiness in sales response, the maximum sales change in each period was restricted by:

$$\Delta D_k \leq z D_k, \quad (15)$$

where *z* was set to 10% and 30% to imitate different length of the period between the recalculations of the product costs. An adjustment of the coefficients in the sales model would have given a similar effect, but then it would have been necessary to adjust the coefficients for each product to obtain realistic responses. The constraint (15) was considered a reasonable simplification to avoid excessive computational efforts.

The max and min values of the products costs, (6), were calculated as 1.5 and 0.5 times the net market prices, respectively. The timber flexibility, r in (5), was set to 1.1 and 2.0. The two cases are referred to as 10% and 100% timber flexibility, respectively. The simulations started by calculating the marginal costs of the products assuming today's sales budget. In the next step the marginal cost were used to direct the marketing efforts, which in turn gave a new sales result that was used in the next iteration. The iterations were repeated 20 times.

7. Results

Sales Changes

When the product change, *z*, were restricted to 10%, which means that the costs are recalculated in short intervals or that the sales change slowly, resulted in a somewhat increasing profit of the sawmill (fig. 4). The profit is calculated as the revenues of all products minus the total (real) costs of manufacturing and sales.

The case with z = 30% tests a longer period between cost recalculations. Fig. 4 shows that the total net profits of the sawmill then had a negative trend. The salesmen changed the sales too much in each period for the calculated product costs to remain valid.

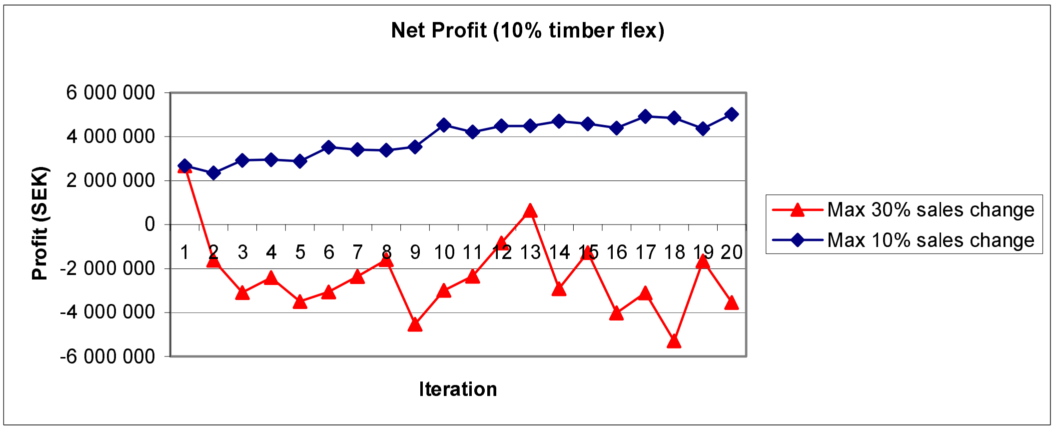

Figure 4. Net profit assuming max 10% and 30% sales changes per product and iteration. 10% timber flexibility.

In the 30% case the actual total sales change was, in average, about 20% per iteration. In the 10% case, the total sales change was about 5% per iteration.

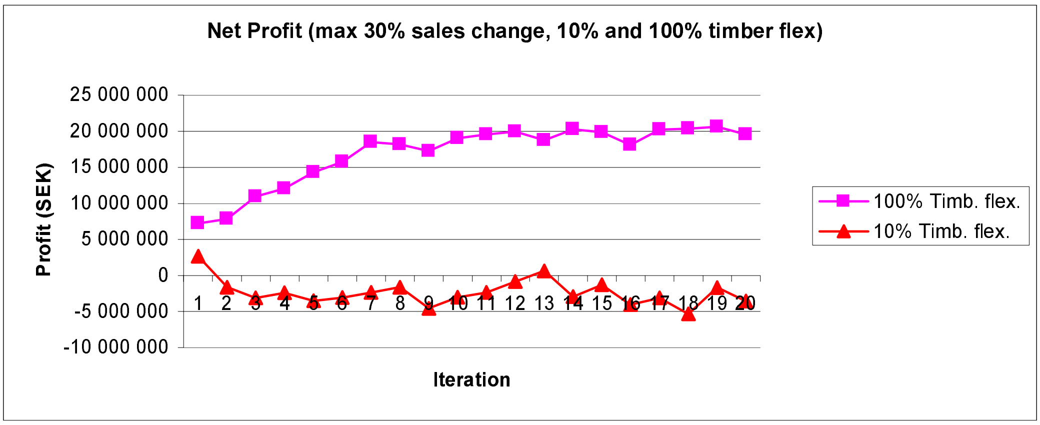

Figure 5. Net profit assuming max sales change restricted to 30%. Timber flexibility 100% and 10%, respectively.

Flexibility in Timber Supply

Figure 5 shows the profit trend with 100% and 10% timber flexibility. It is worth noting that 100% flexibility gave an increasing profit trend although the max sales change was restricted to 30% per iteration and product.

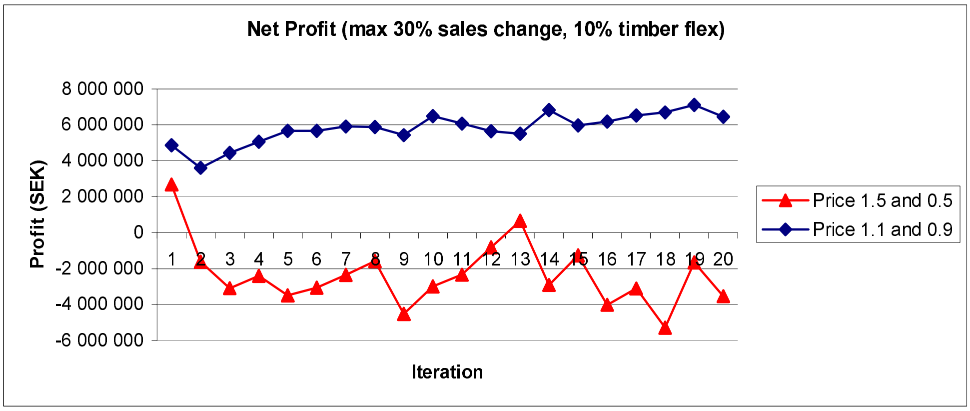

Figure 6. Profit of the sawmill. Max and min prices calculated as 1.5 and 0.5 times the market price, respectively, compared to max and min prices calculated as 1.1 and 0.9 times the market price, respectively. Timber flexibility 10% and max sales changes per product and iteration 30%.

Assuming max 10% or 30% sales changes and 100% timber flexibility, the average profit increased from about 50 SEK/m^3 to 100 SEK/m^3. With 10% timber flexibility, 10% sales change made the average profit to increase slightly, whereas it decreased with 30% sales change per period.

Max and Min prices

If the gaps between the max and min prices shrink, the estimates of the marginal cost would be less erratic and the period between recalculations of the costs may be extended. Figure 6 shows that if the max and min prices of each product is closer to the market price, where the max price is calculated as 1.1 times the market price and the min price 0.9 times the market price, the trend of the company's profit is positive, whereas it is negative when the max price is calculated as 1.5 times the market price and the min price as 0.5 times the market price.

Implied Sales Changes

Figure 7 shows the trends of the average sales change per period for some of the tested cases.

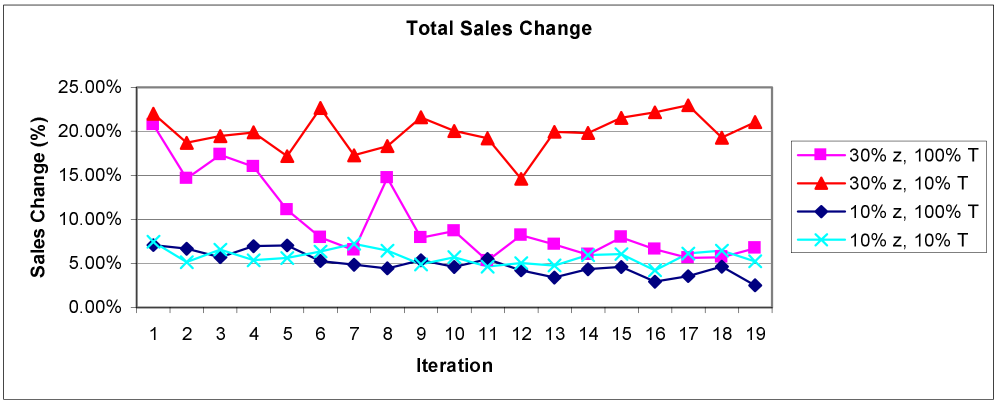

Figure 7. Average sales change per period (proportions of total sales). z denotes max sales change, and T denotes timber flexibility (=r-1).

The negative trend in the case of max 30% sales change and 30% timber flexibility may be explained by the fact that the costs of the products are successively coming closer to the prices. The rapid change might be a sign of great efficiency in the allocations of sales efforts.

8. Concluding Discussion

The tested cases show that restricted flexibility in timber supply, which probably is a quite realistic assumption for many Swedish sawmills, and relatively high costs for selling surplus quantities and buying products in short supply, the product cost have to be recalculated in short intervals. When the sales changes were restricted to 0.1 times the current volumes, there was a positive trend in the long run profits. The average sales change was then about 5%, which corresponds to about 8000 m^3 at the present annual sales of 160 000 m^3. Today, about 70% (112 000 m^3 p.a.) of the sales concern renewed contracts and about 30%(48 000 m^3) are sold to new customers or concern sales changes to regular customers. This may imply that the sawmill has to recalculate the product costs about 48 000/8000 = 6 times per year, which perhaps is an impractical short interval.

However, when the flexibility in timber supply was assumed to increase to 100%, which probably is quite optimistic, the long run profit had a positive trend also when the sales changes were increased to max 0.3 times the current sales volumes, with an average sales change of about 20% in the first sales periods. This should imply recalculation of the product costs between once and twice a year (48/[0.20x160]), probably a quite practical interval.

When the costs of selling surplus volumes and buying products in short supply decreased, there was a positive trend in the long run profit also when the sales changes were restricted by max 0.3 times the current sales volumes. This is probably an effect of fewer or possibly smoother breakpoints in the iso-cost line (c.f. fig. 2), which may give fewer or smaller shifts of the product costs, and therefore more stable cost estimates.

From figure 2 it can be concluded that the marginal cost of a product with unchanged sales may alter when the volumes are changed for other products, which may strengthen the error in the marginal cost estimate, of course. This effect possibly reduces if a large part of the product volume is considered as by-products, which are sold in arbitrary amounts to fixed market prices. However, it is difficult to predict the actual effect of reducing the number of main products, but in general one would guess it should have a positive effect on the cost estimates. Figure 8, which should be compared to fig. 4, shows how the long run profit evaluates when the max sales changes are restricted to 30% of the current volumes and 89 of 150 centre products are by-products.

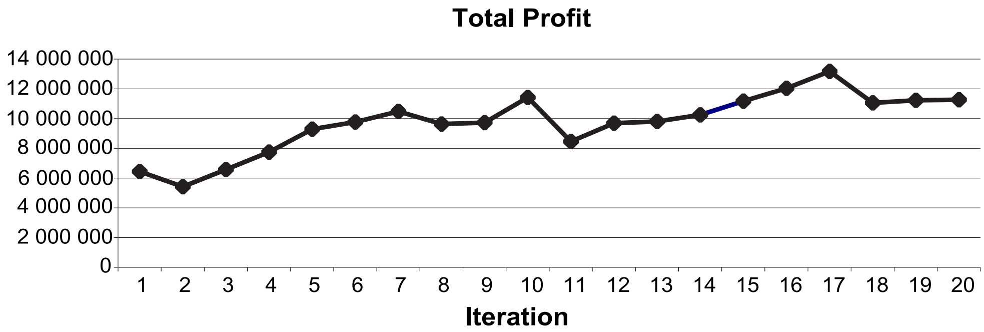

Figure 8. Total profits. Assuming 10% timber flexibility, max 30% sales change per product and iteration. 89 of 152 centre products were considered to be by- products, sold in arbitrary amounts to fixed market prices.

Thus, a sawmill with only a minor part of its production as main products may have easier to manage its sales force through product costs.

Even when the max sales change was restricted to 10% per period, the marginal costs of several products changed considerably between iterations. This may obviously confuse the salesmen that will use the cost figures to allocate their efforts – just a small sales change may make a highly profitable product an unprofitable one and vice versa. Therefore, to obtain organizational confidence of the cost figures, it would be important that the users understand the specific costing situation and its consequences for the cost figures. The excerpt in figure 9 shows that some products have a relatively unchanged marginal cost, whereas other changes considerably between iterations.

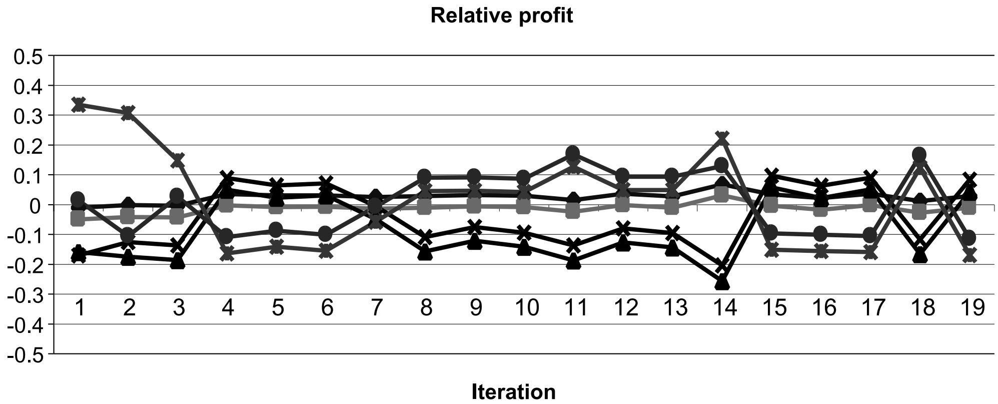

Figure 9. Relative profit measured as the profit divided by the net market price. Six qualities with dimension 38 by 175 mm. 100% timber flexibility, max 10% sales change per product and iteration. Max and min prices calculated as 1.5 and 0.5 times the net market prices, respectively.

The calculated marginal costs concern the long run cost of production. Thus, the implied sales efforts may break short-run capacity constraints, and create waiting lines of customer orders. However, these waiting-lines were not modelled in the simulated cases. An important motive for using long-run costs is that they may create incentives to change the capacities in the right direction.

Technically it would be quite easy to consider the short run costs through extending the cost allocation model with restricted max capacities of all possible bottlenecks. The problem, at least in practice, would rather be to decide the capacity restrictions since they typically depend on the present production situation and may change considerably when the share of different sawing patterns change. In addition, more constraints will presumably make the calculated product cost figures even more erratic.

In the simulations, the salesmen were strictly assumed to optimise their accounting profit. Further research may demonstrate how to design effective reward systems that motivates this salesman behaviour.

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What Drives, Hinders, and Enables Internationalization among Swedish Furniture Producers?

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Abstract

The internationalization of small and medium sized companies has recently received an increased amount of attention. However, no existing model or theory manages to satisfactory explain this process, which is indicated by the varying results from empirical studies. The prime interest of this study is to investigate what drives, hinders, and enables the internationalization of Swedish furniture producers. Thus, the focus is not directly on the internationalization outcomes or activities, but rather on the influencers and their impact on the process. The influencers refer to a firm's key decision maker, the internal organization, and the external environment of the firm. All three influencers simultaneously impact the process by driving it, hindering it, or enabling the firm to overcome the barriers. The empirical material will be collected among small and medium sized Swedish furniture producers. Multiple-case studies will be complimented by an industry wide survey.

Keywords: SMEs, key decision maker, internal organization, external environment

1. Introduction

Accelerated internationalization is becoming a "fact of life" (Ahokangas, 1998, pp. 170) for small and medium sized enterprises (SMEs) (Axinn and Matthyssens, 2002; Chetty and Campbell-Hunt, 2003; Coviello and McAuley, 1999). To study what drives, enables and hinders internationalization among SMEs should therefore be an important research topic. The industry providing the empirical data for this research is the Swedish furniture industry and in particular the producer segment. For a list of definitions of important terms used in this paper, see Table 3 on page 9.

1.1 Theoretical Problematization

Internationalization of SMEs is a complex issue and to consider small and medium sized firms under-sized version of large firms would be a mistake. However, the existing theories and models for internationalization are developed with regards to larger companies and corporations (Coviello and McAuley, 1999, Chetty and Campbell-Hunt, 2003), which is why problems arise when applying the same rules and explanations to the smaller enterprises (Holmlund and Kock, 1998). Also, the traditional internationalization theories were developed during the 1970's and have not been modified or updated along with the internationalization processes in which firms are involved (Axinn and Matthyssens, 2002). Even though the field of SME internationalization has received increasing attention lately (Korhonen et al., 1996; Knight, 2000), empirical support for existing models remains mixed (Coviello and McAuley, 1999; Axinn and Matthyssens, 2002). The internationalization models referred to here include the learning and innovation adoption models, the eclectic decision making model, the resource and capability based approach, and the network approach.

The overall problem-platform of this research refers to the theoretical gap, or un-developed theories, that exist with regards to internationalization of SMEs as briefly mentioned above. Penetrating the subject further by investigating the three factors that simultaneously influence the internationalization process might therefore be fruitful. The three influential factors include the key decision maker, the internal organization and the external environment of the firm (Axinn and Matthyssens, 2002; Fillis, 2002; Leonidou, 1995). How these factors influence the process is through driving and hindering it (Leonidou, 1995), but also by enabling the firm to overcome the barriers.

Extensive material on internationalization barriers exists, even though most of these studies were conducted in the 1980's (Fillis, 2002). Other studies focus on what drives or stimulates export, while the enablers of internationalization seem to be less frequently researched. Also, the relationships between the drivers, hindrances and enablers behind SMEs internationalization are not well established, neither are their origins. Moreover, while most empirical internationalization studies are cross-sectional, the process is considered not only time, but also industry, dependent (Westhead et al, 2001). Fillis (2002, pp. 912) states that "Industry specific studies are needed in order to elicit particular differences". Therefore, it should be beneficial to focus on one specific industry segment to enable a more comprehensive understanding.

1.2 The Swedish furniture industry

Approximately 860 firms make up the Swedish furniture industry, providing employment for about 18,000 people (Trä & Möbel Forum, 2003). Firms within the industry are often small and medium sized with limited resources. This makes it hard for them to become independently involved in international business. In 1996, 98% of the industry members had less than 200 employees (NUTEK, 1997).

Competition from foreign firms is increasing and it is creating a hostile environment for the Swedish furniture producers on their domestic market. One indication of this is the difference in import and export development trends. While import increased with over 27 percent between 2000 and 2003, exports decreased nearly one percent, see Figure 1. One possible explanation for the increased level of import might be the low entry barriers to the Swedish market. Another explanation can be increased interest from the Swedish producers to import parts and components in an attempt to improve their overall competitiveness.

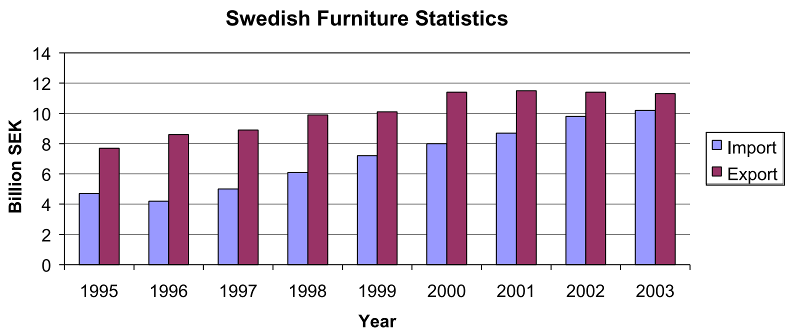

Figure 1. Overview of the Swedish furniture industry considering import, export, domestic consumption and total production (Source: TMF, 2006-06-07)

Since firms operating within small domestic markets have been found to depend heavily on export (Melin, 1992), it is interesting to note that only a minority of the small and medium sized furniture producers reach past the Nordic region. Low level of education and insufficient competence are examples of hindrances facing these firms (NUTEK, 1997; SIND 1986:10). In 1972 it was concluded that the main industry-specific barriers for market entry were related to language, transportation and business contacts (SOU 1972:2). The above barriers might still exist, but conclusive statements like these are not fair to make since the industry is quite heterogeneous. Some of the furniture producers show a high level of performance and have reached many international markets, while the vast majority have not.

Among the more acknowledged studies focused on the Swedish furniture industry is a study of strategic groups (Brege et al., 2001). In this study it is concluded that the disadvantages facing the average Swedish furniture producer with regards to export are: company size, sustainability, and lack of focus during a launch. However, Brege's study ends where an internationalization analysis would begin.

1.3 Research question and purpose

Taken together, the above discussion encourages further and deeper penetration of the internationalization process among the small and medium sized Swedish furniture producers. The focus of this research is therefore on the influential factors and their impact, rather than on the outcome of the internationalization process. The research question reads *what are the reasons behind different internationalization approaches among the Swedish furniture producers?* The purpose of this research is to *explore and describe what drives, enables, and hinders internationalization among the Swedish furniture producers.*

2. Theoretical framework

A firm's internationalization process is influenced by the key decision maker, the internal organization and the firm's external environment. After discussing each one of these factors, their potential impact will be further developed.

2.1 The key decision maker

The key decision maker of a smaller firm has a strong and direct impact on the firm (Holmlund and Kock, 1998) and therefore also on the firm's international involvement. Within the SME internationalization literature the following decision maker characteristics have been identified as potential influencers of the internationalization process: demographics (Riddle and Gillespie, 2003); educational background (Leonidou and Katsikeas, 1996; Riddle and Gillespie, 2003; Chetty and Campbell-Hunt, 2003; Czinkota and Ronkainen, 2001); level of international exposure (Czinkota and Ronkainen, 2001) and experience (Fletcher, 2001); country specific and general market knowledge (Rhee and Cheng, 2002); as well as attitude (Korhonen et al, 1996) and commitment (Czinkota and Ronkainen, 2001).

2.2 The internal organization

Even though SME internationalization is clearly influenced by organizational factors, few studies has taken this into consideration (Leonidou, 2000) Here the internal organization's influence on the internationalization process will be described in terms of firmographics and strategy. Firmographics (Riddle and Gillespie, 2003) refer to firm-specific attributes such as: firm size and age (Riddle and Gillespie, 2003; Eriksson et al, 2000; Moen, 2001); geographic market focus (Moen, 1999; Fletcher, 2001; Eriksson et al, 2000); export intensity (Riddle and Gillespie, 2003; Fletcher, 2001; Moen, 2001), ownership (Riddle and Gillespie, 2003; Korhonen, 1996) and business language (Holmlund and Kock, 1998; Moen, 2001). A firm's strategy is naturally closely linked to the firm's key objectives, which is not always growth. Chetty and Campbell-Hunt (2003) identified maintenance of control, access to and acquisition of resources as other key goals. It is logical to believe that the firm's main objective should affect what drives the internationalization process. Other strategy issues of relevance here are the firm's competitive advantage (Leonidou and Katsikeas, 1996; Moen, 2001, 1999); international responsiveness; R&D focus; and market approach (Moen, 2001).

2.3 The external environment

The third influencer of a firm's international process is to be found within the external context of the firm. The external environment can be divided into domestic (Leonidou, 1995) and foreign industry specific issues and refers to for example the markets' characteristics (Rhee and Cheng, 2002) and attractiveness (Moen, 2001).

2.4 Drivers

Many different internationalization drivers have been identified. These drivers can be divided into proactive, reactive and incidental depending on their nature (Moen, 1999). In Table 1 shows some of these different kinds of drivers presented along with the origin of each driver.

2.5 Barriers

Within the extensive literature on entry barriers facing SMEs in their inter-nationalization process, different authors group barriers differently. Leonidou (2000) discuss attitudinal, structural, procedural, and operational barriers, while Westhead and his colleagues (2004) use the following groupings: strategic, informational, process-based, and operational. In this research barriers will be grouped into psychological, operational, product & market related, and organizational (Hamill, 1997), see Table 2.

2.6 Enablers

What enables firms to overcome international business barriers seem, compared to research related to barriers and drivers, much less studied. Based on the same structure used to discuss barriers and drivers, the enablers will be categorized based on the firm's key decision maker, internal factors and external environment. One important internationalization facilitator linked to the key decision maker is inter-personal relationships. These relationships are informal ties between the decision maker and other people active outside the organization. Examples of inter-personal relationships are social networks (Björkman and Kock, 1997) and friends and family (Riddle and Gillespie, 2003).

Proactive drivers	Example	Source
Key decision maker	Perceived market opportunities	Moen (1999); Andersen & Kheam (1998)
	Management interest & attitude	Holmlund & Kock (1998);
		Calif & Beamish (1995)
	Management experience & skills	Moen (1999); Calif & Beamish (1995)
Internal organization	Growth as a goal	Westhead et al (2004); Moen (1999);
		Holmlund & Kock (1998)
	Unique products need larger market	Czinkota & Ronkainen (2001)
	Accumulated internal knowledge &	Eriksson et al (2000); Riddle & Gillespie
	competence	(2003); Bonaccorsi (1992)
External environment	Tax benefits	Czinkota & Ronkainen (2001)
	Favorable exchange rate	Westhead et al (2004)
Reactive drivers		
Internal organization	Excess capacity & overproduction	Czinkota & Ronkainen (2001); Moen (1999)
External environment	Unfavorable domestic market	Westhead et al (2004); Moen (1999, 2001);
		Czinkota & Ronkainen (2001); Fletcher (2001)
	Demand from customers & partners	Westhead et al (2004); Holmlund & Kock
		(1998); Johanson & Vahlne (1990)
	Need to level out seasonal variation	Westhead et al (2004); Moen (1999)
Incidental drivers		
External environment	Initiatives from abroad	Westhead et al (2004); Moen (1999);
		Holmlund & Kock (1998)

Table 1. Proactive, reactive, and incidental internationalization drivers.

Formal, inter-organizational relationships might also help the firm overcome barriers. Examples of such relationships include business associations (Riddle and Gillespie, 2003; Chetty and Campbell-Hunt, 2003); incubators (Riddle and Gillespie, 2003); support agencies (Coviello and McAuley, 1999); strategic alliances (Blankenburg-Holm et al, 1996); and customers (Korhonen et al, 1996). Other firm-based enablers are the organizations ability to learn (Eriksson et al, 2000); flexible production processes (Axinn and Matthyssens, 2002); and the use of Internet (Hamill, 1997).

Factors that enable the firm to become or increase its involvement in international business can also be found in the firm's external environment. De-regulations of markets and reduction of trade barriers (Axinn and Matthyssens, 2002) are two examples. Johanson and Vahlne (1990) state that stable and homogeneous market conditions can reduce certain barriers such as lack of market knowledge.

Thus, many drivers and hindrances have been found to play a role in a firm's internationalization process. For this research the main interest is to study what drives, hinders, and enables the furniture producers internationalization process as well as detect the relationship between these issues and their origin. For a visualization of this research, see the model illustrated in Figure 2.

Table 2. Barriers to internationalization divided into four groups: psychological, operational, product/ market related and organizational.

Psychological	**Example**	**Source**
Key decision maker	Mental models	Chetty & Campbell-Hunt (2003); Hamill (1997)
	Short term perspective	Fillis (2002); Hamill (1997)
	Foreign markets are perceived too risky	Westhead et al (2004); Hamill (1997); Fletcher (2001)
	Inertia	Leonidou (1995)
Operational		
Internal organization	Lack of language skills	Westhead et al (2004); Eriksson et al (2000); Holmlund & Kock (1998); Hamill (1997); Johanson & Vahlne (1977), (1990)
	Documentation & paperwork difficulties	Westhead et al (2004); Björkman & Kock (1997); Hamill (1997)
	Difficulties related to financial resources	Westhead et al (2004); Leonidou (2002); Chetty & Campbell-Hunt (2003); Fillis (2002); Holmlund & Kock (1998); Björkman & Kock (1997)
	Difficulties related to distribution	Westhead et al (2004); Holmlund & Kock (1998); Bonaccorsi (1992)
External environment	Delay in receiving payments	Hamill (1997)
	Lack of governmental assistance	Fletcher (2001)
Product/ Market		
Internal organization	Cost for product adoption	Hamill (1997)
	Lack of foreign market info	Westhead et al (2004)
External environment	Governmental attitudes & trade impediments	Westhead et al (2004); Fletcher (2001); Leonidou (2000); Holmlund & Kock (1998)
	Cultural differences	Westhead et al (2004); Holmlund & Kock (1998); Johanson & Vahlne (1977), (1990)
	Market size, stability & structure	Bonaccorsi (1992)
	Geographic distance	Holmlund & Kock (1998)
Organizational		
Key decision maker	Acts as a gatekeeper	Moen (1999); Holmlund & Kock (1998)
	Lack of time & experience	Westhead et al (2004); Chetty & Campbell-Hunt (2003)
Internal organization	Lack of qualified & experienced personnel	Westhead et al (2004); Rhee & Cheng (2002); Eriksson et al (2000); Hamill (1997); Johanson & Vahlne (1977), (1990)
	Access to & control of sales channel	Holmlund & Kock (1998); Fillis (2002) Hamill (1997); Fletcher (1997)
	The small size of the company	Fillis (2002)

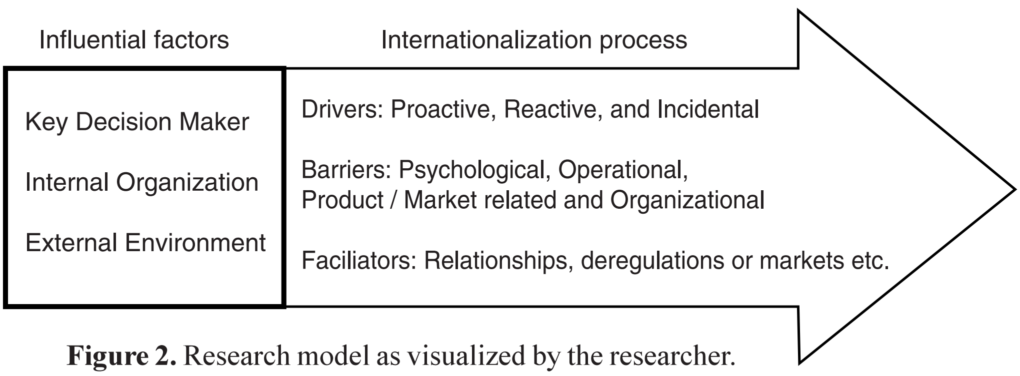

Figure 2. Research model as visualized by the researcher.

3. Method

This research can be viewed as a case study found within the empirical boundary of the Swedish furniture industry. This overarching case will include approximately three subordinate qualitative cases and one quantitative survey. The survey will be industry wide and launched either simultaneously or sequentially with the three cases. Each of the subordinate cases will be restricted to a particular firm. The firms will be selected according to the quota selection method (Merriam, 1994). When using this method, the cases selected should represent different subgroups within the total population to enable maximum variation. For a firm to be considered of interest for this research the following three pre-requisites must be met: Swedish operated and owned, small or medium sized, and be a furniture producer.

Export barriers are perceived differently among firms in different export development phases, but also among firms in the same phase (Leonidou, 1995). Thus, both inter-nationalization approach and firm specific factors influence the perception of barriers. More research on pre-exporters has also been encouraged within the field of inter-nationalization (Leonidou, 1995). Considering these findings, the inward, outward and cooperative model developed by Luostarinen seems to be an appropriate theoretical frame to base the case selection on. For more about this model see Luostarinen (1979) and Korhonen et al (1996). Assuming that three cases will offer enough richness, the following type of firms will be selected: a domestically active firm that expresses interest in becoming internationally active; a firm that is involved in inward international activities; and finally a company that is engaged in outward business.

4. Discussion

This paper outlines a broad plan for how this doctoral thesis will be conducted. Since the empirical material has not yet been collected or analyzed, it is not possible to present any empirically supported conclusions. However, based on existing theory one can conclude that more research is needed within the field of SME inter-nationalization. This research will contribute to the knowledge bank by penetrating the subject deeper, past the activities undertaken by the international companies.

The ambition of this research is to contribute on an academic and theoretical level, and be of value to practitioners and policymakers. By creating a holistic picture of the links and origins of the drivers, hindrances and facilitators found among firms within one industry, add to the research field of internationalization of SMEs. From the practitioners' perspective this research will provide an insight into how other firms in the industry perceive and approach international business. This insight will hopefully stimulate to further discussions and reflections among the industry members. On the policymaker level it is important to expose what kind of support certain firms are in need of. Another key contribution would be to show how firm's needs for support varies with regards to level of international involvement.

In Table 3 below the reader will find definitions of terms used in this paper.

Table 3. Definitions of terms used throughout this paper.

Term	Definition	Source
Barriers	Entry and exit barrier, also referred to as hindrances and obstacles	Porter (1980)
Furniture producer	Manufacturer of chairs and seats; other office and shop furniture. No consideration will be taken to the material used or the function of the furniture.	Statistic Sweden (SCB)
Internationalization	A dynamic and evolutionary process involving both outward and inward activities.	Coviello & McAuley (1999).
Inward activities	Include import of goods, services, finance, and technology through franchising, licensing, direct investments, and alliance agreements.	Korhonen et al.(1996)
Outward activities	Include export through agents or own salesmen, cooperation with other local companies, own sales company, joint ventures, subsidiaries abroad, establishment of own manufacturing facility abroad, acquisition, licensing, franchising and patent.	Holmlund & Kock (1998). Fletcher (2001)
Small and medium sized enterprise, SME	Medium-sized enterprises: Between 50 and 249 employees. Annual turnover rate does not exceed 40 million EURO, or annual balance-sheet total is less than 27 million EURO. Small enterprises: Between 10 and 49 employees. Annual turnover rate does not exceed 7 million EURO, or the annual balance-sheet total is less than 5 million EURO.	The European Commission (Definitions according to the commission's updated recommendation for year 2005.)

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Testing Convergence between Roundwood Prices in Finland and Estonia

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Abstract:

Based on the Johansen's cointegration method, this study analyses the convergence of the Finnish and Estonian coniferous prices and if there exist any long run relationships between the wood assortments and species. The data is monthly time series from nominal delivery prices of spruce and pine sawlogs and pulpwood from the time period 1996 - 2003. Mainly, the results do not support the hypothesis of long run equilibrium of the roundwood prices between Finland and Estonia. Only the prices of pine sawlogs may contain information on the long run relationship. According to the descriptive trend analysis, however, all coniferous prices are converging against each other, and, if the trend growth of Estonian prices continues, they will coincide with Finnish prices in the forthcoming few years.

Keywords: Baltic Sea Area, roundwood markets, long run relationships, coniferous wood, price convergence

1. Introduction

Structure of wood and wood products markets in the North Eastern Europe is currently going through significant changes due to the large investments in sawmilling industry. In addition, accession of the Baltic States and Poland into the European Union in May 2004 will form and deepen economic integration around the Baltic Sea Area. International trade in roundwood has increased about 50 % between the years 1995 and 2001, and trade occurs mainly within this region. The Baltic Sea Area can therefore be considered as a relevant roundwood market area for the forest industry operating in the northern Europe. Since most roundwood traded in Baltic Sea Area is pulpwood, there are also differences between wood assortments regarding openness to international trade.

Development in roundwood prices is a key to understand how markets in different countries are functioning, to anticipate price changes for different roundwood assortments, and to assess how changes in these prices may affect on the investment planning of forest industry enterprises and their profitability. Also, the assessment and information of the development of roundwood prices certainly affect private forest owners' behavior.

Even though some analysis concerning regional integration of roundwood markets has been recently done in e.g. United States (Bingham et al. 2003) and Finland (Toppinen and Toivonen 1998), a deeper analysis of integration of international roundwood prices between different countries is needed. Typically, the studies analyzing market integration and linkages between forestry prices have had shortcomings with proper data sets. For example, integration between roundwood markets in Finland, Sweden and Austria was studied in Toivonen et al. (2002), but due to limited data, they used only simple regression analysis. Thorsen (1998) found countries with largest forest product industry in the Nordic countries, i.e. Finland and

Sweden to be price leaders with respect to smaller forestry countries, Norway and Denmark in the market of spruce sawlogs, but did not consider any other wood assortments. Recently, roundwood market linkages between Nordic and Baltic countries have been studied by Mäki-Hakola (2004), who established strong connections between Finnish and Estonian spruce sawlog prices, but found only a low correlation between spruce pulpwood prices.

In this study we try to deepen the understanding of development of roundwood prices and market integration between Finland and Estonia by using monthly observations of delivery prices of spruce and pine sawlogs and pulpwood (i.e. four main wood assortments in the market) from 1996 to 2003.

