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WOODLOT PRICE FORMATION IN THE EARLY 1980s

METSÄLÖN HINNAN MUODOSTUMINEN 1980-LUVUN ALUSSA

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THE FINNISH FOREST RESEARCH INSTITUTE

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WOODLOT PRICE FORMATION IN THE EARLY 1980s

Metsälön hinnan muodostuminen 1980-luvun alussa

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The aim of this study is to explain both theoretically and empirically the formation of the unit price of a woodlot in the early 1980s in Finland. The structure of the market in which woodlot transactions take place is described by analysing the volume of markets, the heterogeneity of the woodlots, institutional regulation of woodlot ownership and information concerning the market. The decision-making processes of both woodlot seller and buyer are examined using a theoretical model. Using a woodlot transaction sample for 1983 and 1984 woodlot unit price is explained empirically.

Tutkimuksen tarkoituksena on tarkastella teoreettisesti ja empiirisesti metsälön hinnan muodostumista Suomessa 1980-luvun alkupuolella vallinneissa olosuhteissa. Metsälömarkkinoiden rakennetta on kuvattu analysoimalla markkinoiden volyymia, metsälöiden erilaisuutta, metsälöiden omistuksen institutionaalista säätelyä ja metsälömarkkinoita koskevaa informaatiota. Metsälön myyjän ja ostajan päätöksentekoa on tarkasteltu teoreettisen mallin avulla, ja käyttämällä vuosia 1983 ja 1984 koskevaa metsälökauppaotosta on metsälön kauppahinnan muodostumista tutkittu empiirisesti.

Keywords: forest ownership, woodlot purchasing price, woodlot sales price, woodlot transaction price.
ODC 652.51 + 923.4

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1. Introduction

Woodlot price formation is generally explained by one of two ways (Ahonen 1970, p. 66—67):

1) Traditionally, a woodlot is seen as an independent price forming object, the correct price of which can be determined using an objective method appropriate for a particular case. Deviations from the correct price are the result of lack of expertise on the part of the parties concerned, errors and other random factors.

2) According to the other point of view, a woodlot has no correct price as such. Instead, its price is formed as a result of mediation by the economic subject and the way he manages his finances. In a transaction situation, an entrepreneur defines for himself how much it is in his interest to pay or demand for the woodlot in question.

The above approaches may be referred to as the 1) objective and 2) subjective explanation models of woodlot price formation. When one wishes to draw the line between these approaches, one is often confronted by the question of whether a correct, given forestry time horizon and calculatory interest rate exist, or can these be freely selected by the woodlot owner (e.g. Endres 1919, pp. 13—17 and Mantel 1982, pp. 18—22).

The price of a woodlot is an agreement between the buyer and the seller. Various ex ante and ex post methods have been developed with the aim of improving the informative base of woodlot price negotiations. The foremost ex ante methods are

— the sum value method
— the discount (or productive) value method (Keltikangas 1964, p. 1).

Ex post examinations of the prices have, without exception, been carried out using the ordinary least square method with regard to various combinations of explanatory variables (e.g. Airaksinen 1988, Hannelius 1986, Kantola 1983).

The sum value method developed by land rent theoreticians is usually combined with the above-mentioned objective interpretation model of woodlot price formation. Briefly put, the following woodlot specific values are summed up to form a figure indicating the price of a woodlot

— expected values for bare earth
— cost values of recently regenerated areas
— expected values of young stands
— stumpage values of mature stands.

Usually, this method has produced prices which have been too high to serve as guidelines for transactions; considerable reductions have had to be made before obtaining a "current" price (e.g. see Skogsbrukets handbok 1987, pp. 285—290). This adjustment (referred to as total price adjustment or bulk reduction) has been examined using statistical methods on woodlot transactions carried out (Airaksinen 1988, p. 5).

Based on a management plan, the discount (or productive) value method involves calculating the discount value of the net incomes produced by a woodlot to arrive at a figure for the price of a woodlot (Keltikangas 1964, p. 1).

The fundamental differences between the sum value and productive value methods are that in the former the incomes obtained from the woodlot are divided between the site and the growing stock, whereas in the latter the site and the growing stock form a whole. Dividing the incomes between the site and the growing stock often leads to negative expected values for the site.

As a means of improving price information on woodlot transactions, the prices paid for woodlots have been increasingly subjected to statistical examination. One or other of the ex ante methods referred to above has constituted the theoretical frame of reference in these studies. Airaksinen (1988), for example, has employed the sum value in interpreting the total price of a woodlot.

This study was carried out in order to clarify the basis of woodlot price formation in Finland. It was initiated by Professor Jouko Hämäläinen from the Finnish Forest Research Institute by offering the woodlot price statistics gathered in collaboration with his department and the National Board of Survey as empirical background to the study.

Valuable advice was also received from Professors Veli-Pekka Järveläinen, Matti Keltikangas, Päiviö Riihinen, Jens Risvand and Juhani Wirilander, Dr. Mikko Tervo and Messrs. Leo Eerola, Olof Frölander-Ulf and Ilpo Tikkanen. The translation work was carried out by Mr. Erkki Pekkinen. The financial support of the Departments of Social Economics of Forestry and the Department of Business Economics of Forestry at the University of Helsinki rendered the translation possible. At various stages of the data processing and manuscript preparation assistance was received from Heli Suutarinen, Raija Sinisalo and Kaija Westin, and Harri Heinonen, Jarmo Karhula, Risto Laamanen and Ashley Selby.

I express my gratitude to all those who were involved in and contributed to this study. To my family and especially my wife Pirjo I am indebted for the patience permitting nightwork.

2. Aim of the investigation

The aim of this study is to explain, both theoretically and empirically, the formation of the unit price in woodlot transactions in the early 1980s in Finland. The study

— describes the structure of the market in which transactions take place
— examines, using a theoretical model, the decision-making process on the part of both seller and buyer during the transaction
— empirically explains the formation of the woodlot unit price by applying the above-mentioned model as a framework.

3. The premises of woodlot price formation

31. The structure of the woodlot market

This section deals with the structure of the woodlot market in Finland in the 1980s. The following features receive emphasis:

— volume of the market
— heterogeneity of the woodlots
— institutional regulation of woodlot ownership
— information concerning the market.

Volume
The real estate sales price statistics (for 1982—1987) and the annual statistics on farms (Official Statistics of Finland. SVT III:83, 1987) indicate that of the 300 000—350 000 woodlots in Finland 2.5—5 percent are being sold annually. The total area of the woodlots involved can be estimated to be less than 300 000 hectares (i.e. in excess of 1 % of the total forestry land area). This in turn indicates that the selling of a woodlot is a rare occurrence possibly caused by two reasons: woodlots are not demanded for sale or excessive numbers of woodlots are offered for sale. In other words, either woodlot owners are highly confident in the profitability of practising forestry or potential buyers lack the same confidence.

The heterogeneity of woodlots
Each woodlot is unique. The heterogeneity of woodlots being offered for sale can be examined in a number of ways:

— internal characteristics of the woodlot
— location of the woodlot with regard to economic activity
— its shape and degree of fragmentation
— its integration with the rest of the economy

The internal characteristics include, for example, area, growing stock and growth characteristics, and the breakdown of the area into various land use categories. Location is indicated by transportation distances, times and costs of the products and factors of production between the woodlot and other locations of economic activity. There are no distinct indicators for shape and degree of fragmentation, but they do influence the integrability of a woodlot with neighbouring woodlots, their divisibility and the profitability of practising forestry. The actual integration of a woodlot with the rest of the owner's economy, as well as its potential integration with the economy of the potential buyer both have bearing on the woodlot's price formation by way of constraints and other functionalities acting upon the owner's economy as a whole; e.g. finance constraint or tax function.

Institutional regulation of ownership

The regulation of woodland ownership and land ownership in general is characterised by traditions which go back several centuries. The fundamental objectives of this regulation have varied in accordance with the political and economic circumstances. Usually this has resulted in a certain type of ownership being favoured or discriminated against. Regulation is largely based on the acts and regulations connected to their implementation. In the 1980's, the foremost pieces of legislation having either direct or indirect influence on the selling of woodlots are as follows:

— Maatilalaki (Farm Act) (Suomen säädöskokoelma 18.2.1977/188)
— Maanhankintaoikeuslaki (Right of Land Acquisition Act) (Suomen säädöskokoelma 26.5.1978/391)
— Sukupolvenvaihdoslainsäädäntö (Legislation concerning handing over of farm ownership to the younger generation)
— Maatalousyrittäjän eläkelaki (Farmers' Pension Act) (Suomen säädöskokoelma 14.7.1969/467)
— Luopumiseläkelaki (Discontinuation Pension Act) (Suomen säädöskokoelma 4.1.1974/16)
— Perintökaaren 25. luku (Chapter 25 of Inheritance Code) (Suomen säädöskokoelma 20.8.1982/637)
— Maatilatalouden tuloverolaki (Agricultural Income Tax Act) (Suomen säädöskokoelma 15.12.1967/543).

The Farm Act has played a central role in regulating changes in woodland ownership. The objective of the act has been to increase the size of farms, bring about improvements in the location of the lands belonging to individual farms, promote cooperation between farms and prevent farms from becoming fragmented. The Farming Act includes regulations on the use of farming and forestry land and on the manner in which loans may be granted for the acquisition of such land (Luopumisopas 1977, p. 1—1). The Right of Land Acquisition Act concerns the rights of natural persons, companies, cooperative societies, associations and foundations to acquire agricultural and forestry land by purchasing it. The purpose of this legislation is to encourage the transfer of agricultural and forestry land such purposes as will serve the objectives of the Farming Act. The purchase of agricultural and forestry land has been made subject to approval, with the approving authorities acting as middlemen and disseminating market information (Muuramo 1984, pp. 9—24). The Farming Act and the Right of Land Acquisition Act have a direct influence on woodlot transactions. The effects of the legislation concerning handing over of farm ownership to the younger generation and the Agricultural Income Tax Act, on the other hand, are indirect ones. It is often the former which decides whether a woodlot is put up for sale on the open market or whether it is handed over as inheritance. This legislation has a uniforming effect on both price formation, as well as the information connected to it (Luopumisopas 1977). The Agricultural Income Tax Act has an effect on the profitability of owning forest via the forest owner's taxation (Vehkamäki 1986, pp. 28—29).

In addition to the control imposed by legislation, the national budget is an important controlling instrument affecting woodlot sales. The budget defines, to a large degree, the funds available for the implementation of the above laws. Resource administrative decisions constitute a significant part of the implementation of the Farm Act and the Right of Land Acquisition Act.

Information concerning the market

The realisation of the purpose of the Farming Act by means of the Right of Land Acquisition Act's notification, permit and redemption procedures promotes the dissemination of information concerning transactions involving agricultural and forestry land to all buyer candidates fulfilling the conditions set down in legislation. The redemption right and obligation invested in the authorities have a uniforming effect on prices paid for land. Thus, legislation has limited the numbers of those requiring information on woodlot transactions and the dissemination of information concerning them has been made the responsibility of the authorities and the information produced is of a uniform nature. The latter feature is even further influenced by the assessment methods used by the authorities and the advisory organizations serving agriculture and forestry.

