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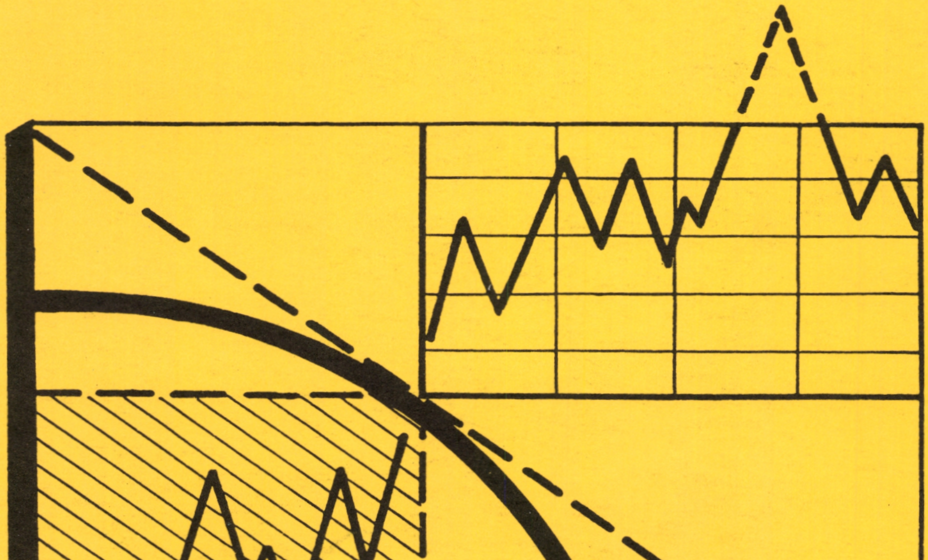
Kansantaloudellisen metsäekonomian tutkimussuunta

THE SELLING FREQUENCY OF FOREST OWNERS: A SEQUENTIAL BINARY ANALYSIS

MARKKU OLLIKAINEN & HANNU SALONEN



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Metsäntutkimuslaitos on maa- ja metsätalousministeriön alainen vuonna 1917 perustettu valtion tutkimuslaitos. Sen päätehtävänä on Suomen metsätaloutta sekä metsävarojen ja metsien tarkoituksenmukaista käyttöä edistävä tutkimus. Metsäntutkimustyötä tehdään lähes 800 hengen voimin yhdeksällä tutkimusosastolla ja yhdeksällä tutkimus- ja koeasemalla. Tutkimus- ja koetoimintaa varten laitoksella on hallinnassaan valtionmetsiä yhteensä n. 150 000 hehtaaria, jotka on jaettu 17 koealueeseen ja joihin sisältyy kaksi kansallis- ja viisi luonnonpuistoa. Kenttäkokeita on käynnissä maan kaikissa osissa.

The Finnish Forest Research Institute, established in 1917, is a state research institution subordinated to the Ministry of Agriculture and Forestry. Its main task is to carry out research work to support the development of forestry and the expedient use of forest resources and forests. The work is carried out by means of 800 persons in nine research departments and nine research stations. The institute administers state-owned forests of over 150 000 hectares for research purposes, including two national parks and five strict nature reserves. Field experiments are in progress in all parts of the country.

Kansantaloudellisen metsäekonomian tutkimussuunnan henkilöstö ja aiemmat tämän sarjan julkaisut on esitelty takakannen molemmilla puolilla.

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This study analyzes the factors that affect the selling frequency of forest owners by means of qualitative response models. The research problem requires the use of a multinominal model. However, the multinominal problem can, in this particular case, be easily simplified to a binary sequential analysis, which is the method used in this study.

The results of the model support the results obtained by conventional binary models, for example nonfarmers seem to have a lower selling frequency than farmers. The selling frequency of nonfarmers seems to be slightly below the mean of the selling freguencies. Perhaps the most interesting result of the sequential model concerned the influence of the bequest motive of old owners on the selling frequencies. It was demonstrated that low selling frequencies occur where an owner does not intend to continue his ownership. On the other hand, new owners also had low selling frequencies. This was hypothesized to be due to the system of inheritance in Finland.