First we analyze differences in market integration between wood assortments and wood species (pine, spruce) and whether there exists any long run relationship in these prices. Secondly, this paper deals with studying possible price convergence in the roundwood markets using heuristic approach and extrapolation of deterministic price trends.

This paper is organized as follows. Section two presents shortly roundwood markets in Finland and Estonia and gives background of the market structure and of the importance of the forest sector. Section three describes the empirical method and data. In section four the main empirical results are presented and evaluated. Finally, section five concludes the study with some remarks.

2. Structure of roundwood markets

Even though Finland and Estonia differ from their land size and number of inhabitants, both countries have similarities regarding forestry, forest industry and nowadays also regarding the structure of roundwood markets. The share of forests of the total land area is over 70% in Finland and 49% in Estonia. Softwood species dominate the growing stock in both countries, even though broadleaved species are more common in Estonia than in Finland. Finland has larger forest resources: growing stock in Finland is about 1.9 billion m^3, and in Estonia about 0.3 billion m^3.

In both countries, forest industry is export oriented and very significant to the national economy. In Estonia, wood industry is currently among the most important export sector bringing about 15% of all export incomes. In Finland, forest industry as a whole is the second most important export sector covering about 25% of export incomes, but pulp and paper industry is much larger than the wood sector. Pulp and paper industry in Estonia is so far almost non-existent.

Forestry in both countries is characterised by private and fairly fragmented ownership structure. In Finland, over 50% of all forestland is owned by private inhabitants and even over 60% when only productive forest land is concerned. There are about 300 000 private forest holdings in Finland (including holdings that are at least five hectares in size). In Estonia, private forest ownership is being created through the land reform process, where real estates are returned to families owning the estates before World War II. Currently, the number of private forest holdings is over 50 000, but finally the number may increase close to 100 000. The share of private land is expected to increase to about 60% of all forestland, which will account for 1-1.2 million hectares. Therefore, roundwood supply has increased sharply from the privatized forests. An average size of a forest holding in Estonia is roughly 10 hectares while in Finland the average size is over 30 hectares.

In Estonia, domestic sawmill companies purchase sawlogs, but pulpwood is being almost totally exported to Germany and Sweden. Thus, the buyer structure has been fairly different regarding sawlog and pulpwood markets, and the number of actual buyers is clearly smaller for pulpwood than for sawlogs. However, the buyer structure is changing in Estonia quite rapidly towards the structure in Finland; large companies buy both sawlogs and pulpwood. In Estonia the domestic sawmill enterprises process sawlogs, and ship the pulpwood to their foreign factories while in Finland large forest companies utilise all assortments in their domestic factories. The number of companies is diminishing in Estonia along with the restructuring of the sawmill industry, and the number of market middlemen is also shrinking. Thus, also in this respect the structure of mechanical forest industry is increasingly similar in Finland and in Estonia.

Table 1. Production, Consumption and Trade of Roundwood and Sawnwood, mill.m^3 (roundwood measured over bark)

	Harvests	Exports	Imports	Apparent consumption	Sawnwood production	Exports	Imports	Apparent per capita consumption	
1995									
Estonia	3.5	2.7	0	0.8	0.4	0.3	0	0.1	(0.07 m^3)
Finland	51.0	1.2	11.3	61.1	9.9	8.4	0.2	1.7	(0.35 m^3)
2001									
Estonia	10.2	3.7	0.6	7.1	1.7	1.1	0.2	0.8	(0.7 m^3)
Finland	53.3	0.8	15.6	68.1	13.4	8.1	0.3	5.6	(1.1 m^3)

Source: Eurostat Forestry Statistics 1998-2001, Statistical yearbook of forestry (Finland 2003)

As shown in Table 1, wood industry has grown significantly both in Finland and in Estonia from 1995 to early 2000s. Relatively speaking, the growth has been stronger in Estonia, where harvests tripled between years 1995 and 2001. The sawmilling capacity has grown quickly in Estonia so that exports of sawlogs turned as net imports in 2002 and 2003 reflecting the fact that production of sawnwood has grown as four-fold while in Finland the growth between 1995 and 2002 was about 35%. The development has continuously and strongly increased the demand for sawlogs in Estonia during 1990s and early 2000s.

The development in Finnish sawmill industry has been somewhat similar as in Estonia during the last ten years; exports of sawnwood collapsed in early 1990s, but grew strongly during the latter part of 1990s. The growth stagnated in 2000 due to the downward development in the construction sector in Germany, and general economic recession in 2001-2003 in other important export destination countries. Even though the exports stagnated, domestic demand has continued to rise even in early 2000s. In 2002, domestic consumption of sawnwood was 5.4 million m^3, which was 54% more than in 1989. Pulp and paper production and exports have been growing continuously during 1990s and early 2000s, with the exceptions of 1991, 1996 and 2001. On the background are several new paper machines and pulp factories built in Finland between 1995 and 2002.

Both demand and supply of roundwood have increased in Estonia and Finland during the last ten years with the exception of years of economic recession. However, the growth has been even much more drastic in Estonia than in Finland. In Estonia, the demand for sawlogs has increased as manifold, while the demand in Finland has increased only some tens of per cents. The development in export demand for pulpwood is more difficult to estimate in Estonia, but in Finland the demand for pulpwood has increased about 30% between 1990 and 2003.

3. Methods data

Integration between Finnish and Estonian roundwood markets will be studied here using the concept of the law of one price (LOP). The fundamental principle of commodity arbitrage implies that prices in two countries should equal in equilibrium (net of transaction costs) when expressed in common currency. In practice, it is more complicated to find the equilibrium price levels because the adjustment of markets is occurring continuously. In our case, for example, we see Estonia catching up with other neighboring forestry countries with higher level of economic development, i.e. Finland and Sweden. Therefore, *a priori* our analysis will more likely demonstrate the adjustment process of Estonian wood markets than the actual state of equilibrium.

First, in order to understand the dynamics of these markets it is essential to know time series properties of wood prices in Estonia and Finland. In order for the LOP to hold in the long run, both prices need to be integrated of the same order. Previous studies analyzing the integration of wood markets have started by testing nonstationarity of time series with augmented Dickey-Fuller (ADF hereafter) approach (Dickey and Fuller 1979). However, testing the null hypothesis of stationary may provide different insights into market analysis, and therefore, along with the ADF test, we use also test introduced by Kwiatkowski et al. (1992) (KPSS hereafter).

In testing of cointegration between prices in Estonia and Finland, we start by using the bivariate version of statistical autoregressive model

$$(3.1.) \qquad z_t = A_1 z_{t-1} + \ldots + A_k z_{t-k} + u_t,$$

where z_t is $(n \times 1)$ vector of endogenous variables and each of the A_i is an $(n \times n)$ matrix of coefficients.[1] k defines the lag length and u_t is the standard vector of error terms with normal IID assumptions. Equation (3.1.) can be reformulated into a vector error correction (VECM) form

$$(3.2.) \qquad \Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k-1} + \Pi z_{t-k} + u_t,$$

where $\Gamma_i = -(I - A_1 - \ldots - A_i)$, $(i = 1, \ldots, k-1)$, and $\Pi = -(I - A_1 - \ldots - A_k)$. The rank of the Π matrix gives the number of cointegrating vectors in the system. If the rank of Π is zero, then Π is the null matrix indicating only a VAR process in differences and no cointegration between the variables. If Π is of full rank, the data in levels are already stationary. The most interesting case is when Π is of rank $0 < r < n$. Then, there are r cointegrating vectors describing the long-run equilibrium relationships, while the error correction mechanics embodies the short-run dynamics of the variables. To see this, the Π matrix can be decomposed as

$$(3.3.) \qquad \Pi = \alpha\beta',$$

where both α and β are $(n \times r)$ matrix. The columns of β matrix give the cointegration vectors including information on the long-run relationships while the elements in α represent the error correction mechanism and the rate of adjustment of the process towards equilibrium. Technically, to get the most reliable estimates of the Π matrix one should apply the multivariate maximum likelihood estimation of Johansen (1988) and Johansen and Juselius (1990).

Johansen procedure is a stepwise analysis including the following steps. First, to apply cointegration analysis one should work with time series that are known to be nonstationary. Second, given that the variables are nonstationary, one should select the precise form of the equation (3.2). Third, one should test the statistical significance of the number of cointegration relationships (rank r). Finally, one should estimate the cointegration equations and, if possible, impose restrictions on them.

The form of the equation (3.2) is selected according to the goodness-of-fit measures and several diagnostic tests. The tests of rank of the matrix Ð are based on the standard trace and maximum eigenvalue tests. When the estimated value of trace test is smaller than the critical value, the null hypothesis of at least r_o cointegrating vectors can be accepted.

Our data for Finnish prices consist of logarithmic nominal delivery prices of spruce and pine sawlogs and pulpwood (i.e. four main wood assortments in the market) as obtained from the Finnish forestry statistics. Delivery sales represent only about 20% of the total market, but due to the high correlation with stumpage prices, delivery prices are also indicative of the whole market development. The time series are monthly average prices of roundwood bought from the non-industrial private forest owners, and they are reported over bark as €/m^3.

The Estonian monthly logarithmic nominal prices for spruce and pine sawlogs and pulpwood at the road side are reported by the State Forest Management Center managing about 37% of forest land. Thus, prices refer to the state forests only, because prices for the wood from the private forests are not available. However, average prices for whole Estonia have a tendency to follow the state forest prices, possibly with a small publication lag. Originally, Estonian prices for sawlogs are EEK per solid cubic meter without bark, while prices for pulpwood are given over bark (Nordic-Baltic Forestry Statistics (2004)). Thus, to make Estonian sawlog price data comparable with that of Finnish data, it was necessary to adjust the Estonian price levels to also include an approximate proportion of measuring the bark (we used 15 %). Thus, we divided original Estonian prices with a constant of 1.15. Average monthly exchange rates were used to transform Estonian prices to Euros. Originally, the research period was 1994.1 – 2003.12, but after initial inspection, the observations for years 1994 and 1995 were excluded due to very high price volatility in Estonian wood markets. Thus, our final sample consists of 96 observations, which should be sufficient for the cointegration analysis although the data span is on the short end of the range.

4. Results

4.1. Time Series Properties and Cointegration Analysis

To ensure that the time series involved in analysis are nonstationary we first used ADF and KPSS tests. However, a few remarks are worth mentioning before reporting the test results. First, in some cases the test statistics were highly sensitive to the inclusion of a constant and/or trend components in regressions. To be consistent in reporting, we included the trend in regression only if its coefficient was statistically significant. According to the test statistics, in addition to the constant, the regressions should include trend only for the pine pulp wood series in Finland, while for Estonia both a constant and a trend should be included in all regressions. Second, the number of the lags in regressions is based on the Akaike's information criteria.[2] While in few cases (Finnish spruce pulp wood and Estonian pine pulp wood) this criteria led to the high tailed autoregressive process (i.e. AR(10)) in regression and declined

[1] See Banerjee et al. (1993) or Harris (1995) for background and technical details of the Johansen's method.

the power of the test statistics, we restricted the number of lags as small as possible which stillensured that the error term is serially independent. Typically, the first or second lag fulfilled this requirement.

Table 2. Stationarity Tests for Variables

Country	Assortment		Constant/Trend	Lags	ADF	KPSS	ADF	KPSS
					Level		First differences	
Finland	Sawlog	Pine	C	1	-1.771	0.905**	-12.946**	0.134
		Spruce	C	2	-1.537	1.228**	-10.078**	0.177
	Pulpwood	Pine	C,T	2	-4.570**	0.063	-4.971**	0.041
		Spruce	C	2	-2.225	0.235	-2.425*	0.402
Estonia	Sawlog	Pine	C,T	2	-3.443	0.109	-9.064**	0.139
		Spruce	C,T	2	-1.704	0.286**	-8.909**	0.249
	Pulpwood	Pine	C,T	1	-2.160	0.148*	-5.815**	0.051
		Spruce	C,T	3	-5.952**	0.142	-5.393**	0.094

The asterisks * and ** denote that the null hypothesis is rejected at 5% and 1% level, respectively. In ADF the null hypothesis is that the time series is nonstationary, while KPSS tests stationary as a null hypothesis.

Keeping in mind these restrictions in estimation the test results are given in Table 2. In most cases the time series are nonstationary (see also Figures 1-4 in Appendix). Only the series for Finnish pine pulpwood and Estonian spruce pulpwood are clearly stationary.[3] The test statistics are conflicting for Finnish spruce pulpwood and Estonian pine sawlogs: according to the ADF test, both series are nonstationary, while KPSS test accepts the hypothesis of stationarity. The first differences of the variables are all stationary. Even though the test results concerning Estonian pine sawlogs are conflicting, we include it into the analysis but refrain from making any strong conclusion of the results concerning it. Because of the stationarity, both pairs of pulpwood price series are extracted from the cointegration analysis.

To proceed, we next tested the adequate form of the vector autoregressive model (3.1) for both species of sawlogs. The lag structure in VAR is based on the Akaike's information criteria. The test for homoskedasticity of the residuals is an extension of White's test to systems of equations. The test statistic is obtained by regressing each cross product of the residuals on the cross products of the regressors and testing the joint significance of the regression. The test for autocorrelation is a Ljung-Box test for the joint hypothesis that all the lagged autocorrelation coefficients are simultaneously equal to zero. Doornik-Hansen test is a multivariate extension of the standard Jarque-Bera residual normality test comparing the third and fourth moments of residuals to those from the normal distribution.

Table 3 depicts the results for the diagnostic tests. If the calculated probability value is lower than 0.05 (5%), the null hypothesis of homoskedasticity, no autocorrelation and/or normality are rejected. According to the Akaike's information criteria, one-lag model minimized the loss function for both sawlog assortments. However, the diagnostic tests for both assortments revealed that the residuals for this one-lag model are not well behaving: the assumptions of

[2] According to the Figures in Appendix the heuristic intuition of the existence of the trend component is often misleading. Also, the test statistics based on different goodness-of-fit measures led sometimes to the conflicting results. For example, according to the Akaike's information criteria the trend component in the series of Finnish spruce sawlogs was not statistically significant, while the SIC criteria accepted the trend in regression.

[3] The exclusion of trend component resulted in nonstationary series for Finnish pine pulpwood

homoskedasticity and normality of residuals are rejected.[4] To improve the statistical performance of the model we also tried to include more lags in VAR models. These experiments did not eliminate the heteroskedastic structure of the residuals or the non-normality for both assortments. According to Gonzalo (1994), however, the results for Johansen's cointegration analysis should not be biased despite of the non-normality of the residuals, while the heteroskedasticity may lead to the inaccurate statistical inferences of the following cointegration test results.

Table 3. Diagnostic Tests of Form of VAR Models

Sawlog assortment	Lags	Homoskedasticity		Autocorrelation		Normality	
		Estimated	p-value	Estimated	p-value	Estimated	p-value
Pine	1	36.796	0.0014	61.092	0.0972	29.949	0.0000
Spruce	1	26.979	0.0289	53.070	0.2851	30.926	0.0000

The critical values to reject the null hypothesis of homoskedasticity, no autocorrelation and normality at 5% level of significance are χ^2 (15) = 24.996, χ^2 (50) = 67.505 and χ^2 (4) = 9.488, respectively. The test statistic for autocorrelation is based on 12 lags.

To identify the existence of cointegation in a case of two variables is a test of null hypothesis that there are no cointegration vectors against the alternative that there is one. The null hypothesis is rejected if the test statistic exceeds the critical value. Table 4 shows the results for cointegration analysis. Clearly, the results do not indicate any long run equilibrium between Finnish and Estonian prices for spruce sawlogs. For pine sawlogs, the hypothesis of one cointegrating equation is accepted giving a long-run relationship

(3.6.) $\quad$ Lepsl – 2.5406 Lfipsl + 6.2739 = 0,

where Lepsl and Lfipsl are logarithmic prices for pine sawlogs in Estonia and Finland, respectively.[5] The respective rate of adjustment, i.e. the error-correction parameter, for the Estonian prices is –0.228 while for the Finnish prices it is only –0.030. Thus, when testing for weak exogeneity between prices, causality is found originating from the Finnish pine sawlog price to that in Estonia.

Table 4. Cointegration Tests

Variable	Hypothesis	Eigenvalue	Test Statistics		Critical Values (5%)	
			λ_{Trace}	λ_{Max}	λ_{Trace}	λ_{Max}
Pine	$r = 0$	0.168	17.310*	20.970*	15.7	20.0
	$r \leq 1$	0.038	3.665	3.665	9.2	9.2
Spruce	$r = 0$	0.119	11.930	14.670	14.1	15.4
	$r \leq 1$	0.029	2.735	2.735	3.8	3.8

The asterisk * denotes that the null hypothesis is rejected at 5% level

[4] It is noteworthy, that even though the joint hypothesis of no autocorrelation for all coefficients cannot be rejected, the coefficient for the twelfth lag turned out to be statistically significant. The reason is easily seen from the Estonian time series: The spruce sawlog prices in Estonia decrease systematically in summers. The reason for this price decrease, however, is difficult to explain.

4.2. Convergence in Prices

According to the results above it seems that, except for the pine sawlogs, there are not any long run equilibrium levels between the Finnish and Estonian coniferous assortments. However, the Figures 1-4 in Appendix reveal that during the past ten years both the sawlog and pulpwood prices have clearly converged in nominal terms. Thus, after few years and after the adjustment process, we may be able to detect long run relationships between the prices. The growth in demand of sawlogs has been stronger than supply, and sawlog prices have increased particularly in Estonia. In 2002, the difference in price levels of spruce sawlogs was about 15-20%, the higher prices being in Finland. The demand-supply balance is different for pulpwood both in Finland and in Estonia: pulpwood is competing with wood chips and in Finland also with imported pulpwood. Particularly in Estonia roundwood trade is concentrated on sawlogs both quantitatively and on the value basis; partly this true also for Finland where the trade tends to be dominated by demand and supply situation of sawlogs.

If the trend growth of Estonian prices continues, *ceteris paribus*, it will be only after few years when the prices between Finland and Estonia converge. A simple extrapolation of the trends shows that the prices for spruce sawlogs will coincide around the end of 2005, for spruce pulpwood in the end of 2007 and for the pine pulpwood in the end of 2006.[6] For the pine sawlogs, the adjustment process seems to take more time even though it was the only assortment where cointegration was found. The corresponding equilibrium euro values for spruce sawlogs, spruce pulpwood and pine pulpwood would be roughly 50€, 31€ and 24€, respectively. However, because of the uncertainty concerning the forestry sector in both countries and international economic growth together with increasing roundwood supply and trade (from Russia and other Baltic Area), these results should be interpreted as preliminary rather than strictly concluding.

5. Concluding remark

This study has analyzed the convergence of Finnish and Estonian roundwood prices for pine and spruce sawlogs and pulpwood, and tested for the existence of long run equilibrium relationships between the prices. After declaring independence the Estonian economy has undergone a significant structural change and showed a remarkable economic success. The forestry sector has been partly privatized and investments on sawmilling capacity have increased considerably. Therefore, along the accession into the European Union in May 2004, it is reasonable to suspect that the roundwood prices in the Baltic Sea Area will converge and eventually constitute an integrated market area.

To summarize, time series properties between Finnish and Estonian pulpwood prices were rather different, and for example the Finnish delivery price for pine pulpwood was found to be stationary according to the test statistics. These results are conflicting with the volumes of international trade, which occurs mainly in the pulpwood side of the market and could be expected to force national prices to converge. The results based on the standard cointegration analyses and monthly time series of nominal delivery prices from the time period 1996 - 2003, however, did not yet give support for the long run equilibrium between the Finnish and Estonian

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[5] Using a simple two step Engle-Granger analysis we, however, found evidence for cointegration between Finnish and Estonian prices of both pine and spruce sawlogs.

[6] It should be stressed that although explanatory power of linear trends was rather good, we made this experiment to emphasize the approaching convergence and not to forecast actual markets.

roundwood prices. Only the prices of pine sawlogs may contain information on the long run equilibrium. Also the statistical performance of the residuals of the VAR models was unsatisfactory. However, our results are also supported by simple price correlations that were very high between sawlog prices and very low between pulpwood prices. Reasons behind this phenomenon should be investigated in further studies possibly using other theoretical assumptions than that of perfect competition. Also, other exogeneous variables (such as inflation or GDP growth) may be used to explain the price convergence.

In any case, the results point out for the importance of analyzing wood prices by specific assortments than by aggregate sawlogs or pulpwood. According to the descriptive trend analyses, there is a clear convergence of the prices. If the trend growth of the Estonian roundwood prices continues, *ceteris paribus*, it is likely that after few years roundwood prices between Finland and Estonia will coincide. However, a more rigorous modeling of factors explaining the convergence of wood prices is needed when the integration of roundwood markets in the Baltic Sea Area is of further interest.

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Appendix: Roundwood Prices and Linear Price Trends (extrapolated to end in 2008) in Finland and Estonia

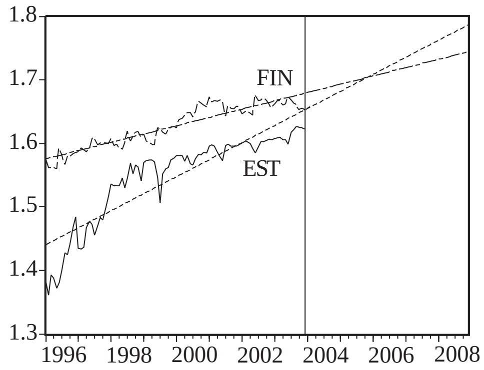

Figure 1. Spruce Sawlogs

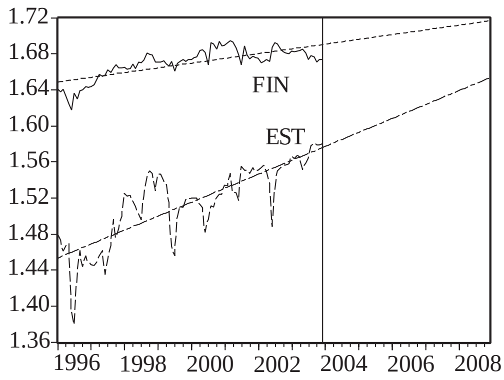

Figure 2. Pine Sawlog

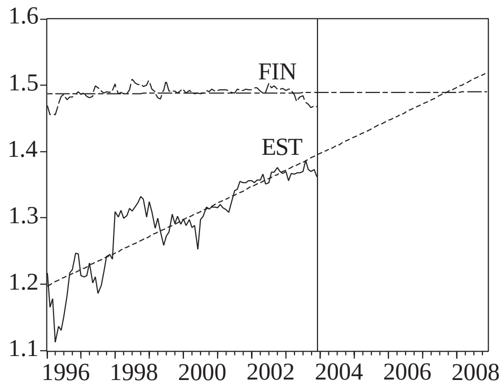

Figure 3. Spruce Pulpwood

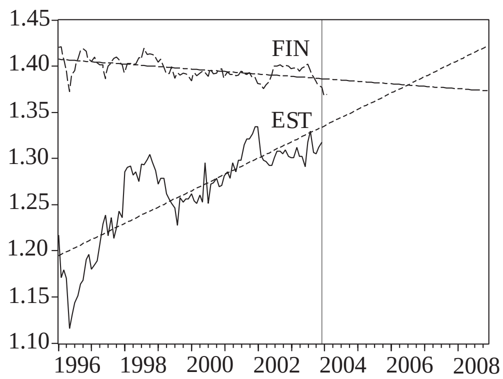

Figure 4. Pine Pulpwood

The Assessment of Floorcovering Materials by End-Consumers and Sales Representatives: *A Comparative Study of Substitute Competition*

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ABSTRACT

The knowledge of factors affecting the end-consumers choice of building material for specific purposes, i.e., the mechanisms of *substitute competition*, necessary to understand the competitive situation of wood, is limited.

In this paper interviews of floorcovering customers and sales representatives are analysed. The results suggest that by using a multivariate projection method, PLS-DA (*Partial Least Square Discriminant Analysis*), it is possible to extract the most important predictors of material preferences from answers to open-ended questions and make comparisons between the two groups, thus allowing parsimony, as there is no need for a follow-up study with pre-structured response alternatives to quantify variables (e.g., using Likert scales).

End-consumers and sales representatives show agreement in their assessment of determinant attributes and appraisal of the different materials. Unlike the other materials, the decisive reasons for choosing wood appear to be exclusively non-functional.

Keywords end-consumer, building material, substitute competition, PLS-DA

INTRODUCTION

The end-consumer of building materials, i.e., the household, plays an essential role in the supply chain, as the ultimate user and payer of the products and / or services in question. The market for reconstruction and conversion is expected to grow markedly in Europe. In this type of building activity the house or flat residents', i.e., the household's, assessments are generally more crucial than in the construction of new houses. This further highlights the importance of the end-consumer.

A number of studies concern the attitude of architects and building contractors towards wood and substitute materials, e.g., Eastin et al. (1999) and Anon. (1992). The general attitude of end-consumers towards wood as a building material, e.g., Anon. (1998), as well as the visual impressions and attitudes toward wood (Broman 1996) have also been investigated. The knowledge of attributes affecting the latter group's choice of material for specific purposes/ applications, i.e., the mechanisms of *substitute competition* (see Ahlmark 1977, p. 1), seems to be limited, though. Consequently, a methodology allowing estimation of decisive predictors of material preferences is called for. Further, it is of interest to investigate whether or not sales representatives and end-consumers differ as to assessing decisive attributes / criteria and appraising different building application materials

In this study a qualitative approach as to data gathering is combined with a multivariate method of analysis, *Partial Least Square Discriminant Analysis* (PLS-DA). The objective is to evaluate the potential of the methodology in extracting decisive attributes / criteria and in making comparisons between end-consumers and sales representatives.

The influence, and involvement, of the end-consumer seems to increase as one moves from the construction- towards the design-sector, i.e., visible parts of the building (Anon 1998). Floorcovering is a material application with a pronounced design profile, and the household typically makes the choice of floorcovering material. This makes floorcovering a good illustrative example.

MATERIALS AND METHODS

The interview data

In Social Sciences there are two main methodological approaches, nomothetic and idiographic. The nomothetic approach emphasises quantitative analysis of a few aspects to test hypotheses and make statistical generalisations. The idiographic approach, in contrast, relies on a case study approach to achieve in-depth understanding of complex phenomena, and is the preferred strategy when little is known about a phenomenon (Eisenhardt 1989; Yin 1984). Consequently, an idiographic approach was used in this instance. *Observational units* (see Ragin 1987) were selected for theoretical reasons rather than for representativity (see Glaser and Strauss 1967). For the purpose at hand it was prudent to select households who were actively engaged in re-flooring of their homes and/or had re-floored in the near past. A convenient method is to interview customers at outlets for different types of floorcovering, in order to include as many materials as possible. Interviews of end-consumers were thus conducted in five different shops in the Greater Manchester area and North Wales. The number of interviews is sixty-seven.

To get an idea about mechanisms affecting household material preferences, open-ended questions concerning the choice of floorcovering material (planned re-floorings and / or re-floorings undertaken the last five years) were used: Type of room(s) considered, type of material(s), and reasons for choosing the material(s) in question ("What made you choose this particular type of flooring material?"/"What makes you choose this type(s) of flooring material(s)?"). The interviews included a probing question to clarify what type of wooden flooring was intended, used whenever a respondent answered "wood" when asked what material he, or she, had used / were planning to use. The alternatives were softwood parquet, hardwood parquet, solid softwood floorboards, solid hardwood floorboards, and laminated flooring (hardwood or softwood printed wood overlay. Laminated flooring is of course not real wooden flooring, but is often mistaken for one). In addition, to get further input, questions concerning the general attitude toward different floorcovering materials ("How would you describe the following types of floorcovering materials?") were used. The materials were vinyl, linoleum, ceramic tiles (henceforth tiles), textile flooring (henceforth carpet), laminated flooring (henceforth laminate), softwood parquet, hardwood parquet, solid softwood floorboards, and solid hardwood floorboards (henceforth wood).

Sales representatives (eleven interviews in all) were interviewed at ten different shops in North Wales, NW England and SW England. The sales representatives where asked what features of floorcovering materials they considered important and what materials to choose in different types of rooms, from the customer's point of view.

The interviews resulted in two types of variables potentially explaining floorcovering material preferences: reasons for preferring a particular floorcovering material, and type of room considered for reflooring. The variables were retrieved directly from respondents (so-called in vivo categories), that is; respondents expressed them. Related words and expressions then formed instances of the same category / variable (e.g., "durable" is an instance of *hardwearing*, as is "sitting room" an instance of *Living room*). All the variables are binary (1 for presence, 0 for absence of the variables in question).

Multivariate projection methods

Multivariate projection methods like *Principal Component Analysis* (PCA) and *Partial Least Square Discriminant Analysis* (PLS-DA) are able to handle binary variables. This is a necessity when analysing answers from open-ended questions. Further, these analytic tools cope with many variables and few observations as well as collinear variables (Wold et al. 1987).

A fundamental assumption in PCA is that directions in multivariate space with maximum variation are more or less coupled to so-called latent variables, or principal components. The first principal component captures the largest variation structure in the data. The second component, fitted orthogonally to the first, describes as much of the remaining variation as possible, and so forth. Though PCA finds the directions in multivariate space with maximum variation, it is not necessarily so that these maximum variation directions coincide with maximum separation directions among classes. In these instances PLS-DA is more apt (Eriksson et al. 1999). PLS-DA takes already in the problem formulation explicitly into account the class membership of observations, an attractive feature in the present context as the classes, i.e., the preferred floorcovering materials, are initially known. The objective of PLS-DA is to find a model that separates classes of observations on the basis of their *X*-variables (predictors).

When deciding the appropriate number of components in a PLS-DA model, it is desirable to find a model with an optimal balance between fit, R^2 (= explained variation), and prediction ability, Q^2 (= predicted variation). R^2 is inflationary and approaches unity as model complexity (number of terms, number of components, etc.) increases, whereas Q^2 is not, as at a certain degree of complexity Q^2 will not improve any more. When using SIMCA with cross validation, the tested dimension is considered significant if Q^2 for the whole data set (Rule 1) or for at least one Y-variable (Q^2_V) is larger than a significance limit (Rule 2). In evaluating the overall performance of a PLS model it is to be noted that without a high R^2 it is impossible to get a high Q^2. Generally, an accumulated (over all PLS dimensions) predicted variation share, $Q^2_{(cum)}$, larger than 0.5 indicates a rather strong model.

In interpreting the influence on *Y* (the matrix of responses) of every term (x_k) in the model, the interpretation tool VIP (*variable influence on projection*) is of good use. VIP is the weighted sum of squares of the PLS weights over all model dimensions. The attractive feature of VIP is the parsimony, as one VIP–vector summarises all components and *Y*-variables. Terms with a VIP value larger than 1 are the most relevant for explaining *Y*. For discriminating between important and unimportant predictors a cut-off around 0.7 to 0.8 works well in most cases[11].

To evaluate which conditions/ variables are decisive for each outcome (chosen material); studying PLS regression coefficients is useful. These regression coefficients are directly related to the weights, W*, describing the correlation between *X* and *Y*. An advantage of PLS regression coefficients are that they provide one vector of concise model information per response, not several vectors of weights.

RESULTS AND DISCUSSION

Methodological implications

The importance of the context and situation in *substitute competition* is apparent in the interviews of end-consumers. The *usage context* seems to be the most important contextual factor; a given household often chooses different materials depending on type of room. Ownership and the style of the dwelling are other aspects of *usage context* sometimes referred to, as the following remarks on wooden flooring indicate: "*Very beautiful, but expensive, more applicable for house owners*" - "*Our house is to modern for that*". This confirms Ajzen and Fishbein's (1980) proposition: It is more fruitful to consider attitudes toward the act of using a product, rather than attitudes toward the product itself. Another contextual factor, the life situation, e.g., child(ren) living at home, asthma in the household, the presence of pets, apparently affects material preferences through perspectives produced, as proposed by phenomenological consumer research (see, e.g., Thompson et al. 1989): "*Because of kids, easy maintenance and no dust*" - "*Because of large dog and parquet has thin grooves, laminate is better*". In *substitute competition*, then, benefit importance weights do not, as Howard (1989) suggests in the case of brand competition, appear to be the main source of individual differences in choice behaviour. Rather, these differences can be explained by differences as to criteria applied, i.e., materials are chosen or rejected on the grounds of desired attributes being perceived as present or not. This state of affairs makes the use of scales irrelevant. Instead open-ended questions, resulting in dichotomous variables, is both sufficient and appropriate.

Multivariate projection methods have potential for examining causally complex data, as they cope with many variables and few observations as well as collinear variables (Wold et al. 1987). In addition, multivariate projection methods, like *Partial Least Square Discriminant Analysis* (PLS-DA), are able to handle binary variables, a necessity when analysing answers from open-ended questions. Thus, PLS-DA was conducted in order to extract the most important attributes/ criteria, and to make comparisons between end-consumers and sales representatives.

Empirical

The interviews of end-consumers resulted in nineteen binary variables regarding reasons for preferring a particular floorcovering material, i.e., there are nineteen attributes/ criteria cited. The type of room considered for reflooring is represented by nine binary variables.

Initially a PLS-DA with five classes was conducted: carpet, laminate, tiles, vinyl and linoleum, and wood. Few observations and the fact that there is no discernible difference in consumer assessment between the different types of wooden flooring (henceforth wood) motivate treating these responses as one class. In this connection it should be noted that knowledge of wooden flooring was poor amongst the consumers. Respondents were not (with one exception) able to specify the kind of wood in instances of real wood preference, nor were they able to specify the kind of printed wood overlay in instances of laminated flooring preference (in all instances where laminate was the preferred floorcovering, it was of the printed wood overlay type). Hence laminate constitute one class only. Vinyl and linoleum is likewise treated as one class, due to few observations and the fact that the consumers make no distinction between these materials. A model with four significant components, according to the more stringent Rule 1 used in this study to avoid modelling noise, resulted. The $R^2_{Y(\text{cum})}$ of 0.64 and $Q^2_{(\text{cum})}$ of 0.59 indicate a rather good overall model. However, class no. four, vinyl and linoleum preference, is poorly accounted for: $R^2_{VY(cum)} = 0.017$ and $Q^2_{V(cum)} = 0.008$, probably because there are only four instances of vinyl/ linoleum preference. Excluding these observations, i.e., conducting a PLS-DA with the four remaining classes, resulted in a model with three significant components, $R^2_{Y(cum)} = 0.81$ and $Q^2_{(cum)} = 0.77$. The model can be considered strong, as the $Q^2_{(cum)} > 0.5$.

Table 1. VIP values end-consumers: Attributes.

Variable	VIP	Variable	VIP
aesthetic2	1,99	"Wood feeling"	0,62
warmth	1,80	good price	0,61
aesthetic3	1,62	fashion	0,59
hygienic	1,41	softness	0,50
waterproof	1,23	aesthetic1	0,50
natural	1,10	DIY	0,50
aesthetic	1,09	acoustics	0,50
hardwearing	0,77	foothold	0,41
"a change"	0,74	tradition	0,41
health	0,74		

VIP values are displayed in Table 1. Predictors with large VIP values are the most relevant for explaining material preferences. Aesthetic considerations apparently play an important role, as do more objective criteria / attributes related to the nature and function of the different floorcovering materials (*warmth*, h*ygienic*, *waterproof,* and *natural*).

Regression coefficients are, in this instance, useful for evaluating which variables are decisive for the choice of a particular material. As the type of room apparently affects the choice of floorcovering, it is appropriate to include these variables in the analysis. Consequently, a PLS-DA with the more important attributes, i.e., with a VIP value ≥ 0.75 (= the cut-off value adopted in this study), and variables for the type of room considered, was conducted: Three significant components, $R^2_{Y(cum)} = 0.77$ and $Q^2_{(cum)} = 0.72$. Hence, a strong model.

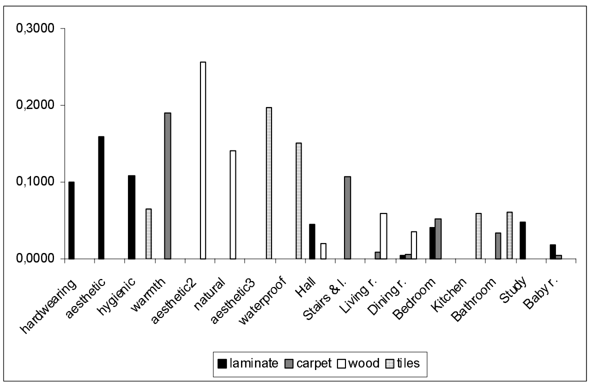

Figure 1. Regression coefficients end-consumers: Attributes and type of room.