32. Model examination

321. Approach

The model examination includes specifying the woodlot transaction situation thereby enabling the theoretical examination of the bases of price formation of

— the minimum price charged by the owner (seller) for his woodlot
— the maximum prices offered by buyer candidates for the woodlot.

The aim is to deduce general, empirically verifiable regularities in special cases.

322. Minimum selling price

The minimum selling price is deduced by

— formally describing the model
— interpreting of the model
— presenting the characteristics of the minimum selling price.

Model

The woodlot owner's decision making situation at moment 0 is depicted by the following comparison set out in the form of inequalities:

$$(3.1)\quad \max \left[A(\alpha h_0 - s_0) + q(K_0) - i_0 - t(R)\right] + \left[(1-\rho)F(AG(V_1, S_1), Q(K_1))\right] \gtrless ((\lambda A + \kappa K_0)\,\pi + \epsilon)\,\frac{1-\rho^{N_s}}{1-\rho},$$

$$\begin{bmatrix} \hat{h} \geq h_0 \geq 0 \\ \hat{s} \geq s_0 \geq 0 \\ \hat{i} \geq i_0 \geq 0 \end{bmatrix}$$

in which

A = woodlot area
h = cutting per unit area
s = silvicultural investment per unit area
i = investment in associate livelihood
$q(\cdot)$ = production function of associate livelihood
K = capital stock of associate livelihood
$t(\cdot)$ = total tax function
R = taxable income
$F(\cdot)$ = plan function of woodlot seller's economy expressed as present value of total consumption at moment 1
$G(\cdot)$ = forest management plan function
V = growing stock
S = silvicultural level
$Q(\cdot)$ = plan function of associate livelihood
N_s = extent of time horizon
α = stumpage
ρ = rate of time preference
λ = unit price of woodlot (per unit area)
κ = selling price of associate livelihood (its capital stock)
π = rate of return on financial investments
ϵ = woodlot seller's alternative earnings, e.g. wage income or pension

Functions in the model

The following deals with the functions involved in the comparison (3.1) and their characteristics. The income function of an associate livelihood

$$(3.2)\quad q = q(K_n)$$

indicates the economic result of an associate livelihood (e.g. agriculture) at a moment n as a function of the capital stock. It is defined so that

$q_K > 0$ and $q_{KK} < 0$.

The total tax function

$$(3.3)\quad t = t(R)$$

is defined so that

$t_R > 0$ and $t_{RR} \geq 0$.

The taxable income is defined as

$$(3.4)\quad R = \tau A + Q(K_n),$$

in which

τ = taxable income from forestry determined administratively on the basis of site quality characteristics per unit area

The woodlot owner's plan function indicates the present value discounted to moment 1 of his intended consumption to be derived from economic activity, forestry and associate livelihood during the planning period $1\text{-}N_s$. The plan function

$$(3.5)\quad F = F\,(AG(V_1, S_1), Q(K_1))$$

is defined so that

$F_{(AG)} > 0,\ F_{(AG)(AG)} < 0\,;\ F_Q > 0,\ F_{QQ} < 0;\ F_{(AG)Q} > 0,$

and that the Hessian matrix formed using the second derivatives is negatively definite. Using the per unit area defined management plan function, the contribution of forestry to the plan function of the owner's economy is expressed as a function of the resources at the beginning of the planning period. These resources are the growing stock and the level of silviculture. This function may be realized by way of the planned cut or forestry surplus. For the sake of simplicity, the function in this connection is treated as a scalar-valued function, its practical applications are often vector-valued. The management plan function

$$(3.6)\quad G = G(V_1, K_1)$$

is defined so that

$G_V > 0,\ G_{VV} < 0\,;\ G_K > 0,\ G_{KK} < 0\,;\ G_{VK} > 0,$

and the Hessian matrix formed from the second derivatives is negatively definite and the inheritance value constraints at the end of the time horizon are taken into account in it.

With reference to the above function, the plan function of the woodlot owner's associate livelihood expresses the contribution of this source to the plan function of the economy of the owner. The function

$$(3.7)\quad Q = Q\,(K_1)$$

is defined so that

$Q_K > 0,\ Q_{KK} < 0.$

Model dynamics

The following dynamics is involved on the lefthand side of comparison (3.1) during the time interval 0 to 1:

1) The mean growing stock is acted upon by felling

$$(3.8)\quad V_1 = V_0 + g(V_0, S_0) — h_0,$$

in which the function

$$(3.9)\quad g = g(V_0, S_0)$$

represents the woodlot's concave total growth function (e.g. Vehkamäki 1986, pp. 9—12).

2) Changes in the index for the level of silviculture are controlled by investments in silviculture

$$(3.10)\quad S_1 = (1—\sigma)S_0 + S_0$$

in which

σ = rate of deterioration of the level of silviculture.

3) The capital stock of the associate livelihood is controlled by investments directed at it

$$(3.11)\quad K_1 = (1—\gamma)K_0 + i_0,$$

in which

γ = rate of deterioration of the capital stock.

Model interpretation

If the lefthand side of comparison (3.1) is greater than the righthand side, then

1) the woodlot owner will continue to be an active practitioner of forestry and the associate livelihood.

If the righthand side is greater than the lefthand side, then

2) the owner of the woodlot will sell his real estate, invest the income received therefrom in the capital market and commence to live on his alternative earnings and the interest received from his investments.

If (3.1) is realized as an equation, then

3) alternatives 1) and 2) are of equal value to the woodlot owner; i.e. his decision will remain undefined.

The lefthand side of the comparison includes the task of maximizing the present value of the woodlot owner's consumption. The solution is realized as the regulation of instrument variables in the case where the owner decides to continue with active forestry and its associate livelihood. These instrument variables include cutting, investments in silviculture and his associate livelihood. The goal function of the maximization task (i.e. the lefthand side of comparison (3.1)) has been defined in such a manner as to make it concave with regard to the instrument variables. The opportunity set of instrument variables is convex and this is why the task has an unequivocal maximum

(Intriligator 1971, pp. 20—43). What is actually involved is the optimum allocation of resources between two periods; for consumption at moment 0 (i.e. the present) and as the initial stocks for the next period (i.e. planning period $1\text{-}N_s$). The goal function may also be expressed in the form of a dynamic optimization problem. In which case, the woodlot owner's plan function $F(\cdot)$ expresses the optimum policy for the period $1\text{-}N_s$, i.e. the remaining part of the time horizon, as the function of decisions made at moment 0.

The righthand side of comparison (3.1) indicates the alternative to the woodlot owner's active forestry and its associate livelihood:

1) He sells his real estate and invests the income thus obtained in the capital market on which he has no influence.

2) On ceasing to look after real estate, the woodlot owner begins to receive earnings from alternative sources.

3) His aim is to live on his earnings from alternative sources and the returns from his invested capital. The invested capital will be passed on as inheritance.

Characteristics of the minimum selling price

Assuming that the result of comparison (3.1) is equality, one is able to determine from it the minimum price that the woodlot owner should obtain for his woodlot to make it worth his while to sell it. If the righthand side of comparison (3.1) is greater than the lefthand side, then selling the woodlot is the better alternative for the owner. The condition in defining the minimum selling price is that the righthand side of comparison (3.1) is equal to or greater than the lefthand side. In the following, the unit woodlot price and the capital stock price of the associate livelihood are interpreted as constituting a total offer made by potential buyers resulting in the maximum total righthand yield in comparison (3.1). The following designation is used:

λ^* = Unit woodlot price of best total offer
κ^* = Unit price of capital stock of associate livelihood of best total offer

The values for the initial stocks for the planning period $1\text{-}N_s$ obtainable as the results to the maximum solution to the lefthand side of comparison (3.1), are designated by

V_1^*, growing stock
S_1^*, level of silviculture
K_1^*, capital stock of associate livelihood

and the values of the respective instrumental variables by

$\hat{h} > h_0 > 0$, cutting
$\hat{s} > s_0 > 0$, investment in silviculture
$\hat{i} > i_0 > 0$, investment in associate livelihood.

In other words, what is involved here is an internal solution to the opportunity set of the instrumental variables.

When the above variables are entered in comparison (3.1) and the condition connected to defining minimum selling price is taken into account, the following expression is obtained for the minimum selling price:

$$(3.12)\quad f^s = \frac{1}{\pi A}\Big[[A(\alpha h_0^* — s_0^*) + q(K_0) — i_0^* — t(R) + (1—\rho)\,(F(AG(V_1^*, S_1^*), Q(K_1^*))]\,\frac{1—\rho}{1—\rho^{Ns}} — (\pi\kappa^* K_0 + \varepsilon)\Big]$$

In (3.12), $f^s(\cdot)$ is the minimum selling price function. It is used in the following to examine the stability of the minimum selling price subject to a ceteris paribus assumption in relation to the following parameters involved in a woodlot selling decision situation:

- resources
  - area
  - growing stock
  - level of silviculture
  - capital stock of associate livelihood
- stumpage price
- rate of time preference
- capital market interest
- alternative earnings
- price of capital stock of associate livelihood
- taxable income from forestry per unit area.

The stability of the minimum selling price is examined by studying the sign alternatives of the first partial derivatives of the minimum selling price function derived in relation to the above-mentioned woodlot selling decision parameters. It should be pointed out that this examination does not explain the result of the comparison

$$(3.13)\quad f^s \gtreqless \lambda^*$$

but merely the manner in which the minimum selling price behaves in relation to its parameters.

With regard to *area*, the partial derivative of the minimum selling price function is

$$(3.14) \quad f^s_A = \frac{1}{\pi A} \left\{ [(\alpha h^*_0 - s^*_0)\, \tau t_R + (1-\rho)\, F_{(AG)}\, G(V^*_1, S^*_1)] \frac{1-\rho}{1-\rho^{N_s}} - \pi f^s \right\}$$

whose sign depends on the sign of the expression inside the curled brackets. The expression inside the square brackets can be interpreted as the contribution of marginal forest ownership to the forest owner's economy during the entire time horizon 0 — N_s. When multiplying by the inverse value of the capitalization factor of the periodic sum, we obtain

$$(3.15) \quad Z_1 = [(\alpha h^*_0 - s^*_0) - \tau t_R + (1-\rho) F_{(AG)} G(V^*_1, S^*_1)] \frac{1-\rho}{1-\rho^{N_s}}$$

which may be interpreted as the marginal periodical contribution of forest ownership. The latter term in expression (3.15)

$$(3.16) \quad Z_2 = \pi f^s$$

may be interpreted as the periodical contribution to the forest owner's economy obtainable from marginal selling income at the minimum selling price in the capital market. When expression (3.16) is subtracted from expression (3.15), we obtain the sign of the partial derivative of the minimum selling price function deduced in relation to area. This sign depends on the sign of the difference between the woodlot's marginal contributions, owned and sold at the minimum price.

With regard to the *growing stock*, the minimum selling price function's partial derivative and its sign alternative are

$$(3.17) \quad f^s_{V_0} = \frac{1}{\pi A} (1-\rho) F_{(AG)} G^*_V\, (1 + g_V) \frac{1-\rho}{1-\rho^{N_s}} > 0.$$

The above mentioned sign alternative is valid on the condition that

$$(3.18) \quad g_V > -1,$$

which is quite a reasonable assumption.