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Foreword

Markku Ollikainen was employed in 1984 by Finnish Forest Research Institute in search of new approaches for research in forest economics. The immediate impetus for initiating this investigation was received by the authors during the seventh Yrjö Jahnsson post-graduate course on applied micro-economic analysis of choice behavior, which was given by Daniel McFadden and Charles Manski. Veli-Pekka Järveläinen kindly gave the authors an access to the empirical data. Erkki Koskela, Jari Kuuluvainen, Heikki Loikkanen, Ville Ovaskainen, Heikki Pajuoja and Jorma Salo commented on the manuscript. Ashley Selby checked the English language.

On behalf of the Division of Social Economics of Forestry in the Finnish Forest Research Institute I wish to express our gratitude to all persons engaged with the present investigation.

Helsinki, September 1986

Matti Palo

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1. Introduction

It is well known that under conditions of an imperfect capital market the characteristics of the producer influence the production decision. This old Fisherian result has recently been established also in the economics of forestry (see Lohmander 1983 or Johansson and Löfgren 1985) and the number of the studies into timber supply under imperfect capital market is growing (see e.g. Koskela 1986).

The separability theorem justifies the research strategy of many empirical studies published in the 1980's. They concentrate on analyzing how various socio-economic variables affect the forest owners' cutting decision as well as the quantity they decide to sell.

Those recent empirical socio-economic studies that use the qualitative response models as their econometric method are of special interest, because they have given new information about the cutting behavior of forest owners (see Binkley 1981, Kuuluvainen et al 1983, Loikkanen et al 1985 and 1986, Carlen and Muller 1985, Carlen 1985).

The basic results of these studies are briefly summarized as follows. (1.) Farmers have a greater probability to sell their timber in the market than nonfarmers. (2.) In the long run the average supply does not necessarily differ between these two groups, because nonfarmers sell their timber in larger quantities. (3.) Farmers seem to be more sensitive to the timber prices than nonfarmers. (See Kuuluvainen et al 1983 and Loikkanen et al 1986).
Binkley's results correspond to the first and third point. Carlen and Muller found that farmers are eager to sell their timber in delivery whereas nonfarmers are eager to sell their timber in stumpage. This is partly in accordance with the first point above. Carlen used a Tobit model to analyze the quantities sold and found no statistically significant difference between farmers and nonfarmers. This corresponds to the second point above.

The binary forms of the qualitative response models are developed into an analysis of a choice decision between two alternatives. The decision to cut or not to cut during a given cutting year is a typical discontinuous two alternative choice problem. Therefore the binary choice models well suit the analysis of cutting behavior.

The studies made so far have analyzed the cutting decision during a given cutting year or years. There is, however, another interesting variable to be analyzed: **the cutting/ selling frequency** of forest owners, which has been studied so far only in Kuuluvainen et al 1983. The selling frequency shows the past cumulated cutting behavior of forest owners. This makes it different from the usual cutting variable.

The analysis of the cutting/selling frequencies requires a different version of the qualitative response models. Because the selling/cutting frequency is a many alternative variable, the usual binary 1-0 choice models cannot be used. A natural model type is, of course, **a multinominal model**, which is used to analyze choices between many alternatives.

Our data has five selling/cutting frequency alternatives. It means that the multinominal model to be used would be a complex one. Fortunately, there is a way of simplifying the multinominal analysis into **a sequential binary one**. This is the model to be derived and used in this study. The advantage of the sequential binary model is that it permits a much more detailed analysis than the conventional binary model. In addition, it can be used in the analysis of a multinominal problem. It can, therefore, complement the usual binary models whenever the possibility exists to construct a selling/cutting frequency variable.

Thus, our aims can be summarized as follows:

(i) We want to determine which factors affect the selling/ cutting frequencies of forest owners and, especially, we want to see if the differences between the behavior of farmers and nonfarmers found in the earlier studies will persist when the selling frequency variable is analyzed.

(ii) We also try to find new ways to use the qualitative response models in the analysis of cutting behavior. Therefore, in order to compare the results of the sequential binary model with the conventional binary model, we also use a conventional binary (logit) model to analyze the cutting decision during one cutting year and compare the results with each other.