Figure 1 displays the PLS regression coefficients for the four responses (classes). The coefficient profile suggests that:

· Laminate, apart from aesthetic considerations (*aesthetic*) is the preferred floorcovering when hygiene and durability (*hardwearing*) are present as important criteria. Laminate has a comparative strength in halls, bedrooms, studies, and, to a lesser degree, in children's bedrooms (*Baby room*). It should be mentioned that the aesthetic property of laminate appreciated by consumers favouring this material is the "wood effect", as is apparent from this representative quotation: "*Because I like the look of wooden floors*".

· Carpet is chosen if: (tactile) warmth is at hand as an important criterion. Carpet is mainly used in stairs & landings, bedrooms and bathrooms.

· Those who find it aesthetic appealing (*aesthetic2*) and who appreciates it being a natural material favour wood. It is used in living rooms and dining rooms mainly. Unlike the other materials, the decisive reasons for choosing wood are apparently exclusively subjective and non-functional.

· Tiles are chosen for kitchens and bathrooms on hygienic grounds, because it is regarded as waterproof and has aesthetic value (*aesthetic3*).

The interviews of sales representatives resulted in twelve binary variables regarding reasons for preferring a particular floorcovering material. The type of room considered for reflooring is represented by seven binary variables.

Initially a PLS-DA with five classes was conducted: carpet, laminate, tiles, vinyl, and wood. A model with three significant components, according to the more stringent Rule 1 used in this study to avoid modelling noise, resulted. However, class no. five, tiles, is poorly accounted for: an $R^2_{VY(\mathrm{cum})}$ of 0.17 and a $Q^2_{V(\mathrm{cum})}$ of 0.09 only. Excluding these observations, i.e., conducting a PLS-DA with the four remaining classes, resulted in a model with three significant components, $R^2_{Y(\mathrm{cum})} = 0.77$ and $Q^2_{(\mathrm{cum})} = 0.60$. The model appears to be rather strong as the $Q^2(\mathrm{cum}) > 0.5$, but the small number of observations calls for caution in interpreting the modelling power.

Table 2. VIP values sales representatives: Attributes.

Variable	VIP	Variable	VIP
aesthetic2	1,63	natural	0,91
waterproof	1,45	hardwearing	0,88
warmth	1,28	acoustics	0,56
aesthetic	1,18	good price	0,47
softness	0,95	aesthetic 1	0,39
hygienic	0,94	DIY	0,39

VIP values are displayed in Table 2. Comparing Table 1 and Table 2, important criteria / attributes, i.e., predictors with VIP values ≥ 0.75, are apparently almost identical in the two samples. Hence, end-consumers and sales representatives seem to agree in their assessment of determinant attributes. However, the total number of attributes listed by end-consumers is higher, they include more subjective, non-functional, attributes: "*a change*", "*Wood felling*", *fashion*, and *tradition*.

As was the case for the end-consumers, a PLS-DA with the more important attributes, i.e., with a VIP value ≥ 0.75, and variables for the type of room, was conducted: Three significant components, $R^2_{Y(cum)} = 0.84$ and $Q^2_{(cum)} = 0.72$.

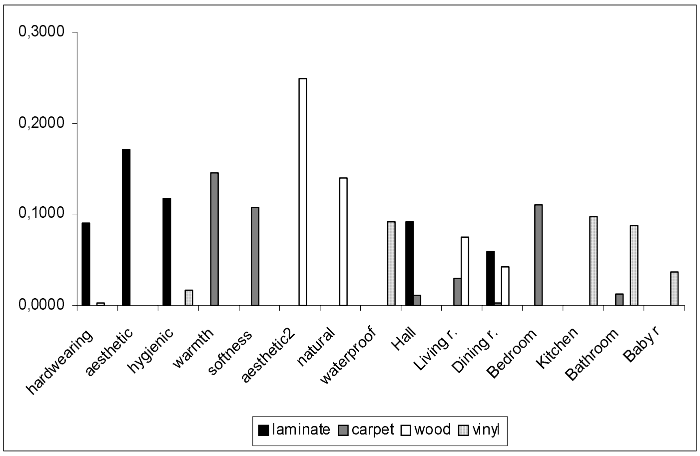

Figure 2. Regression coefficients sales representatives: Attributes and type of room.

Figure 2 displays the PLS regression coefficients for the four responses (classes). The coefficient profile of Figure 2 is quite similar to the one of Figure 1. End-consumers and sales representatives thus show agreement in their appraisal of the different materials (vinyl replaced tiles in the sales representatives case). There are some small divergences though, e.g., sales representatives do not consider laminate a popular floorcovering in bedrooms.

CONCLUSIONS

The results suggest that by using PLS-DA it is possible to simplify complexity, by extracting the most important causal conditions for each outcome (preferred material), the models used were quite strong. The conducted PLS-DA depicts as decisive the same attributes/criteria emerging with salience in the interviews. PLS-DA makes it possible to detect both between and within sample differences as to the choice of application material from the answers to open-ended questions, thus allowing parsimony in the analysis, as there is no need for a follow-up study with pre-structured response alternatives to quantify variables (e.g., using Likert scales).

The fact that end-consumers and sales representatives on the whole show agreement in their assessment of determinant attributes and appraisal of the different materials could be taken to imply that it would suffice to interview sales representatives only. However, end-consumers list more subjective, non-functional criteria, and further, obtaining in-depth understanding of underlying motives / perspectives necessitates interviews of end-consumers. To grasp this contextual influence calls for an analysis including variables capturing the life situation of the households (see the section *Methodological implications*).

The results of this study imply that, unlike the other materials, the decisive reasons for choosing wood are exclusively subjective and non-functional. One of the apparently decisive reasons for choosing wood is its natural material property, natural. Broman (1996), in studying people's visual impressions and attitudes toward Scots pine wood surfaces, likewise noted the importance of this attribute. This quality of wood, being part of its intrinsic nature / character, could provide an edge on laminate and should be stressed in marketing efforts.

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Testing for variation in the log price structure in western Oregon

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Abstract

Timber owners in western Oregon have been concerned about the erosion of price premiums for higher quality grades of Douglas-fir sawlogs over the past decade and the associated impacts on rotation decisions. Time series tests indicate that the ratio of #3 (lower quality) to #2 (higher quality) sawlog prices did rise over the 1990-2000 period indicating a trend towards a convergence between the prices. To identify causes of this shift, reduced form equations for Douglas-fir sawlogs with time-varying coefficients were estimated using flexible least squares. Relative changes in reduced-form coefficients between grades suggest that prices of higher quality lumber grades became more important for #3 than #2 logs during this period while lower quality lumber grades became more important for #2. These shifts may have been the result of changes in the distribution of qualities within log grades (input quality) and log grade-specific technical improvement in sawmilling. Counterfactual simulations of log prices without historical trends in the reduced form variables had no impact on the #2-#3 log price relation though some cases did effect the relations of both #2 and #3 with #4 (the lowest grade).

Keywords: Forest management, log prices, lumber production

TROPICAL / INTERNATIONAL FORESTRY

The Japanese Pulp and Paper Industry
An Analysis of Financial Performance 1991-2001

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Abstract

The purpose is to find differences in return on capital for Japanese pulp and paper companies. The hypothesis is that return on capital can be explained by mill size, productivity, production line, financial data and use of wood resources. Return on capital is measured as income before tax related to stockholders' equity. This variable can be split into profit margin and asset utilization rate. The dataset from 1991-2001 consists of 13 larger Japanese pulp and paper companies. The best model fit is found when using asset utilization rate as dependent variable. Significant variables are asset utilization rate lagged one time period, labor productivity, capital productivity, paper production as a share of total paper and board production, total value of assets on the books and solidity. Among these variables, lagged dependent variable, capital productivity, and total value of assets on the books are negatively correlated with asset utilization rate; the others are positively correlated.

Keywords: return on capital, profit margin, asset utilization rate, vertical integration, timberland ownership

Introduction

In 1937 the Nobel Prize winner R.H. Coase published his famous article "The Nature of the Firm". Since then vertical integration has attracted the interest of many researchers. Some other renowned researchers are Williamson (1985) and Perry (1989). Against this background it is interesting to note the discussion about forestland ownership. It started during the 1990s, not the least by economic journalists that raised the question about forest based companies' rate of return, investments and financing. In the US some companies have soled or made other structural changes for the forestland. The same development has happened in the Nordic countries. Will this contribute to increased profitability for the companies? We are interested in this question. When Lars Lönnstedt was invited as guest professor to Kyoto University an opportunity to study Japanese forest companies arouse. As these companies more or less operate without owning forestland our intention is to compare the financial performance of pulp and paper companies in Japan, the US and Sweden. However, this report deals only with

Japanese companies and the purpose is to give information in English about the companies and also try to find reasons for differences in return on capital. Of course, profitability for the forest-based companies depends on several factors; timberland ownership is only one factor and probably not the major explanation. The hypothesis is that return on capital can be explained by mill size, productivity, production line, financial data and use of wood resources. Return on capital is measured as income before tax related to stockholders' equity. This dependent variable can be split into profit margin and asset utilization rate.

The dataset consists of thirteen larger Japanese pulp and paper companies listed in Pulp & Paper Statistics. For the period 1991-2001data about financial performance, production and use of wood fibers has been collected. The major source is an annual consultancy report bought by The Japanese Federation of Pulp and Paper Industry (Kami Parupu Sangyou Hakusyo). The individual companies have also checked and supplemented the dataset. Table 1 presents some data about the companies for 2001.

A full length report can be found in Lönnstedt and Nordvall (2004).

Table 1. Data about the companies, 2001

	Production (1,000 tons)			Use of wood raw material (1000m^3)	Use of Waste paper (1,000 tons)	Number of employees	Assets (billion Yen)	Stockholders' equity (billion Yen)	Net sales (billion Yen)	Income before tax (billion Yen)
	Paper	Paperboard	Pulp							
1. OJI PAPER	4,305	1,636	2,741	12,040	2,819	7,646	1,209	407	744	-29.0
2. NIPPON PAPER	3049	6	1,938	5,043	0	5,721	813	330	575	44.1
3. DAISHOWA PAPER	1,867	618	1,097	4,331	0	2,547	525	74	282	6.0
4. DAIO PAPER	1,680	544	1,028	3,936	956	2,976	468	114	322	20.4
5. RENGO	0	1,883	0	0	1,890	3,355	333	99	259	10.8
6. MITSUBISHI PAPER	901	46	683	2,005	0	2,373	309	93	175	4.4
7. HOKUETSU PAPER	821	290	650	1928	0	1,104	205	86	129	13.5
8. CHUETSU PULP & PAPER	821	31	659	1,263	154	1,142	151	49	98	6.0
9. JAPAN PAPERBOARD INDUSTRIES	48	983	117	343	0	943	120	17	77	0.1
10. TOKAI PULP	156	459	192	780	450	549	64	15	46	1.1
11. NIPPON KAKOH SEISHI	356	0	97	310	92	805	69	12	49	1.2
12. LINTEC	134	0	0	6	12	2,593	166	72	142	5.7
13. KISHU PAPER	312	0	200	620	0	859	62	35	45	0.7

Model frame

Our model frame is general, i.e. the thinking is not based on a particular region or country. When we are referring to consumption or capacity we have in mind the total of the region or the globe.

One basic relationship is between return on capital, investments and lower production costs. The thinking is that *return on capital* will in a first step positively influence investments in new production capacity and in next step *productivity* and production costs. Later the return on capital will be effected and so on. Let us try more in detail explain the relationship between investment and production costs. New investments (and closing down of old facilities) mean that new, the latest technology will be installed. All experience shows that this means higher productivity and with unchanged factor costs lower production costs per ton. New investments may also mean increase of the production capacity and thus increased economies of scale. The effect will be reduced production costs per ton. Disregarding financial matters and interest rates the conclusion is obvious, rapid investments are positive for the development of return on capital. However, in the long run some “counter balancing forces” exist. High return on capital for the forest industry, for example due to high product prices, usually means that more or less at the “same time” many company boards decide to invest in new capacity. During a relatively short same time span this capacity will come on line. It is very rare that demand or consumption has increased with the same rate. The consequence will be increasing stocks that will put a downward pressure on market prices and on return on capital. Investments will be cancelled or delayed. Sooner or later prices and return on capital will be affected and once again investments will increase and so on. (In the short run the business cycle through the variation in demand will have the same influence on price and return on capital.) The market influence on prices depends on type of product. Generally the price variations are much more obvious for bulky products than for more developed products. In summary, intense competition among pulp and paper manufacturers result in a vicious industry cycle of “demand boom – production increase – capital investment – excessive production – recession - market stagnation – profit deterioration – curtailment of operations and abandonment of excessive equipment.”

Another relationship has to do with financial matters and interest rates. The return on capital will have an impact on companies’ ability to finance an investment from own sources. However, it will also have an impact on the possibility for companies to get external financing. The amounts of debt related to equity and return on capital influence both the opportunity of getting new loans and their price (interest rate). Companies with low solidity will have high costs for interest rates, which have a negative impact on return on capital. Besides, repayments influence cash flow and ability to finance investments from own sources.

Still another relationship of special interest in this case is the roundwood, chip and waste paper markets. At least to some extent high return on capital reflects the ability of the company to pay for fibers. High return on capital may also reflect high demand for forest industrial products and thus need of fibers. One-way for the company to signal this need and to increase supply of fibers is to increase the offered prices. The choice between roundwood, chips and waste paper is a matter of price but also of structure and traditions of the forest sector.

An increasing number of forest industrial products can totally or partly be produced from waste paper. Since long waste paper has been used in countries with limited supply of wood raw materials. Japan is an example of this. Waste paper has been cheaper to use than importing wood. Technological development has also meant that it has become possible to use or mix waste paper with virgin fibers for more and more products. For the last decades another reason for using waste paper is consumers environmental concern. Recycling has become an important issue for the general public. In addition forest, forestry and forest industry may play an important role for assimilating carbon dioxide and decrease the use of fossil fuels.

Hypothesis

The introduction indicates that *return on capital* is central for the study. This is the dependent variable. The difference between different companies (and countries) should be explained from a set of independent or explanatory variables. Our model frame shows that *mill size* and *productivity* may explain the differences. Another explanatory variable is *solidity*. Also the *production line* may be of importance. Use of wood resources, as wood raw material (roundwood and chips) and waste paper will also be included in this study. However, we do not expect to find that timberland ownership is of importance. It may be that use of waste paper has an influence. However, this may also be reflected in production line.

In short, we expect that the following relationship exists:

Return on capital = f(mill size, productivity, solidity, production line, use of waste paper) (1)

+ + + +/- +

Mill size is supposed to indicate economies of scale, which is for example reflected in productivity. High solidity means less payment of interests and thus higher profit for the shareholders. If production line or type of production indicates specialized well-priced paper products the effect on the profit level and return on capital will be positive. However, if the production line means bulky products where the competition is high the opposite may be the case. Waste paper is in general lower priced and has lower processing costs than roundwood, which as a consequence will generate higher profit and also higher return on capital.

Financial performance

The Japanese pulp industry produces annually about 10 mill. Tons and the paper and paperboard industry about 30 mill. tons. The customers can be found on the domestic market. Import is marginal but increasing for paper and paperboard.

In 1955 pulpwood was equal to logs, to day chips are totally dominating. Today the total pulpwood supply is about 36 mill. m^3. Another major change that has taken place is the dramatic increase of import. At the beginning of 2000s about 70% was imported. Another important papermaking raw material is wastepaper. More than half of the fiber material used by the paper and paperboard is wastepaper.

For return on equity and profit margin the business cycle can easily be seen (Figure 1). The studied period starts with a decrease in the cycle. The bottom seems to be reached just before the middle of the decade. The following peak occurred around 1996-1997 and is once again followed by slowing businesses.

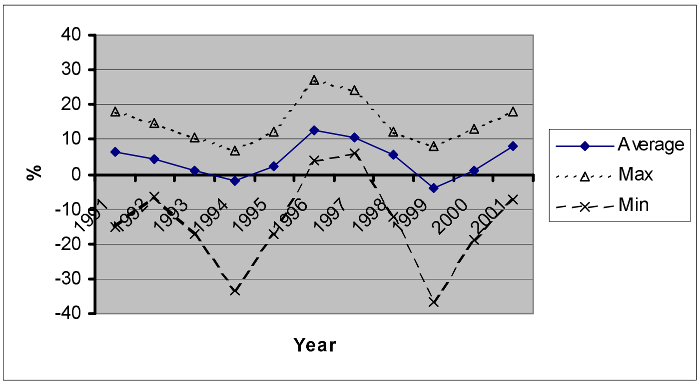

Figure 1. Return on equity.

As the maximum and minimum values shows the difference in profitability between the companies is large. This reflects that management has chosen different strategies or business niches. A major task for this paper is to try to explain the differences in profitability of the companies. Could it be explained by differences in product lines, economies of scale or something else? In the following sections we will come back to this question.

Solidity has been quite stable. The average value of assets on the books is 320 billion Yen. The range is very large with a maximum average value of 1,085 billion Yen and a minimum of 56 billion Yen. The average standard deviation is 324 billion Yen. The average value of assets on the books have been quite stable but an effect from the merges around the middle of the decade can been noticed. Another measure of company size is number of employees. The average for the thirteen studied companies and for the studied period is 3,000 with a standard deviation of 2,688. The number has been quite stable. However, once again the influence from mergers can be seen. During the later part of the period a slow decrease can be noticed.

The average mill size varies depending on the production line for the company. Companies with both paper and paperboard production has the highest average mill sizes while the smallest mill sizes can be found among companies only producing paper. Probably some of these companies have quite specialized paper products. For companies only producing paperboard the average mill size decreased quite dramatically after 1996, because of merges. In 2001 the average was back at the same level as in 1996. The average pulp mill size has slowly increased. The companies own production of pulp, measured as pulp production related to paper and paperboard production, has slowly decreased from 52 % in 1991 to 42 % in 2001.

As could be expected, labor productivity has increased from 600 tons in 1991 to 970 tons per employee and year in 2001. Capital productivity measured, as tons per mill. Yen of value of assets on the books has been fairly stable.

The import share of wood raw material related to total use has decreased quite substantially, from 36 % in 1991 to 48 % in 2001. The use of wood raw material per ton of paper and paperboard has described the opposite development, from 1.43 to 0.88 m^3 per ton. Use of waste paper per ton of paper and paperboard has increased, from 32 % in 1991 to 39 % in 2001. Table 2 summarizes some of the results.

Table 2. Summary of some key measures for the studied variables measured as averages for all the studied companies and for the studied years (1991-2001).

VARIABLE	AVERAGE	STANDARD DEVIATION
PROFITABILITY		
Return on equity	4.2 %	7.7 %
Return on equity after tax	-0.1 %	8.4 %
Profit margin	2.0 %	2.9 %
Asset utilization rate	2.1	1.6
SOLIDITY	32 %	12 %
SIZE OF COMPANY		
Value of assets on the books	320 billion Yen	324 billion Yen
Number of employees	3,000	2,688
AVERAGE MILL SIZE		
Paper and paperboard	414,000 tons/year	209,000 tons/year
Paper (only)	184,000 tons/year	76,000 tons/year
Share of only paper product.	71 %	38 %
Paperboard (only)	277,000 tons/year	60,000 tons/year
Pulp	322,000 tons/year	274,000 tons/year
Share of pulp production	45 %	29 %
PRODUCTIVITY		
Employee	0.75 tons/employee	0.39 tons/employee
Capital	7.0 tons/mill. Yen	3.0 tons/mill. Yen
USE OF FIBRES		
Import share of wood & chips	43 %	29 %
Use of wood & chips	1.43 m^3/ton	0.88 m^3/ton
Use of waste paper	34 %	32 %

Grouping of the companies

When trying to group the studied Japanese pulp and paper companies the main purpose has been to explore if differences in return on equity, profit margin and asset utilization rate could be found when making a logical grouping of the studied companies? We have looked at time series for averages of the total material but also at individual companies. In the text we will mainly present averages for all companies and for the whole period (1991-2001). We have tried to identify clusters of companies having distinctive features, i.e. that differ from each other. Clusters have been identified depending on type of production, size, use of waste paper, mill size and productivity. A comparison between the different clusters shows that companies with higher profitability than the average are characterized by

· A mixture of pulp, paper and paperboard production. (Two companies with only paper and paperboard production, respectively have also high profitability.)
· Low or high use of waste paper
· High average pulp mill size
· High labor and capital productivity

The clusters depending on company size and paper mill size showed profitability below the average.

Based on the result a hypothesis was formulated that “middle sized” companies were more efficient and had a higher profitability than “large” and “small” companies (Table 3).

Table 3. Return on equity, profit margin and asset utilization rate as an average for two clusters of companies depending on number of employees and value of assets on the books.

Cluster: Number of employees and value of assets	No. of companies	Return on equity	Profit margin	Asset utilization rate
>4,000 & 600 billion Yen	3	2.5	1.3	2.5
<1,000 & 100 billion Yen	3	1.3	0.4	3.2
Total	13	4.2	2.0	2.5

It should be remembered that the used dataset covers quite a short time span; a time span that from some aspects was quite special for Japan. It could be argued that the time span is too short for showing the effect of the merges during the 1990s. In that respect it may not give justice to big companies. Another type of criticism is that the analysis is based on averages for the whole period. Differences or a tendency in the development for an individual company is not reflected. In next chapter, we will base the analysis on time series.

Statistical analysis

Economic theory often suggests relations between variables in the long run and in levels. The theory provides little evidence about the underlying processes, which determine the observed data, i.e. the features of the data we have to work with (Charemza & Deadman, 1992; Harris, 1995).

Often (close to always) there are stochastic trends present in economic time series. If not considered, these trends may result in spurious regression, i.e. results that are based on correlated time trends. This is an old problem, which has been discussed for many years (Yule, 1926; Wold, 1953; Granger & Newbold, 1974). A common way of dealing with this is to transform the levels of the variables into first order differences (i.e. $\Delta y_t = y_t - y_{t-1}$). The drawback is that some information may be lost and that the connection to economic theory may become a bit loose or strained.

Economic modeling can have static or dynamic approach. Due to the commonly presence of inertia or adjustment in economic time series, reflecting technological development, institutional factors and psychological reasons (cf. Gujarati, 1988) a dynamic approach may be preferred. Dynamics can be modeled in different ways, i.e. by lagging one or all explaining variables. The most common way is to sum up the dynamics by lagging the dependent variable one or more time periods (Wonnacott & Wonnacott, 1979).

A study of each company with respect to the relations in eqv. (1) presupposes a large number of observations (i.e. at least 50-60 observations). Available observations in this study are yearly observations 1991-2001. This excludes studies of each company. However, the relations in (1) may be studied with respect to common features of all companies by applying a time series cross section model (cf. Hsiao, 1986; Baltagi, 2002):

$$y_{it} = \beta \mathbf{X}_{it} + u_{it}, \quad i = 1, \ldots, N; \quad t = 1, \ldots, T \qquad (2)$$

where $\mathbf{y}_{it}$ is the dependent variable; $\mathbf{X}_{it}$ is a vector of explaining variables; u_{it} is a residual term which is presumed to be random; i = the observed companies; t = the observed time period.

This type of model has two types of estimators (fixed and random effects estimators) to handle a tendency of u_{it} to be higher for some *i* and *t* (RATS, 2000). Fixed effects do this by using a separate intercept for each *i* or *t*. Due to the fact that there is often a scarcity in observations/data, these intercepts are often eliminated by subtracting individual and/or time means before the regression. Random effects is based on the following decomposition:

$$u_{it} = \varepsilon_i + \lambda_t + \nu_{it} \qquad (3)$$

where ε is the individual effect, λ the time effect and γ the purely random effect.

There are advantages and disadvantages with the two types of estimators, e.g. fixed effects cannot estimate a coefficient on a time-invariant explanatory variable; ε (and λ) are parts of u in random effects and may be correlated to the explanatory variables (cf. Hausman & Taylor, 1981).

There are two qualified statistical packages that can be used in this kind of analysis: PcGive (Doornik & Hendry, 2001a, 2001b and 2001c) and RATS (RATS, 2000a and 2000b). PcGive has the advantage of being interactive and thereby user friendly. RATS has the disadvantage of assuming a certain amount of programming skills by the user, and the advantage of being successively updated by the latest econometrical progresses. Another advantage of RATS is that it has a larger flexibility in effects estimators. Taken together, RATS is preferred and chosen to carry out the statistical analysis in this study.

The analyses tested which of the following dependent variables (y_{it}):

Profitability:
RET = Rate of return: profit before tax related to stockholders' equity
RETX = Profit after tax related to stockholders' equity
PMARG = Profit before tax related to total sales
CAPT = Asset utilization rate: sales related to value of assets on the books

that best could be explained by the following variables ($\mathbf{X}_{it}$):

APBP = Average paper and paperboard mill size: total production of paper and paperboard divided by total number of mills
APUP = Average pulp mill size: total production of pulp divided by total number of mills
PROE = Labor productivity: total production of paper, paperboard and pulp divided with total number of employees
PROC = Capital productivity: total production of paper, paperboard and pulp divided with total value of assets on the books
PASH = Paper share: production of paper related to total production of paper and paperboard
PUSH = Pulp share: production of pulp related to total production of paper and paperboard
ASSE = Total value of assets on the books
SOLI = Stockholders' equity related to total value of assets

RWCT= Use of virgin fibers (roundwood and chips) related to total production of paper and paperboard
WAPR = Use of waste paper related tot total production of paper and paperboard
IMPW = Import of virgin fibers related to total use of virgin fibers

Due to the fact that some of the explaining variables contained time-invariant sequences, the random effects estimator (3) was applied.

Before the statistical analysis was carried out, the economic time series were deflated by the GDP deflator with 1995 basis (Bank of Japan, Statistics). This was done to avoid any inflationary effects on the results. GDP deflator is prices in the calculation of the Gross Domestic Product; 1995 basis = 100.

All dependent and explanatory variables were tested successively, including different combinations of levels and first differences. The best model fit had asset utilization rate as dependent variable. The best model fit required that all variables that not were expressed in (%) or (1), had to be transformed to (%) and into their first differences (Δ). Other dependent variables (profit before tax related to stockholders' equity; profit after tax related to stockholders' equity; profit before tax related to total sales) could not be explained in this model context and was therefore excluded from the analysis.

Explanatory variables that did not improve the model fit were: employment and debt degree. Employment was not significant and is not motivated in (1); debt degree was excluded due to high correlation with solidity. This is no surprise as debt degree can be deducted from solidity and the other way around. We did not found any significant model fit by grouping the companies. This may be due to a scarcity in observations/data.

The best model fit is shown in Table 4; Table 5 shows analysis of variances for the residuals with respect to differing means regarding *i*, *t* and joint. Table 6 shows test of equal variances for the residuals. In the following, the number in brackets give the order of time delay (i.e. lags); i.e., ΔCAPT{1} indicates that the variable is lagged one time period.

Table 4. Panel regression – estimation by random effects

Dependent variable: ΔCAPT
Panel of annual data: $i = 1, \ldots, 13$; $t = 1991, \ldots, 2001$
Usable observations: 117; DF: 104
R^2 (adj.): 0.57506
Std error of estimation: 0.06097

Variable	Coefficient	Std. error	T-stat	Significance Level
1. Constant	-0.00971	0.01277	-0.76067	0.44685
2. ΔCAPT{1}	-0.17699	0.05914	-2.99276	0.00277
3. ΔAPBP	-0.08825	0.05621	-1.57004	0.11641
4. ΔAPUP	0.03765	0.02261	1.66526	0.09586
5. ΔPROE	0.19275	0.08351	2.30828	0.02098
6. ΔPROC	-0.21910	0.09563	-2.29114	0.02196
7. ΔPASH	-0.00313	0.00183	-1.71028	0.08721
8. ΔPUSH	0.00328	0.00233	1.40984	0.15859
9. ΔASSE	-0.59571	0.09642	-6.17806	0.00000
10. ΔSOLI	0.00567	0.00243	2.33140	0.01973
11. ΔRWCT	-0.07430	0.04900	-1.51614	0.12949
12. ΔWAPR	0.02046	0.02773	0.73799	0.46052
13. ΔIMPW	-0.00158	0.00132	-1.19447	0.23229

Table 5 Analysis of variance for residuals

Source	Sum of Squares	Degrees	Mean Square	F-stat	Significance Level
INDIV	0.00359	12	0.00030	0.08280	0.99998
TIME	0.03562	8	0.00445	1.23050	0.28978
JOINT	0.03921	20	0.00196	0.54180	0.94074

Table 6. Test of equal variances for residuals

χ^2**(12)**	= 86.95033
Significance Level	= 0.00000

The first table (Table 4) indicates a low but acceptable R^2. The low R^2 may be due to the difference transformation. Table 4 also indicates reasonable model features with respect to dynamics, signs and size of the coefficients. Table 5 underlines this by not indicating any significant individual, time or combined effects. The spread of the residuals are also acceptable (Table 6). The model may therefore be regarded as acceptable.

Conclusions and further research

Profitability

Asset utilization rate (CAPT) is significant and has a negative lagged effect in correlation with asset utilization rate; the coefficient indicates that close to 18% of the model behavior is explained by inertia (of one time period) in the adjustment of the time series.

An acceptable fit between observed and estimated time series could be observed. It is possible that more information about some companies could have improved the model fit for these companies. Dummies or trend dummies could have modeled this information. On the other hand, the model is constructed to capture common features of the companies and thus, it will always be individual discrepancies.

Asset utilization rate is relatively low (0,5-1,0) and constant for most of the companies. Only a few companies have a decreasing asset utilization rate. No company has an increasing asset utilization rate. It is interesting to note that there is a limited impact from business cycles to asset utilization rate.

Mill size

Average paper and paperboard mill size (APBP) and average pulp mill size (APUP) are significant or close to be significant, respectively, but have opposite signs. The negative sign for average paper and paperboard mill size indicates that an increase of average mill size of paper and board is not correlated with an increase in asset utilization rate but with a decrease. This may indicate an increased importance of production of special paper and paperboard. Smaller and more numerous mill sites can be located closer to consumer markets and this closeness to consumer demand may be more important than economies of scale in production of bulky products. The situation is reversed for average pulp mill size: an increased average mill size is correlated with an increased asset utilization rate. In this case economies of scale is important.

A conclusion that may be drawn is that paper and paperboard companies focusing on producing special qualities will continue to increase its purchases of market pulp and waste paper, rather than expand its internal pulp production, whereas producers of bulky paper and paperboard products needs to be more efficient in economies of scale.

Productivity

Labor productivity (PROE) and capital productivity (PROC) are both significant but with different signs. It is interesting to note that labor productivity is positively correlated with asset utilization rate, but a bit surprising that capital productivity is negatively correlated with asset utilization rate, i.e. there is profitability in labor productivity but not in capital productivity. The reason and the implication of this are not obvious; it needs to be subject to further research.

Production line

Paper share (PASH) has (cf. average paper and board mill size (APBP)) a negative effect in correlation with asset utilization rate; paper share is also significant but the effect is minor compared with the effect of average paper and paperboard mill size. The similar can be said regarding pulp share (PUSH) and average pulp mill size (APUP); pulp share has a positive (but not significant) effect in correlation with asset utilization rate, but the effect is rather minor compared with the effect of average pulp mill size. This indicates that there is profitability in pulp production (mill size and production line) but not in paper and paperboard production (mill size and production line).

Financial data

Total value of assets on the books (ASSE) has a major negative and significant effect on asset utilization rate. This indicates that size (measured as total value of assets on the books) is not automatically correlated with increased profitability. Solidity (SOLI) is on the other hand significant and positively correlated with asset utilization rate. The effect is minor, which may be due to large differences between the companies and that these differences taken together result in a minor effect.

Use of wood resources

Use of roundwood and chips related to total production of paper and board (RWCT) is close to having significant negative effect in correlation with asset utilization rate. Use of waste paper related to total production of paper and board (WAPR) has positive but no significant effect. This may reflect that roundwood and chips have become more expensive and this has been replaced by wastepaper. An increased wastepaper use with a not significant effect in correlation with asset utilization rate may indicate that this has been done without significant effect on profitability. Import of roundwood and chips related to total use on roundwood and chips (IMPW) has a minor negative, but not significant effect. The minor effect may reflect large differences in import rates among the companies. Different companies may import in different ways; i.e. from importing from whole- or part-owned forest plantations combined with purchasing by long/short term contracts, to importing mainly by short term contract on the spot-market. Adding to this complexity in different ways of importing are local and regional price differences, which may differ quite substantially from time to time. This is a complex field, which may need to be subject to further research.

Comments

It has to be noted that 1991-2001 is a special time period where the Japanese economy went through a period of stagnation, which may have had a distorting effect on the results. It is possible that prolonged time series backwards may have produced different results. Besides, the study is based on a sample of companies. If all the Japanese pulp and paper companies had been included in the study, one cannot rule out another outcome of the results.

The results are only preliminary due to lack of similar studies to compare with. However, the results are interesting and encourage further research, i.e. to carry out corresponding studies of Sweden and the US. The countries can be studied country by country, focusing on country specific features, or together focusing on common features. How to proceed will depend on the availability of the data and the stochastic features of the time series (Royal Swedish Academy of Science, 2003).

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Data sources:
BANK OF JAPAN, Statistics
FAOSTAT Forestry

Road and Trail Network Optimisation for Low-intensity Selective Logging in Tropical Forests

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Abstract

Selective logging operations in natural tropical forests often involve a very limited number of commercial tree species and if the density of these species is low, the number of trees felled may be only a few per ha. Consequently the costs of road and trail networks have a significant impact on the overall profitability of forest use. Furthermore, the damages resulting from inappropriate routing of skid trails may be severe and, therefore, the need for optimisation of the transport network layout is evident. However, optimisation involves deciding what trees to cut, designing the best possible road and trail network and choosing the best possible winding route for each trail segment and is therefore a difficult task. In this study a self-organising procedure is tested as a means of optimising the temporary road and trail network in a heterogeneous terrain with scattered trees. The paper outlines the method and presents preliminary test results for a hypothetical forest area.

Keywords: Self-organisation, ant colony algorithm, swarm intelligence, skid trails, forest operations

1. Introduction

Selective harvesting in tropical forests has been observed to cause considerable damage to the remaining trees and soil of stands with relatively high densities of commercial trees (Gullison & Hardner 1993, Webb 1997). For example, in a study where reduced-impact logging was carried out in a humid tropical forest in Bolivia and 4.35 trees/ha were felled it was found that, for every tree that was extracted, 44 trees with DBH greater than 10 cm were damaged (Jackson et al. 2002). However, usually the damages can be limited by careful planning of skid trails and logging roads, directional felling, cutting of lianas prior to felling, etc. (d'Oliveira & Braz 1995, Douglas 1998, Sist 2000). Nevertheless, in a comparative study in East Kalimantan in Indonesia it was found that, although reduced-impact logging reduced damages by 50% compared to conventional logging, 25% of the original tree population was damaged when the felling intensity was 8 trees/ha (Sist et al. 1998). Moreover, the effectiveness of reduced-impact logging techniques in reducing the damages decreases when the logging intensity increases (Gullison & Hardner 1993, Sist et al. 1998). The area covered by skid trails and the resulting disturbance of the topsoil also depends on the way that harvest is planned and executed. For example, in a study in Malaysia it was found that in an area where conventional, uncontrolled harvest had been carried out 17% of the area was covered by roads and skid trails whereas, in an experimental area with reduced-impact logging, only 6% of the area was disturbed (Pinard et al. 2000).

The applied felling regime and the associated planning effort have repeatedly been shown to have a significant impact upon drainage, water runoff, soil erosion and stream water quality in tropical forests (Yusop et al. 1987; Nik & Harding 1992; Hartanto et al. 2003). The main sources of sediments in stream waters of logged-over forests are logging roads and skid trails. For example, Baharuddin et al. (1995) found that the surface runoff from skid trails and logging roads were 14.5% and 20.3% of the total annual rainfall, respectively, compared to 2.3% for an undisturbed area of forest. Similarly, in the first year after logging the soil loss from skid trails and logging roads was 22 and 29 times greater, respectively, than from an undisturbed forest. The difference gradually diminished from one year after logging when secondary vegetation started covering gaps and trails. According to Nik & Harding (1992) the adverse effects of logging can to some extent be ameliorated by proper planning of the road network, installation of cross drains and use of buffer strips.

Studies like those of Barreto et al. (1998) and Ahmad et al. (1999) have shown that the economics of selective logging is improved considerably when logging operations and road construction are properly planned. On a per cubic metre basis it appears that planning reduces costs of all work elements of selective logging, including the number of working hours used on tree felling, the number of machine hours used on opening logging roads and log landings and the number of hours used on skidding. In addition, the number of logs that are wasted, either because they are damaged due to poor felling techniques or because machine operators do not find them, is reduced when logging operations are properly planned. The cumulative effects of the increased productivity in felling and skidding more than compensate for the cost of planning (Barreto et al. 1998, Ahmad et al. 1999). Nevertheless, as also mentioned by Howard et al. (1996), there are a number of barriers to the application of sustainable management practice, including a high interest rate and the lack of enforcement of forestry regulations.