With regard to the *level of silviculture*, the minimum selling price function's partial derivative and its sign alternative are

$$(3.19) \quad f^s_{s_0} = \frac{1}{\pi A} (1-\rho) F_{(AG)} (G^*_V g_S + G^*_S (1-\sigma)) \frac{1-\rho}{1-\rho^{N_s}} > 0.$$

The above sign alternative is valid on the condition that

$$(3.20) \quad g_{s_0} > - \frac{G^*_S (1-\sigma)}{G^*_V},$$

In other words, the initial level of silviculture has to be reasonable. It is hardly a realistic possibility for g_{s_0} not to be positive.

With regard to the *capital stock of the associate livelihood*, the minimum selling price function's partial derivative is

$$(3.21) \quad f^s_{K_0} = \frac{1}{\pi A} \left\{ [q_K (1-t_R) + (1-\rho) F_Q Q^*{}_K (1-\kappa)] \frac{1-\rho}{1-\rho^{N_s}} - \pi \kappa^* \right\},$$

the sign of which depends on the sign of the expression inside the curled brackets as was the case with area. *Mutatis mutandi,* the same interpretations applied in this connection were also made in interpreting the partial derivative deduced with regard to area.

Partial derivative expressions deduced with regard to the other parameters connected to a woodlot selling decision situation are not presented here because they do not include sign alternatives. The signs for the minimum selling price function's partial derivatives in these cases are as follows:

With regard to the *stumpage price*

$$(3.22) \quad f^s_\alpha > 0$$

With regard to the *rate of time preference*

$$(3.23) \quad f^s_\rho < 0$$

With regard to the *rate of return on financial investments*

$$(3.24) \quad f^s_\pi < 0$$

With regard to *alternative earnings*

$$(3.25) \quad f^s_\varepsilon < 0$$

With regard to the *capital stock price of the associate livelihood*

$$(3.26) \quad f^s_{\kappa^*} < 0$$

With regard to the *taxable income per unit area*

$$(3.27) \quad f^s_\tau < 0$$

323. Maximum purchasing price

The procedure for deducing the maximum purchasing price is the same as that used for the minimum selling price: description and interpretation of a formal model, presentation of the characteristics of the maximum purchasing price. The symbols used in describing the woodlot buyer's decision making situation are much the same as those used for the woodlot seller.

Model

The basic decision-making situation on the part of the woodlot buyer at moment 0 is described using the following comparison written in the form of inequalities:

$$(3.28) \quad \max \left\{ (\alpha h^1_0 - s^1_0) A^1 + q(K_0) - i_0 - t(R^1) + (1-\rho)\, (F(A^1 G(V^1_1, S^1_1, Q(K_1)) \right\}_{\begin{bmatrix} \hat{h}^1 \geq h^1_0 \geq 0 \\ \hat{s}^1 \geq s^1_0 \geq 0 \\ \hat{i}^1 \geq i^1_0 \geq 0 \end{bmatrix}} \gtreqless$$

$$\max \left\{ (\alpha h^1_0 - s^1_0) A^1 + (\alpha h^2_0 - s^2_0) A^2 + q(K_0) - i_0 - t(\bar{R}) - \mu \lambda^2 A^2 + (1-\rho)\, (F(\bar{A} G(\bar{V}_1, \bar{S}_1), Q(K_1))) - (1-\mu) \lambda^2 A^2 \frac{\pi (1+\pi)^{N_d}}{(1+\pi)^{N_d} - 1} \left(\frac{1-\rho^{N_d}}{1-\rho}\right) \right\}_{\begin{bmatrix} \hat{h}^1 \geq h^1_0 \geq 0 \\ \hat{h}^2 \geq h^2_0 \geq 0 \\ \hat{s}^1 \geq s^1_0 \geq 0 \\ \hat{s}^2 \geq s^2_0 \geq 0 \\ \hat{i}^2 \geq i^2_0 \geq 0 \end{bmatrix}}$$

in which

— symbols designated by the upper index 1 represent variables, parameters and functions connected to the woodlot owner's initial economy
— symbols designated by the upper index 2 represent variables, parameters and functions connected to the woodlot which is being purchased
— symbols marked with a bar over them (e.g. $\bar{A}$) represent variables, parameters and functions connected to the post-transaction economy of the woodlot transaction to be decided upon
— symbols lacking upper indexes and bars represent variables, parameters and functions not influenced by the woodlot transaction being decided upon

μ = self-financed share of the woodlot transaction
$1-\mu$ = loan-financed share of the woodlot transaction
N_d = extent of woodlot buyer's time horizon which is equal to the repayment period of the loan granted to the woodlot buyer

The dynamics and the functions on the lefthand side of comparison (3.28) are of the same form as are those in the case of the seller. The form of the righthand side functions is also the same as those applying to the seller; this is also the case with the capital stock dynamics with regard to the associate livelihood. The dynamics of forestry stocks on the righthand side are, however, described differently:

1) The equation for mean growing stock formation for the post-woodlot transaction period 1-N_d is defined as

$$(3.29) \quad \bar{V}_1 = \frac{A^1(V^1_0 + g(V^1_0, s^1_0) - h^1_0) + A^2(V^2_0 + g(V^2_0, s^2_0) - h^2_0)}{\bar{A}}$$

and the equation for level of silviculture as

$$(3.30) \quad \bar{S}_1 = \frac{A^1((1-\sigma) S^1_0 + s^1_0) + A^2((1-\sigma) S^2_0 + s^2_0)}{\bar{A}}$$

Thus, the mean growing stock and the level of silviculture have been defined as mean values weighted by the areas of the original woodlot and the woodlot being purchased.

The taxable income on the righthand side of the comparison is defined as

$$(3.31) \quad \bar{R} = \tau^1 A^1 + \tau^2 A^2 + Q(K_n)$$

On the righthand side, the factor

$$(3.32) \quad W = \frac{\pi (1+\pi)^{N_d}}{(1+\pi)^{N_d} - 1}$$

indicates the sum which has to be paid periodically for the loan required for purchasing the woodlot to be paid back with interest within N_d periods.

Model interpretation

If the lefthand side of comparison (3.28) is greater than the righthand side, then

1) it is not profitable for the buyer to purchase the woodlot in question.

If the righthand side is greater than the lefthand side, then

2) it is profitable for the buyer to purchase the woodlot in question.

If the comparison is realized as an equality, then

3) the woodlot buyer's decision remains undefinable.

The solutions to two maximization tasks are thus being compared. On the lefthand side the object is the maximization of consumption with the help of the initial woodlot and associate livelihood. And on the righthand side the effects of the woodlot which is the object of purchasing have been connected to the maximization task. The object functions have been defined as being strictly concave with regard to the instrument variables and the opportunity set of instrument variables is convex.

Characteristics of the maximum purchasing price

By assuming the result of comparison (3.28) to be an equality, it is possible to go on to solve the maximum price that it is in the interests of the woodlot buyer to pay. The designation

λ' = unit price demanded by the seller for the woodlot in question.

The initial stocks of the planning period 1-N_d obtained as the result of the maximum solution for the lefthand side of comparison (3.28) are designated by

V^1, growing stock
S^1, level of silviculture
K^1, capital stock of associate livelihood

and the values of the instrument variables by

$\hat{h}^1 > h^{1*} > 0$, cutting
$\hat{s}^1 > s^{1*} > 0$, investment in silviculture
$\hat{i}^1 > i^{1*} > 0$, investment in associate livelihood.

The maximum for the righthand side in the comparison is solved with regard to five instrument variables. The result thus obtained represents three initial stocks for the planning period 1-N_d and these are designated by

$\bar{V}^1$, growing stock
$\bar{S}^1$, level of silviculture
$\bar{K}^1$, capital stock of associate livelihood.

and the values of the instrument variables, as an internal solution, by

$\hat{h}^1 > h_0^{1'} > 0$, cutting in the initial woodlot
$\hat{s}^1 > s_0^{1'} > 0$, investment in silviculture in the initial woodlot
$\hat{i}^1 > i_0^{1'} > 0$, investment in the associate livelihood
$\hat{h}^2 > h_0^{2'} > 0$, cutting in the woodlot which is the object of purchasing
$\hat{s}^2 > s_0^{2'} > 0$, investment in silviculture in the woodlot which is the object of purchasing.

Entering the above variables in comparison (3.28) results in the equation

$$(3.33)\quad f^d A^2 Z = X,$$

in which f^d is the maximum purchasing price and

$$(3.34)\quad Z = \mu + (1-\mu)\,\frac{\pi(1+\pi)^{N_d}}{(1+\pi)^{N_d}-1}\,\frac{1-\rho^{N_d}}{1-\rho}$$

and

$$\begin{aligned}(3.35)\quad X = {} & A^1[\alpha(h_0^{1'} - h_0^{*}) - (s_0^{1'} - s_0^{*})] + \\ & A^2[\alpha h_0^{2'} - s_0^{2'}] - [i_0^{'} - i_0^{*}] - [t(\bar{R}) - t(R^1)] + \\ & (1-\rho)\,[F(\bar{A}G(\bar{V}_1, \bar{S}_1), Q(K_1)) - \\ & F(A^1G(V_1, S_1), Q(K_1)].\end{aligned}$$

Expression (3.34) is the present value coefficient for the woodlot's unit purchasing price and (3.35) is the benefit gained from purchasing the woodlot, and is defined as the present value of an increase in consumption. The maximum purchasing price may be solved from equation (3.33) and it is

$$(3.36)\quad f^d = \frac{X}{A^2 Z}\,.$$

According to equation (3.33), the maximum purchasing price realizes the equality of the present values of increases in consumption and increases in costs caused by purchasing.

If the condition

$$(3.37)\quad f^d \geq \lambda'$$

is realized, then the woodlot transaction is feasible. The maximum purchasing price is used next to examine its stability with regard to the following purchase decision situation parameters:

— stocks of the woodlot which is the object of purchasing
 — area
 — growing stock
 — level of silviculture
— taxable income per unit area for the woodlot which is the object of purchasing
— capital stock of the livelihood
— self-financed share of the woodlot purchase
— stumpage price
— rate of time preference
— capital market interest rate
— cutting revenue finance.

The above parameters are examined in the same manner as was used for examining the minimum selling price.

With regard to the *area*, the examination of the sign alternatives of the maximum purchasing price's partial derivative

$$(3.38)\quad f^d_{A^2} \gtreqless 0$$

may be changed for examining condition

$$(3.39)\quad X_{A^2} \gtreqless \frac{X}{A^2}$$

i.e. for examining the area-based marginal benefit and the mean benefit of the woodlot which is the object of purchasing.

With regard to the *growing stock*, the sign of the maximum purchasing price function's partial derivative is

$$(3.40)\quad f^d_{V^2} = F_{\bar{A}G}\,G_{\bar{V}}(1 + g_{V^2})\,\frac{1}{\bar{A}Z} > 0$$

on the condition that

$$(3.41)\quad g_{V^2} > -1$$

which is a realistic assumption.