1.1 Road and trail network planning

An important element in the planning of selective logging is the design of road networks. Traditional models used to plan forest road networks are based on rigid simplifying assumptions, e.g. that the forest is spatially homogeneous with respect to volume or value, and the optimal distance between roads is determined by minimising the transportation cost per cubic metre. The optimum is found where the construction cost per unit volume served by the road equals the travelling portion of the skidding and forwarding costs expressed in the same unit (FAO 1977, Wijngaard & Reinders 1985, Yeap & Sessions 1989). Under the condition that road density is constant and that distance is the only important concern, the road network layout can be optimised using geographical optimisation techniques such as the one described by Ishikawa et al. (1995). Other studies operate with more complicated conditions where spatial structure, existing roads, topography (Wijngaard & Reinders 1985, Dean 1997), differential costs (Setyabudi 1994) and environmental constraints (Richards & Gunn 2000) are taken into account. In such cases heuristic solvers or combinations of tools (e.g. GIS and linear programming) are used to identify the optimal road network.

When designing a road and trail network the risk of erosion, deteriorated drainage and long-term degradation of forest productivity is greatly influenced by the extent to which topography, soil conditions and location of major watercourses are taken into account. However, the task of designing an optimal road and trail network that includes secondary forest roads and skid trails with links to every single tree is tremendous, particularly if differential costs and risks of damages are to be taken into account.

The optimal road and trail network problem shares basic characteristics with the classic Travelling Salesman Problem, where each of a number of points must be visited once and only once by following the shortest possible route, and with the Vehicle Routing Problem where products must be delivered to a number of points by vehicles starting at a common source point while keeping the sum of the travel distances at a minimum. In the road network problem the points to be visited are trees, the routes all go from a timber landing to the tree and back, and apart from horizontal distance, the transportation cost depends on slope, soil conditions, density of vegetation and occurrence of obstacles such as rivers, swamps and pools. The objective is to minimise a cost function that may include both direct costs and indirect costs associated with anticipated damages. At least three variants of the problem may be distinguished, (I) a simplified (restricted) version where every relevant tree is felled, (II) a version where only those trees that yield a positive contribution margin are felled and (III) a 'complete' version where only those trees are felled for which the sales value exceeds the cost of felling and transportation plus the (discounted) opportunity cost resulting from damages to soil and remaining vegetation. Model I is a pure road network optimisation model whereas (II) and (III) are combined harvest and road network optimisation models. A fourth model that may be considered is one that emphasises harvest and road networks both at the current point in time and in the future (IV). Obviously, to apply such a model reliable growth forecasts and estimates of entry costs and opportunity costs must be available. Based on optimisation in such a model one may both decide how much and how often to harvest, and how to design permanent and temporary road and trail networks. In this paper the emphasis will be on the comparatively simple Model I.

As illustrated by the study of Richards & Gunn (2000) a tabu search procedure can handle quite large road network design problems. On the other hand, as mentioned by Bonabeau et al. (1999), with respect to the Travelling Salesman Problem collaborative, self-organising optimisation procedures known as ant-based algorithms may obtain performance similar to that of the best heuristics, such as tabu search. Ant colony optimisation is one variant of what is also known as 'swarm intelligence' and owes its name to an analogy with the foraging behaviour of ants, where positive feedback is obtained through pheromone deposits indicating the routes previously followed by other ants.

In Section 2 a self-organising procedure will be outlined, which is designed to solve complex multi-objective road and trail network problems. The 'ants' can be thought of as agents, or 'contractors', who communicate their experiences (costs) to other agents. For example one may imagine that each contractor draws a sketch map showing what route he has followed, writes a note on his transport costs and that any contractor has access to the sketch maps and notes provided by all of his predecessors. The optimisation procedure is intended for application on data from Bolivian concession areas but, so far, it has only been applied to idealised examples. To illustrate the potential of the procedure preliminary results are presented for a hypothetical forest area including all the features considered in the model.

2. Basic features of models and methods

We will consider a forest area that is divided into square cells using a regular quadratic grid. Each cell is assigned eight properties, six of which are static. First, some cells hold a commercial tree while others are 'empty'. This is indicated by the binary function $T(cell)$ which is 1 if a tree is present and 0 if the cell is empty. The contribution margin associated with visiting the cell and felling the tree is assumed known and is given by the real-valued function $W(cell)$. If no tree is found in a cell, $W(cell) = 0$. The location of existing permanent roads is indicated by the binary function $R(cell)$, which has the value 1 if the cell is part of an existing road and 0 if it is not. Similarly, the location of protected areas that must be avoided completely is indicated by the binary function *P*(*cell*), which is 1 in protected areas and 0 otherwise. The cost of accessing a given cell and using it for transportation is indicated by the real-valued transport difficulty function *D*(*cell*). Similarly, the present value of the long-term opportunity cost, that is assumed to be associated with damages caused when using a cell, is indicated by the sensitivity function *S*(*cell*). Finally, at any given time the amount of positive feedback from previous visitors is expressed by the function *F*(*cell*) and the number of previous visits by the current agent, the associated type of road or trail and the resulting costs of using the cell this time is expressed by *U*(*cell*).

As regards the moves of the skidders (agents), four different schemes can be distinguished, [i] one where a skidder is allowed to move to any of the eight cells surrounding it, [ii] one where the skidder is allowed to move in any direction except back to where it came from, [iii] one where the angle between the direction in which the skidder arrived and the direction of the next move cannot exceed 90 degrees, and [iv] one where the angle cannot exceed 45 degrees. In the example presented here the third scheme including five different moves is applied.

As mentioned in Section 1.1 four different problems can be specified. Only the simple Model I will be considered here. In Model I the aim is to minimise the total direct cost of the road and trail network plus the present value of the opportunity cost associated with damages to soil and vegetation. Leaving out details the objective function can be outlined as:

$$C_I^* = \min\left\{\sum_{trees}\left(\sum_{cells} U(cell) + D(cell) + S(cell)\right)\right\} .$$

The undesirability of moving to a particular cell (*j*) is measured using an inconvenience function *I*(*j*). This function includes the three cost elements of the objective function (*U*, *D*, *S*) plus weighted effects of distance to nearest tree (DIS_N) and distance to the value-weighted centre of the spatial distribution of the trees (DIS_W) minus positive feedback from previous visitors to the cell (*F*):

$$I(j) \quad = \quad U(j) + D(j) + S(j) \quad + \quad DIS_N(j) + DIS_W(j) - F(j) \ .$$

At any time the direction of move is determined randomly using a probability function based on the relative desirability of choosing a particular move (*j*). The probability function can be expressed as:

$$\pi(j) = \frac{\left(\max_{m'}\{I(m')\} - I(j)\right)^{\beta}}{\sum_{m=1}^{M}\left(\max_{m'}\{I(m')\} - I(m)\right)^{\beta}} ,$$

where â is an adjustable parameter, *M* = 5 is the number of allowed directions, and max{*I*(*m'*)} is the maximum inconvenience value observed in any of the allowed directions.

3. Example

A hypothetical forest area has been created to test the self-organising algorithm. The area is rectangular (600 × 480 m; 28.8 ha) and includes 40 commercial trees and examples of all other features considered in the model. Figure 1 illustrates the economic properties of the forest area. The passability landscape to the left shows the variation of the transport difficulty function $D(\cdot)$. Similarly, the sensitivity landscape to the right shows the variation of the sensitivity function $S(\cdot)$. The dark high-difficulty, high-sensitivity band snaking its way through the area is a river that must be bridged to get access to trees in the northeast corner of the area. The dark patches in the passability landscape can be thought of as marshy areas or backwaters of the river. Similarly, the dark areas in the sensitivity landscape are mainly areas close to the river, which are likely to be damaged severely when logged and/or ought to be protected to avoid heavy soil erosion.

The left-hand part of Figure 2 shows the passability landscape overlaid by a network of shortest possible paths to the existing road. Although such a network is not the poorest solution one might imagine, it still crosses the river in two places, crosses three swampy areas, and by comparing the network with the sensitivity landscape in Figure 1 it also appears that a considerable part of the network is located in highly sensitive areas along the river. Of course it is unlikely that difficult and sensitive areas can be avoided completely but at least it must be ascertained that a well-considered and balanced compromise solution is used. This is the aim of the methods described here.

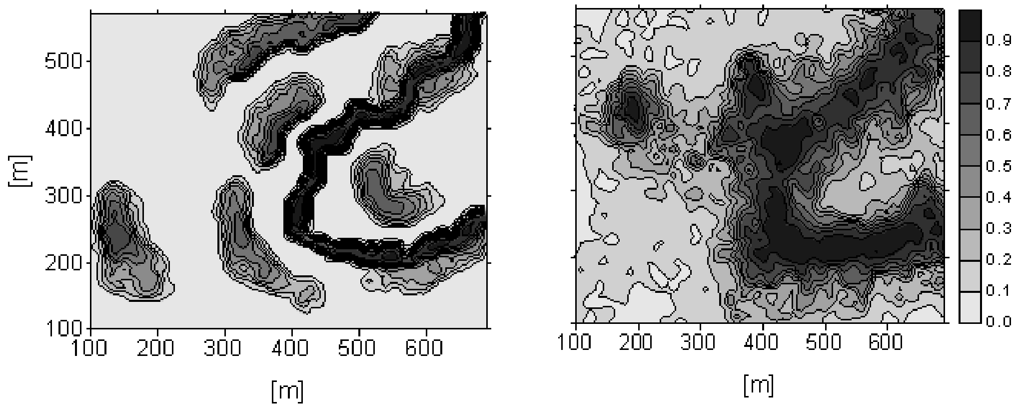
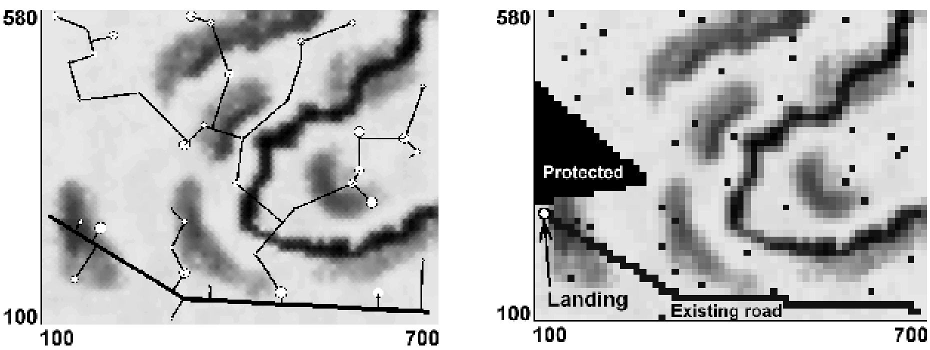


Figure 1. Left: Passability landscape, $D(\cdot)$; dark areas are rivers or swamps that are difficult (expensive) to pass. **Right**: Sensitivity landscape, $S(\cdot)$; dark areas are particularly sensitive and skidding is associated with considerable opportunity costs.

Figure 2. Left: Passability landscape, $D(\cdot)$, with shortest path trail network overlaid.



The thick line is an existing road; other lines are suggested skid trails. Circles are trees and their diameter is proportional to stumpage value. **Right**: Passability grid $D(\cdot)$ with protected area $P(\cdot)$, trees $T(\cdot)$ and existing road $R(\cdot)$ overlaid.

In the optimisation runs all agents start at the landing, see right-hand part of Figure 2. At every step they evaluate the desirability of each of the five allowed moves according to the principles described above. When moving they record the cost and when they end up in a cell with a tree they receive the stumpage value of this tree and return to the landing following the route they used on their way out. When an agent has visited all trees the objective value is evaluated and compared to the current best result. The better the relative performance of the agent, the more positive feedback (experience) is left behind as guidance for other agents. In the run presented below 50 agents are applied and when all 50 agents have finished their search the feedback pattern, $F(\cdot)$, is weakened by multiplying all values by 0.85. In that way the effect of inferior solutions diminishes over time. In addition the feedback function is bounded, implying that its effects on the agent's decisions, compared to other components of the probabilistic decision model, remain within a certain range.

4. Results

In this section the results of a single optimisation run including 4000 iterations are described. As mentioned above the hypothetical forest area is 600 × 480 m and in this run a spatial resolution of 60 × 48 cells was applied, each cell thus having a size of 10 × 10 m. Clearly, 10 metres is considerably more than the width of a skid trail (3-4 m according to Jackson et al. 2002, Table 5), and therefore, the area disturbed by roads and trails will not be examined here. The optimisation algorithm was written in Borland Delphi; the optimisation was executed on a PC with a 1 GHz processor and the 4000 iterations took 14 minutes. In initial test runs it was observed that the improvement of the solution was very slow when fixed optimisation parameters were applied and, hence, the results presented here are based on a schedule where the agents become more focused over time and, conversely, exhibit less explorative behaviour.

The development of the objective function is illustrated in Figure 3. The graph shows both the current solutions (thin line) and the current best solution (thick line) and it appears from the graph that the algorithm continues to improve the solution to the very end of the optimisation run. Thus, it is evident that the algorithm was not really allowed to converge completely. This is a consequence of the mentioned parameter adjustment schedule that forces the agents to become more focused but, on the other hand, does not allow them to fully explore the range of possibilities at any particular stage.

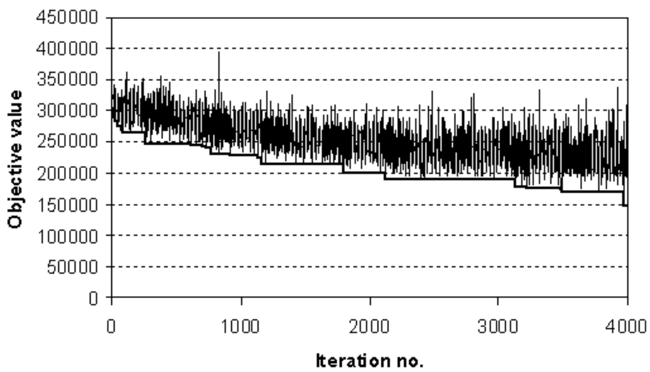


Figure 3. Development of the objective value for an optimisation run with 4000 iterations. The bold line indicates the objective value of the current best solution

Figure 4 shows the accumulated number of visits to each cell at the end of the optimisation run (iteration 4000). Firstly, it appears that due to the low cost of using the existing road, cells that form part of this road have very high frequencies of visits, at least for those parts of the road that are situated close to the timber landing (cf. right-hand part of Fig. 2). Secondly, it appears that due to the fact that many trees are situated north and northeast of the protected area, cells immediately south of the protected area are used very often. It is also interesting to note that, due to the high cost of passing the river and the marshy areas, cells in these areas are not visited very often. The river is most frequently crossed at the three points marked A, B and C. At these points it is relatively narrow (A, B) or trees are located on either side, near the banks (A, B, C). Finally, it should be noted that with the weights applied here, the agents usually prefer to pass a swampy area (marked D) to reach the northernmost trees in the middle, instead of taking the slightly longer route to the west (marked E).

In Figure 5 the development of the feedback function $F(\cdot)$ is shown at six stages of the optimisation. It appears that in the beginning of the process (iteration 50) no spatially continuous feedback pattern has formed and the pattern appears highly erratic. During the next one thousand iterations evidence accumulates, but at iteration 1000 it is still difficult to judge what paths will eventually be preferred although certain routes have indeed been ruled out, e.g. the one marked E in Fig. 4. Finally, during the last 3000 iterations the most preferable paths gradually crystallise. However, at iteration 4000 there are still many alternative routes that have not yet been ruled out.

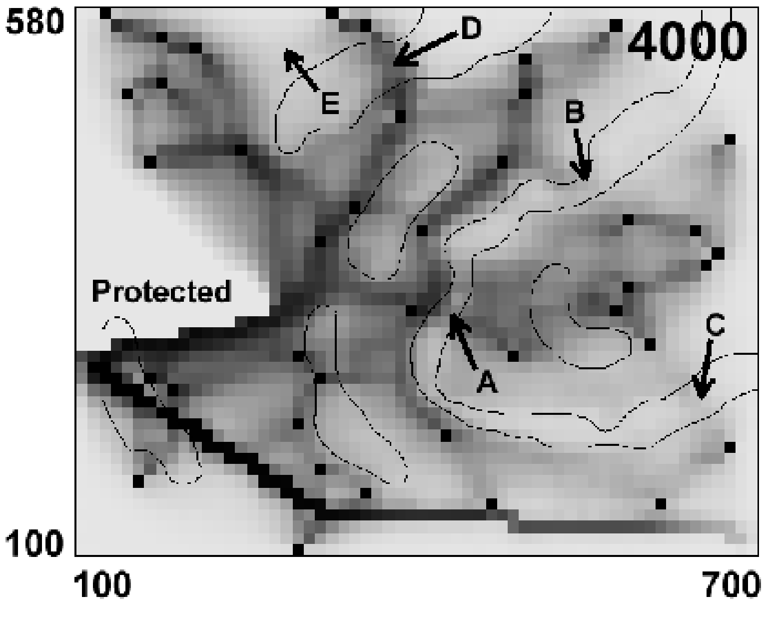


Figure 4. Accumulated number of visits at iteration 4000. Most frequently visited areas are darkest. Location of river and (marshy) areas with low passability are marked with thin black lines.

The current best solutions are shown in Figure 6 and confirm the impression already obtained from Figure 5, namely that the explorative behaviour of the agents continues at least to iteration 1000 and that, only after then, they become so focused that less muddled solutions gradually result. The solution obtained at iteration 4000 clearly underlines the fact that the process was not allowed to fully converge. The overall structure of the solution may be close to the optimum but even if this is the case, it still includes a couple of doubled routes and a considerable number of cells that are visited for no apparent reason.

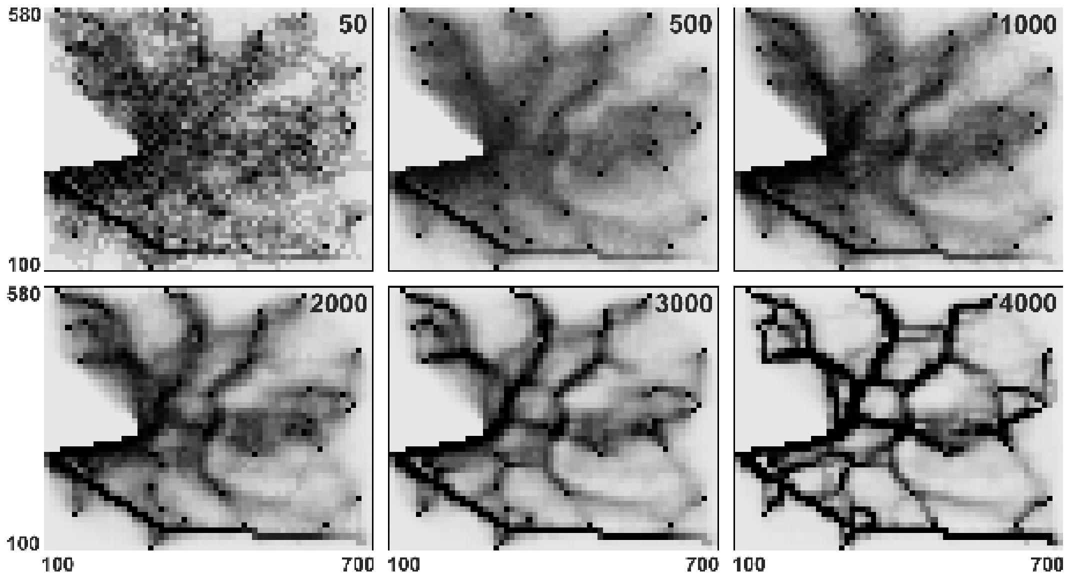


Figure 5. Intensity of feedback from previous passes $F(\cdot)$ at iterations 50, 500, 1000, 2000, 3000 and 4000. Shading is proportional to $F(\cdot)$, darker areas being more attractive.

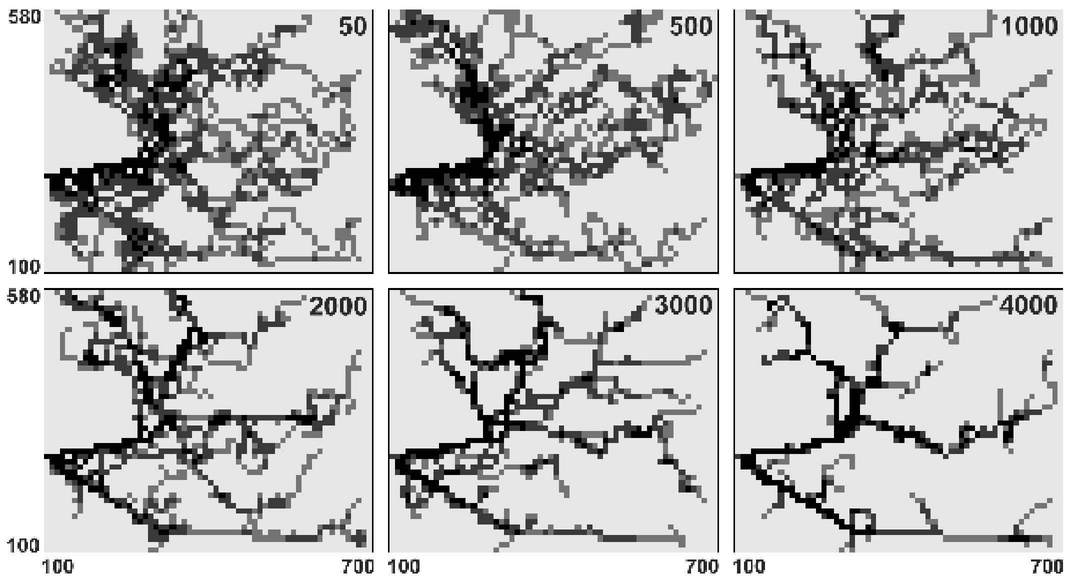


Figure 6. Current best trail networks at iterations 50, 500, 1000, 2000, 3000 and 4000. Shading indicates intensity of use (light grey: not in use; black: used more than three times).

5. Discussion

A self-organising algorithm for road and trail network optimisation has been outlined and applied to a hypothetical forest area. The next step is to apply the algorithm to a real forest and to compare the results with those obtained using other methods. Moreover, still a considerable amount of work needs to be done to identify ideal optimisation schedules that ensure that near-optimal solutions are invariably found within the lowest possible number of iterations. However, it may emerge that the ideal optimisation schedule is problem-specific, implying that an adaptive parameter adjustment procedure should be developed. At any rate the method is considered promising as it allows all elements of a transportation network to be handled within one common framework.

In this paper a constrained version of the 'real' optimisation problem has been considered, i.e. a version where all trees included must be felled (Model I). This is a considerably simpler problem than one which both involves identifying the optimal road and trail network, and sorting out those trees that are too costly to reach or imply unacceptable damages to soil and vegetation. To solve this problem each agent must report on its achievements for each tree individually as well as for the whole set of trees, and the applied algorithm must be modified to exclude trees that are not profitable to fell. However, the cost of choosing a particular route to a tree depends on whether a trail has already been opened. Therefore, the cost of reaching a tree depends both on the chosen path to this particular tree and on the paths chosen to other trees, and consequently, for any suggested primary solution (trail network) a secondary, combinatorial optimisation problem arises in which the optimal combination of trees to fell must be identified. As the number of different solutions is exponential in number of trees this problem becomes hard to solve even for a relatively small area. For example, the hypothetical forest area used in this paper includes 40 trees so the number of different combinations would be $2^{40} = 1.1 \times 10^{12}$. Therefore, for each primary solution it will be necessary to accept approximate solutions to the secondary problem. However, also in this context it may be possible to make use of feedback from previous iterations, implying that the secondary optimisation problem may prove less demanding than it currently appears.

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Economic Accessibility of Forest Resources in the Novgorod Region, Russia

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Abstract

The European part of Russia forms an important and growing part of total timber trade of Europe. While forest resources in the European part of Russia are vast, the accessibility of these resources limits their potential use. Economic accessibility of forest resources can be calculated based on forest inventory data as well as from satellite based forest resource information. The economic accessibility calculated in this study is based on the costs occurring from harvesting, forwarding, road side processing, transportation to lower landing or leskhoz center and reforestation. Comparing the two different forest resource information data there is only a slight difference in the results. It can be assumed that the forest resource data obtained from the satellite images is just as reliable as the traditional forest inventory data. In terms of western economics all forests in the seven leskhozes studied can be considered economically accessible. Further attention should be given to the accuracy of the harvesting costs and to costs occurring in different harvesting chains.

Keywords: forest inventory, GIS

Introduction

The European part of Russia forms an important and growing part of total timber trade of Europe. While forest resources in the European part of Russia are vast, the accessibility of these resources limits their potential use. Poor road conditions as a whole, frost damaged roads, lack of forest roads and large amounts of wetlands make it difficult to access these resources. Although, with modern methods, it is possible to harvest forests in remote, almost impassable areas, the costs of these operations can rise to a point where it is not economically feasible to harvest. Using highly detailed forest inventory data combined with road network and management unit map information it is possible to estimate the costs of harvesting timber in these areas. As an alternative to traditional inventory data, satellite based information can also be used. Currently, satellite based forest resource information is available for the entire European part of Russia. Accessibility measures, both economic and technical, are discussed in this study.

Background

Forestry in the Russian Federation

For European forest industry the most important and interesting part of Russia is the European part. The North and North-West districts of the Russian Federation (northwestern Russia) are especially important to forest industry in Scandinavia. The oblasts of Arkhangelsk, Vologda, Murmansk, and the Republics of Karelia and Komi form the North district, and Leningrad, Novgorod and Pskov make up North-West district.

The area of stocked forest lands under the authority of the Federal Forest Service of

Russia in the North district is 71,1 million ha and 6,8 million ha in the North-West district. In contrast, the area of forest land in Finland is 20 million ha, about a fourth of the area of forests in northwestern Russia. The total growing stock of these 8 oblasts is 8,3 billion m3 which is roughly four times as much as the total growing stock in Finland. In 1997 there were 26 National parks in the European part of Russia. Northwestern Russia contains 7 National Parks with a total area of 3 million hectares (Pisarenko, A. et al, 2001).

Russian forests are classified into three management groups. *Group I* forests are shelter belts along roads, railroads, rivers and lakes as well as protected forests and other forests outside of industrial use, where clear cuts are forbidden. *Group II* forests are located close to urban areas and industrial sites and only limited fellings are allowed. Forest regeneration is obligatory in these forests. *Group III* forests are intended solely for industrial use and are the main source of raw material for the industry. Clear cuts are allowed with a maximum size of 50 ha. Regions with a high population density and thus an extensive road system, such as Novgorod and Leningrad, and areas with a lot of wetlands have no Group III forests, but are made up mostly of Group II forests.

Novgorod Oblast

The case study of Novgorod region, located in the North-West district of the European part of Russia will be presented in this study. The region is 55,3 thousand square kilometres in size with a population of 751,5 thousand. 70% of the population is concentrated in the cities, with the biggest ones being Novgorod, Borovichy and Staraja Russa. Novgorod region is divided into 21 administrative districts and 24 state forest management enterprises (leskhozes).

The Novgorod region has a total of 4,1 million hectares of forest land of which 98,9 % is owned by the Committee of Novgorod Region. Dominant tree species in Novgorod (by area) are birch (40%), spruce (19%), pine (24%), aspen (11%) and other (6%). The annual allowable harvest has increased steadily since 1996, from 5,77 million cubic meters to 6,91 million cubic meters in 2001. The actual cutting is only a small share of the allowable cut. In 1996 the actual amount cut was 938 thousand cubic meters (16% of the allowable harvest) and in 2001 the actual amount cut was 2,86 million cubic meters (41% of the allowable harvest). The number of logging contracts in Novgorod varied between 24 in 1998 and 94 in 2001 (Lyubimov, 2002).

Data

Inventory data

Forest inventory data in Russia is gathered as a compartment based assessment. Inventory work starts with the acquisition of aerial photographs on which the borders of compartments are delimited. The compartments are visited and the following variables, by forest group are measured:

- kvartal area, hectares (estimated by measuring the area enclosed within kvartal boundaries)
- total growing stock, cubic meters
- pre-merchantable stand area, hectares
- pre-merchantable volume, 10s of cubic meters
- merchantable stand area , hectares
- merchantable volume by tree species, 10s of cubic meters

Compartments are organised into kvartals, with an average of 100-200 ha each, kvartals are grouped into forest districts, lesnichestvos of appr. 20 000 ha and forest districts are grouped into forest management units, leskhozes. The leskhozes in the Nogorod region are approximately 100 000 ha in size. When talking about inventory data a question on the reliability of the data is taken up. Despite the large size of the Russian Federation and the vastness of its forest resources, errors in forest resource estimates are not that much larger than those normally found in western European countries. A recent study (Kinnunen, J. et al, 2003) has shown that stand volumes in the Novgorod region have been underestimated by 13.4%, on average. The biggest differences occurred when comparing inventory data in larger volume classes. An overestimate of 12% was observed in the small volume class (<200m^3/ha) while an underestimate of 28% was observed in the large volume class (>400 m^3/ha). The data used for this study are kvartal (management unit) level volume estimates which have been derived from detailed compartment level data.

Map data

The map data included in this study includes the general layers of kvartal, leskhoz (24 in the Novgorod region), parks, wildlife reserve boundaries, relief, roads and railroads, urban areas, leskhoz centres, management units not controlled by forestry authorities, forests, non-forest and marsh areas, lakes and rivers.

The road network of the Novgorod region is rather comprehensive and increases the industrial attractiveness of the region. With an average amount of 17 km of roads per 100 km^2, a total of 1147 km of railroad and more than 300 km of open waterways for navigation, cargo can be carried effectively and with ease to the Baltic states, other regions of the Russian Federation, Scandinavia, and CIS countries. The road network crosses the region and leads to major cities such as St. Petersburg, and from there onwards to Finland and the Baltic Sea as well as through Moscow to other areas of eastern Europe. The railroads cross the region in practically all directions and, in addition to main line railroads, there are some narrow guage railroads, which can be used locally. Waterways make it possible to carry cargo in vessels and boats from Lake Illmen, to the Baltic and White seas and then onwards to other regions in Europe and countries outside of Europe, such as Turkey. The forest road network in the Novgorod region forms a less comprehensive network, with an average of 4,5 km of forest roads per 1000 ha, and will, hopefully, be improved within 10 years as a result of new forest legislation. The current amount of forest roads is only a third of the recommended amount.

Methods

The economic accessibility of forest resources is measured in this study, using costs occurring between harvesting and delivery to a lower landing. Stumpage is not included in the method as the stumpage value can be either evaluated with this method (by way of assessing the ability to pay for wood at the lower landing/mill gate and deducting the costs from that) or by using the (minimum) stumpage price given by the authorities. This method has been derived from an earlier study by Niskanen, et al (2002, 2003) where the method was slightly different in that forest inventory data was not used. The basic idea is the same, but a different view on economic accessibility is obtained. The costs calculated are felling, forwarding, roadside processing, forest road transportation, road transportation and regeneration (Table 1). The parameters used for cost calculations were obtained from the Russian partners but it should be noted that these parameters are from one forest management enterprise, and thus, cannot be considered to represent the whole area.

Table 1. The harvesting costs used for assessing the economic accessibility

Activity	Setup Costs (per kvartal)	Variable Costs	
Final Cuts	380,0	32,1	Rubles/m3
Forwarding	290,0	6,2	Rubles/m3/km
Roadside Processing	125,0	0,4	Rubles/m3/km
Forest Road Transport	125,0	7,1	Rubles/m3
Road Transport		0,2	Rubles/m3/km
Total Fixed Setup Costs	920,0		Rubles/kvartal
Planting		1850,0	Rubles/ha
Sowing		572,0	Rubles/ha
		Revenue	
Conifer Mill Gate Price		650,0	Rubles/m3
Soft Hardwood Mill Gate Price		480,0	Rubles/m3
Hard Hardwood Mill Gate Price		750,0	Rubles/m3

In this study it is assumed that all roads are accessible all year around, so no periodic frost damage or wet seasons were taken into account. Although it is obvious that many roads, especially forest roads, are not drivable in the wettest spring and summer months, it was not possible to examine the effect of these factors on the accessibility of forests at this time. For this kind of examination more detailed road network data as well as data on relief of the region is necessary.

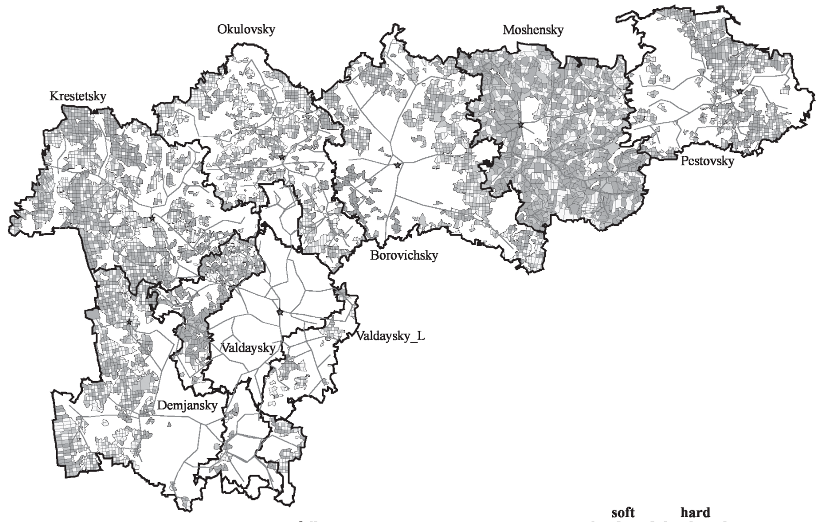
The information for each inventory block is linked to the respective map kvartals after which costs associated with harvesting and hauling harvested timber to lower landings near the leskhoz centres are calculated. The distance from a kvartal to the leskhoz center is calculated by calculating the shortest distance from the kvartal center to the nearest road segment after which the length of the path along road network segments to the leskhoz center can be added to that.

Satellite based information

Detailed enough forest inventory data in the Russian Federation, or elsewhere for that matter, is not easy to acquire. An extensive project developing satellite based measurements of forest resources in Europe has been conducted as a joint project by the European Forest Institute, the Joint Research Center of the European Commission, the European Space Agency and VTT. The resulting maps indicate the amount forest coverage as a percent of land area over most of Europe and in European part of Russia (Päivinen et al, 2001; Schuck et al, 2002).

Results

The map data is combined with the inventory data in seven leskhozes (figure 1). As usual in Russia, the timber is assumed to be transported to the lower landing near or in the leskhoz centre. From there, the timber can be forwarded to long distance transportation by trucks or railroad. The costs occurring after delivery to the landing site are not taken into consideration.



kvartal volume (m3/ha)	number of kvartals	full kvartal area (ha)	merchantable area (ha)	merchantable volume (1000 m3)	conifer volume (1000 m3)	soft hardwood vol. (1000 m3)	hard hardwood vol. (1000 m3)
> 375	16	1 850	206	102,0	49	53	0
275 - 375	958	116 160	34 667	10 362,6	3 301	7 060	1,6
225 - 275	2 096	277 834	84 943	21 194,6	7 645	13 541	8,6
175 - 225	1 853	256 672	65 525	13 387,2	4 816	8 563	8,2
75 - 175	632	98 700	14 896	2 355,2	946	1 409	0,2
1 - 75	7	723	45	2,0	1	1	0,0
<1	909	137 059	0	0	0	0	0,0
Total	6 471	888 998	200 281	47 404,6	16 758	30 628	18,6
Group 1	1 383	176 391	29 043	7 137,9	2 557	4 580	0,9
Group 2	5 088	712 607	171 238	40 265,7	14 201	26 047	17,7
no inventory	200	22 994					

Figure 1. Merchantable volume of kvartals (m^3/ha)

The conifer volume by distance to the nearest road (along the forest road) is in general less than 7,5km (figure 2) and no timber has to be transported on these forest roads beyond 12,5 km. The distance from kvartals to leskhoz centers, where the lower landing is, is assumed to be an average 35 km (figure 3) and with the cost of 57 rubles/m^3, one can acquire a total of approximately 12 mill m^3 in the seven leskhozes mentioned (figure 4), excluding the stumpage as mentioned in the methods.

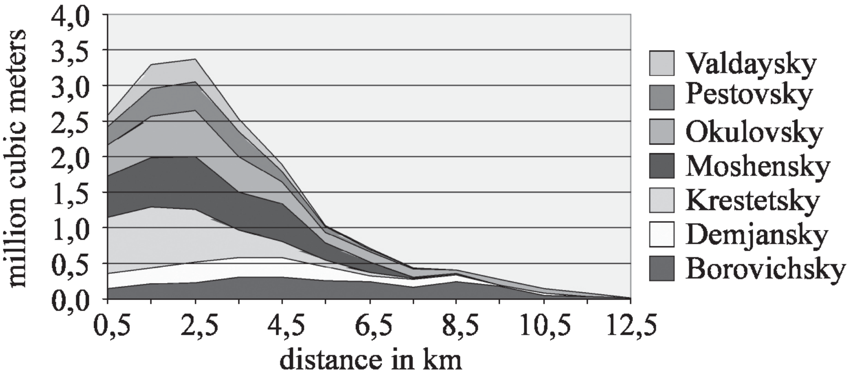


Figure 2. Coniferous volume (mill. M3) by distance from the kvartal to the road

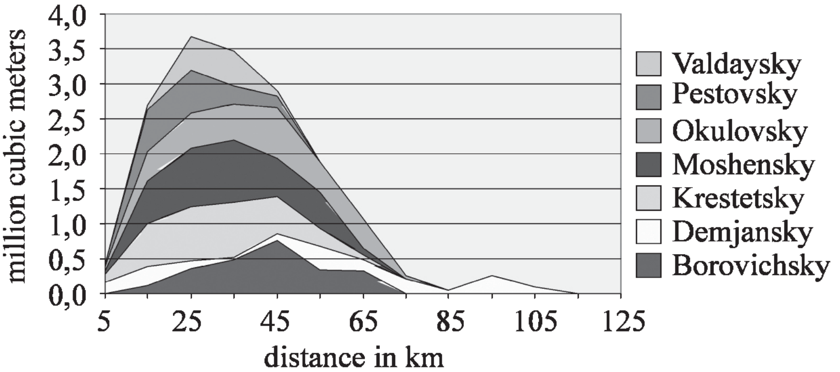


Figure 3. Coniferous volume by distance to lower landing

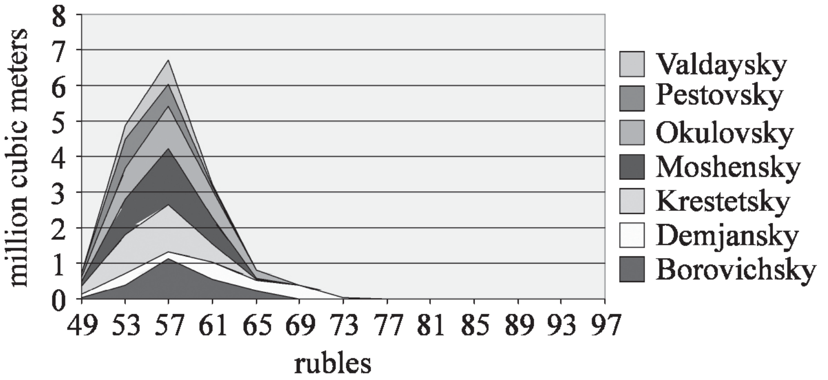
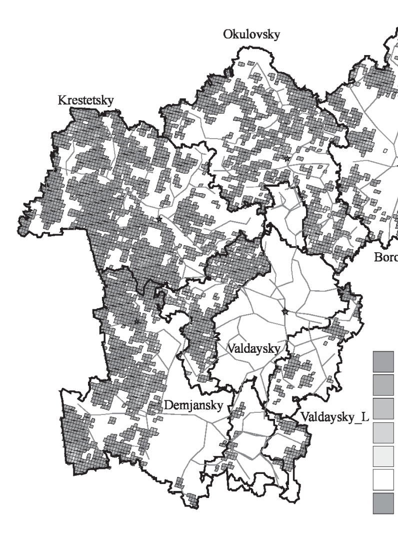


Figure 4. Coniferous volume by cost/m^3

The map combined from the forest inventory data (figure 1) was compared with a map combined from the satellite based information (figure 5). The forest resource satellite map has $1km^2$ * $1km^2$ pixels which can be put on top of the map data and can then be compared with the available forest inventory data.

The results show a slight differentiation in terms of area (figures 6 and 7). The total area is slightly higher in the forest inventory based calculations (area of management units) (figure 6) than in the satellite based calculations (area of pixels) as pixels falling only partly on top of management units have not been included. The merchantable forest area within management units is only a quarter of the amount of the forest cover area. This can easily be explained by the fact that the inventory data consists of areas designated for forest use and of merchantable areas only. Therefore there are no agricultural lands included in it, neither pre-merchantable areas. The satellite based information has no possibility of defining whether the area is controlled by the agricultural administration or if it is pre-merchantable forest area.



percent forest cover	number of pixels	full pixel area (ha)	forest cover (ha)
75 - 100	2 586	258 600	209 159
50 - 75	4 603	460 300	308 514
25 - 50	715	71 500	30 258
10 - 25	159	15 900	2 936
1 - 10	8	800	69
no data	22	2 200	0
water	50	5 000	
total	8 143	814 300	550 936

Figure 5. Forest coverage by percent

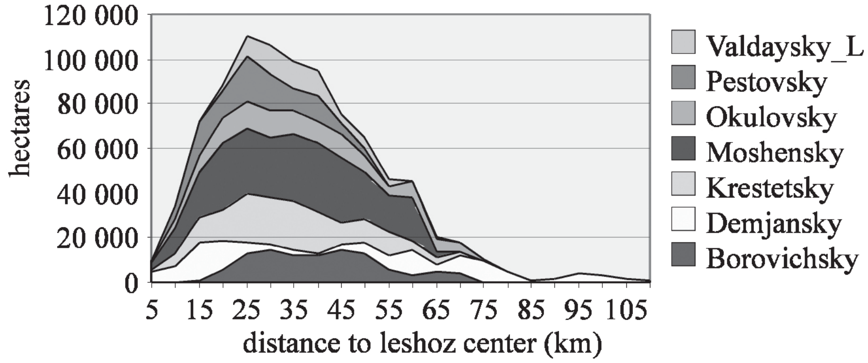


Figure 6. Total area of kvartals (ha) by distance to leshoz center, from the inventory data

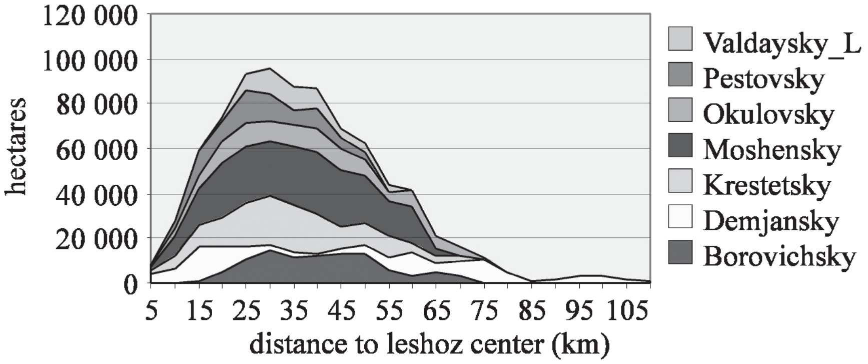


Figure 7. Total area of pixels (ha) by distance to leshoz center, from the satellite image

The distance from management units to leskhoz centers by the merchantable area of management units (figure 8) does not vary from the distance from pixel centers to leskhoz centers by the total area of the pixels (figure 9) too much.

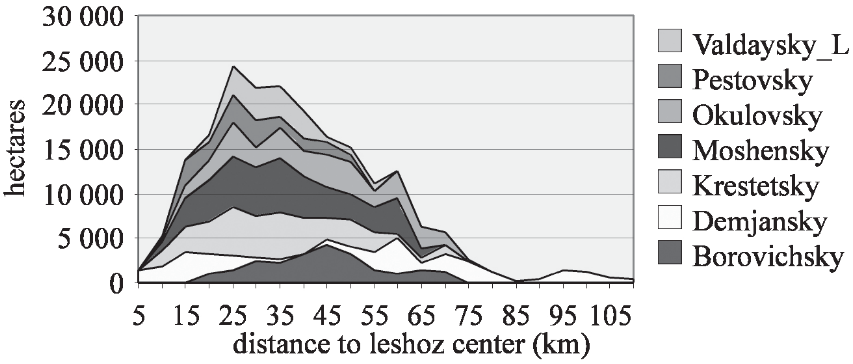


Figure 8. Merchantable forest area inside the kvartals (ha) by distance to leshoz center

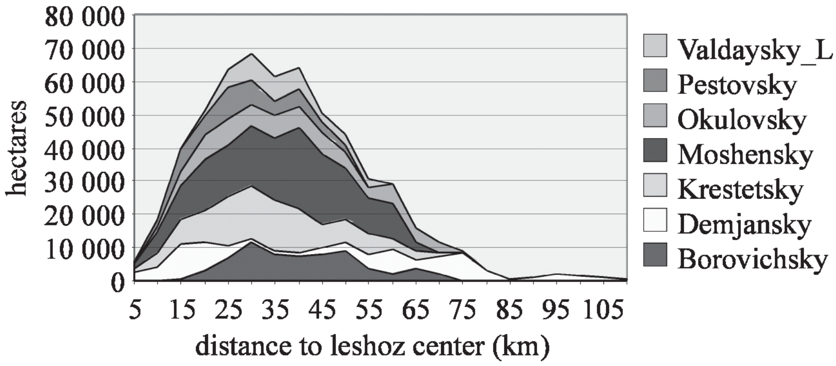


Figure 9. Forest cover area (ha) inside the pixels by distance to leshoz center

Discussion

Clearly, having full access to inventory data allows a more exact measure of the economic accessibility of merchantable timber. However, economic accessibility of forest land can be estimated from alternative sources of information such as satellite based information which are more broadly available. Figures 5-9 show that the results of this type of investigation are similar whether they are based on detailed management level information or on satellite based information.

Using the shortest distance from management units to roads may not be entirely realistic, given that marshes, rivers and lakes may block or restrict access along this shortest path. Methods that disallow paths that cross obstructions are less than satisfactory since they often result in inaccessibility to the management units. A system of penalties for crossing obstructions would allow feasible solutions, but then procedures for testing a large number of possible paths before optimizing the path would have to be developed. Adding existing forest roads to networks would be, perhaps, the best solution since each forest road can be used to access several management units. Temporary forest roads have been used for access, for example during winter time. These forest roads might also be considered for upgrading to permanent roads in the future.

The parameters used for cost calculations include some amounts of uncertainty. It is hard to obtain reliable cost estimates from Russia since there are no statistics available. Therefore the results on harvesting costs should be considered as guiding, not as definite costs occurring when harvesting. Generally the costs seem to be too low. It should also be noted that the costs used in these calculations are from one enterprise only and that the costs vary between logging companies, areas and different harvesting chains. Modern harvesting equipment would most certainly increase the cost of harvesting, but at the same time increase the productivity of work.

Conclusions

A careful consideration of the figures 2-4 lead to the conclusion that forests in the management units are managed and that no structural differences between very remote and more accessible forests is apparent in Novgorod region. These results clearly demonstrate that the leskhoz system as practiced in the Novgorod region of Russia has managed the forests rather equally regardless of the location. The methods described in this paper will allow the comparison of the economic accessibility of the existing forest resources in different parts of Russia.

Forest resources in Novgorod are cheap and economically accessible in western standards. Accessibility of these resources can be measured and minimum stumpage prices evaluated using the calculations described in this paper when full forest inventory information is available. Should inventory data be lacking then the accessibility of forest land can be estimated using satellite based information. New road locations can be evaluated using economic accessibility calculations. In more remote regions of North and North-West Russia long distance hauling costs should be included. Techniques described in this study will allow the design of future transport systems which will be more efficient than those currently in use. Nature conservation may increase in the future leading to a need to increase the effectiveness of forest management in the most accessible forests and leaving the more remote forests for nature conservation.

Acknowledgements

This study has been funded by the Ministry of Agriculture and Forestry of Finland. The authors would like to thank the St. Petersburg Forest Technical Academy for their cooperation and especially in providing data which would have been impossible for us to acquire by ourselves.

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Evaluating Three Innovative Financial Instruments of the Costa Rican Plantation Forestry System.

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Introduction

Costa Rica has promoted reforestation and plantation forestry (RPF) for the last 24 years. At the beginning, RPF was used as an instrument for reducing the country's high deforestation rate, but later on it became a tool to ease fears of a possible timber famine (Navarro 1999). At that time the Costa Rican State promoted initially fast growing species with low prices or no-markets at all which yielded not very positive outcomes. Nowadays however, the Costa Rican State has accepted native, high-value timber species with longer rotation cycles, which could yield better social and private returns. These plantations are expected to generate a higher income but also an increased value of the forest asset itself. Nonetheless, theses long-rotation plantations need to solve problems associated with the lack of cash flow in the early years because forest owners require a cash flow to cover up plantation expenses and for their private income. Three innovative financial mechanism of the Costa Rica forest sector are evaluated in this paper in order to explore their effect on the profitability and the cutting decision. One of them is the pre-purchased timber (PPT) system implemented by the Foundation for the Central Volcanic Range (FUNDECOR), a non-governmental organization working in the protection and management of forest ecosystems in Costa Rica's central plateau. The other two are administrated by the Costa Rican National Forestry Fund (FONAFIFO). One is the payment of environmental services (PES), and the other is the timber loans (TL), which was derived from the PPT system.

Financial Instruments for Plantation Forestry

FUNDECOR's pre-purchase timber (PPT) fund was established with a World Bank's International Financing Corporation (IFC) loan. PPT funds are managed with an endowment fund set up at a Costa Rican private bank, which serves as an instrument for carrying out financial transactions and as a guarantor for annuity payments for the landowner; however, all procedures are supervised by FUNDECOR. Basically, landowner sells FUNDECOR 40m^3 of the total final harvest; in this way obtaining a financing option. FUNDECOR sets the rotation age using technical rather than financial criteria, usually around 15 years of age, the idea is that plantation owners do not need to wait until the rotation age for obtaining their income, rather they can receive a cash flow before the last thinning. This last thinning is assumed to bring an important positive net revenue that can help the landowner to wait for the rotation age. FUNDECOR guarantees annual payments in US dollars, based on plantation's age, rotation, location, and the timber price of the forest species. Amounts range between US$46.30 and US$232 per hectare per year, and are given in equal annual payments. A forest

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[2] Carlos Herrera, 2003: Personal communication.

plantation is eligible at 3 years of age and with a maximum of 9 payments. The immature timber value calculation is done by discounting the timber value of the 40 m^3 from the rotation age at 11% annual interest rate using today's timber price, and a relationship between Costa Rican timber inches (pmt) and cubic meters of 300pmt/m^3. The final harvest value is discounted from a rotation age to the year before the last thinning, then the sinking fund factor formula is used to calculate the equal annual payments. To ensure the existence of the plantation and commitments assumed by the owner, a security guarantee figure was created by which the commitment is written in the margin of the ownership title for the property, at the Public Registry. This way, any third party will be aware of the timber contract existing between FUNDECOR and the owner. FUNDECOR's commitment is to guarantee the technical assistance and financial resources necessary for developing silviculture activities required by the plantation payments[2].

The forest law N°7575 introduced the concept of Payment for Environmental Services (PES), which a payment given to the forest owners for the services provided by their forest systems (CO_2 fixation, water quality and erosion prevention, scenic beauty and biodiversity). PES concept is aimed to increase the attractiveness of forestry compared to other competing land uses by recognizing the value of the environmental services that these systems provide to society. In this manner, PSA represents a payment that society, which demands and enjoys these environmental services, gives to the forest landowners for producing the environmental services coming from their forest systems. With the PSA program, landowners have to give the rights for CO2 fixation and other environmental services during the length of the contract to FONAFIFO. So, these environmental certificates may be negotiated in the international market. PES is about $450/ha in present value terms, and it is paid during a 5-year period in 50, 20, 15, 10 and 5% installments respectively. However, the land owner will loose between 15% and 20% of this funds in regency services and transaction costs. This system operates with funding coming form a fuel tax, and other agreements with local and national utility and water companies interested in the protection of forests for water production (Navarro, 1999).

Likewise, timber loans (TL) are aimed not only at making plantation forestry more competitive in regard to other land uses, but also to improve the cash flow distribution in the typical forest plantation project, and to bring sustainability elements in the commercial plantation forestry. The expected impact of this program is to improve the landowner liquidity, avoid the anticipated harvest of forest plantations in order to obtain forest products with desired dimensions and qualities, and to maintained a positive commercial reforestation rate. Timber loans are financed with the emission of medium term bonds. These TL bonds have not only the immature timber as a guarantee, but also a solidarity guarantee of the Global Environmental Facility (GEF), and FONAFIFO patrimonial fund. A timber loan is given based on the value of 50m^3 at rotation age; however, 100% of the inventory is used as loan guarantee. It is a requirement that the forest plantation has at least 250 high quality trees, a minimum of 10 hectares, growth rates are above the national average, free from pests and diseases, good access all year round, and farms must bare a title in the National Property Register. A forest plantation is eligible at the age of 4 with a maximum of 8 payments. The immature timber value is calculated by discounting at 11.9% real annual interest rate the projected stumpage revenue from the rotation age to the year before the last thinning, using today's timber price, and with a scaling relation of 325pmt/m^3. Similar to FUNDECOR's system, once the discounted value is at the year before the programmed thinning, the sinking fund factor formula is applied for calculating the annual payments[3].

A Case Study Calculation

In order to evaluate the three financial systems described above it is necessary to introduce a case study calculation using the land expectation value (LEV) o willingness to pay for land (WPL) model for analyzing the investor behavior for choosing the rotation age that maximizes benefits in monetary terms in presence of these financial mechanisms. The optimal rotation age is determined by the plantation age that maximizes the WPL value. Moreover, the reference land price is used as a criteria guideline for accepting or rejecting these investments. The case study calculation uses a *Cedrella odorata* stand. Cedar, as it is commonly known, is a highly valued endanger native forest species used in plantation forestry and agroforestry systems in the region. Despite the problems associated with the *Hypsipilla grandela* attacks, it is possible to implement a plantation under close supervision and management. In any case, there is no harm to use such an example in an experiment of this nature. It is important to know that the first drawback to the models implemented by FUNDECOR and FONAFIFO is that there is no scientific evidence for using investment criteria for selecting the optimal stand's rotation age. The question is, how does the policy instrument designer know that a "silvicultural" rotation yields the optimal rotation for production of environmental services and maximizing the landowner benefits? This experiment will prove how important for landowners and society is to estimate an investment-efficient rotation age rather than a technical o a silvicultural rotation for implementing financing mechanisms. In this exercise, it is assumed that the financial mechanisms are accessed independently to better understand their effect on profitability and optimum rotation age.

Table 1. Cedrella odorata timber harvest options.

(a) Age (yr)	(b) Diameter (cm)	(c) Volume (m^3/ha)	(d) Harvest US$/ha	(e) Capitalized cash flow US$/ha	(f) WPL US$/ha
13	31.5	75.40	$6,511.2	$5,370.3	$3,123.0
14	33.5	90.09	$7,779.4	$6,532.3	$3,372.0
15	35.4	105.94	$9,148.0	$7,786.1	$3,584.5
16	37.2	122.88	$10,610.3	$9,124.5	$3,761.2
17	39.0	140.82	$12,159.4	$10,539.7	$3,903.6
18	40.7	159.67	$13,787.9	$12,023.7	$4,013.2
19	42.3	179.37	$15,488.6	$13,568.2	$4,092.1
20	43.9	199.82	$17,254.1	$15,165.0	$4,142.4
21	45.5	220.93	$19,066.2	$16,794.9	$4,163.5
22	**47**	**242.63**	**$20,950.8**	**$18,483.0**	**$4,166.1**
23	48.5	264.83	$22,868.1	$20,187.9	$4,144.1
24	49.9	287.46	$24,822.5	$21,912.8	$4,102.6
25	51.3	310.45	$26,807.7	$23,650.2	$4,043.8
26	52.6	333.73	$28,817.7	$25,392.6	$3,969.9
27	53.9	357.23	$30,846.7	$27,132.6	$3,882.7
28	55.2	380.89	$32,889.5	$28,863.2	$3,784.3
29	56.4	404.64	$34,940.9	$30,577.6	$3,676.4
30	57.6	428.45	$36,996.4	$32,269.1	$3,560.7

[3] Edgar Ortiz Malavassi, 2003: Personal communication

The case study calculation used a biological growth model for *Cedrella odorata* adjusted for a average site of the CATIE´s farm. It was assumed an initial acceptable mortality of 10% of the original planting density (1111/trees/ha), and 3 thinning. Prior to the third thinning, the average tree diameter is still below 30cm, which is assumed to be the minimum acceptable diameter for the plantation timber production. In addition, the typical investor was defined with a minimum acceptable rate of return (MAR) equal to 8% in US$.

Table 1 presents the maximum WPL calculated assuming different final harvesting options for a one hectare stand of *Cedrella odorata* after it reached 30cm dbh. Columns (a), (b) and (c) present possible clear-cutting ages, average diameter of the stand in cm, and commercial harvested timber volumes in m^3. The commercial volume determination was done taking into account the growth and yield models, the relationship between total and commercial volume, and Smalian and the traditional rope scaling systems. Based on the land value system developed for the area of study (Turrialba, Costa Rica), the market value of land for a fertile soil was reported to have a price of US$4000/ha. Planting, site preparation and maintenance cost for the first year was estimated in $661/ha. Maintenance cost per hectare for years 2 to 6 are $312, $228, $132, $129 and $190 respectively. First, and second-third thinning have a cost of $147 and $70/ha each. Pruning costs are estimated at 29.37/ha the year after thinning. The annual administrative costs are set at $15/ha. Column (d) presents the harvest income in US$/ha, and it is actually the potential clear-cut revenue. The stumpage prices with an average tree dimension bigger or equal than 30cm dbh were set at US$86.35/$m^3$ (¢110/pmt). Column (e) totals the establishment and maintenance revenues and costs compounded to each potential final harvest age in a per hectare basis.

Finally, column (f) in Table 1 shows the WPL, which is equal to column (d) plus column (e). Then, the result is discounted to year 0, considering all future rotations. Thus, the maximum WPL option, as a measure of the landowner's investment net benefit, defines the preferred age for cutting the stand, and also gives information on whether to accept of reject the project. The maximum WPL for *Cedrella odorata* is US$4,166.1/ha at rotation age 22-years at a MAR of 8%. Since the maximum WPL is higher than the US$4,000/ha land price, then the investment is accepted. The WPL maximization is the process of estimating the correct land holding value which is the investor's maximum bidding price for farmland to be used in a *Cedrella odorata* plantation investment in Turrialba region.

Economic Analysis

This case study is used as a reference to evaluate the effect that the 3 financial mechanisms have on the profitability of the investment and investor rotation age choice that maximizes the investment. FONAFIFO´s PES is a payment that society makes for the environmental services provided by plantation forestry. PES reduces establishment and maintenance costs in the first 5 years of the investment. This reduction on production costs rises the asset value (WPL) to $4651/ha, but decreases the rotation age to 21-years in relation to the reference case. Such behavior is suggested by the economic theory, and it is shown in Table 2 (Johansson and Löfgren, 1985). However, from the policy standpoint, such payment scheme produces a contrary effect on the provision of environmental services. If the PES, as a policy instrument, decreases the rotation age; it also reduces the life span for providing environmental services, and reduces the expected social benefits paid for. Society's expected benefit is to maximize environmental services, not to increase profits for the landowner. In this sense, a good economic concept such as the market for environmental services may have negative effects if it is

implemented with the wrong financial instrument.
FONAFIFO´s timber loan (TL) produces a decrease in the WPL to $3754/ha below the land price rejecting the investment, and it also decreases the optimal rotation age to from 22 to 20-years. The TL interest rate is 4 points higher than the reference case. Therefore, it should produce a reduction in the WPL and the optimal rotation age (Johansson and Löfgren, 1985). One of the aims of a timber loan was to increase the rotation age and to improve profitability. The financial instrument used for the TL produced a contrary effect in respect for its objectives. FONAFIFO's two financial instruments fails to meet society goals on enhancing the provision of environmental services from plantation forestry.

Table 2. Three official financing mechanisms for plantation forestry and their effect in the profitability and optimal rotation age for *Cedrella odorata*

Institution	Financial Mechanism	Interest Rate	Volume m^3/ha	Number of Payments	Amounts US$/ha	WPFL US$/ha		Optimal Rotation Age	
Reference Case Study	Self-funded Investment	8%				$4166.3	ref	22	ref
FONAFIFO	Payment of environmental services (PES)	None		5 decreasing payments	$243.9 (50%) $89.6 (20%) $61.7 (15%) $37.7 (10%) $17.3 (5%)	$4,651.8 (+$488.4)	↑	21 (-1)	↓
FONAFIFO	Timber Loan (TL)	11.90%	50 (325pmt/m3)	8 equal payments (age 4-11)	$114.72 / year	3754.6 (-$411.70)	↓	20 (-2)	↓
FUNDECOR	Pre-purchase timber (PPT)	11%	40 (43.3 with 300pmt/m3)	9 equal payments (age 3-11)	$79.28 / year	$3,906.1 (-$260.12)	↓	24 (+2)	↑

According to Table 2, FUNDECOR´s PPT system also results in a decrease in the WPL below market price, $3906.1/ha. However, PPT increases rotation age in respect to the reference case to 24-years. The PPT reduces the harvest income by taking 43m³ out of the final commercial volume, which reduces investor revenues; decreasing WPL and increasing the optimal rotation age (Johansson and Löfgren, 1985). FUNDECOR's PPT is the financial mechanism which reduces less the WPL in comparison with the base case and the PES option, but increases the optimal rotation age in two years in comparison to the base case.

It has been proved that PES and TL decrease the period of environmental services, and TL and PPT make the investment not profitable for this case study. Could it be possible to solve the optimal rotation problem of the PES and the profitability problem of the PPT? Table 3 presents three theoretical models designed, one to improve the problems with the PES and two evaluate more in depth the PPT. In one hand, PES by definition is a payment for services coming from the forest ecosystem, and these services are provided in a continuous way until the final harvest. PES should be associated with an income or production capital, and not as investment capital for afforestation. Therefore, a theoretical PES has been designed by establishing a annual equal payment of $35/ha from the first year to the final harvest year. This theoretical PES increases the WPL, $4,603.8/ha, and maintains the optimal rotation age at the same level compared with the reference case. On the other hand, two theoretical PPT models were designed improving several things: Scaling method (325pmt/m^3), lower the interest rate (8%), and the introduction of annual purchase method for the immature timber with a progressive payment method, which pays more for the wood as it get closer to maturity. PPT Model 1 was similar to the FUNDECOR's PPT where they purchased 40m^3 in 9 payments. This model was implemented by buying 4.4 m^3/ha/year from age 3 to age 11, and every year the amount paid was higher as the timber got closer to maturity. The result was an increase on the WPL making the investment profitable at 4123/ha, and it kept the optimal rotation of the original PPT (24-years). On the other hand, a second model of the PPT used conditions similar to the FONAFIFO's TL with 50m^3 in 8 payments. The result for Model 2 also increased the WPL to a profitable conditions just above the land price, but increase the optimal rotation age to 25-years. From society point of view, PPT Model 2, in this exploratory analysis, is the desired financial system because maintains the profitability of the investment, a bit lower from the reference case, but increases the rotation age in three years, which provides society more environmental services and also will provide to the market bigger round wood.

Table 3. Three theoretical models for plantation forestry and their effect in profitability and the optimal rotation age for a hectare of Cedrella odorata

Institution	Financial Mechanism	Interest Rate	Volume m^3/ha	Number of Payments	Amounts US$/ha	WPFL US$ / ha		Optimal Rotation Age	
PES Theoretical	Payment of environmental service (PES) in annual payments	None		Annual equal payments	$35.00	$4,603.8 +$437.50	↑	22 0	-
PPT Theoretical model 1	Pre-purchase timber (PPT)	8%	4.4m3 / yr 40 (325pmt/m3)	9 progressive payments (age 3-11)	$78.65 (age 3) $84.9 (age 4) $91.7 (age 5) $99.1 (age 6) $107.0 (age 7) $115.5 (age 8) $124.8 (age 9) $134.7 (age 10) $145.5 (age 11)	$4,123.0 (-$43.1)	↓	24 +2	↑
PPT Theoretical model 2	Pre-purchase timber (PPT)	8%	6.3m3 / yr 50 (325pmt/m3)	8 progressive payments (age 4-11)	$112.8 (age 4) $121.8 (age 5) $131.6 (age 6) $142.1 (age 7) $153.5 (age 8) $165.8 (age 9) $179.8 (age 10) $193.4 (age 11)	$4,082.65 (-$83.61)	↓	25 +3	↑

Concluding remarks

The economic model for a "market" of environmental services where those who enjoy such services must pay for those who produce them is a strong concept that could help to preserve and enhance the quality of the natural environment and reduce the pressure of other competing uses on forestry investments. However, It is important to evaluate the effect that a financial instruments will have in the behavior of the forest investor to make sure that the financial instrument achieved positive financial and environmental goals. Finally, it has been proved that the analysis with microeconomic models, such a the WPL, are helpful tools for evaluating and designing monetary policy instruments for promoting plantation forestry as a competitive investment and also as a way to compensate for the provision of environmental services.

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Investigating Globalization: The Case of Forest Products' Markets

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Abstract

This paper intends to investigate whether forest products prices are converging on a global basis. Recent market integration studies have analyzed price linkages within limited geographic regions, and have frequently concluded that regional forest products markets are integrated. Industrial roundwood prices from all continents are investigated in order to test the hypothesis that forest products markets are globalized. The results indicate that forest products markets have become increasingly global during the last 40 years.

Keywords: Forest products prices, forest products markets, globalization, Heckscher-Ohlin trade theory, factor price equalization

Introduction

The aspect of international integration and globalization has recently gained substantial attention both from the public and scientific environments. In the forestry and the forest industry the discussion has often focused on how markets have developed, both the markets for forest products (e.g. Baardsen 1998; Toppinen and Toivonen 1998; Sande 2001; Shushuai Zhu et al. 2001; Turner and Buongiorno 2001; Nyrud 2002; Toivonen et al. 2002; Yin et al. 2002; Nyrud and Størdal 2003; Størdal and Nyrud 2003) and the markets for the production factors (e.g. Palo 1998; Sande 2001; Uusivuori and Laaksonen-Craig 2001; Palo 2003).

This paper investigates the development in the world markets for forest products during the last four decades. The concept of globalization, as it may be understood in the context of the forest sector, is defined and previous empirical work in the forest industry is reviewed in order to develop a hypothesis related to investigating globalization. Finally, we test the hypothesis on a dataset of world trade in forest products since 1962.

While being used extensively, the term globalization is often poorly understood. Dicken (1999) has defined globalization as "a complex of inter-related processes, rather than an end-state". Sklair (1999) argued that "the central feature of globalization is that many contemporary problems cannot be adequately studied at the level of nation-state … Instead they need to be conceptualized in terms of a global process". The difference between processes of globalization and processes of internationalization needs to be acknowledged. According to Dicken (1999) "internationalization processes involve the simple extension of economic activities across national boundaries", being a "quantitative process which leads to more extensive patterns of geographical activity", while "globalization processes are qualitatively different from internationalization processes. Globalization processes involve not merely the extension of activity across national borders, but also – and more importantly – the functional integration of such internationally dispersed activities".

Important drivers of economic integration are (1) the continuing reduction in the cost of communication and transportation due to new technologies, (2) the increasing similar tastes and needs of people – irrespective of geographical origin – and (3) the public policies after World War I emphasizing liberalization of the international markets for goods, services, capital and labor, thus facilitating global economic integration (Mussa 2000). In the forest products sector, Bourke (2000) reviewed the restriction on trade in forest products. They reported that the world forest products trade is subject to low tariffs compared to other industries, and that tariff rates were low already in 1986 when the Uruguay Round started. Other non-tariff measures may, however, be more significant for certain forest products in particular countries.

This study will focus on the economic aspects of globalization, but it must be acknowledged that there are different types of globalization processes, and that these are interconnected. Economic globalization is one type of globalization process, and, considering the definitions of Dicken (1999) and Sklair (1999), may be understood as economic integration. Economic integration can happen in two primary ways, either by trade or by shifting the movable factors of production, labor and capital. If forest products markets are becoming increasingly globalizied due to the driving factors mentioned above, we should observe more trade relative to total production (Dicken 1999). The effects of more trade may be analyzed through the Heckscher-Ohlin model. Generally, the effect of trade is convergence in the relative prices of both products and production factors between the trading countries (Dicken 1999). Hence, globalization can be investigated through investigating increase in trade relative to total product of various products or to what extent prices have converged. The latter indicator is the approach applied in this analysis. It is of particular interest because it is an important determinant of profitability in the industry, employment opportunities in the forest sector in different countries, land rents for forest owners, and product prices for industrial customers and end users of forest products.

Data and Method

Data

Five product categories were analyzed during a period of 40 years (1962-2001); coniferous industrial roundwood, coniferous sawnwood, unbleached sulfphate pulp, paper (newsprint and printing paper) as well as wood-based panels and boards (plywood, particleboard and veneer). This includes products from primary forestry and the most important processed wood commodities. Roundwood is the dominant input in the wood processing industries, but output from primary production is frequently also used as inputs in other wood processing industry, chips and residues from sawmilling are for instance frequently used as an input in the production of pulp, paper or particleboard.

Forest products prices were estimated based on data from EFI/WFSE Trade Flow Data Base. The database compiles trade flow data as reported by country in their national trade statistics. Only import prices were used in the analysis; total value of imports was divided by total volume imported. Import prices are reported c.i.f. (cost, insurance, and freight) and transaction costs are therefore included in the estimated price. In order to maintain a global focus, the data from all countries reporting imports was aggregated on six regions (Africa, Area of former USSR, Asia and Pacific, Europe, Latin America and the Caribbean, North America).

Table 1. Annual global production of various wood products, five-year averages.

Year	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	1992-96	1997-01
Roundwood1	800601	885799	939058	985114	1026724	1129598	924830	968227
Sawnwood1	286833	313416	326987	339331	3402243	68519	311345	283679
Unbl. sulphate pulp2	10540	21355	29869	37396	45701	59093	70109	78733
Newsprint2	16301	20191	21897	24436	27245	31881	33806	37706
Printing paper2	18717	24960	31355	39064	48048	65885	77303	93182
Particleboard1	7050	13959	16726	17490	17067	20177	20007	30255
Plywood1	22178	31566	38705	41195	43847	49539	51192	54531
Veneer1	1808	2956	3704	4291	4971	4973	6087	7317

1 1000 Cubic meters
2 1000 Metric tons

The EFI/WFSE Trade Flow Database

World trade data for forest products trade is compiled in the EFI/WFSE Trade Flow Database (cf. Wardle and Michie 1998) for an elaborate description of the data base. Commodities are distinguished according to the Standard International Trade Classification (SITC) system. Data is converted from metric tons to cubic meters (solid wood products only). Where data are reported in weight units (metric tons) a standard conversion factor is applied to convert from weight to quantity. These conversion factors come mainly from the FAO Yearbook of Forest Products (FAO 1998). Quantity and value data are checked and replaced if missing or inconsistent. Missing quantity data occurs when the value of a trade flow exists but no corresponding quantity data exists. Quantity data is considered to be inconsistent when the unit price of a trade flow is more than 5 times the appropriate average unit price or less than 1/5 of the average unit price; most common quantity errors (or inconsistencies) arise from misplaced decimal points (e.g. data in kg or 100 kg rather than tons).

Countries have joined together and split apart over the 1962-1999 time period covered by the data and the data are therefore aggregated in one part of the time series so that it can be compared with data in other parts of the time series, cf. Appendix A.

Hekschler-Ohlin trade theory

International trade theory and theory describing the consequences of free trade is to a great extent relying on the seminal work of Heckscher and Ohlin, Heckscher-Ohlin trade theory (Heckscher 1919; Ohlin 1933)). Their approach to the theory of international trade focuses on the relationships between the composition of countries' factor endowments and commodity trade patterns and the consequences of free trade for the distributions of income within countries.

The Heckscher-Ohlin theorem states that production patterns reflect the different compositions of (countries') endowments and, unless demand differences are significant, so will patterns of trade. A greater concentration of trade of resources encourages specialization in production and allows a country to import commodities whose factor requirements are far from proportions found at home. If the activities requiring factors of production have similar endowment bundles between countries, Heckscher-Ohlin theory implies international trade leads to factor price equalization (Eatwell et al. 1998).