With regard to the *level of silviculture*, the sign of the maximum purchasing price function's partial derivative is

$$(3.42)\quad f^d_{S^2} = F_{\bar{A}G}(G_{\bar{V}}\,g_{S^2} + G_{\bar{S}}\,(1-\sigma))\,\frac{1}{\bar{A}Z} > 0$$

on the condition that

$$(3.43)\quad g_{S^2} > -\frac{G_{\bar{S}}(1-\sigma)}{G_{\bar{V}}}$$

i.e. the initial level of silviculture must be a reasonable one.

With regard to the woodlot's administratively defined *taxable income per unit area*, the sign of the maximum purchasing price function's partial derivative is

$$(3.44)\quad f^d_{r^2} = t_{\bar{R}}\,\frac{1}{\bar{A}Z} < 0$$

With regard to the capital stock of the *associate livelihood*, the sign alternatives of the maximum purchasing price's partial derivative are

$$\begin{aligned}(3.45)\quad f^d_K = {} & [(1-\rho)(1-\kappa)(F_Q Q_{\bar{K}} - F_Q Q_K) + q_K(t_R - \\ & t_{\bar{R}})]\,Z \gtreqless 0\end{aligned}$$

i.e. the effect of the capital stock of the associate livelihood depends on the effect of the woodlot transaction on the economic plan function and tax function.

With regard to the self-financed share, the examination of the sign alternatives of the maximum purchasing price's partial derivative

$$(3.46)\quad f^d_\mu \gtreqless 0$$

may be done by examining condition

$$(3.47)\quad \frac{\pi(1+\pi)^{N_d}}{(1+\pi)^{N_d}-1}\,\frac{1-\rho^{N_d}}{1-\rho} \gtreqless 1$$

where the left-hand side is the unit loan's present value as a function of the purchaser's time preference and the interest rate of the loan.

The partial derivative expressions deduced with regard to the other purchasing decision situation parameters are not presented. Their signs are as follows:

With regard to the *stumpage price*

$$(3.48)\quad f^d_\alpha > 0.$$

With regard to the *rate of time preference*

$$(3.49)\quad f^d_\rho < 0.$$

With regard to the *capital market interest rate*

$$(3.50)\quad f^d_\pi < 0.$$

The following additional constraint is introduced to the right-hand side of (3.28)

(3.51) $A^2(\alpha h_0 - \mu\lambda^2) \geq 0$,

i.e. the self-financed share of the purchase is to be financed by means of the cutting revenue from the woodlot which is the object of purchasing. The tightness of the constraint in case it is binding is formally depicted by the Lagrangean coefficient associated with the constraint (3.51)

$\nu > 0$.

With regard to the *tightness of the cutting revenue finance* the sign of the partial derivative of the maximum purchasing price equation is

(3.52) $f^d_\nu < 0$,

i.e. the decrease in the initial growing stock for the planning period 1-N_d caused by the cutting is taken into consideration. In case the constraint (3.51) is not binding, the influence of the cutting revenue finance is undefined in the framework of the model used.

324. The transaction situation

According to the above examination, a woodlot transaction is possible between such a seller and such potential buyers between whom the following initial transaction situation prevails

(3.53) $f^s \leq \lambda^* \leq \lambda' \leq f^d$

and

(3.54) $\lambda^* \leq f^d$

(3.55) $\lambda' \geq f^s$.

When a transaction takes place

(3.56) $f^s \leq \bar{\lambda} \leq f^d$,

in which

$\bar{\lambda}$ = unit price which realizes the transaction

and

(3.57) $f^s \leq f^d$.

Competition between potential buyers depends on the information structure of the market. Assuming that perfect knowledge prevails, then in a situation with two or more potential buyers, whose maximum purchasing price function realizes condition (3.55), the potential buyer who possesses the second highest maximum purchasing price function defines the unit price which realizes the transaction. In a situation with only one potential buyer whose maximum purchasing price function realizes condition (3.55), then one or the other or both sides of (3.56) are realized as an equality.

4. Empirical examination

41. Statistical material

Hypotheses deduced from the model discussed in Chapter 3 were tested using the same material as employed by Airaksinen (1988) and Hannelius (1988). The material contains information on 574 woodlot transactions (minimum area of 10 hectares) from 1983 and 1984, of which 432 representative transactions were selected for this investigation. Representativeness here means that the transactions selected have not been between relatives. No extra conditions have been applied to the transactions and each woodlot was an unequivocally defined area (Hannelius 1988, pp. 9—14).

The following variables have been selected or formed from the above material for this study:

Y	=	unit price of the woodlot (FIM/0.1 ha)
X1	=	total area of the transaction (0.1 ha)
X2	=	ratio of forest area to total area (relative figure)
X3	=	mean increment (m^3/ha/a)
X4	=	distance from woodlot to nearest densely populated area (km)
X5	=	buyer's status (farmer or other private person = 1, others = 0)
X6	=	loan finance per unit area (FIM/0.1 ha)
X7	=	cutting revenue finance per unit area (FIM/0.1 ha)
X8	=	sawtimber per unit area (m^3/0.1 ha)
X9	=	need for silvicultural work (FIM/ha)
X10	=	woodlot's location county (Häme or Kymi or Mikkeli = 1, other counties = 0)
X11	=	development of locally taxed per-capita income in woodlot's location municipality (income ratios for 1983 and 1980)
X12	=	mean forest taxation site quality (0.1 m^3/ha/a)
X13	=	length of shoreline (m/0.1 ha)

The variables are presented graphically by means of Box-and-Whisker Plots in Appendix. Also two-variable scatterplots (Draftsman Plots) for all combinations of variables are presented in Appendix.

The explanatory variables are defined as follows:

Area
The total area involved in the woodlot transaction (X1) is used to operationalize the woodlot transaction area; the total area may also include land belonging to land use categories other than forestry. The aim is to prevent the other land use categories from affecting unit price formation by using as a variable the ratio (X2) of forest land to total land area involved in the transaction. Land area other than forest land consists mainly of poorly productive and underproductive land (Hannelius 1988, pp. 9—14).

As a further means of eliminating the influence of other land use categories, the following variables are employed: development of locally taxed per-capita income in woodlot's location municipality (X11) and length of shoreline (X13).

Growing stock
Sawtimber per unit area (X8) is used to operationalize the growing stock in the model examination. Mean increment (X3) is included as a means of taking into account the structure of the growing stock. It also gives an indication of the long-term cutting opportunities in the woodlot.

Level of silviculture
The need for silvicultural work per hectare (X9) is used to operationalize the level of silviculture. The need for silvicultural work has been determined as the aggregate sum weighted by costs per hectare of urgent silvicultural jobs deemed necessary in conjunction with the drawing up of management plans. The cost weightings are based on the average costs for the whole country in 1984 (Official Statistics of Finland. SVT XVII A:17. 1986).

Taxable income
The mean site quality (X12) of the woodlot is used to operationalize taxable income.

Stumpage price
The location of the woodlot is one of the most stable determinants of the stumpage price, and that is why the distance from the woodlot to the nearest densely populated area (X4) and the dummy variable formed from the county of location (X10) are used to

operationalize the stumpage price. The woodlot's actual mean stumpage price is not used; instead, the variables referred to in the above have been used to prevent the growing stock, structure of extracted timber and the market fluctuations from momentarily affecting the stumpage price. The dummy variable formed using the county of location is intended to depict the demand for round timber and its structure is the outcome of an experiment based on the distribution of wood industry enterprises in the various counties (e.g. Statistical Yearbook of Finland 1987).

Government regulation of forest ownership
It is assumed that regulation of forest ownership by legislation will lead to improved market information for private buyer candidates as well as favouring private forest ownership by means of loans at low rate of interest. These factors are operationalized using the dummy variable (X5) which is given the value 1 when the buyer is a private person; otherwise, its value is zero.

Terms of finance
The operationalization of the terms of finance is carried out indirectly by means of using per-unit-area loan financing (X6) because individual parameters for terms of finance are not available. The effects on the woodlot price of revenue obtained from cutting carried out in connection with the transaction are estimated by using as a variable the per-unit-area financing with revenue from cutting (X7).

42. Method and results

The econometric methods employed are the ordinary least squares-technique (OLS) and the two-stage least squares -technique (2SLS). OLS is applied in order to estimate the coefficients of the transaction price equation and 2SLS when the coefficients of equations from a simultaneous equation system are considered (Koutsoyiannis 1981).

Simultaneous consideration of selling and purchasing price equations
The coefficients of the selling and purchasing price equations are estimated from the equation system specified as follows:

Selling price equation

(4.1) $Y^s = f_s(X1, X3, X4, X8, X10, X11, X12, X13)$

Purchasing price equation

(4.2) $Y^d = f_d(X1, X2, X6, X7, X8, X9, X10, X12)$

Loan financing

(4.3) $X6 = f_{X6}(Y^s, X4, X5, X7, X8, X10)$

Equilibrium condition

(4.4) $Y^s = Y^d$

The equation system is specified by leaving variables out of some equations so that the identification of selling and purchasing price equations is realized. The hypotheses concerning the signs of the coefficients of selling and purchasing price equations are as follows

	X1	X2	X3	X4	X5	X6	X7	X8
Ys	—		+	—				+
Yd	+/—	+	+			+/—	+/—	+

	X9	X10	X11	X12	X13
Ys		+	+	—	+
Yd	—	+		—	

where X6, X7 are the computed values of the endogeneous variables using the reduced form coefficients.

The sign hypotheses are concluded from the theoretical examination of the minimum selling price and maximum purchasing price. It is to be kept in mind when the specification and hypotheses of the above system are considered that

— the system is specified in the framework of the available data which does not contain variables concerning e.g. the seller's alternative livelihood or the buyer's economic state needed for identification of the equations.

Transaction price equation
The transaction price is specified with a single equation as a function of exogeneous variables

(4.5) $Y = f(X1, X2, X3, X4, X5, X8, X9, X10, X11, X12, X13)$

The hypotheses concerning the relationships between the dependent variable, woodlot unit price, and the independent, exogeneous variables concluded from the theory derived above are as follows:

	X1	X2	X3	X4	X5	X8	X9	X10
Y	+/—	+	+	—	—	+	—	+

Y	X11	X12	X13
	+	—	+

Estimation
The estimation is carried out using Statgraphics statistical system (STSC 1988). The following transformations of the variables are used

— reciprocal transformation of the total area of transaction (X1) and the distance from woodlot to nearest densily populated areas (X4) in all estimations to linearize the relationships with the price variable (Y)
— square root transformation of the independent variable, the woodlot's unit price in the estimation of the transaction price equation coefficients to eliminate heteroscedasticity observed.

Results
The main results are presented in Table 1. The correlation matrix and detailed regression results are presented in Appendix. Statistically the most significant independent variable is the sawtimber growing stock (X8), i.e. the immediate cutting possibilities. The sign of the area variable (1/X1) in the purchasing price equation reveals that the marginal benefit with respect to area is less than the mean benefit (cf. 3.39). The corresponding sign in the selling price equation is negative as expected (cf. 3.14—3.16) on the basis of the theoretical examination. The signs of the finance variables (X6, X7) can be interpreted as follows

— The terms of loan finance have been such that they improved the purchasing price in a woodlot trading situation
— The cutting revenue finance decreasing the growing stock and the value of the woodlot is taken into account in advance in the purchasing price.

Table 1. Estimation results of woodlot price equations

Variable	Coefficients of equations, t-values in brackets Selling price, Y^s	Purchasing price, Y^d	Transaction price, Y	Square root of transaction price, $\sqrt{Y}$
Constant	—261.2 (—2.3)	—332.4 (—4.1)	—476.8 (—4.1)	—2.2 (1.1)
1/X1	18 173.3 (4.1)	40 035.5 (7.5)	16 549.0 (3.7)	255.2 (3.2)
X2		475.8 (5.4)	370.2 (4.4)	11.8 (8.0)
X3	6.2 (7.0)		5.1 (6.3)	0.1 (7.9)
1/X4	294.5 (3.5)		277.9 (3.4)	5.0 (3.4)
X5			—88.5 (—3.2)	—1.3 (—2.7)
$\overline{X}6$		0.6 (4.7)		
$\overline{X}7$		—2.7 (—8.0)		
X8	84.4 (19.9)	150.5 (18.4)	85.0 (20.7)	1.4 (19.4)
X9		—0.2 (—6.4)		
X10	209.9 (7.6)	172.6 (6.3)	185.0 (7.0)	3.5 (7.4)
X11	249.2 (3.3)		202.6 (2.8)	4.3 (3.4)
X12	—1.2 (—0.8)	—1.1 (—0.7)		
X13	9.3 (0.8)			
R^2	0.73	0.74	0.75	0.77
F	147.3	157.7	159.5	177.8
d.f.	423	423	423	423

Other signs of the coefficients in Table 1 are as expected on the basis of the theoretical examination. The coefficients for the transaction price equations are calculated by using only the exogeneous variables having a statistically significant coefficient ($|t| \geq 2.0$).

5. Discussion

In this study woodlot price formation has been *examined theoretically* with the help of the seller's minimum price and the buyer's maximum price. A woodlot transaction is made possible if the maximum price is equal to or greater than the minimum price. Both of these prices have been derived from a comparison in which, on the one side, the woodlot which is the object of the transaction is a part of the decision-maker's (i.e. seller or buyer) economy and, on the other side, economic activity is conducted without the woodlot which is the object of the transaction. The minimum and maximum woodlot price is derived from its net contribution to the decision-maker's economy. This procedure can be seen as complying with the productive value method, but it does share some common features with the sum value method, too. In the method applied, the conditions sought for the price effects of the growing stock and level of silviculture are analogical to the sum value method's expected values for bare land and growing stock and the cost values of establishing and tending young stands.

Although the theoretical examination leads to the conclusion of explaining woodlot unit price formation via subjective decision-maker premises, it does appear that, given the institutional circumstances in which the statistical material of the *empirical study* was collected, price formation takes place mainly on the basis of the characteristics of the woodlot in question.

In future empirical research work, special attention has to be given to the choice of relevant variables and to the relevant definition of the population of the woodlot transactions. In this study the available investigation data was limited to the characteristics of the woodlots so that the subjective points of view of the decision-makers could not be adequately taken into consideration.

Attention is also to be given on administrative processes in the woodlot price formation. A good impression of the administrative practice applied can be gained, for example, from court cases involving land acquisition permits (see Wirilander 1984, pp. 25—60). It would seem that in practice woodlot prices are determined in a very stereotyped manner, and the new owner of a woodlot is determined administratively from within that group of potential buyers whose maximum purchasing price exceeds the price obtained using a rule of property assessment applied by authorities.

To compare this study to most of the other related studies (e.g. Kantola 1979, Matikainen 1979) is pointless because the statistical material used in them is from a period when a different type of forest ownership regulation was in operation or because of the different problem formulation (e.g. Hannelius 1986, Airaksinen 1988). Generally speaking, comparing price formation at different periods of time is made difficult by the fact that forest ownership is controlled by highly flexible legal phraseology via which some legislative power has been transferred to the administrators. Hannelius (1986) has used regression analysis to explain the transaction price. The independent variables employed were the cutting value of the woodlot, mean development class and proportion of sawtimber in the growing stock. Using the same statistical material, Airaksinen (1988) employed regression analysis to study the dependence between the woodlot's total selling price and the sum value in order to determine the sum value correction factors. The premises in the studies conducted by Hannelius and Airaksinen differ so much from the present study that there are no grounds for comparison. In this study the purpose has been to explain the woodlot price formation from the economic point of view. The aspects of justness, objectivity and reasonableness of the woodlot price which are important in the surveying and administration are ignored.

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Total of 22 references

Seloste

Metsälön hinnan muodostuminen 1980-luvun alussa

Metsälön hinnan muodostumista selitetään tavallisesti objektiiviseksi ja subjektiiviseksi nimetyillä lähestymistavoilla. Ensin mainitun tavan kannattajat pitävät metsälöä itsenäisenä oman arvonsa muodostavana objektina, jonka oikea hinta voidaan määrittää objektiivisella, kuhunkin tapaukseen sopivalla menetelmällä. Subjektiivisen tavan kannattajat ajattelevat, että metsälöllä ei ole oikeata siitä itsestään johtuvaa hintaa, vaan että hinta muodostuu vain taloutta harjoittavan subjektin ja hänen taloudenpitonsa välityksellä.

Tämän tutkimuksen tavoitteena on selittää metsälöiden hinnan muodostumista Suomessa 1980-luvun alkupuoliskolla sekä teoreettisesti että empiirisesti. Teoreettinen tarkastelu aloitetaan metsälömarkkinoiden kuvauksella, jossa todetaan:

1) Suomen metsälöiden lukumäärästä 2,5—5 prosenttia ja pinta-alasta runsas prosentti on ollut kaupan kohteena vuosittain ajanjaksona 1982—1987, ts. metsälökauppa on harvinainen ilmiö.
2) Metsälöt ovat erilaisia metsällisten ominaisuuksiensa, sijaintinsa, muotonsa, pirstoutuneisuutensa, integroituvuutensa suhteen.
3) Metsänomistusta säädellään institutionaalisesti voimakkaasti. Tärkeimmät 1980-luvulla metsälökauppaan vaikuttaneet säädökset ovat

— maatilalaki
— maan hankintaoikeuslaki
— sukupolvenvaihdoslainsäädäntö
— maatilatalouden tuloverolaki.

Mainittuihin joustaviin oikeusnormeihin perustuen on vaikutettu välittömästi metsälöiden hinnan muodostumiseen ja sen perustana olevan tiedon saatavuuteen.

Teoreettista tarkastelua jatketaan määrittämällä metsälökaupantekotilanne, jonka avulla tutkitaan

- omistajan (myyjän) metsälöstään vaatiman vähimmäishinnan
- ostajaehdokkaiden metsälöstä tarjoamien enimmäishintojen

muodostumisen perusteita. Tavoitteena on johtaa määritetystä erityistapauksesta tilastollisesti todennettavia säännönmukaisuuksia.

Vähimmäismyyntihinnan ominaisuuksien tarkastelemiseksi määritellään tilanne, jossa metsälönomistajan on päätettävä

- jatkaako hän aktiivisesti metsätalouden ja sen liitännäiselinkeinon harjoittamista vai
- siirtyykö hän elämään eläkkeellään ja reaaliomaisuutensa myynnistä saamillaan pääomatuloilla.

Metsänomistajan jatkamisvaihtoehtoa kuvataan mallilla, jossa hän maksimoi kulutuksensa aikomansa hakkuun, metsänhoitoinvestoinnin ja metsätalouden liitännäiselinkeinon avulla. Eläkevaihtoehdossa metsänomistaja on passiivinen pääomamarkkinoiden ja eläkkeensä hyödyntäjä.

Vähimmäismyyntihinnan muutosta tarkastellaan seuraavien päätöstilanteen tekijöiden vaihtelun suhteen

- metsälön pinta-ala
- metsälön puusto
- metsälön metsänhoidon taso
- liitännäiselinkeinon pääomakanta
- kantohinta
- pääomamarkkinoiden korko
- eläke
- liitännäiselinkeinon pääomakannan myyntihinta.

Metsälön pinta-alan ja liitännäiselinkeinon pääomakannan muutoksen suhteen vähimmäismyyntihinnan muutos on riippuvainen metsänomistajan taloudellisesta tilanteesta. Puuston ja metsänhoidon tason suhteen vähimmäismyyntihinta on positiivisessa riippuvuussuhteessa varsin yleisten olettamusten vallitessa. Kantohinnan suhteen vähimmäismyyntihinta on positiivisesti ja muiden parametrien suhteen negatiivisesti riippuvainen.

Enimmäisostohinnan ominaisuuksia tarkastellaan vertailulla, jossa ostajaehdokkaan vaihtoehtoina ovat

- jatkaa taloudenpitoaan jo omistamansa metsälön ja sen liitännäiselinkeinon varassa tavoitteenaan kulutuksen maksimointi hakkuun, metsänhoitoinvestoinnin ja liitännäiselinkeinon investoinnin avulla
- ostaa tarjolla oleva metsälö lisämetsäksi edellä mainitun omaisuutensa täydennykseksi tavoitteenaan kulutuksen maksimointi käyttämällä keinoina edellä mainittujen lisäksi uuden metsälön hakkuuta ja metsänhoitoinvestointia.

Taulukko 1. Metsälön hintayhtälöiden estimointitulokset

	Yhtälöiden kertoimet, t-arvot suluissa			
Muuttuja	Myyntihinta, Y^s	Ostohinta, Y^d	Kauppahinta, Y	Myyntihinnan neliöjuuri, $\sqrt{Y}$
Vakio	—261.2 (—2.3)	—332.4 (—4.1)	—476.8 (—4.1)	—2.2 (1.1)
1/X1	18 173.3 (4.1)	40 035.5 (7.5)	16 549.0 (3.7)	255.2 (3.2)
X2		475.8 (5.4)	370.2 (4.4)	11.8 (8.0)
X3	6.2 (7.0)		5.1 (6.3)	0.1 (7.9)
1/X4	294.5 (3.5)		277.9 (3.4)	5.0 (3.4)
X5			—88.5 (—3.2)	—1.3 (—2.7)
$\overline{X}6$		0.6 (4.7)		
$\overline{X}7$		—2.7 (—8.0)		
X8	84.4 (19.9)	150.5 (18.4)	85.0 (20.7)	1.4 (19.4)
X9		—0.2 (—6.4)		
X10	209.9 (7.6)	172.6 (6.3)	185.0 (7.0)	3.5 (7.4)
X11	249.2 (3.3)		202.6 (2.8)	4.3 (3.4)
X12	—1.2 (—0.8)	—1.1 (—0.7)		
X13	9.3 (0.8)			
R^2	0.73	0.74	0.75	0.77
F	147.3	157.7	159.5	177.8
vapausasteet	423	423	423	423

Enimmäisostohinnan muutosta tutkitaan seuraavien ostopäätöstilanteen tekijöiden suhteen

- metsälön pinta-ala
- metsälön puusto
- metsälön metsänhoidon taso
- metsälön verotettava tulo pinta-alayksikköä kohti
- liitännäiselinkeinon pääomakanta
- kantohinta
- aikapreferenssin aste
- pääomamarkkinoiden korko

Pinta-alan suhteen tarkastelu voidaan muuntaa oston kohteena olevan metsälön pinta-alan suhteen määritetyn marginaalihyödyn ja keskimääräisen hyödyn väliseksi tarkasteluksi. Pinta-alan vaihtelun hintavaikutus voi mallitarkastelun perusteella olla positiivinen, negatiivinen tai nolla. Puuston ja metsänhoidon tason vaihtelu ja enimmäisostohinnan vaihtelu ovat hyvin yleisten olettamusten mukaisesti positiivisessa riippuvuussuhteessa. Liitännäiselinkeinon pääomakannan vaikutus enimmäisostohintaan riippuu metsälökaupan vaikutuksesta ostajan verotukseen ja tulevaisuuden kulutusvaikutuksista, jotka hän mallitarkastelussa ottaa huomioon taloussuunnitelmassaan. Kantohinnan suhteen enimmäisostohinta on positiivisessa ja aikapreferenssin asteen sekä pääomamarkkinoiden koron suhteen negatiivisessa riippuvuussuhteessa.