Commodities that are traded internationally in free, international markets, indeed the case of forest products, are likely to converge over time. Based on this, the hypothesis of globalized markets can be investigated through evaluating factor price equalization, *id est* evaluate if wood products prices are either equal (e.g. integrated as stated in the law of one price, cf. Richardson 1978) or converging towards a state of equality over time.

Several approaches can be adopted to investigate the aspect of factor price equalization. An indication of price patterns can be investigated by visual inspection of price series, and, in the next chapter, figures of price development the last 40 years are provided for this purpose. In this analysis the variability of prices is also investigated by the means of calculating a variance for given periods of time. According to the hypothesis, globalized markets are characterized by either decreasing or constant, low variance.

Results

Prices from the six regions are investigated during the period 1962-2001; all prices are in real terms (base year = 1962). The results are reported according to product categories; both graphically and estimated variance.

Coniferous industrial roundwood

Both the graphic presentation (Figure 1) and the estimated variances (Table 2) indicate that the prices of coniferious roundwood have converged during the period studied. Like other commodities, roundwood prices were subject to irregular fluctuations during the energy-crisis in the 1970s (cf. Figure 1), but the overall impression is that prices are converging and therefore supporting the hypothesis of a globalized market for industrial fiber. The converging prices indicate that the industrial roundwood market is becoming increasingly integrated.

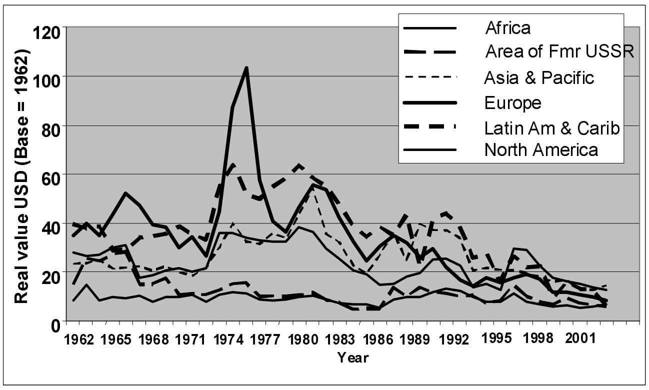

Figure 1. Coniferous roundwood prices in six regions. Real prices (1962 = 100).

Table 2. Mean and variance for coniferous roundwood prices, five-year averages.

Year	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	1992-96	1997-01
Mean	26.99	22.98	33.52	33.22	22.13	23.80	16.76	12.25
Var	114.29	120.67	544.82	360.90	172.29	130.69	45.51	23.94

Coniferous sawnwood

Coniferious sawnwood prices differed from roundwood prices. Visual inspection of the data indicates that prices exhibit a co-mowing pattern (Figure 2). Variance fluctuated less than roundwood prices during the period (cf. Table 3); from being very low in the 1960s and early 1970s the variance increased after the energy crisis, but decreased during the following decades. The results indicate that prices are co-moving, and, although somewhat ambiguous, imply a globally integrated market.

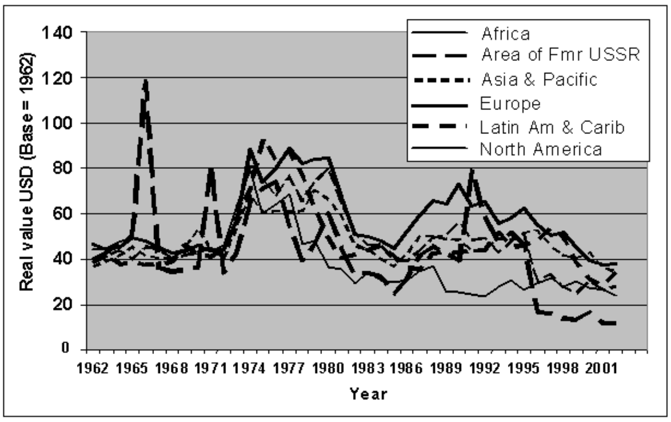

Figure 2. Coniferous sawnwood prices in six regions. Real prices (1962 = 100).

Table 3. Mean and variance for coniferous sawnwood prices, five-year averages.

Year	1962-66	1967-71	1972-76	1976-81	1982-86	1987-91	1992-96	1997-01
Mean	45.77	43.65	63.60	62.81	40.00	47.37	45.35	32.97
Var	203.45	64.97	230.63	254.31	57.25	171.51	143.76	139.32

Wood-based panels and boards

Prices of both plywood and particle board appeared to exhibit co-moving patterns except for some abnormal price fluctuations in the former Soviet Union (Figure 3, Figure 4). During the 1990s the fluctuations dampened off, and both the statistical and visual evidence indicate that the markets for plywood and particle board have become increasingly integrated during the 1990s (Table 4). The result therefore indicates that the markets for plywood as well as particle board are global.

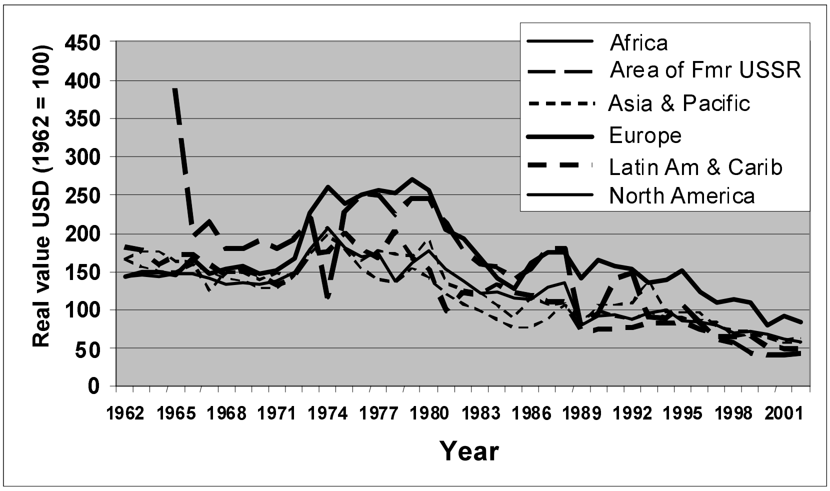

Figure 3. Plywood prices in six regions. Real prices (1962 = 100).

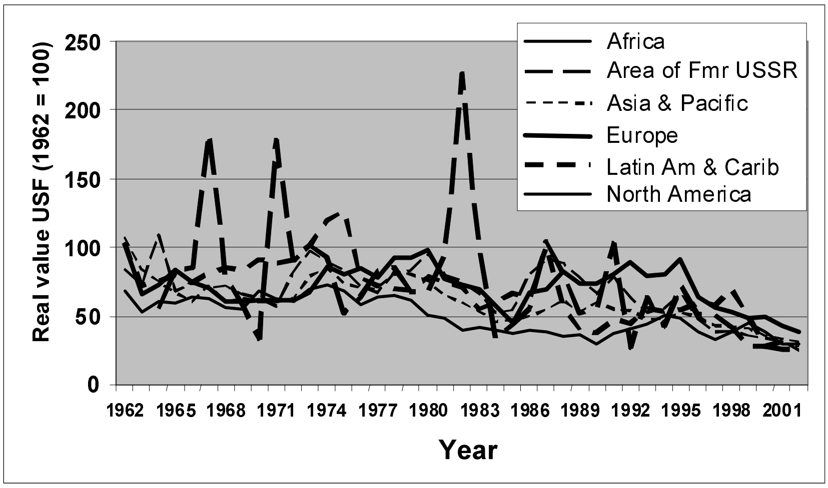

Figure 4. Particleboard prices in six regions. Real prices (1962 = 100).

Both the visual evidence (Figure 5) as well as estimated variance (Table 4) indicated that prices have been converging and that the prices may have become integrated during the 1990s, indicating a globalized veneer market.

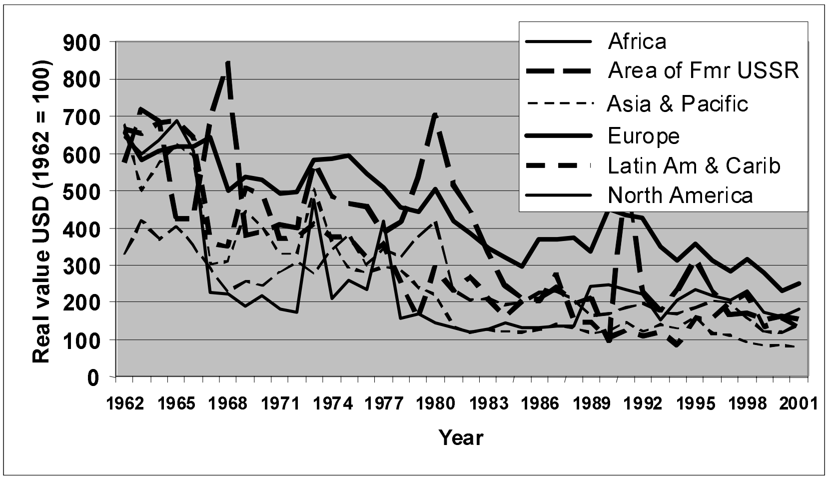

Figure 5. Veneer prices in six regions. Real prices (1962 = 100).

Table 4. Mean and variance for wood based panels and boards, five-year averages.

Product	Year	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	1992-96	1997-01
Particle board	Mean	168.12	150.31	187.86	185.15	127.27	114.75	102.12	69.55
	Var	2068.01	412.25	1282.95	2209.73	795.90	1184.67	562.38	330.76
Plywood	Mean	76.24	74.23	80.75	75.65	62.32	64.19	56.29	40.77
	Var	220.94	977.58	302.48	150.69	1169.95	469.27	212.13	106.13
Veneer	Mean	576.13	387.84	392.83	336.13	216.95	222.45	206.62	172.24
	Var	13137.16	25219.60	14138.64	20405.30	8295.74	13435.32	6867.27	3689.09

Wood pulp

If data from the 1970s are disregarded, a visual inspection strongly suggests that global unbleached sulphate pulp prices are integrated and that there exists a global market for this commodity (cf. Figure 6). This impression is also reflected by the estimated variances, except for the period of heavy price fluctuations in the 1970s, the variances have dampended off in the 1980s and 1990s. In spite of the ambiguous variances, the prices are co-moving and appear to be responding almost simultaneously to market trends. The strong co-movement indicates that the pulp market is global and has been integrated throughout the period.

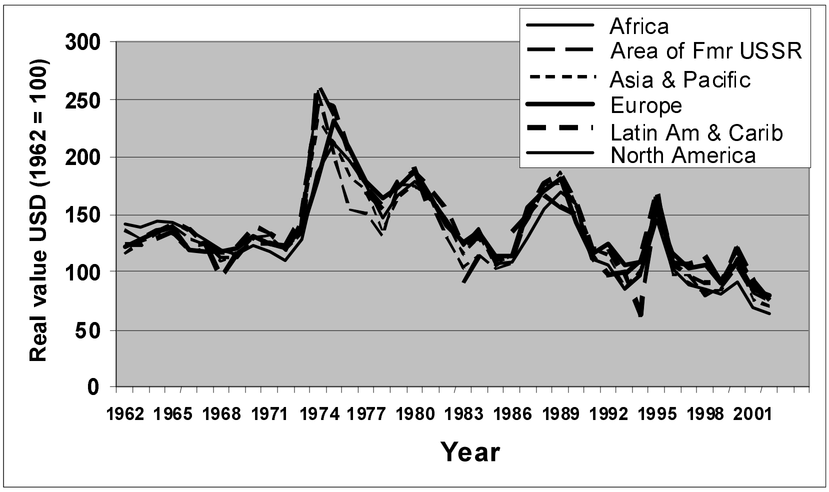

Figure 6. Bleached sulphate pulp prices in six regions. Real prices (1962 = 100).

Table 5. Mean and variance for bleached sulphate pulp prices, five-year averages.

Year	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	1992-96	1997-01
Mean	131.77	121.49	178.66	167.15	120.95	152.38	113.23	93.46
Var	70.07	74.96	2419.07	199.26	226.97	526.95	714.69	162.53

Paper

Both the market for newsprint and writing paper exhibit strong co-movement (Figure 7, Figure 8) and the markets appear to be integrated. Again, the estimated variances vary considerably and yield ambiguous results, mostly due to the fluctuations related to the 1970s energy crisis, and the variances also dampens off at the end of the period. The results indicate that prices are converging or becoming increasingly linked and that the paper market is globalized.

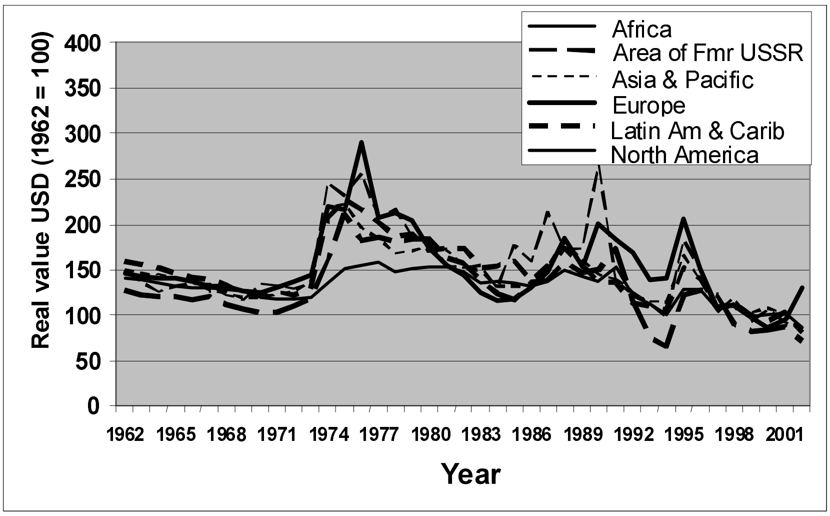

Figure 7. Newsprint prices in six regions. Real prices (1962 = 100).

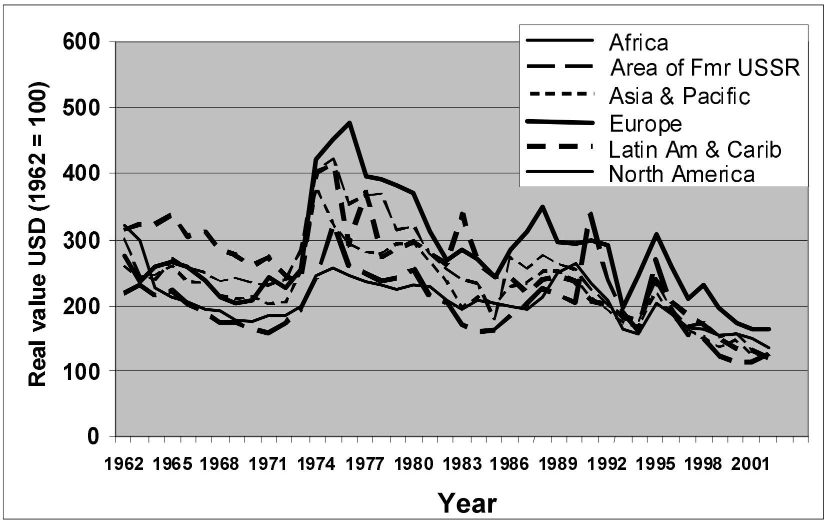

Figure 8. Writing paper prices in six regions. Real prices (1962 = 100).

Table 6. Mean and variance for paper prices, five-year averages.

Product	Year	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	1992-96	1997-01
Writing paper	Mean	138.13	123.79	175.78	178.45	141.54	162.05	128.05	101.38
	Var	108.63	80.17	2573.82	387.60	246.85	775.13	857.46	98.83
Newsprint	Mean	259.90	218.04	296.02	292.00	228.03	249.62	206.30	156.06
	Var	1531.68	1479.39	7652.36	3100.18	1746.20	1562.70	1464.66	698.52

Conclusions

The results suggest that the wood products markets investigated in this paper are global and contributing to the globalization of the economy. Prices from different regions appear to be either co-moving – indicating market integration, but not necessarily integration according to the Law of One Price – or converging – indicating that markets are becoming integrated. Comparison of the different product categories should be conducted with care, since real prices are used for each product direct comparison is not applicable.

For all products investigated, real prices have been dropping most of the 40-year period, indicating that forest products have become relatively less valuable and that prices in all regions are approaching the lowest global price level. European prices are usually higher than in the other regions and have in most cases been subject to the biggest drop in value. Obviously, low raw material prices provides a competitive advantage in some regions. Furthermore, the prices of most products investigated were affected by the 1970s energy crisis; variability in prices increased substantially in this period. This is a strong indication that forest products prices are sensitive to the overall state of the global economy, for example in terms of business cycles.

Aggregation in product categories implies that the wood products imported to all regions are homogenous and comparable. The product categories used in this analysis are general, and for some purposes comparison of specific products may be a more adequate approach. Also, the large geographical regions used in this analysis several regions may include countries with substantially different economies (for example in terms of standard of living) thereby partly violating the basic assumption of Heckscher-Ohlin trade theory. It is, however, likely to assume that the trends exhibited in the data are credible.

To the best of our knowledge there are not other analyses focusing on investigating global world markets, but the results corresponds with previous analyses for regional forest products markets. This is not surprising since the forest products markets are relatively unconstrained by barriers to trade – except for transportation cost that in some cases are substantial. Results from previous analyses on other commodity markets (e.g. cereals and wool) also correspond with the results reported in this analysis (cf. O'Rourke and Wiliamson 1999).

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Marketing Environment of Structural Lumber in Japan

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Abstract

This paper presents the latest information on the Japanese marketing environment of structural lumber that is used for house construction. The demand for lumber has decreased, while the demand for structural laminated lumber has been rapidly increasing. The changes in end-users' requirements have created demand for structural laminated lumber. The imports in lumber and structural laminated lumber from Europe have been increasing in Japan. Europe succeeded in meeting the changing end-users' needs. The distribution system for lumber has been changing a great deal. The emergence of the pre-cut business has sharply reduced the items distributed through conventional routes. The pre-cut mills have an influential role in the structural item selection. The pre-cut mills in the metropolitan area are becoming larger. They give higher priority to stable supply and tend to do business with the suppliers who are able to supply large amount of materials steadily.

Keywords: marketing environment, Japan, Information Environment Model, structural lumber, pre-cut industry

Introduction

Japan is the major importer of wood products in the world. Europe has gained an impressive market share in Japan since the past decade. There is likely to be an oversupply of sawn softwood of about 2 million m^3 by 2010 in Europe (Finnish Forest Industries Federation 2000, p.11). The Japanese market is important in order to balance the demand and supply in European markets (Finnish Forest Research Institute 2002, p.21).

The Japanese marketing environment has drastically changed recently. The appreciation of the euro has led to European wood products losing their price advantage, and the pre-existing and new competitors are gaining power in return. The Japanese customers became more rigorous in product quality after the regulatory reforms in the house construction sector. The distribution system for lumber has been changing a great deal in Japan.

The purpose of the study is to provide the latest information on the Japanese marketing environment. Several authors have presented insights into the Japanese market from European perspective (e.g. Pesonen 1993; Nilsagård 1999; Cohen 2001). The study is aiming to add something new to the existing knowledge and to bring it up to date. The analysis will focus on structural lumber used for house construction that is a major offering of European suppliers. The facts revealed by the study will also form the basis of future empirical research in Japan within the wood products marketing arena.

Study framework

The marketing environment refers to the external business environment of a company (Juslin and Hansen 2002, p.183). In order to analyse the marketing environment in a systematic manner, the Information Environment Model (ibid., p.186) is used as a framework of the study. The model consists of two major categories: macro environment and micro environment. It is designed to fit different approaches and levels of marketing planning.

The macro environment contains three components: demand, supply and other macro environment. Demand and supply for a company's products are vital factors in marketing planning, while other macro environment includes those factors considered in the PEST analysis. The micro environment consists of four components: competitors, distribution, industrial customers and final customers. A company needs to recognise its competitors, to be able to learn from and to compete against them (Juslin and Hansen 2002, p.219). A company must adjust to the general distribution structure in the markets, although it has control of its own marketing channel. Information on both industrial and final customers is of great value.

Data collection

The study is mainly based on the secondary data. Statistics published by government and trade associations, research reports and trade journals are thoroughly reviewed for the study purpose. Data has also been collected through the Internet. Besides collecting data within Finland, I went to Japan shortly in January 2004 and conducted personal interviews as well as material collection. The trends in the pre-cut industry are particularly described on the basis of the interviews.

Macro marketing environment

Demand

Lumber: Lumber has accounted for about 40% of the total wood demand in Japan, and came to 35.4 million m^3 (log equivalent) provisionally in 2003 (Figure 1). Under the sluggish economy in Japan, the demand has been lowered since the late 1990's. Since 70 % of lumber is used for house construction, housing starts have a large impact on the demand for lumber (Forestry Agency 2003a, p.141). The tax reform enforced in 1997, when the rate of consumption tax rose from 3% to 5%, caused a sudden drop of housing starts and negatively affected the demand for lumber in the following year. Though the demand was once regained to 40 million m^3, it has decreased again.

There have been indications recently that the Japanese economy will take a favourable turn. Low mortgage rates and temporal tax reductions led the increasing demand in wooden house construction, and the demand for lumber went up slightly in 2003. However, new housing starts are likely to go down in the long term due to the decrease in population. It would affect negatively the future demand for lumber. On the other hand, the growing demand for housing reform and rebuilding would increase the use of lumber.

Structural Laminated Lumber: Despite the stagnant demand for primary processed lumber, the demand for structural laminated lumber has been rapidly increasing and reached 1.7 million m^3 in 2003 (Figure 2). Japan became the largest market of this assortment in the world (Forest Policy Research Institute 2003, p.27), and structural laminated lumber is a major end-use of imported lumber from Europe (UNECE/FAO 2002, p.99). Structural laminated lumber would cause expansion in the market, as long as pre-cut building materials are increasingly applied in wooden house construction, even if the number of new houses will

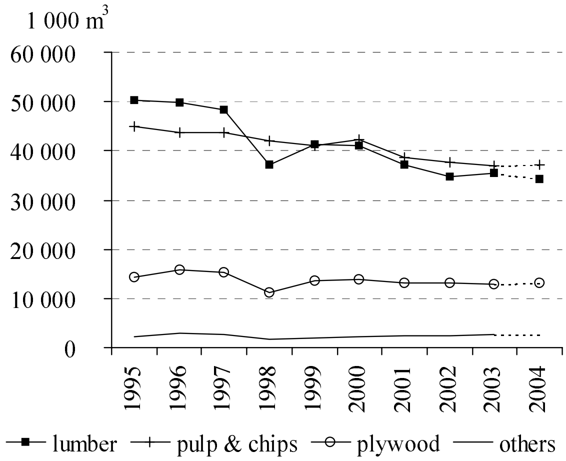

Figure 1. Demand for wood in Japan 1995-2004 (log equivalent)
Source: Forestry Agency 2003b
Note: The figures in 2004 refer to the forecast by Forestry Agency.

not grow in the future (Anon. 2003c).

Small dimension laminated lumber, which is mainly used for posts, was dominant at the early stage of market expansion. It accounted for about 70% of the supply until 1997. However, the share has decreased recently. Laminated connective posts is assumed to be used for around 60% of house construction in 2002, and the proportion is less likely to be over 65% (Forest Policy Research Institute 2003, p.44). On the other hand, medium dimension laminated lumber that is used for beams has increased recently, and the share came to 44% in 2003. Laminated beams made from European red pine have become popular in the Japanese market (Anon.

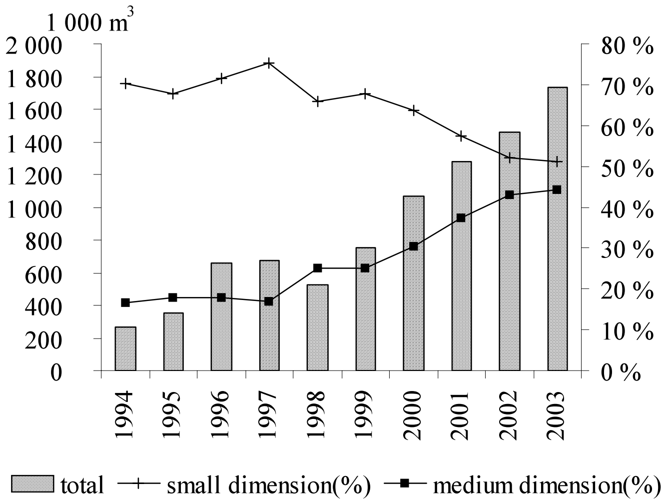

Figure 2. Demand for structural laminated lumber in Japan 1994-2003
Source: Japan Laminated Lumber Industry Association
Note: The breakdown of small and medium dimension refers to the share in domestic production.

2003c).

Supply

Lumber: Japanese domestic lumber produced from domestic logs accounted for 32% of the total supply of lumber in Japan in 2002 (Forestry Agency 2003b, p.5). Domestic industry also supplied 29% of lumber using imported logs. Imported lumber came to 39% of the total supply. The imports of logs have been gradually replaced by imported lumber, while the share of domestic log usage has been stable.

Japan imports in lumber amounted to 8.8 million m^3 in 2003. Figure 3 shows that the imports from Europe have been increasing since the mid 1990's. The imports from Europe (mainly Finland, Sweden and Austria) were 2.7 million m^3, and the market share reached 31% in 2003 from only 2% in 1993. On the other hand, North America has lost its market share from 75% in 1993 to 43% in 2003.

Structural Laminated Lumber: Japanese domestic industry supplied 69% of structural laminated lumber demanded, whereas imported lumber accounted for 31% in Japan in 2003. The share of imported lumber reached its peak to 48% in 1996, and then it has been decreasing steadily (Forest Policy Research Institute 2003, p.27).

Japan imports in structural laminated lumber amounted to 541,000 m^3 in 2003 (Figure 4). European laminated lumber's market share has been drastically growing in the Japanese market. The imports from Europe were 410,000 m^3 in 2003. Though the market share reached an astonishing 78% in 2002 from only 2% in 1993, it went slightly down to 76% in 2003. It is worth noting that the imports from China has drastically increased in 2003 to 64,000 m^3 (12%) from 24,000 m^3 (5%) in 2002.

Forest and Lumber Association is actively promoting structural wood products in Japan

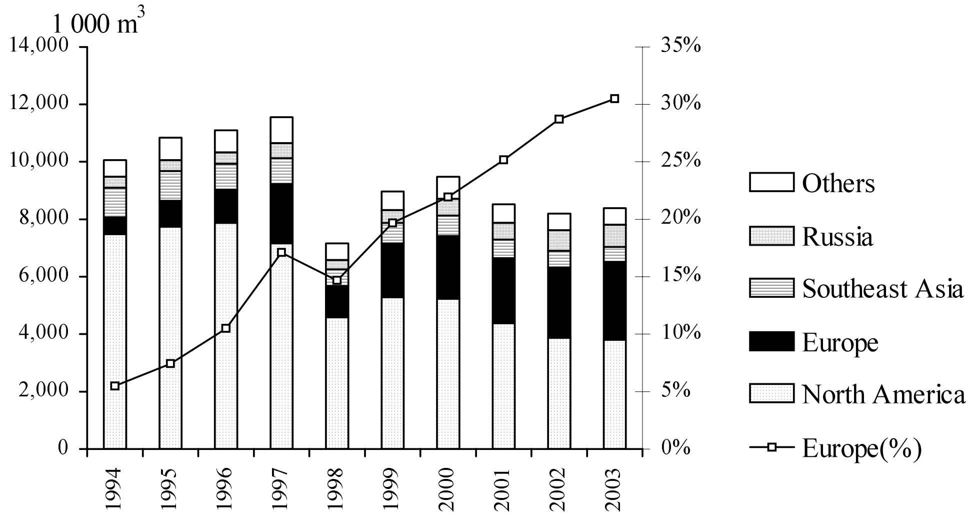

Figure 3. Japan imports in sawn lumber by countries 1994-2003
Source: Trade Statistics, Ministry of Finance

with its brand name “CANADA TSUGA E120” (Canada Tsuga 2004).

China: As mentioned above China’s laminated lumber exports to Japan have been growing at a surprising rate since 2003. Japan is one of the main target markets of the Chinese wood industry (Anon. 2003b), and the number of JAS certified mills is increasing in the country (Anon. 2003f). The main items exported are laminated beams made of Russian red pine (Anon. 2003e).

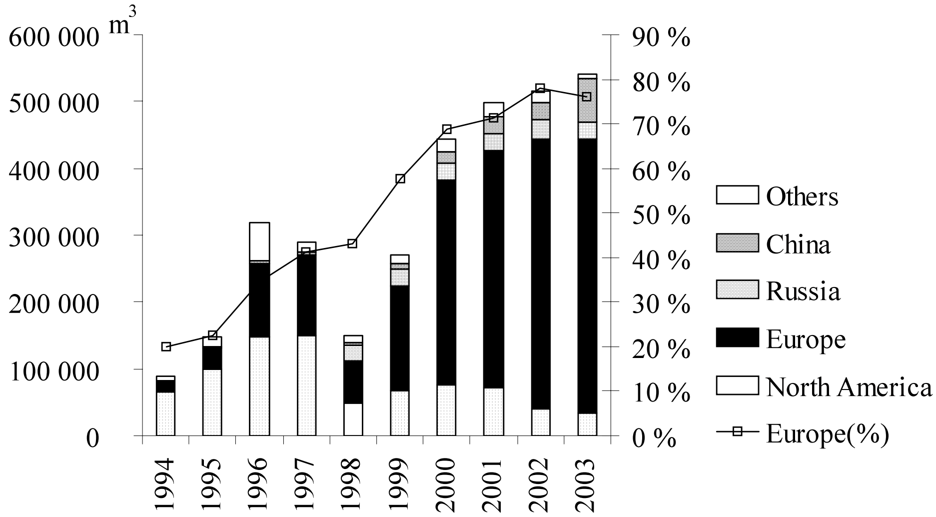

Figure 4. Japan imports in structural laminated lumber by countries 1994-2003
Source: Trade Statistics, Ministry of Finance

Other Macro Environment

Exchange Rate: The exchange rate between Japanese yen and the European currencies has largely fluctuated since the early 1990’s. Though it is unpredictable and uncontrollable by nature, it has affected both positively and negatively the marketing of European wood products in Japan.

For the European wood industry, the turning point in entering the Japanese market came in 1992-93, when the prices of North American wood suddenly soared. Japanese buyers of wood products were compelled to seek alternative sources for their imports. Finnish mark and Swedish krona were depreciated at that period. It allowed European wood products to become price-competitive, and succeeding in entering the Japanese market. Depreciation after late 1999 also helped the European wood industry market products in Japan.

However, the euro has been strong compared to the Japanese yen since the beginning of 2003. The currency appreciation of the euro makes European wood products less price-competitive. Since European softwood lumber and laminated products for Japan have little competition at the moment, direct impact of this currency fluctuation is not so intensive. There is little hope to raise lumber prices in Japan, so that European suppliers are unwillingly taking low prices for Japan (Anon. 2003f).

Laws and Standards: Since the disastrous Hanshin-Awaji earthquake in 1995 Japanese consumers have been much more sensitive to earthquake-proof of structural materials. Under

Europe: The competition among European suppliers in the Japanese market is becoming difficult. Large European lumber producers are aiming to strengthen their position in Japan. They have invested in their production facilities in Russia and the Baltic States so that the production would increase in the near future. The harsh competition may lead some European suppliers to drop out of the business in Japan.

Japan: The Japanese laminated lumber industry is not only a major customer segment for European lumber but also a major competitor for European laminated lumber suppliers. The industry profile will be given later in this paper.

Distribution Systems

Distribution: There are various importers of European lumber existing in Japan, e.g. general and specialised trading firms, laminated lumber mills, house manufactures. It is said that one of the trade barriers in Japan is long, complex and exclusive distribution systems. However, the emergence of the pre-cut business has sharply reduced the items distributed through conventional routes, resulting in driving the lumber retailers to difficulties or even to give up their businesses. The pre-cut industry would have supplied 79% of structural materials for traditional wooden house construction in 2002, assuming that all the lines were fully operational (National Wooden Housing Machine Pre-cut Association 2003, p.6).

Japanese home centres have been reinforcing their wood products business for several years. There were 4,358 home centres in Japan and the total turnover was 3.7 trillion yen in 2002. Home centres with over 50 employees accounted for 17%, while 54% had less than 20 employees (Ministry of Economy, Trade and Industry 2004). The Japan DIY Industry Association reported that wood and building materials accounted for 3.8% of the total sales in 2001 (Takeda 2003). Although structural lumber used for new house building is mainly distributed through pre-cut mills, professional carpenters and small builders are inclined to buy wood products from a nearby home centre for house remodelling usage, which is a potential market for the future.

Transportation: Container ships are mostly used for the delivery of European wood products to Japan. Exported products are first transported to Hamburg or Rotterdam by either surface transportation or coastal ships, then loaded onto container vessels and ship to Japan via the Suez Canal. It takes 35-40 days to sail from Hamburg/Rotterdam to Japan (Forest Policy Research Institute 2003, p.21). Shipping charges are currently soaring due to the stringent supply of ships.

The Trans-Siberian railway (TSR) could become a possible alternative route especially for Finnish suppliers. It takes 16-18 days to transport goods from Finland to Pusan, South Korea, via Vostochny, Russia (Tsuji 2003, p.3), which results in the shortening of the delivering period to a half of all water routes. According to Korean forwarders there is no difference in shipping charge between TSR and all water routes (ibid., p.3). Regular services are frequently available between Pusan and more than 30 city and local ports in Japan. The use of local ports
The substantial changes in the market environment have created a new marketing opportunity for structural lumber in Japan. The Japanese end-users have become willing to use structural laminated lumber for the residential house construction. European lumber is suitable for the structural applications, resulted in gaining the market. Indeed, Europe succeeded in meeting the changing end-users' needs in the Japanese market.

The changes in the Japanese marketing environment are still going on. Every supplier could use the changing situation as a marketing opportunity. A major change is currently enables reduced charges for custody and surface transportation (Forest Policy Research Institute 2003, p.20).

Customers

The Laminated Lumber Industry Profile: There were 351 laminated lumber mills in Japan, of which 46% had a turnover of 100 - 500 million yen and 31% earned over 500 million yen in 2001 (Ministry of Agriculture, Fishery and Forestry 2002, p.4). Quite a number of mills only produce laminated lumber for interior furnishing, and fewer mills produce structural laminated lumber. The Japan Laminated Lumber Industry Association has 167 member companies as of April 2004, of which 61, 56 and 36 produce small, medium and large dimension structural laminated lumber, respectively (Japan Laminated Lumber Industry Association 2004).

The total inflow of raw material into the Japanese laminated lumber industry amounted to 1.7 million m^3 in 2001, of which 42% were delivered through intermediaries including wholesalers, trading firms and auction markets (Figure 5-a). Domestic sawmills and direct imports accounted for 30% and 17%, respectively. A half of the products were delivered

a) Laminated Lumber Industry

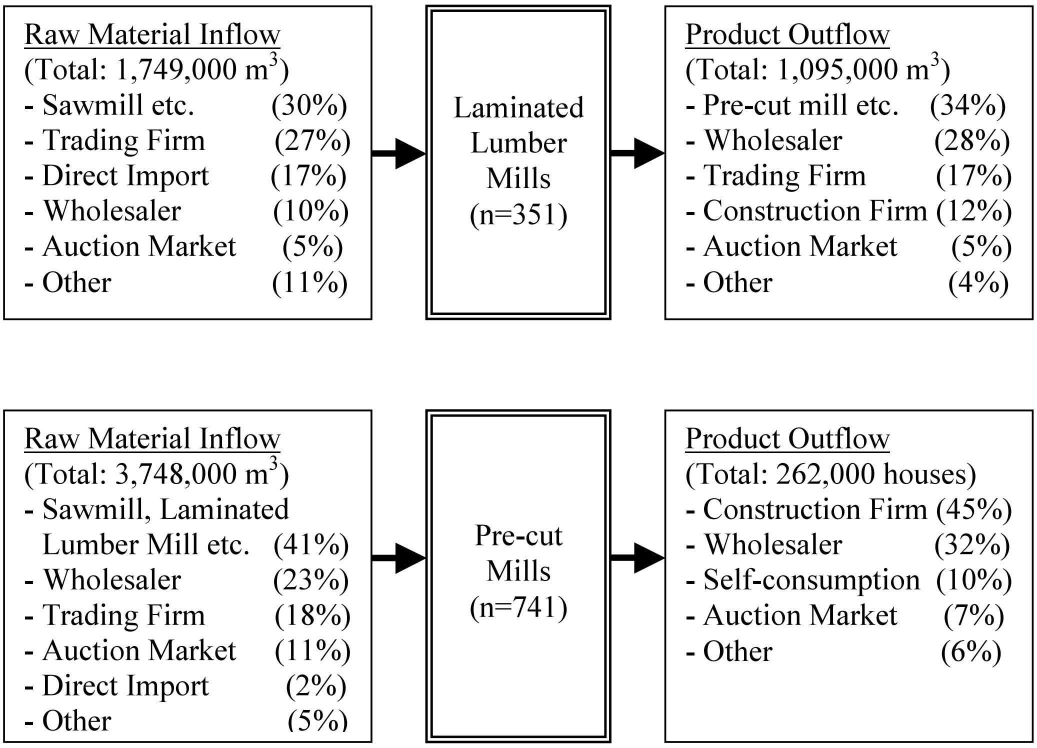

Figure 5. Raw material inflow and product outflow in the Japanese laminated lumber mills and the pre-cut mills 2001
Source: Ministry of Agriculture, Fishery and Forestry 2002

The Pre-cut Industry Profile: There were 741 pre-cut mills in Japan, of which 35% had a turnover of 100 - 500 million yen and 27% earned over 500 million yen in 2001 (Ministry of Agriculture, Fishery and Forestry 2002, p.4). The total inflow of raw material into the Japanese pre-cut industry came to 3.7 million m^3 in 2001, of which intermediaries delivered about a half (Figure 5-b). Domestic sawmills and laminated lumber mills accounted for 41%, while direct imports were only 2%.