Metsälökauppa on mahdollinen sellaisessa tilanteessa, jossa ostajaehdokkaiden enimmäisostohinnat ovat vähintään yhtä suuret kuin myyjän vähimmäismyyntihinta. Ostajaehdokkaiden välinen kilpailu riippuu heidän käytettävissään olevasta informaatiosta ja enimmäisostohinnoista.

Vähimmäismyyntihinnan ja enimmäisostohinnan realisoituessa kaupan toteuttavana epäyhtälönä lopullinen hinta määräytyy myös informaatiorakenteen, institutionaalisen säätelyn ja kaupan osapuolten neuvotteluvoimasta.

Käytettävissä olevan tilastoaineiston avulla testataan laadittuja teoreettisia malleja tutkimalla empiirisesti metsälön yksikköhinnan muodostumista. Tutkimuksessa käytetään seuraavia muuttujia:

Y = metsälön yksikköhinta (mk/0,1 ha)
X1 = kaupan kokonaispinta-ala (0,1 ha)
X2 = metsäpinta-alan ja kokonaispinta-alan suhde (suhdeluku)
X3 = keskikasvu (m^3/ha/a)
X4 = metsälön etäisyys lähimpään taajamaan (km)
X5 = ostajan status (maanviljelijä tai muu yksityinen = 1, muut = 0)
X6 = lainarahoitus pinta-alayksikköä kohti (mk/0,1 ha)
X7 = hakkuutulorahoitus pinta-alayksikköä kohti (mk/0,1 ha)
X8 = tukkipuusto pinta-alayksikköä kohti (m^3/0,1 ha)
X9 = metsänhoitotyötarve (mk/ha)
X10 = metsälön sijaintilääni (Hämeen lääni tai Kymen lääni tai Mikkelin lääni = 1, muut läänit = 0)
X11 = metsälön sijaintikunnan kunnallisverotettavan per capita -tulon kehitys (vuosien 1983 ja 1980 tulojen suhdeluku)
X12 = metsäverotuksen keskiboniteetti (0,1 m^3/ha/a)
X13 = rantaviivan pituus (m/0,1 ha)

Tutkimuksessa tarkastellaan yhden yhtälön kauppahintamallia ja neljän yhtälön metsälökauppamallia, joista vain metsälön myynti- ja ostohintayhtälöiden kertoimet ratkaistaan. Kertoimet on esitetty selosteen taulukossa 1. Kaikissa tapauksissa tukkipuusto eli välittömät hakkuumahdollisuudet on tärkein metsälön yksikköhinnan selittäjä. Metsälön yksikköhinta on käänteisesti riippuvainen pinta-alasta. Lainarahoituksella on myyntihintaa pienentävä ja ostohintaa parantava vaikutus. Saatujen tulosten mukaan hakkuutulorahoituksen metsäomaisuuden arvoa pienentävä vaikutus otetaan huomioon ostohinnassa.

Appendix: Description of the variables and estimation results

Contents

List of variables

Y = unit price of the woodlot (FIM/0.1 ha)
X1 = total area of the transaction (0.1 ha)
X2 = ratio of forest area to total area (relative figure)
X3 = mean increment (0.1 m^3/ha/a)
X4 = distance from woodlot to nearest densely populated area (km)
X5 = buyer's status (farmer or other private person = 1, others = 0)
X6 = loan finance per unit area (FIM/0.1 ha)
X7 = cutting revenue finance per unit area (FIM/0.1 ha)
X8 = sawtimber per unit area (m^3/0.1 ha)
X9 = need for silvicultural work (FIM/ha)
X10 = woodlot's location county (Häme or Kymi or Mikkeli = 1, other counties = 0)
X11 = development of locally taxed per-capita income in woodlot's location municipality (income ratios for 1983 and 1980)
X12 = mean forest taxation site quality (0.1 m^3/ha/a)
X13 = length of shoreline (m/0.1 ha)

Appendix table 1. Box-and Whisker Plots

Explanation (STSC 1988):

The *height* of the box covers the middle 50 % of the data values between the lower and upper quartile.

The *central line* of the box is at the median.

The *notch* of the box corresponds to the width of a confidence interval at 95 % level for the median.

The *width* of the box is proportional to the square root of the number of observations.

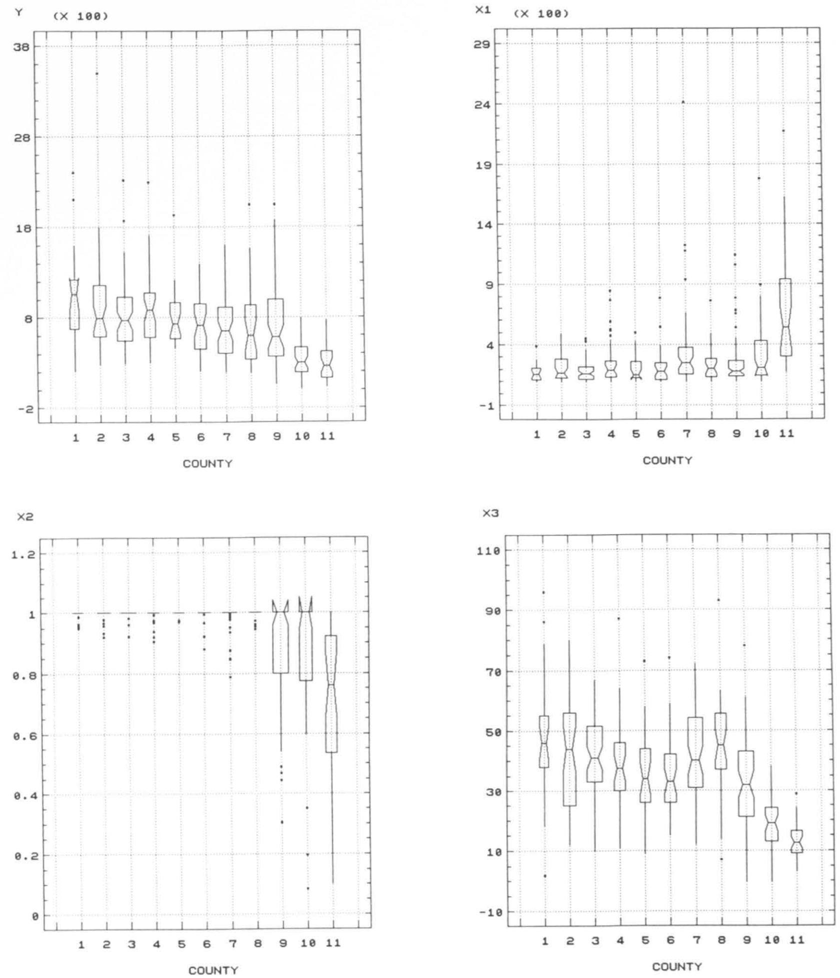
The *whiskers* extend out to the extremes in case they are within 1.5 times the interquartile range.

The *unusual values* outside 1.5 times the interquartile range are plotted as separate points.

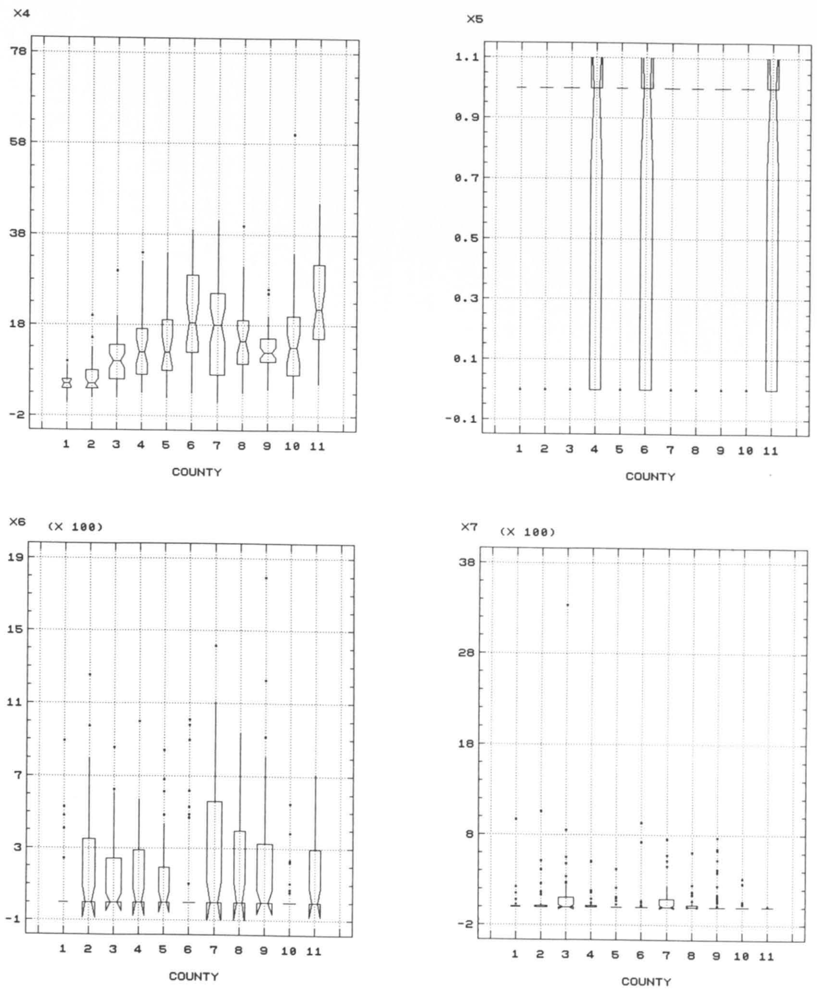
List of counties

1 = Uusimaa
2 = Häme
3 = Turku and Pori
4 = Kymi
5 = Mikkeli
6 = Pohjois-Karjala
7 = Kuopio
8 = Keski-Suomi
9 = Vaasa
10 = Oulu
11 = Lappi