According to the National Wooden Housing Machine Pre-cut Association 557 pre-cut mills operated with CAD/CAM processing lines in 2002 (National Wooden Housing Machine Pre-cut Association 2003, p.4). The association conducted a mail survey to 337 pre-cutters in 2002. Two thirds of 101 respondents consumed less than 10,000 m^3 of wood per year, while 12% consumed over 20,000 m^3. The average wood consumption was 8,600 m^3 (ibid., p.22). Many pre-cut mills are cautious to procure their raw material from overseas at the moment (ibid., p.44).

Trends in the Pre-cut Industry: The increasing use of pre-cut semi-structural lumber (*hagara-zai*) and structural plywood is another trend in the Japanese house construction sector. The use of structural plywood for walls and floors allows reducing the construction period and reinforcing the framing of house, hence it is being widespread among the Japanese house builders. On the other hand, this trend would cause decreasing the demand for floor joist (*neda*) and lateral bracing (*sujikai*).

The enlargement of pre-cut mills is currently going on in the metropolitan area, resulting in the excessive competition. The larger pre-put mills tend to do business with the suppliers who are able to deliver large amount of materials steadily. They give higher priority to stable supply, since they are not allowed to make excuses to their customers for no products to sell.

Although the purchasing section in a house building company decides structural items used for house construction, the pre-cutters have an influential role in the decision process. One of the major reasons why the house builders adopted to use European red pine for beams would be the recommendation by pre-cut mills. The use of domestic larch for ground sills (*dodai*) has been increasing since last year, and the pre-cut industry may also influence the adoption.

Conclusions

The substantial changes in the market environment have created a new marketing opportunity for structural lumber in Japan. The Japanese end-users have become willing to use structural laminated lumber for the residential house construction. European lumber is suitable for the structural applications, resulted in gaining the market. Indeed, Europe succeeded in meeting the changing end-users' needs in the Japanese market.

The changes in the Japanese marketing environment are still going on. Every supplier could use the changing situation as a marketing opportunity. A major change is currently taking place in the distribution systems for lumber. Above all, the pre-cut industry is leading the changing movement. Building a closer relationship with the pre-cut mills is a key for success in the Japanese market.

The limitation of the study is mainly due to the data used. In order to get deeper insights into the Japanese market environment, further marketing research should be done based on the primary data. The profiles of the industrial customer groups shown in the study will form the basis of the data collection. The buying behaviour of the Japanese customers should be explored through extensive surveying. The Japanese industrial customers in general give higher priority to a long-term relationship with the suppliers. It is of importance to conduct research from the relationship-marketing point of view.

Acknowledgements

I have been at the Department of Forest Economics, University of Helsinki, during 2003-2004. I am grateful to Professor Heikki Juslin for his guidance. I also thank to the Finnish Forest Industries Federation for the courtesy of showing literature and to the interviewees who gave me insights into the Japanese market.

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The Relations Between Population, Income, and Forest-based Products in China

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The relationship between population, per capita gross domestic product (GDP) and timber and bamboo outputs in China is examined. The data consist of annual national level observations between 1953 and 2002. The results indicate that the elasticities between population, income and timber outputs are diffenent in two periods, planned economy in 1953-1978 and market oriented economy or transformative ecomoy in 1978-2002. The econometric specifications allowed studying the over-time development of the relationship as well. The results indicate that the population and income elasticites of forest products differed between the periods 1953-78 and 1979-2002. During the first, planned economy, period, the income elasticities were increasing, but they were decreasing during the latter, transition economy, period. Throughout the entire study period, the population elasticity of bamboo output showed a positive and an increasing pattern.In general the results can be used to derive global lessons, to forecast future consumption of forest-based products and in the planning of national forest policies.

Key words: China's forestry; economic development; output elasticity.

Economic Treatment of Recreational Congestion

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Abstract

Recreation economics treats spatial problems of varying dimensionality. Travel cost models, once fashionable but no longer so, take recreation sites as point destinations, ideally, located rationally in relation to population. One-dimensional problems, concerning extent of trails, have received little attention. As a problem of land-use competition, planar extent of site is the most important: unless congestion is a negative externality, recreational needs can be met with little allocation of land. Evidence on the existence of congestion problems is mixed, though claims that there is no problem are dismissed by deeper investigation. Tree cover may reduce the sense of congestion, depending on its type. Optimal distribution of recreationists within a space is arguably best achieved by allowing free choice of movement: there is no compelling evidence that management reduces negative externalities of congestion. Charging for access may be both more efficient than exclusion, and no less equitable.

Keywords: Spatial economics, optimal use, distribution

Introduction

Since about 1990, spatial aspects of recreation economics seem to have become of less interest. Travel cost analysis, once the dominant model, has been sidelined by the popularity of contingent valuation and the controversies surrounding its validity. (When was the last travel cost presentation at an SSFE meeting, for example?) Congestion of recreation sites, a popular research topic of the 1970s and 1980s, has been displaced by ecological carrying capacity and sustainability.

At the same time, spatial aspects have grown *more* important in outdoor recreation policy. Most of the British Forestry Commission's forests, planted prior to 1980, were located more than 50 km from major population centres (Grayson *et al*., 1973). Yet since 1990 twelve major community forests have been designated with the primary objective of providing recreational opportunities to populations previously lacking them (Countryside Commission, 1994, 1997a). The Countryside and Rights of Way Act 2000 is expected to permit access to about 1.5 million ha of "open country". However, this does not include forested land, and there is concern that most of the area is still relatively remote from heavily populated regions.

Meanwhile the Forestry Commission has effectively made timber production subsidiary to community involvement and recreational and environmental objectives, although nominally timber production has equal status (Forestry Commission, undated; National Assembly for Wales, undated). But if recreation is to justify the continuation of forestry - widely seen as unprofitable in the UK (Price, 2004) - then the recreational contribution of marginal hectares needs to be re-examined. What recreational opportunities are lost or degraded if the remotest parts of forests, or even the remotest forests, are "restored" to open land - as conservation organisations are now proposing? Does it matter to recreationists if they are crowded into a smaller area of intensively used forests?

After a brief review of the zero-dimension (point location) and single-dimension (trail provision) aspects of outdoor recreation, this paper concentrates on the two-dimension aspect (spatial extent) of recreation resources and issues of crowding or congestion. To what extent do these constitute a case for designating more land for recreation? If congestion is a problem, should it be managed by physical regulation or economic instruments? With a given size of resource and number of recreationists, in what circumstances is management to redistribute use of the site desirable?

The paper abstracts from other aspects of recreational carrying capacity - ecological vulnerability and limitations imposed by physical facilities such as access roads, car parks and toilets.

"Point" and linear recreation

For three decades following publication of Clawson's seminal paper in 1959 (Clawson, 1959; Clawson and Knetsch, 1966), all recreation economists "did" travel cost models. The recreation site was a point in space, as were all origins of recreational visits. Widely interpreted as yielding an absolute value for a site, on the whole Clawson's method gives a value in relation to the next best alternative site (Price 1978). That is to say, the spatial aspect includes implicitly not only origin-destination distance, but the spatial distribution of substitute sites. With clustered sites, the method tended to over-state, and with systematically spaced sites to under-state the contribution of a site to a system of recreational resources (Connolly and Price, unpubl.). The economics of point location might now be said to focus on travel cost saving (time, fossil fuels, road space, road traffic accidents) by locating new resources close to poorly served populations.

Linear recreation sites do not require substantial dedicated land area - about 600 ha for the entire UK longidstance trail network. Nor under UK law is public ownership of the land they cross necessary. Instead, the resources needed are those for design, designation and management - particularly costs of maintaining gates and stiles at field boundaries. There are also substantial costs of maintaining path surface in ecologically vulnerable zones. However, it should be noted that most of the network runs on pre-existing rights of way along which there would in any case be an obligation to maintain boundary crossings (on the land-owner) and path surface (local highway authority). Much of the remainder utilises routes across open-access land which were well-used long before official designation of the trails. In particular, the lengths showing severe erosion damage are generally popular mountain climbs on which long-distance walkers form a small proportion of the users.

As to why resources should be devoted to *expanding* the network of trails, one answer is a qualitative one: more trails enable aficionados to reach more different places, through more different types of scenery. But to my knowledge the willingness to pay for this facility has hardly been thought about, let alone assessed. The costs of maintenance are known, but not how they would increase with expansion of the network. Would a greater route length reduce ecological pressure below significant thresholds, thus avoiding damage and repair costs? Or would the spreading of pressure leave some trails with insufficient usage to maintained a trodden-out route? Do gates and stiles and paths and traversed land depreciate with use or with the lapse of time? If the former, a greater length of trail itself implies no increase of cost: if the latter, it does. At one time some work was done on congestion of wilderness trails in the USA (Shechter and Lucas, 1978). A greater route length would relieve this. Much of what is said in the following sections about the reality of problems and management solutions also applies to management of congestion on trails. However, one survey of trail users in the UK (Countryside Commission, 1997b) found that only 5% had had their enjoyment impaired by the presence of other walkers, and it is doubtful whether designation of more trails would significantly reduce this small number.

Recreation and congestion: making more space

Unless crowding is a negative externality, recreation needs can be met with little allocation of land. Many management problems (information, security, fire, repair) are alleviated by spatial concentration of use. If there is conflict between recreational use and biodiversity conservation, this can be minimised by confining recreation to the robustest parts of the site.

On the other hand, if congestion is a negative and mutual externality, extending the recreational space may be worthwhile. The classic analysis is attributed to Fisher and Krutilla (1972), and is represented in figure 1. The heavy line represents the locus of feasible management strategies: as the number of experiences supplied increases, so the quality of experience deteriorates, and a lower demand curve is relevant.

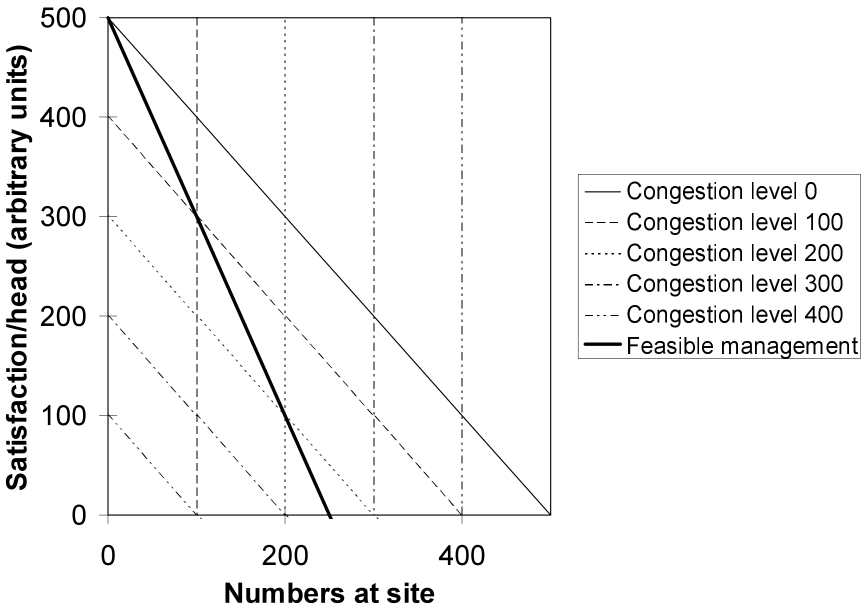

Figure 1. Demand (sloping) and supply (vertical) functions: various levels of congestion

Without regulation of use, recreationists will increase visits while the marginal satisfaction (net of access costs) exceeds zero, that is, to 250 visitors. A marginal reduction in visits brings little net loss, but improves the satisfaction to the remaining visitors. In this case maximum total satisfaction is achieved if usage is regulated to 167 visitors.

To increase supply while staying on the same demand curve requires designation of extra recreational space. The intuitive response, not infrequently articulated, may be that extra open-access recreation sites will soon become as congested as the original ones. However, it is easy enough to show that expanding the recreational space available will both:

· increase the number of recreational experience; and

· reduce the congestion encountered (Price 1981a).

Is more recreational space really needed?

But in the 1970s a variety of emerging evidence cast doubt on whether the effects of crowding at recreation sites were negative. (Haas and Nielsen, 1974; Shelby and Nielsen, 1975; Manning and Ciali, 1980; Shelby, 1980). A travel cost study by Vaux and Williams (1978) showed, apparently, a greater consumers' surplus at congested than at uncongested sites. Most extraordinarily, a survey at Tarn Hows, a popular and well-wooded recreation site in the English Lake District, showed that the greater the numbers at the site, the less congested

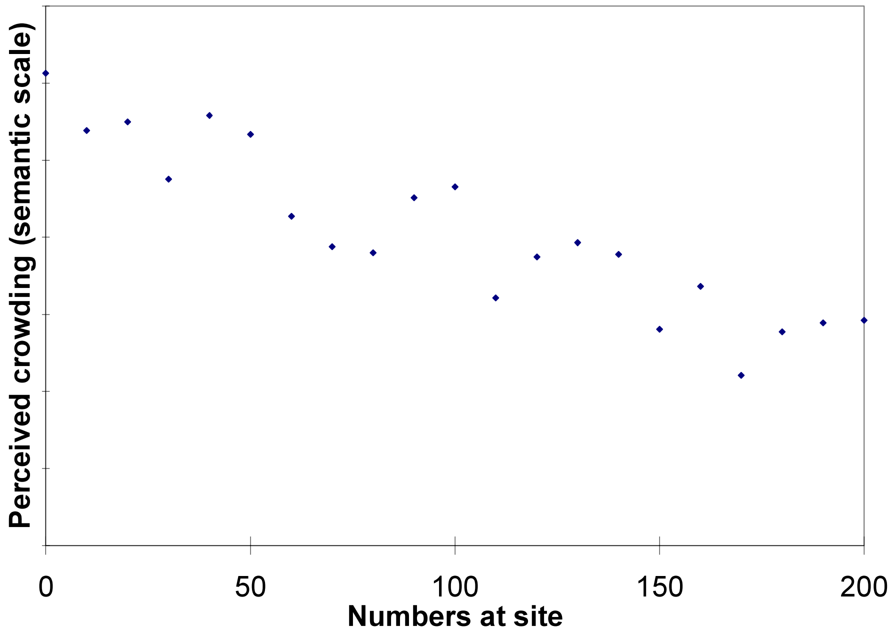

Figure 2. The kind of result found at Tarn Hows

In the words of an eminent forestry academic of the time: "People *like* congestion - you always find more of them at congested sites."

However, recreation psychologists soon advanced several hypotheses to explain these divergences from expectation (Heberlein and Shelby, 1977). Our work in the Forest of Dean, Gloucestershire, England found much evidence in favour of several of these named hypotheses. Questionnaires were combined with behavioural studies and objective measures of visitor density. The responses of 491 visitors were disaggregated in various ways, and the different parameters of regression relationships used to test the validity of the hypotheses. The following sections summarise results. Much fuller accounts are given in Chambers (1984), Chambers and Price (1986) and Price and Chambers (2000).

Environmental and psychological confounding

The relationship between actual density of recreationists and satisfaction is rather indirect. The configuration of the ground and vegetation affect the numbers present who can actually be seen. Psychological factors influence whether large visible numbers are interpreted as crowded or not, and also whether a given perceived level of crowding should be considered a source of dissatisfaction. Table 1 shows individual steps of the relationship, indicating that statistical explanation is good for individual links of the causal chain, but much less satisfactory between the ends of the chain, along which important explanatory variables are not included. Here, and elsewhere, relationships are shown between actual density, *D*, measured by angle gauge; numbers in sight, *N*, obtained by counting; and perceived density, *P*, and satisfaction, *S*, derived from questionnaires.

Table 1. Interrelationships of satisfaction and various measures of density

Regression of	On	Equation	R^2	Probability
Numbers in sight	√ Actual density	$N = 4.27 + 56 \times \sqrt{D}$	0.534	0.0001
Perceived density	Numbers in sight	$P = 2.96 + 0.00236 \times N$	0.233	0.0001
Satisfaction	Perceived density	$S = 6.39 - 0.431 \times P$	0.147	0.0001
Satisfaction	√ Actual density	$S = 5.14 - 0.0541 \times \sqrt{D}$	0.013	0.02

A more systematic bias occurs when attractive environments or favourable weather attract both high visitor numbers and high levels of satisfaction. Uniformly good conditions through the study period avoided the weather problem, and the site problem was circumvented by disaggregating the data by site - with improvement for two sites as shown by the statistical relationships in table 2. The non-significant relationships will be discussed later.

Table 2. Satisfaction–density regressions disaggregated by site

Sites in regression	Equation	Sample	R^2	Probability
All	$S = 5.14 - 0.0541 \times \sqrt{D}$	491	0.013	0.02
Speech House	$S = 4.61 + 0.0143 \times \sqrt{D}$	128	0.001	NS
Wenchford	$S = 5.23 - 0.0437 \times \sqrt{D}$	87	0.015	NS
Mallards Pike	$S = 5.82 - 0.208 \times \sqrt{D}$	125	0.057	0.01
Beechenhurst	$S = 5.36 - 0.137 \times \sqrt{D}$	151	0.051	0.01

Vegetational influence

The claim is often made that forests are more effective than open vegetation at absorbing crowds. Our objective data tended to support this: the density measured using an angle gauge device changed as follows as the sweep enclosed successively larger areas:

· in broadleaved woodland with dense understorey, recorded density fell rapidly

· in grassland on folded topography, recorded density fell more slowly

· in old conifer woodland with little understorey, on flat terrain, there was no change in recorded density.

This result was supported by the greater degree of explanation, greater statistical significance and larger slopes parameters of relationships between variables at the grassland and conifer sites (table 3).

Table 3. Regressions of numbers in sight and perceived density on actual density in different vegetation types

Site character	Equation	Sample	R^2	Probability
Broadleaved I	$N = 19.0 + 0.224 \times D$	128	0.316	0.0001
Broadleaved II	$N = 32.3 + 0.176 \times D$	87	0.180	0.0001
Coniferous	$N = 7.69 + 0.889 \times D$	125	0.475	0.0001
Grassland	$N = 14.7 + 0.604 \times D$	151	0.491	0.0001
Broadleaved I	$P = 3.74 + 0.00650 \times D$	128	0.069	0.005
Broadleaved II	$P = 3.98 + 0.00203 \times D$	87	0.015	NS
Coniferous	$P = 2.68 + 0.0648 \times D$	125	0.239	0.0001
Grassland	$P = 3.25 + 0.0231 \times D$	151	0.170	0.0001

Cognitive dissonance

According to Festinger (1957), people redefine motives and satisfactions when circumstances might otherwise imply that they had made wrong choices. Thus when people have invested time and effort in journeying to a site, they may feel it would evince irrationality to claim that they were not satisfied with the experience so gained.

Analysis of our data disaggregated by distance from trip origin shows clearly that there are indeed weak adverse relationships between crowding and satisfaction for those who travelled longer distances, whereas those from close at hand were more prepared to express *dissatisfaction* with crowds. By contrast, there was no such trend in the relationships between perceived density and numbers in sight: at all distances visitors *noticed* the crowds.

Table 4. Regressions of satisfaction and density, disaggregated by distance of origin

Distance zone (km)	Equation	Sample	R^2	Probability
0–20	$S = 7.23 - 0.56 \times P$	162	0.236	0.0001
20–60	$S = 6.59 - 0.33 \times P$	194	0.136	0.0001
60–180	$S = 4.97 - 0.23 \times P$	71	0.030	0.1362
>180	$S = 6.39 - 0.31 \times P$	64	0.102	0.0112
0–20	$P = 2.11 + 0.026 \times N$	162	0.245	0.0001
20–60	$P = 4.34 + 0.020 \times N$	194	0.200	0.0001
60–180	$P = 3.20 - 0.036 \times N$	71	0.200	0.0047
>180	$P = 3.75 + 0.036 \times N$	64	0.300	0.0004

No expectations

If people have no expectations of what crowding will be like, they may not respond adversely to whatever it is that they find. (Unfortunately our questionnaires did not allow us to distinguish the sub-set of this group who were unpleasantly surprised.) Table 5 shows a remarkably different parameter of response to numbers in sight for the two categories.

Table 5. No-expectations hypothesis and regressions of satisfaction on numbers in sight

Category of visitor	Equation	Sample	R^2	Probability
Had expectations	$S = 5.35 - 0.0145 \times N$	250	0.062	0.0002
No expectations	$S = 4.91 - 0.00145 \times N$	241	0.001	NS

Product shift

If the intended recreational activity (e.g. bird watching) turns out to be unsuitable to the conditions of crowding actually found, recreationists may engage in a different, more compatible activity (e.g. joining in a fun run). We did not include questions about intended and actual activity and motivations for any difference, so offer no evidence here.

Displacement

Another group of individuals modifies its behaviour in quite a different way. Instead of adapting their activity to the condition of the site, they design visits to sites to accord with their desired activities. Thus crowd-averse visitors may

· move on if the site is found to be crowded on arrival (studies of stay-time at car parks showed, to a slight degree, more rapid onward movement at times of high crowding)

· visit at off-peak times (see table 6)

Table 6. Regressions of satisfaction on perceived density: off-peak and peak

Time of day	Equation	Sample	R^2	Probability
Off-peak	$S = 6.56 - 0.45 \times P$	177	0.21	0.0001
Peak	$S = 6.25 - 0.35 \times P$	314	0.11	0.0001

Questions about visitors' perception of crowding also allowed a crowd aversion index to be established. The greater the crowding was *perceived* to be for any *actual* visitor density, the greater the value of the index. Disaggregating the data by crowd aversion index showed clearly that populations do contain psychological sub-groups whose response to crowding is negative and strong. This response may be masked by variation in crowd aversion when the data are not disaggregated.

Table 7. Satisfaction–density regressions disaggregated by crowd-aversion

Crowd aversion index	Equation	Sample	R^2	Probability
< 0.8	$S = 5.50 - 0.0068 \times N$	115	0.021	0.1261
0.8 to 1.6	$S = 5.35 - 0.0122 \times N$	147	0.042	0.0129
1.6 to 3.2	$S = 5.66 - 0.0296 \times N$	114	0.173	0.0001
> 3.2	$S = 5.24 - 0.0492 \times N$	115	0.150	0.0001

At times of lesser *real* crowding, crowd-averse visitors are likely to constitute a greater proportion of interviewees, who are therefore likely to express low satisfaction even with low crowding: at times of greater crowding, the expectedly less crowd-averse visitors perceive less crowding and so express greater satisfaction. This mechanism explains many of the results obtained in the 1970s, especially the perverse results at Tarn Hows.

Displacement between sites also explains the results of Vaux and Williams (1979), given that the travel cost method measures site value in relation to the value of substitute sites. At times of great congestion such as public holidays, crowd-averse recreationists are displaced to remoter sites, more costly to access. At such times these sites may be quite crowded, but they allow a much better experience relative to the extremely congested sites lying closer to population centres.

By contrast, visitors to the Speech House site seemed to respond, if anything, positively to crowding, while those at Wenchford were neutral (see table 2). These sites are known to be recreation focuses, and people go there to have a good time in the company of many others.

Managing congestion at a site of given extent

There is enough evidence above to suggest that recreational congestion is a problem, to the extent that at least a significant proportion of visitors perceive it as such. Self-interested decisions - on whether to come to the site or to go elsewhere or to stay at home, and on how to distribute themselves through the site - will not in these circumstances produce the optimal use of the site. Some management actions may be justified.

Charging versus exclusion

The economists' tool of charging to ration use may be preferred to physical exclusion with good reason (Price, 1981b). Exclusion of some arrivals entails visitors making more than one journey per realised visit. It may therefore be no less costly to recreationists than paying a substantial admission charge. Yet admission costs are transfers, and generate funds for useful site expansion and management, while travel costs are real resource costs, with externalities of road pollution, accidents and congestion.

Nor are equity issues in favour of physical regulation. Physical exclusion has a variable effective cost owing to the varied length of repeated journeys, unlike an admission cost, which is the same irrespective of journey length. Moreover, those who have furthest to travel will be relatively late in arriving, and therefore have lower probability of admission. Those who live far from the site therefore pay effectively more under regulation than under charging. Given the distribution of rich and poor in relation to rural recreation areas, the poor are likely to pay a higher premium under exclusion.

Given these difficulties of exclusion, it may be economically preferable not to regulate access, than to regulate by exclusion - particularly when site demand is inelastic (see Price (1981) for proof).

On the other hand, there is instinctive opposition to charging for what is regarded as *allermannsrätten* (even if access has no legal authority). Free access to a resource has a value in addition to that of the resource itself. Hence, perhaps, visitors to Durham Cathedral voluntarily contributed more per visit than the willingness to pay for entry that they declared in a contingent valuation exercise (Willis *et al*., 1993). In this context it is not so much the *actual* efficiency and equity effects of charging that matter, but the *perception* of these effects.

Distribution of visitors within the site

Zoning a site for various levels of usage is an appealing management strategy. To a degree recreationists organise themselves into zones of different crowding levels. However, it is not clear either that they do so in an optimal manner, or that management to modify the "natural tendency" of zoning is beneficial. A mathematical approach is developed below.

Initially, let the response to crowding be uniform among recreationists, and let it be represented as

$$\left[\begin{array}{c} individual \\ satisfaction \end{array}\right] = \frac{a}{[density]^{b}} \qquad (1)$$

b is the absolute of the elasticity of satisfaction, s, and for convenience satisfaction is given in arbitrary units such that $a = 1$. Let n be numbers per 100 ha.

$$s = \frac{1}{n^b} \quad \text{and} \qquad (2)$$

$$\frac{GV}{GQ} = \frac{-E}{Q^{E+1}} \qquad (3)$$

Let two 100-ha zones of the site exist such that in one the density is *c* times that in the other, *N*.

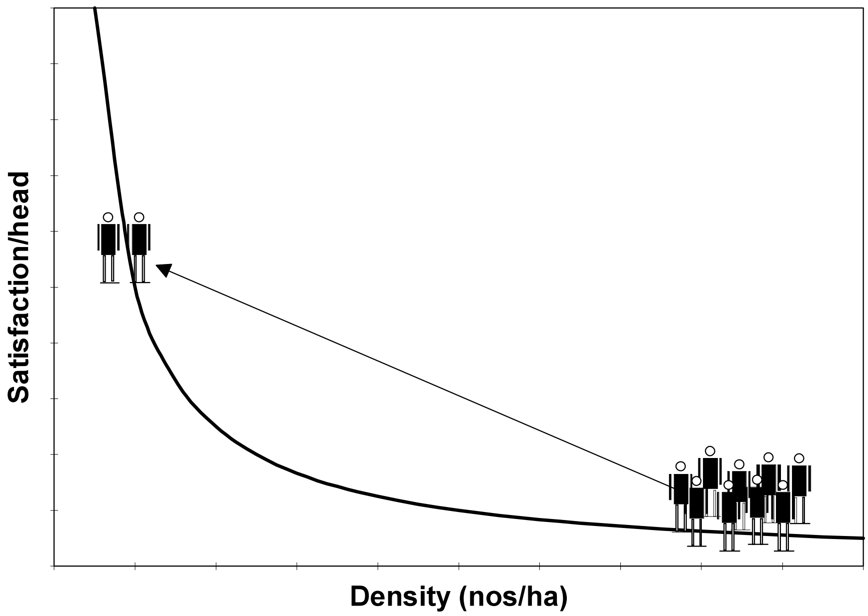

Figure 3. Redistribution of crowding within a site

Let *N* be >>1. Now let one user transfer from the more to the less crowded zone, this being the self-interested satisfaction-maximising tendency. For the transferer, from equation (2) the benefit is

$$\left[\textit{new satisfaction} \right] - \left[\textit{old satisfaction} \right] = \frac{1}{N^b} - \frac{1}{(cN)^b} \qquad (4)$$

For those remaining in the more crowded zone, from equation (3) the benefit of the transfer is

$$\left[\textit{number affected} \right] \times \left(- \left[\begin{matrix} \textit{rate of change of} \\ \textit{satisfaction with crowding} \end{matrix} \right] \right) = cN \times \frac{-(-b)}{(cN)^{b+1}} = \frac{b}{(cN)^b}$$

(5)

For those remaining in the less crowded region, the [dis]benefit of the transfer is

$$\left[\textit{number affected} \right] \times \left[\begin{matrix} \textit{rate of change of} \\ \textit{satisfaction with crowding} \end{matrix} \right] = N \times \frac{-b}{N^{b+1}} = \frac{-b}{N^b} \quad (6)$$

The summed change in benefit is thus (6) + (4) + (5) =

$$\frac{-b}{N^b} + \left\{ \frac{1}{N^b} - \frac{1}{(cN)^b} \right\} + \frac{b}{(cN)^b} = \frac{1-b}{N^b} + \frac{b-1}{c^b \times N^b} = \frac{\left(c^b - 1\right)}{c^b \times N^b} \times (1-b) \quad (7)$$

Since $c > 1$, and $N > 0$, both numerator and denominator of the quotient in (7) are always positive; and summed benefit given by equation (7) is positive, zero or negative as b is less than, equal to, or greater than 1.

Empirically, responses to questionnaires (Price, 1979) suggest that $b = 1$ is close to reality. This indicates that there is no benefit in encouraging users to distribute themselves evenly throughout an area, but neither is there benefit in trying to differentiate density of use (except for ecological reasons). Also, with this parameter value, the total satisfaction (= [numbers] ´ [individual satisfaction]) derived from a site of given area is invariant with numbers at the site, since individual satisfaction is inversely proportional to density (= [numbers] / [site area]). This is in marked contrast to the result of Fisher and Krutilla (1972), as discussed above.

If, however, the users in the less crowded zone are more crowd averse than those in the more crowded one, the negative element in (6) is increased relative to the positive element in (5). Self-distribution may fail to achieve optimality, even where $0 < b < 1$. Moreover, attempts to improve the situation may fail, since *unselective* evening-out of densities may crowd the crowd averse, while dispersing the crowd tolerant.

However, to a degree the problem is self-regulating, especially if part of the population has a positive preference for a degree of crowding.

· Such crowd-seeking recreationists, by congregating in one part of the site, will automatically reduce the crowding experienced by the crowd averse.

· If parts of the site are less attractive by reason of accessibility or aesthetic quality, users will arrange themselves within the site so that the most crowd tolerant seek the most attractive locations, while the most crowd averse tolerate the less attractive ones. By "congesting" the best landscapes, the best use of them is made.

Nonetheless an optimal outcome is not guaranteed. For example, those most averse to congestion may also be most appreciative of landscape quality. This belief probably underlay the "honeypot site" strategy of the 1960s and 1970s in Britain: recreation sites were designated to intercept "the masses" before they could reach the high quality landscapes of the national parks. But here issues of justice are added to those of efficiency. Arguably, those whose preference for uncongested conditions makes them heavy demanders of spatial extent should "pay" for their requirements by accepting a recreational environment of lower quality or higher access cost. Applied on a large spatial scale, it was just such a recreation resource, remote and not particularly beautiful, that the Forestry Commission created in Britain in the middle years of the twentieth century.

Conclusion

The spatial economics of recreation are clearly far from being fully resolved. In many cases it seems that the relevant questions are not being asked any more. There is work even for the contingent valuation method to undertake. Yet there remain persistent resistance and puzzlement with aligning money and environmental scales (Clark *et al*., 2000). Sometimes it is not necessary to invoke money in resource choices: questions about recreationists' preferences among feasible management strategies (Price, 1979) may give enough information to assist improved efficiency of spatial resource use.

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Hyperbole, Hypocrisy and Discounting that Slowly Fades Away

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Abstract

Mainstream economists have begun voicing disquiet about how discounting affects values ascribed to the distant future. It has been proposed that discount rates should decline through time. Some reasons for this (hyperbolic discounting by one individual, fair treatment of future generations, different time perspectives of presently living individuals) lead to inconsistent decisions through time. Diminishing marginal utility provides a robust and stable justification for discounting. Combination of different income groups, different goods and different scenarios yields discount functions in which discount rate does tend to decline, though not always similarly. Uncertainty about future return on investment affects discounting arguments based on compensation or endowment of future generations, but drives these arguments in opposite directions. Time preference rates so derived have no normative significance. The most politically appealing argument for declining discounting is that it rejects environmentally damaging projects, and supports the claims of the distant future, without requiring great sacrifice in the present.

Keywords: time preference, intergenerational justice, diminishing marginal utility, rate of return, disaggregation

Introduction

The fashionable though ill-defined concept of sustainability is difficult to reconcile with the long-established and clearly delineated process of discounting. Sustainability requires the same attention to be paid to the well-being of the future as is done to the present generations. Yet at customary commercial discount rates, 4%-10%, the value attributable even to massive environmental catastrophe 500 years in the future is entirely negligible (see figure 1). Increasing numbers of economists are beginning to express doubts about the validity of the process when applied to very long-term decisions. (See the collection of views given in Portney and Weyant, 1999.)

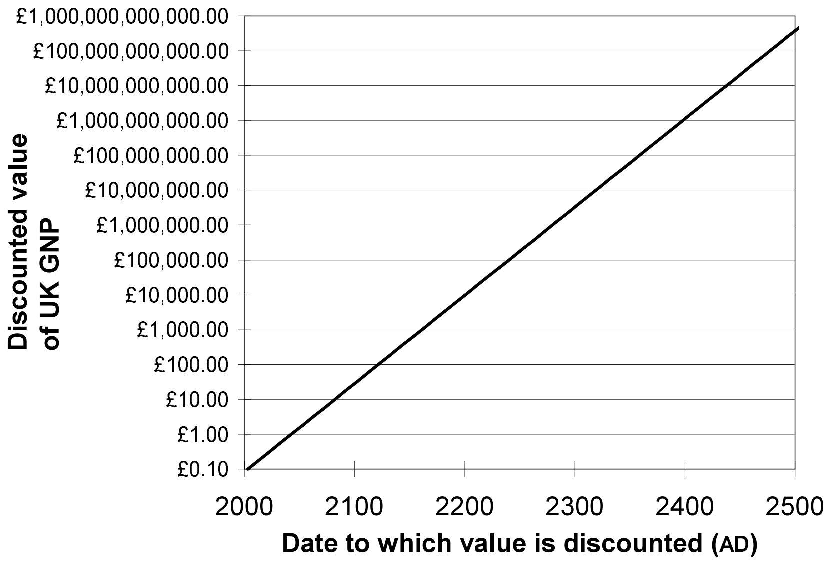

Figure 1. Effect of discounting on the value of a huge distant-future sum

Yet, mindful perhaps of the capital rationing role of discounting, economists are reluctant to give up this investment appraisal tool all at once. The suggestion is increasingly heard, from many quarters and perspectives, that lower discount rates should be set for longer time periods. This paper critically examines the credentials of arguments advanced for declining discount rates. Some suffer from inconsistency of results. Others are better met by disaggregating the entities to which discounting is applied. In some cases similar arguments can result in discount rates which increase through time. From the political perspective, a declining discount rate may produce convenient results, excluding certain types of investment which are, for unspecified reasons, not favoured. It may also excuse a political entity from taking immediate action in favour of the distant future, by representing delayed action as economically less costly.

A further written account is forthcoming in Price (in press a).

Not a negative exponential …?

Recently a number of academics have proposed that discounting should be done in a way that differs from the traditional negative exponential. Journal papers (Weitzman, 1998), reports of research institutes (Newell and Pizer, 2001), advice to government departments (OXERA, 2002) and even government departments themselves (Her Majesty's Treasury, undated) have begun to recommend that the discount rate employed should be reduced, the longer the period over which discounting prevails. If the discount rate varies discontinuously, the result is a cusped profile of discount factors over time (see figure 2). This is far from convenient: there are no continuously differentiable net present value functions; discount factors increase sharply in the year following a change of discount rate - in optimal rotation calculations, for example, rotations lasting 31, or 76, or 121, or 201, or even 301 years would be suddenly popular.