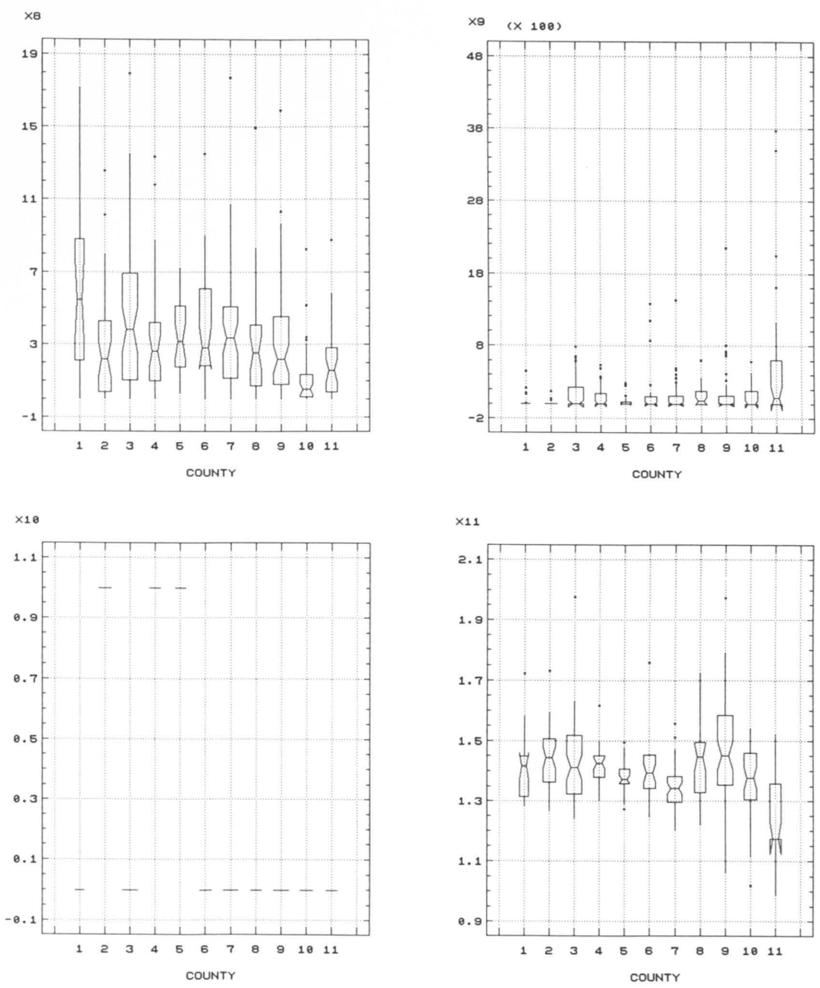
Appendix table 1a. Box-and-Whisker Plots of variables Y, X1, X2 and X3.



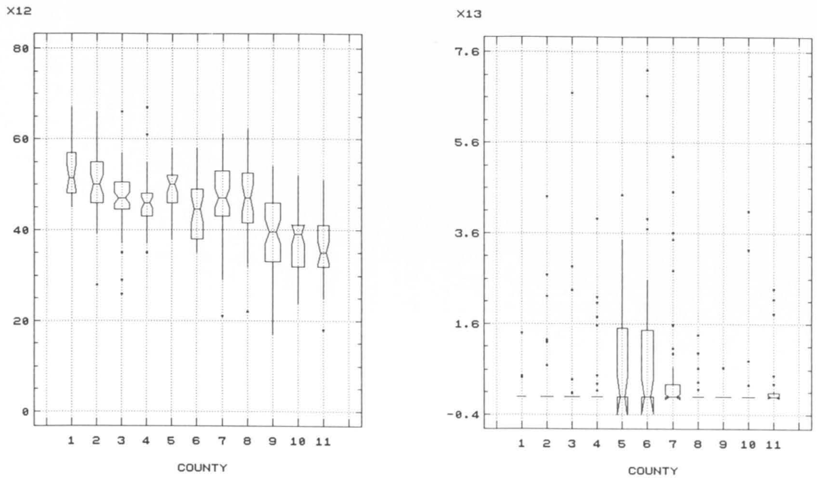
Appendix table 1b. Box-and Whisker Plots of variables X4, X5, X6 and X7.

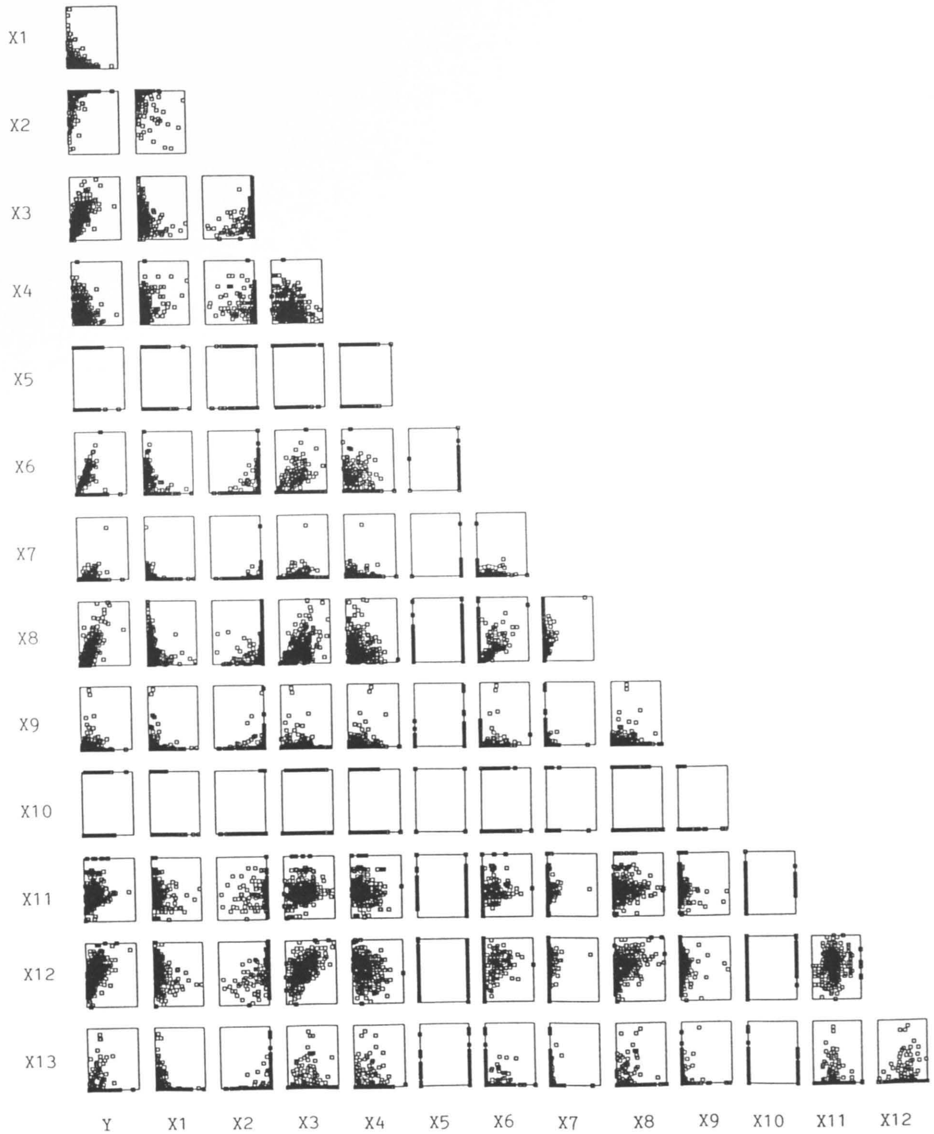


Appendix table 1c. Box-and-Whisker Plots of variables X8, X9, X10 and X11.



Appendix table 1d. Box-and-Whisker Plots of variables X12 and X13.





Appendix table 2. Draftsman Plot (pairwise scatter diagrams for all combinations of variables).

Appendix table 3. Correlation coefficient matrix.

	Y	1/X1	X2	X3	1/X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Y	1													
1/X1	0.3011	1												
X2	0.3342	0.2728	1											
X3	0.6489	0.2023	0.3285	1										
1/X4	0.2169	0.1072	0.1291	0.1739	1									
X5	−0.0164	0.1936	0.1542	0.0702	0.0647	1								
X6	0.2726	−0.0223	0.1165	0.2619	0.1796	0.2757	1							
X7	0.3142	0.1424	0.0742	0.1533	0.0167	0.1494	0.0804	1						
X8	0.7723	0.1843	0.1321	0.5694	0.0875	0.0303	0.2762	0.3573	1					
X9	−5.6733E−3	−0.0326	−6.1927E−3	−0.1055	−0.0443	0.0803	0.1315	−0.0244	0.1197	1				
X10	0.2316	0.0799	0.1856	0.1072	0.1136	−0.0405	−0.0249	−0.0242	−0.0166	−0.1316	1			
X11	0.1675	0.1389	0.1406	0.1323	0.320	−0.0395	0.0112	0.0237	0.0408	−0.1296	0.0542	1		
X12	0.4544	0.2345	0.3980	0.5575	0.2171	0.643	0.1395	1357	0.3893	−0.0539	0.2532	0.1130	1	
X13	0.1049	0.0502	0.0618	0.0894	−0.0211	−0.0168	−0.0125	−3.5581E−3	0.0831	0.0251	0.0713	−0.0569	0.052	1

Appendix table 4. Regression analysis results

Table 4.1. Selling price

Model fitting results for: Y^s

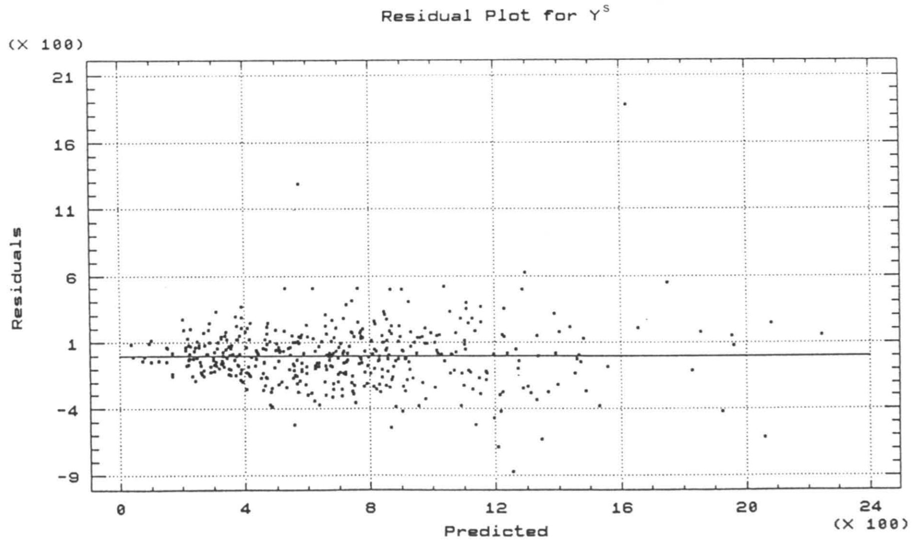
Indep. variable	coefficient	std. error	t-value	sig. level
CONSTANT	—261.19267	114.796571	—2.2753	0.0234
1/X1	18173.25742	4485.401781	4.05116	0.0001
X3	6.150286	0.879267	6.9948	0.0000
1/X4	294.450914	85.195139	3.4562	0.0006
X8	84.447966	4.254082	19.8510	0.0000
X10	209.870502	27.563405	7.6141	0.0000
X11	249.235474	74.330218	3.3531	0.0009
X12	—1.23771	1.605893	—0.7707	0.4413
X13	9.301724	11.413899	0.8149	0.4156