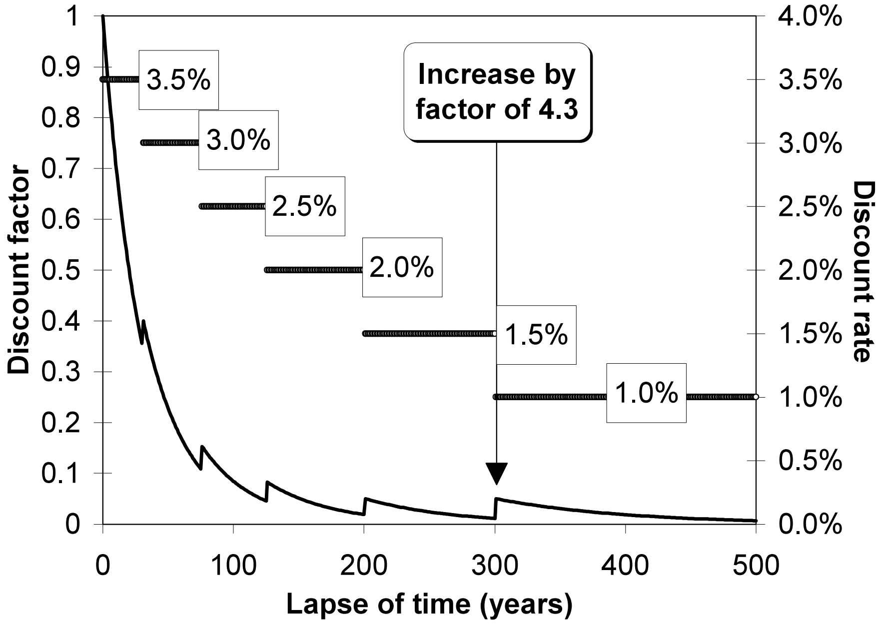

Figure 2. Discount factors based on rates proposed by OXERA (2002)

However, the basis for such discount profiles is not simply aversion to the results of negative exponential discounting, but derives from some belated rethinking of the rationale of discounting. This rethinking has been done from empirical, ethical and theoretical perspectives.

Hyperbolic discounting

It has very often been observed that humans' impatience puts heavy weight on the immediate rather than delayed gratification of desires, but very much less weight on the distant-future rather than the further-delayed gratification of desires (Thaler, 1981; Benzion *et al.*, 1989; Ainslie, 1991; Henderson and Bateman, 1995; Cropper and Laibson, 1999). In extreme cases, we discount heavily over a day's delay in the immediate future, but hardly at all over a day's delay ten years in the future. This profile of values has given rise to what is termed hyperbolic accounts of discounting, in which, typically, the discount factor is

$$\frac{1}{\left(1+[\text{discount rate}]\times[\text{delay}]\right)} \quad \text{rather than} \quad \frac{1}{\left(1+[\text{discount rate}]\right)^{[\text{delay}]}}.$$

(It might be noted in passing that neither this, nor other formulations appearing in the literature, are strictly hyperbole.)

Figure 3 gives an illustrative profile of hyperbolic discount factors, and the discount rates equivalent to them. The annual factor is the ratio between values given to consumption occurring after 49, and after 50 years. As lapse of time brings time 49 closer, so the annual discount factor declines: eventually, dramatically.

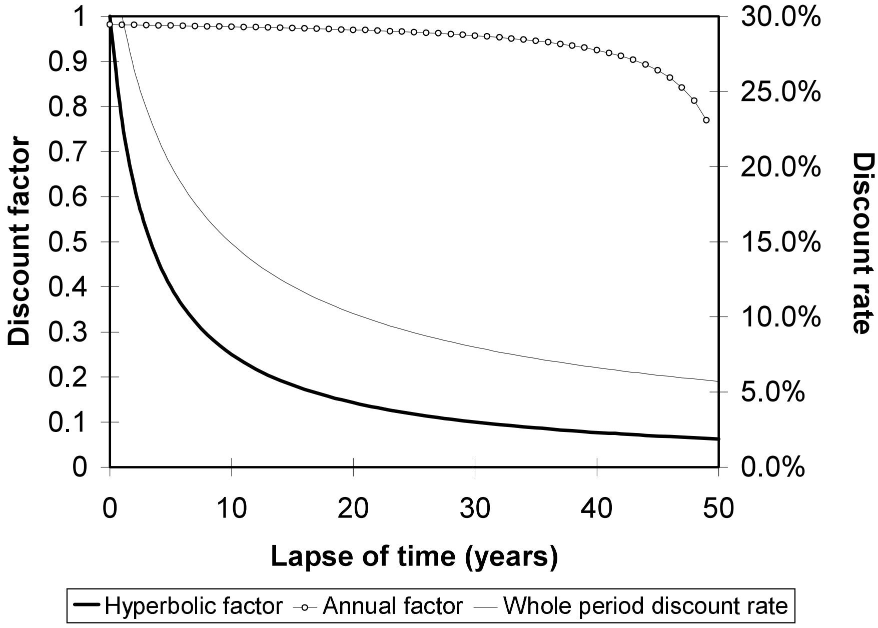

Figure 3. Hyperbolic discounting functions

A propensity to discount like this has clear survival value in a world without proprietary rights, where the imperative is to "seize the day" - take whatever opportunities for feeding or mating come one's way, before they are seized by another individual. It is much less appropriate in a world where postponed consumption is nonetheless reasonably *assured* consumption, and even less so where individuals have the option of transforming consumption through time by investing at interest. Such, nonetheless, is our evolutionary heritage, and we can evade it only by paying attention to our intellectual rather than our instinctive inclinations.

The rights of future generations ("ethical" discounting)

A similar profile of declining discount rates arises from concern for future generations. Under consumers' sovereignty, it is argued, the present generation is entitled to discount its own future well-being, but not that of future generations. A number of formulations have been put forward which use different protocols for discounting the share of consumption accruing to present and future generations (Kula, 1988; Bellinger, 1991; Bayer, 2003). The most persistent of these has been Kula's formulation, which combines normal [time preference based] discounting of the share of future consumption that falls to the present generation, with discounting of the share to future generations only during the period from their birth up to the accrual of consumption. This yields the following profile of discount factors for separate and combined generations (see figure 4).

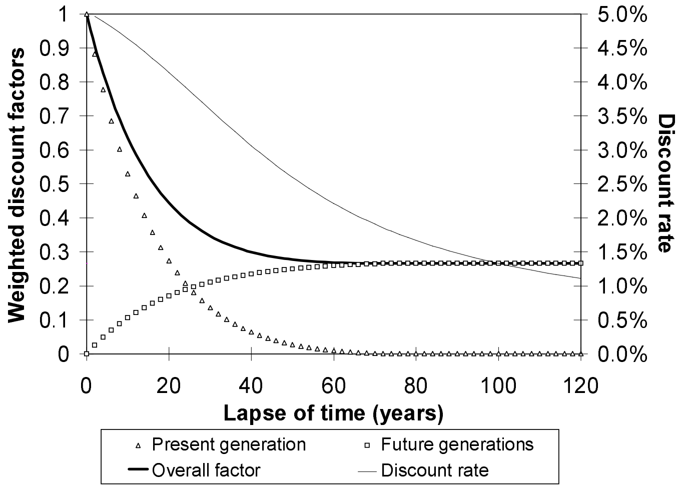

Figure 4. Discount factors according to Kula

Different time preferences

This account follows a protocol similar to that suggested by Li and Löfgren (2000). "Society" is represented by one conservationist who does not discount, and three utilitarians who discount at 5%. [This characterisation of utilitarians is actually quite inappropriate: as Broome (1991) argues, there are many versions of utilitarianism, and there should be no presumption that the philosophy is short-termist in outlook. Indeed, the utilitarian philosopher Sidgwick (1874, p.414) asserts that "… the interests of posterity must concern a Utilitarian".] The social discount factor is the weighted mean factor for these four representative persons.

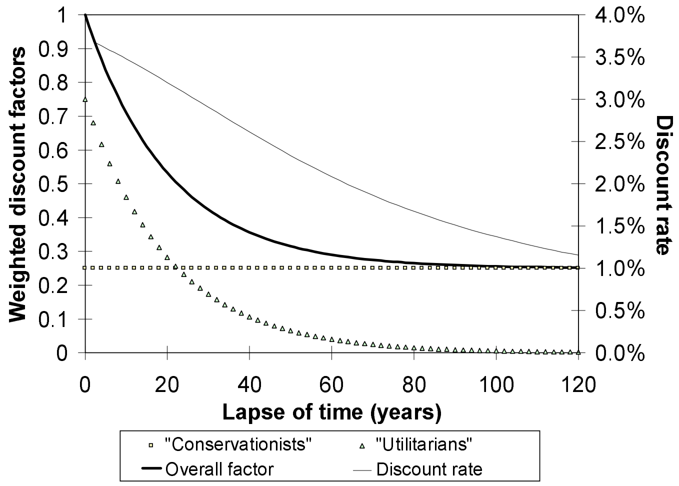

Figure 5. Components of the discount factor according to Li and Lofgren's protocol

Dynamic inconsistency

The above three very different arguments for declining discount rates share a practical problem: dynamic inconsistency (Strotz, 1956). Suppose Scots pine (*Pinus sylvestris*) is established on a low productivity site, with cash flows per hectare as shown in table 1. Discount factors for 40, 80 and 120 years are 0.35653, 0.26513 and 0.25215, derived by summing utilitarian and conservationist factors as in figure 5. From the perspective of AD 2004, a rotation of 120 years appears profitable. However, in AD 2084 the revenue from immediate felling exceeds the discounted revenue from delaying until AD 2124. The crop is felled at age 80 years. Yet, had that felling age been anticipated at the time of establishment, the crop would not have been deemed worth planting.

Table 1 Options for Scots pine (*Pinus sylvestris*) rotation

Event	Cash flow per hectare	Discounted value seen from time AD 2004	Discounted value seen from time AD 2084
Establish	–£2000	–£2000	
Fell at age 80	£6000	£6000 × 0.26513 = £1591	£6000
Fell at age 120	£12000	£12 000 × 0.25215 = £3026	£12 000 × 0.35653 = £4278

Similar results arise with the hyperbolic and “ethical” discount factors.

More sums of negative exponentials

Differences in discount rates are not confined to individuals’ time preference, nor are they a radically new concept. Li and Löfgren’s protocol is but a special case of the general result of combining more than one discount rate, of which numerous previous examples have been discussed (Price, 1993). The most consistent source of such varied discount rates is diminishing marginal utility - the reduction in value of an additional unit of consumption as the total of consumption increases. Diminishing marginal utility is the easiest cause for discounting to defend ethically (Price, 2003). In a world of advancing technology and rising personal affluence, the standard expectation is of marginal utility of consumption decreasing indefinitely into the future.

Income growth

But not every entity or agency is affected to the same extent. Suppose the costs of future global climate change were to fall equally on two representative countries, each having the same population. One has a growth rate of real income per head of 2.5% (similar to the UK presently): the other, 0.5% (like many developing countries where high official growth rates probably overstate the gain in real income per head (Price, 2003)). The elasticity of marginal utility of income is taken illustratively as -2, but similar results are obtained with lower and higher elasticities. Suppose that both countries’ income started at the same level. A discounting protocol based on the weighted sum of discount factors for the two groups would indeed produce a profile of discount rates like OXERA’s (see figure 6).

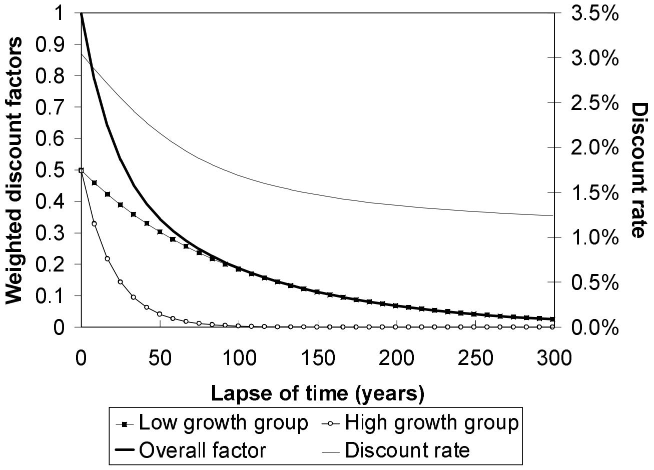

Figure 6. Discounting the effect of climate change: two different income growth rates

But if the low-growth country is also a low-income country, a very different picture emerges. Suppose its initial income per head is a twentieth that of the high-growth country. The lower curve in figure 7 shows that the discount rate based on individual utilities is uniformly low. The utility function gives little weight to marginal costs falling on the rich country. The upper curve, by contrast, shows a discount rate based on the income of the two countries taken together, and thus is dominated from the outset by the high-income country. The obvious conclusion is that the fundamental problem is disparity in appropriate discount rates between groups, rather than that any disparity emerging over time periods. The imperative is to disaggregate the appraisal by income group, not time period.

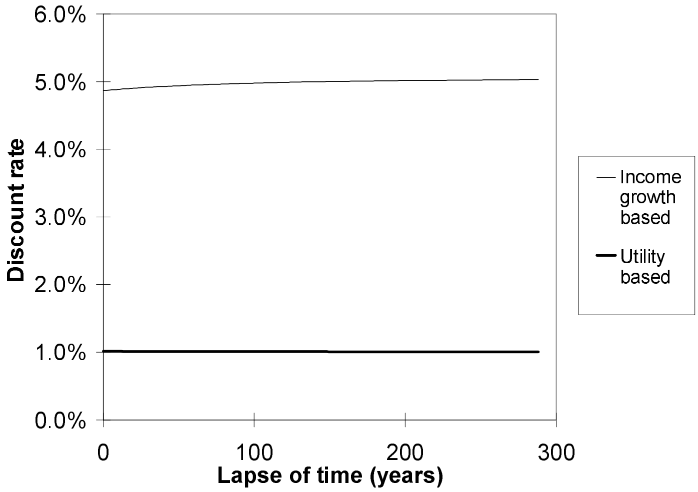

Figure 7. Discounting the effect of climate change: two different initial income levels

See Price and Nair (1985) for a fuller account.

Aggregating goods

Like marginal utility of income, so marginal utility of goods falls at different rates with increasing consumption. Figure 8 presents the case for two products with very different elasticities of utility of consumption. For simplicity, these two are taken to represent the whole consumption basket. At low income levels, consumption is dominated by the good having high elasticity of marginal utility of consumption. This is often associated with basic needs goods, such as wood products for fuel and house construction. As income rises, at first the (rapid) diminution of marginal utility of consumption is attributable largely to this basic good. But the "luxury good" - perhaps consumption of aesthetic services of forests - comes increasingly to dominate marginal purchases, and the implicit discount rate declines. The situation superficially resembles Li and Löfgren's formulation of overall discount rate for two individuals with different discount rates (figure 5). However, the profile of discount rates is quite different: there is an initial flat section where the basic good dominates, before the rate declines asymptotically to the rate appropriate to the luxury good. It is also noticeably different from that advocated by OXERA (2002).

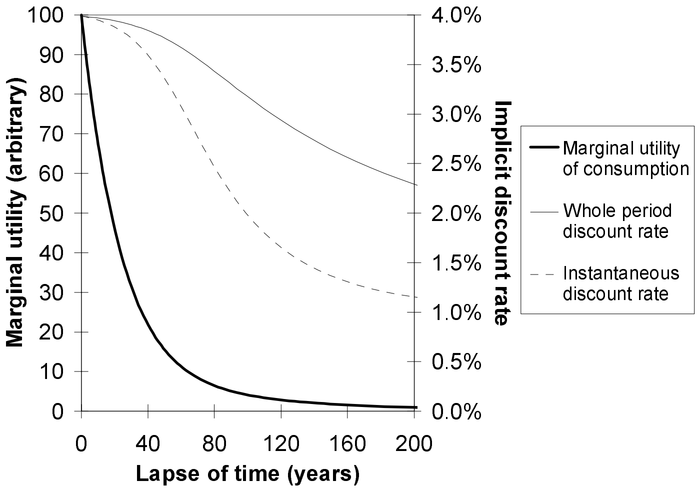

Figure 8. Discount rates for a basket comprising one basic and one luxury good; constant income growth rate

Aggregating scenarios

In an uncertain world, neither the growth of future income nor the future abundance of goods is known. Nor, therefore, is the appropriate discount rate based on diminishing utility.

Figure 9 considers the value of projected future effects of climate change, with two polar economic projections. The optimistic scenario projects economic growth of 5% per year, and zero population growth: the pessimistic scenario projects economic growth at 2% per year, and 1.5% per year population growth. Elasticity of marginal utility of consumption is again taken as -2. Growth of income per head is economic growth rate minus population growth rate. As customary (Fankhauser, 1995), damage resulting from climate change is proportional to economic activity, so that the rate of economic growth offsets discounting due to diminishing marginal utility.

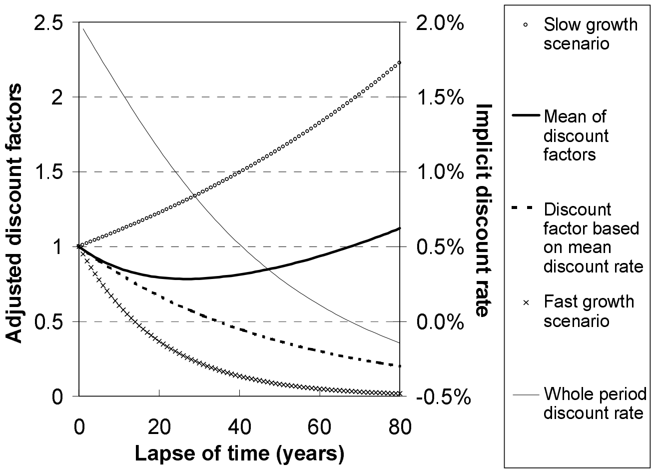

Figure 9. Averaging discount rates and discount factors for climate change damage

Thus under the optimistic scenario the appropriate diminishing marginal utility discount rate is (5% - 0%) ´ |-2| - 5% = 5%; under the pessimistic scenario it is (2% - 1.5%) ´ |-2| - 2% = -1%; and, it might be thought, if both scenarios were deemed equally probable, that the mean discount rate would be 2%. But figure 9 shows that the discount rate consonant with the mean of discount factors changes not only in magnitude through time, but also in sign, being positive initially, eventually becoming negative.

Figure 10 represents values accruing to a poor household. Its income is derived entirely by gathering and selling a portfolio of non-timber forest products, whose price fluctuates randomly by anything up to 50% over one time period. The figure is derived by the aggregation of 100 000 replicates of a 25-year time period. As might be expected with so many replicates, the mean portfolio price is constant through time.

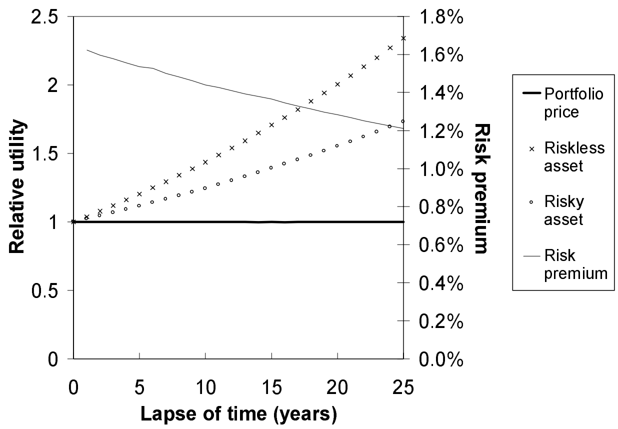

Figure 10. Randomly varying price and risk premium on discounting

The household has the opportunity to invest either in a riskless income-yielding asset, or in the means of increasing the efficiency of utilisation of the non-timber forest products - which owing to price fluctuation is risky (technically, the beta-coefficient is +1). At times of low prices, both investments have enhanced value, because of the high marginal utility of income. This more than offsets the low value at times of high prices. Thus both assets grow in value through time, as the limits of possible variation of the portfolio price become wider. However, the riskless asset is more valuable because the income derived from it is constant. Figure 10 shows the expected value of the two additional investments through time. The declining risk premium represents the difference in rates of value change between risky and riskless investments. Given the large potential scale of fluctuation, the risk premium might seem surprisingly small: but it declines, as in all the other instances of aggregating values discounted at different rates.

Comparable results with different elasticities of marginal utility of income are presented in Price (1993). Gollier (2002) has also treated uncertainty via diminishing marginal utility effects.

Intertemporal transformation of funds

The traditional basis for discounting is the rate of return on investment, which may transform purchasing power between time periods. Early possession of funds is more valuable than later possession, because early funds may be transformed into greater purchasing power over the intervening time period.

This concept has recently found new expression via capability to pay compensation for environmental and other harms. The later the degradation occurs, the less need be invested presently in order to generate adequate compensation. On the other hand, the later that revenues accrue from resource exploitation, the less is their ability to fund compensation at a given future time. The norms of negative exponential discounting are perfectly justified.

The argument does of course require the following improbable premises.

1. Funds for compensation are *actually* set aside.
2. They are protected absolutely as an investment until the time when compensation is required. If on the other hand they are increasingly at risk of depredations as time goes on, that would result in a declining discount rate.
3. Diminishing marginal utility of money (in an increasingly affluent world) does not significantly reduce the value of a given compensatory sum.

Compensation for environmental and other harms

If premise (3) is not true, the required monetary compensation for a given harm will increase progressively, the later the harm occurs. If the marginal utility of income is more elastic than -1, the required present investment will also increase for later harms, implying a negative discount rate (Price, 2000). For all plausible cases, the discount rate decreases through time - but not with the same profile as OXERA use. Figure 11 shows the appropriate discount rate decreasing at an increasing rate through time, becoming negative, and eventually indefinitely so.

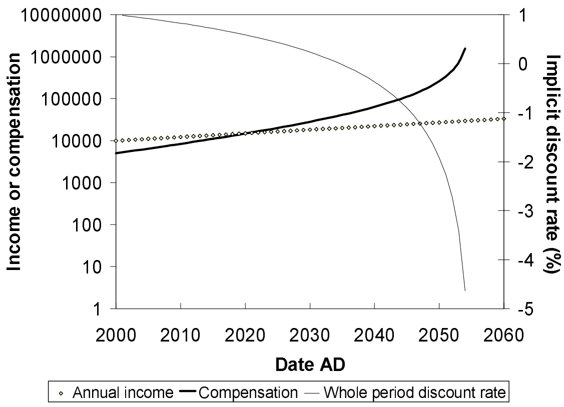

Figure 11. Discounting and compensation for harms

This issue is discussed in detail elsewhere (Parfit, 1984; Broome 1994; Price, 2000).

Compensation from a fund of uncertain returns

The future entails uncertainty about rates of return, as well as about environmental and market conditions. Suppose the rate of return follows a random walk. It is possible that a sequence of high rates of return will reduce the investment required to finance a given amount of future compensation. Thus the theoretical lower limit of required investment tends towards zero through time. It is also possible that a sequence of low rates of return will increase the investment required. Unless returns are allowed to be negative, the theoretical upper limit of required investment tends through time towards equality with the final compensation. As with the several other cases already reviewed, the aggregation of these and less extreme time paths yields a mean expectation of a falling discount rate, as shown in figure 12.

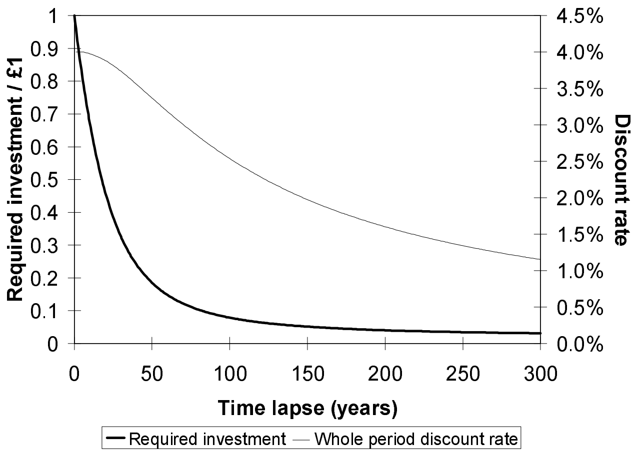

Figure 12. Mean investment required for compensation with risky returns, based on 10 000 iterations of a stochastic model, with 4% starting rate of return and maximum variation ±20% per period.

The profile, derived from similar data to that in Newell and Pizer (2001), is itself similar to theirs.

The maximum endowment for future generations

In complete contrast, the traditional rate-of-return argument for discounting is this. Investment funds have opportunity cost. If they were not invested in a forestry project, they could grow at the general investment rate of return. Concern for future generations requires the present generation to invest in whichever way provides the greatest possible future endowment.

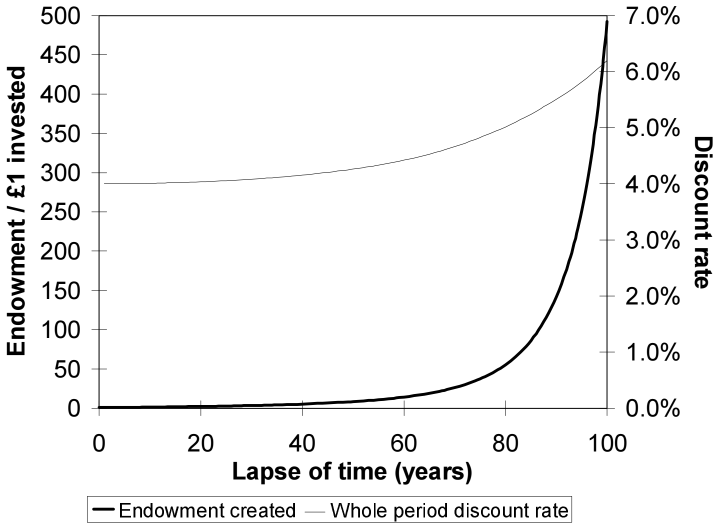

Figure 13. Mean endowment generated with risky returns, based on 10 000 iterations of a stochastic model, with 4% starting rate of return and maximum variation ±20% per period

The interpretation of figure 13 is this. If forestry would provide a revenue after 50 years, the investment required, alternatively invested, would on average yield an endowment which is equivalent to a rate of return only slightly above 4%. But if forestry revenue were expected after 100 years, the opportunity cost rate of return by that time exceeds 6%. [The result is rather unstable, as it is dominated by very rare events in which the rate of return grows to very high levels.] As with the "compensation" argument, the *mean expected rate of return* remains at the initial 4%. But as time elapses, the rate of return that would generate the *mean final endowment* is increasingly dominated by increasing rate of return scenarios. Of course, stochastic variation in forestry returns should be included for a balanced analysis.

The compensation and endowment arguments, superficially similar, in fact lead to opposite conclusions on the appropriate profile of discount rates. Essentially, this is because the compensation argument averages negative exponentials (discounting), while the endowment argument averages positive exponentials (compounding).

The conversion from Newell and Pizer to time preference rates

However, Newell and Pizer (2001) interpret the discount rates so derived quite differently: because of the supposed equilibrium in capital markets, time preference rates are "dragged" in whatever direction and to whatever extent rates of return may vary.

There are many problems with the concept of equilibrium in the capital market, such as the effect of the "wedge" between pre- and post-tax rates of return. Particularly, the equilibrium position represents not only the marginal rate of return (which *is* relevant to transforming marginal funds), but also the *marginal* rate of time preference (which is *not* relevant to discounting the utility of the *entire basket* of consumption).

Besides, as many others than myself have argued, individual pure time preference is an extremely unsatisfactory basis for public choices about the future.

· It under-represents the interests of future generations.
· It is inconsistent over time periods.
· It changes not only magnitude but also sign as time elapses, bringing the future to the present, and the present into the past.
· It may be conflated with diminishing marginal utility effects which are variable by circumstance.

The interpretation of time preference most consistent with the array of evidence is that it represents a preference for *immediate time* rather than *early historical time*. As future time moves into the present, consumption in that moment is given the heaviest weighting. Quite simply, time preference is not relevant to discounting as conventionally practised (Price, 1993; in press b).

With time preference seen in this light, what matters is not the rates at which utilitarians and conservationists discount future values, but the values that future utilitarians and conservationists will put on their own well-being (and even what value present utilitarians and conservationists will put on their own well-being when the future has become their present).

Whatever else the expected variation in future rates of return tells us therefore, it does not tell us what weight should be put on consumption in the future.

Political convenience

Given the differences between circumstances, the cases reviewed above seem to favour disaggregation of discounting by the kind of cost or benefit, rather than by time period. Moreover, those arguments for declining discount rates which are based on compensation or time preference seem to have fatal weaknesses. So why should politicians have taken any interest in the declining discount rate protocol?

Discounting to avoid headaches

One reason is its relative simplicity: once the tariff of discount rates is allocated unambiguously to time periods, nobody has to think about discounting any more. There is minimal scope for wrangling among turbulent economists about how a particular product or income group should be treated.

But there are subtler political reasons.

Correctly used, discounting delivers advice to politicians on what should, given a set of values, be the preferred option. However, discounting is often deployed in the opposite way: a discounting protocol is sought to select an option which is already politically favoured. There are two specific circumstances in which the declining discount protocol might meet this requirement.

Discounting to filter out disfavoured projects

It may be desired to reject projects, such as nuclear power stations, whose characteristic profile is a short period of cost (often construction cost) followed by a moderate period of benefit, followed by a very long period of cost (often environmental damage). Evaluations of such projects have sometimes been used to demonstrate the unwanted effects of lowering the discount rate, which may cause medium-term benefits to outweigh short-term costs, thereby admitting an environmentally damaging project.

Figure 14 represents the cash flow predicted for the UK's Sizewell B Nuclear Power Station. An annual £12 million cost for monitoring and health hazards, no doubt omitted through an oversight, has been added at the end of the generating life.

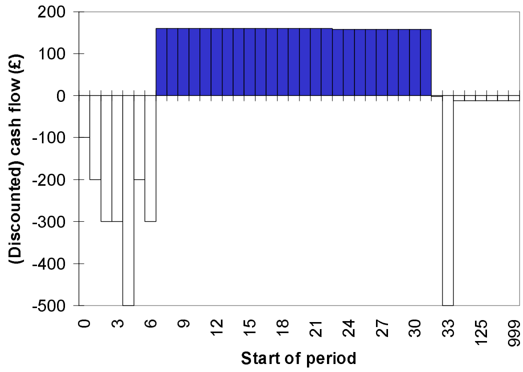

Figure 14. Undiscounted cash flows for a nuclear power station

At a 3.5% discount rate, discounted long-term costs are negligible. At a 1% discount rate, the medium-term benefits suffice to outweigh long-term costs. In either case the project is deemed worthwhile. By contrast a medium-term discount rate of 3.5% (substantially reducing discounted benefits), but falling eventually to 1% (substantially increasing discounted long-term costs) produces the "required" rejection of the project.

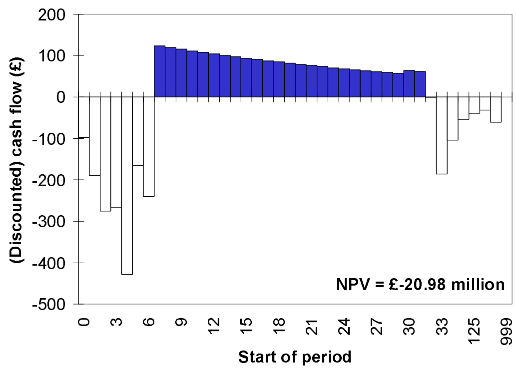

Figure 15. Cash flows for a nuclear power station discounted using OXERA's rates

However, if long-term environmental damage is the focus of concern, the same outcome may more simply be arrived at by discounting at a uniformly low rate - anything below about 0.7% achieves it. Such an approach may have politically undesired consequences, as below.

Discounting to put off the evil day

The moral force of sustainability, and its popular appeal, cause astute politicians publicly to embrace its broad philosophy (Gummer, 1994; Brown, 2004). However, as long as the voting population expresses a preference for good things *now*, it would be imprudent to follow through, ruthlessly, the implications of not-discounting future generations' well-being. Much would have to change. Much would have to be sacrificed. The politically convenient presentation of sustainable development is as a win-win strategy, in which both present and future generations can be made better off.

The declining discount protocol gives politicians what they need: the appearance of moving - with prudent caution - towards a more equitable treatment of the future, combined with an appraisal tool that in practice leaves things little changed.

Newell and Pizer (2001) show that the cost attributed to CO_2 emissions may rise from \$5.74 with constant discounting to \$10.44 with a declining discount rate (though their costing profile is in either case based on a serious misconception about CO_2 dynamics - see Price (1995)). Similarly, the capitalised value of \$1 000 000 damages caused every year in the future increases from \$29 000 000 at 3.5% to only \$44 000 000 with a declining discount rate. (After 300 years, the effect of discounting at 1% is just as belittling as the effect of discounting at 3.5% for 80 years.) Thus these changes imply no radical shift in policy, as cessation of discounting environmental effects, or an immediate reduction of rate to 1% would do.

Take, further, a world-wide project with benign long-term consequences, such as regenerating forests to absorb CO_2 or retain biodiversity - or even to provide the ground of material well-being. Take a simplified cash flow of £1 000 000 000 during the first year, followed by an annual benefit of £25 000 000 each year thereafter. This yields the 2.5% internal rate of return typical of forestry projects.

With the declining rate protocol, the project has positive NPV of £95 million. However, if the project's initiation were to be delayed by a generation - 30 years say - the NPV rises significantly to £282 million: the delayed project is a better project.

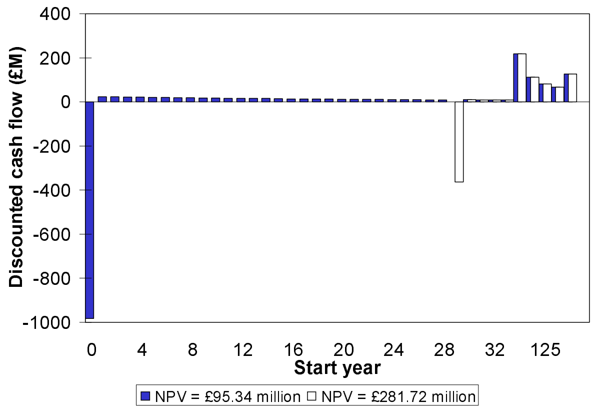

Figure 16. Discounted cash flows and project timing: dark bars show immediate implementation, light bars delayed implementation

In the same way, a phased programme to do the same thing, but with investment of only £33 000 000 per year for 30 years, would be repeatedly rolled forward, this year's share being successively reallocated to 30 years in the future.

Thus, while all generations might agree that the project is worth doing, each may pass responsibility for implementation to the next generation. Dynamic inconsistency rules, just as it does with other forms of (approximately) hyperbolic discounting. As St Augustine of Hippo might have said, "Let me be sustainable, but not yet". And all on an electoral ticket that promises concern for the future. Does the title of this paper need to be explained further?

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One Bird still is Singing in Pasila

In night-time Pasila,
the last song-bird still
alive in a forest of concrete and glass,
has flooded the air
with her song, and the rare
interventions of measuredly corporate grass
listen: for soon this blithe moment will pass.

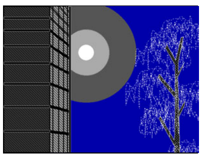
In the financial centre,
all greenspace has meant a
remission of rentals, lost targets for tax.
But the saplings and seating
leave enclaves where, fleetingly,
people can listen, and look, and relax
with the one song-bird east of the grey railway tracks.

The sterile-slabbed acres –
whose movers and shakers
of daytime have fled from these tracts of despair –
were inflicted by faceless
designers of graceless
and cosmos-wide sameness of functioning, where
once a bird *might* have sung in a Saarinen square.

The workers have vanished
from offices, banished
to Helsinki's suburbs and further afield:
but lone men in the sinister
centre administer
heart-pumping episodes, nerve-endings steeled
to confront deadly dangers deep shadows may shield.

Once, the night air bore freight
of tree fragrance, a state
that a resin-spiked wind for an instant restores,
expressing the spruces'
alternative uses
of land, now surmounted by twenty-five floors
and vents out of which the reprocessed air pours.

The bird's song has ended;
and steps have descended
to threatening thresholds that yet must be crossed.
And the silence is stiller
in night-time Pasila
because of the memory of melody lost.



by Colin Price

Presented at the SSFE Dinner in Järvenpää May 14, 2004 by the author.

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ISSN 0355-032X