R-SQ. (ADJ.) = 0.7308 SE= 230.539397 MAE= 159.805305
432 observations fitted, forecast (s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	62622179.	8	7827772.	147.281	.0000
Error	22481779.	423	53148.4		
Total (Corr.)	85103958.	431			

R-squared = 0.735832 Std. error of est. = 230.539
R-squared (Adj. for d.f.) = 0.730835



Appendix table 4. Regression analysis results

Table 4.2. Purchasing price

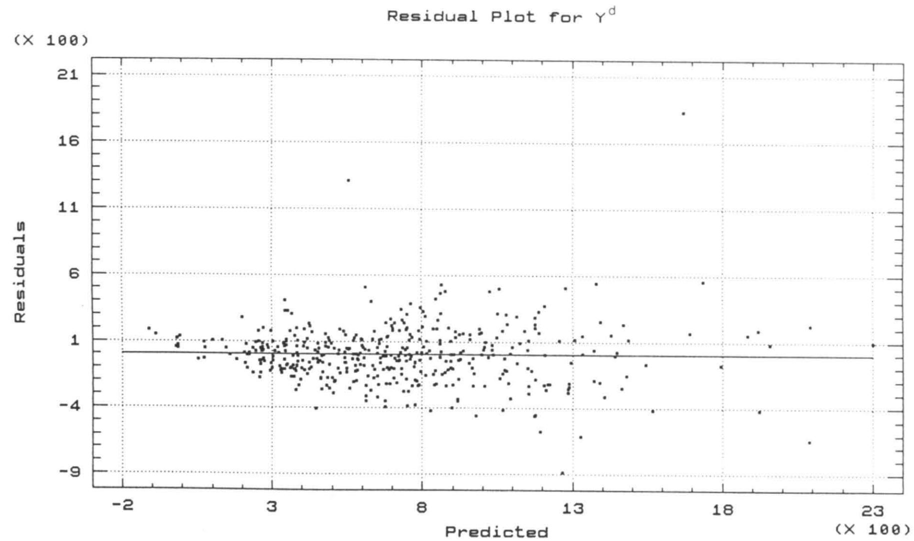
Model fitting results for: Y^d

Indep. variable	coefficient	std. error	t-value	sig. level
CONSTANT	—332.36746	81.180952	—4.0942	0.0001
1/X1	40035.5457	5318.985127	7.5269	0.0000
X2	475.75178	87.494277	5.4375	0.0000
X6	0.597193	0.125828	4.7461	0.0000
X7	—2.661335	0.332576	—8.0022	0.0000
X8	150.550206	8.195442	18.3700	0.0000
X9	—0.238876	0.03749	—6.3717	0.0000
X10	172.594451	27.372078	6.3055	0.0000
X12	—1.125639	1.533523	—0.7340	0.4633

R-SQ. (ADJ.) = 0.7441 SE= 224.776640 MAE= 154.562795
432 observations fitted, forecast (s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	63732078.	8	7966510.	157.676	.0000
Error	21371880.	423	50524.5		
Total (Corr.)	85103958.	431			
R-squared = 0.748873			Std. error of est. = 224.777		
R-squared (Adj. for d.f.) = 0.744124					



Appendix table 4. Regression analysis results

Table 4.3. Transaction price

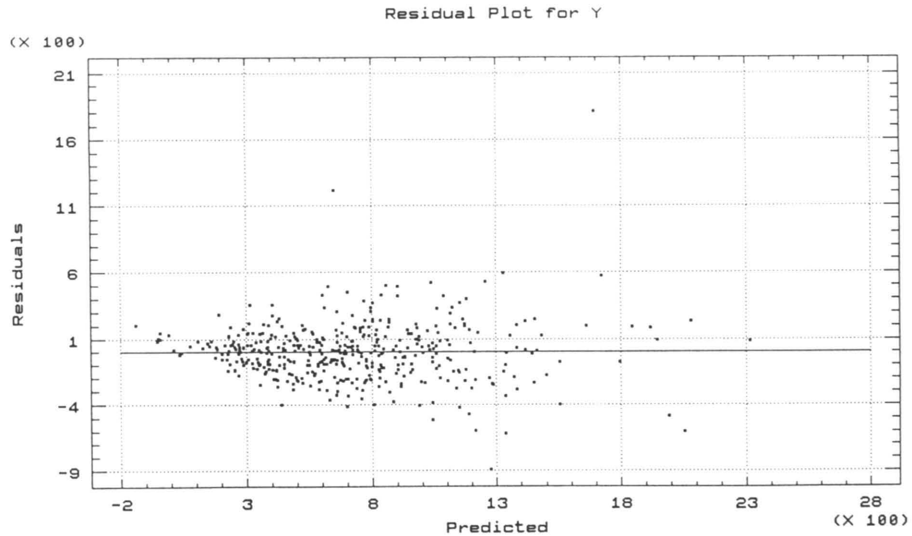
Model fitting results for: Y

Indep. variable	coefficient	std. error	t-value	sig. level
CONSTANT	—476.77458	117.504968	—4.0575	0.0001
1/X1	16549.01721	4480.076215	3.6939	0.0002
X2	370.21887	83.545543	4.4313	0.0000
X3	5.11013	0.810725	6.3032	0.0000
1/X4	277.89368	82.164928	3.3821	0.0008
X5	—88.46636	27.274845	—3.2435	0.0013
X8	85.04621	4.105379	20.7158	0.0000
X10	184.93783	26.299056	7.0321	0.0000
X11	202.56260	72.359026	2.7994	0.0054

R-SQ. (ADJ.) = 0.7463 SE= 223.802686 MAE= 154.181376
432 observations fitted, forecast (s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	63916885.	8	7989611.	159.513	.0000
Error	21187073.	423	50087.6		
Total (Corr.)	85103958.	431			
R-squared = 0.751045			Std. error of est. = 223.803		
R-squared (Adj. for d.f.) = 0.746336					



Appendix table 4. Regression analysis results

Table 4.4. Square root of transaction price

Model fitting results for: $\sqrt{Y}$

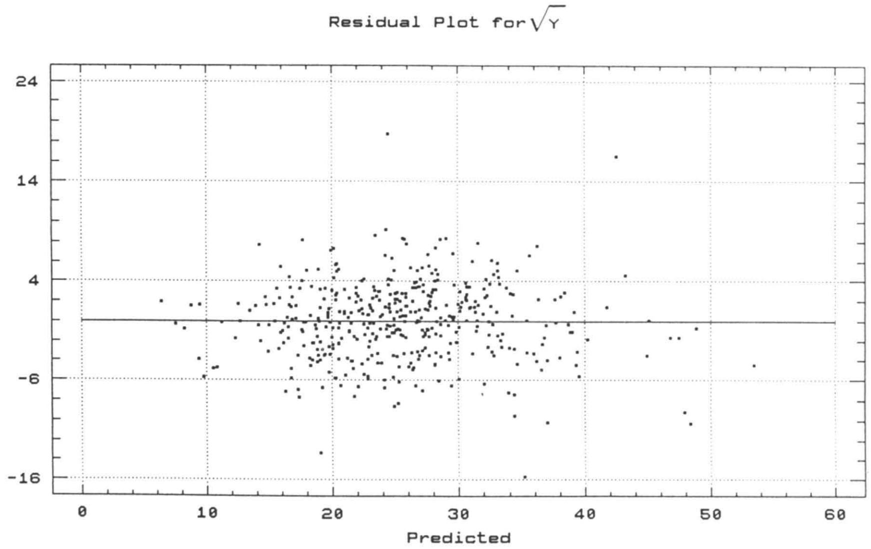
Indep. variable	coefficient	std. error	t-value	sig. level
CONSTANT	—2.212536	2.077539	—1.0650	0.2875
1/X1	255.179428	79.209708	3.2216	0.0014
X2	11.842420	1.477122	8.0172	0.0000
X3	0.112666	0.014334	7.8601	0.0000
1/X4	4.957324	1.452712	3.4125	0.0007
X5	—1.289972	0.482231	—2.6750	0.0078
X8	1.411204	0.072585	19.4421	0.0000
X10	3.455813	0.464979	7.4322	0.0000
X11	4.324058	1.279339	3.3799	0.0008

R-SQ. (ADJ.) = 0.7664 SE= 3.956929 MAE= 2.990282
432 observations fitted, forecast (s) computed for 0 missing val. of dep. var.

Analysis of Variance for the Full Regression

Source	Sum of Squares	DF	Mean Square	F-Ratio	P-value
Model	22270.0	8	2783.76	177.793	.0000
Error	6623.0	423	15.6573		
Total (Corr.)	28893.1	431			

R-squared = 0.770774 Std. error of est. = 3.95693
R-squared (Adj. for d.f.) = 0.766439



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Metsäntutkimuslaitoksesta lähtöisin olevien käsikirjoitusten hyväksymismenettelystä on ohjeet Metsäntutkimuslaitoksen julkaisuohjesäännössä.

Muista käsikirjoituksista lähetetään Suomen Metsätieteellisen Seuran toimitukselle kolme täydellistä, viimeisteltyä kopiota, joihin sisältyvät myös kopiot kaikista kuvista ja taulukoista. Originaaliaineistoa ei tässä vaiheessa lähetetä.

Vastaava toimittaja lähettää käsikirjoituksen valitsemilleen ennakkotarkastajille. Tekijän on otettava huomioon ennakkotarkastajien ja toimituskunnan korjausesitykset. Korjaukset on tehtävä vuoden kuluessa siitä, kun käsikirjoitus on palautettu tekijälle. Jos tekijä ei voi hyväksyä korjausesityksiä, hänen on ilmoitettava eriävä mielipiteensä vastaavalle toimittajalle tai toimituskunnalle, joka tarvittaessa ottaa asian uudelleen käsittelyyn.

Acta Forestalia Fennican toimituskunta päättää kirjoituksen julkaisemisesta ennakkotarkastajien lausuntojen ja muiden ilmenneiden seikkojen perusteella. Päätös tehdään kolmen kuukauden kuluessa siitä, kun käsikirjoituksen lopullinen korjattu versio on saapunut toimitukselle.

Hyväksymisen jälkeen käsikirjoitukseen ei saa tehdä olennaisia muutoksia ilman vastaavan toimittajan lupaa. Suuret muutokset edellyttävät uutta hyväksymistä.

Tekijä vastaa kirjoituksen tieteellisestä asiasisällöstä ja kieliasusta. Tekijä ei saa julkaista kirjoitusta muualla ilman Acta Forestalia Fennican julkaisijoiden suostumusta. Acta Forestalia Fennicaan hyväksytään vain aiemmin julkaisemattomia kirjoituksia.

Tekijän tulee antaa lopullinen käsikirjoitus ja kuvaoriginaalit toimitukselle kahden kuukauden kuluessa hyväksymispäätöksestä. Käsikirjoituksen saatteesta pitää selvästi ilmetä, että käsikirjoitus on lopullinen, painoon tarkoitettu kappale. Teksti otetaan mieluiten vastaan mikrotietokoneen levykkeellä, jonka lisäksi tarvitaan paperituloste.

Käsikirjoitusten ulkoasu

Käsikirjoituksen asun tulee noudattaa sarjan kirjoitusohjeita, joita saa toimituksesta.

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