Our data was collected by Veli-Pekka Järveläinen in 1974 and his results have been published in Järveläinen 1974. The differences in the econometric methods employed prevent us from comparing the results. The age of the data is problematic, but it has the advantage of the selling/cutting frequency variable, which deserves closer analysis and is necessary to the model type that we are going to use. The data has 878 observations covering the whole Finland.

The plan of the study is as follows. The sequential model is spesified in chapter 2. The variables and data are described in chapter 3. The results are presented in chapter 4 and, finally, the results are discussed in chapter 5.

2. The sequential binary model

Today there is a large number of good introductions to the models of discrete choice (see e.g. the comprehensive presentation of Maddala 1983, or the short introduction of Amemiya 1983; for an application to the forestry case see Loikkanen et al 1986). We are going to take the binary models as given and derive the sequential binary model which has a logistic spesification.

Sequential binary models are typically used to make the analysis of multinominal choice problem easier. These models transform the multinominal problem into a sequence of binary problems. Sequential models are conveniently analyzed, because the maximum likelihood function of the models is maximized by maximizing repeatedly the likelihood functions of dichotomous (sub)models belonging to the sequential model (The reader is referred to a brief summary in Amemiya 1983, 41-51, a more detailed discussion in Amemiya 1975 and a slightly different version of the models in Uhler and Cragg 1970).

We apply the sequential model directly to our forestry case. Therefore we must start by listing the dependent variable, cutting/selling frequencies. The economic meaning and nature of this variable is discussed in the next chapter. In our data the following frequencies are listed.

(1.) Forest owner has never sold/cut.
(2.) Forest owner has sold/cut less seldom than every third year.
(3.) Forest owner has sold/cut every third year.
(4.) Forest owner has sold/cut every second year.
(5.) Forest owner has sold/cut every year.

We are going to explain why a given forest owner belongs to some particular selling frequency class. First, let us briefly state the multinominal nature of the problem. We denote the selling frequency classes by $Y_1 - Y_5$. Now the probability that a given forest owner j belongs to the selling frequency class i can be expressed in equation 3.1., where b' is a vector of coefficients, X is a vector of explanatory variables and the number of alternatives m is 5 in our case.

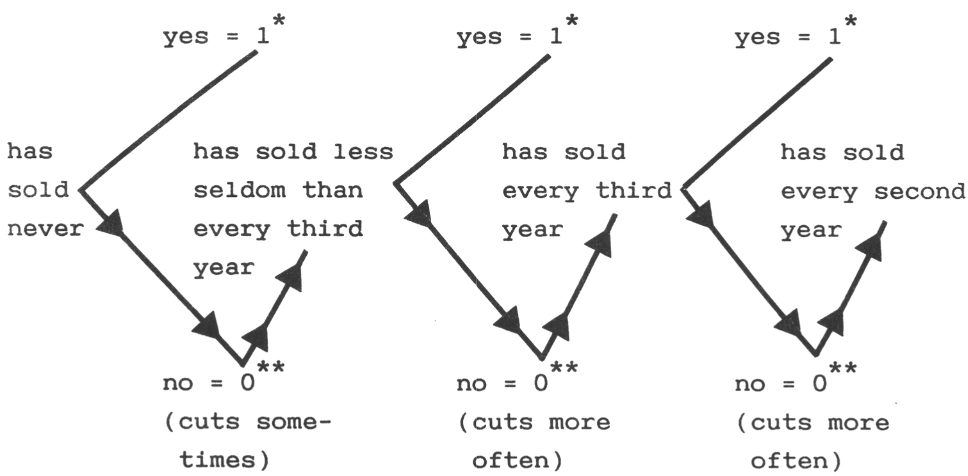
$$2.1 \quad Pr_j(Y_i = 1) = \exp(b'X_{ij}) / \sum_{m=1}^{5} \exp(b'X_{mj})$$

Now the task is to make the multinominal choice problem into a sequence of binary models. This is done step by step, starting from selling frequency class Y_1 and from analyzing the probability of forest owners to belong to this class. Then the same will be done to the following selling frequency classes.

In order to analyze the probability of forest owners to belong to the class Y_1 we form the dependent 1-0 variable in which 1 is "has never sold" and 0 is "has sold sometimes". (The reason for choosing the selling frequency "never" as the starting point is that information about those owners who have a low selling frequency is interesting. For an additional reason, see section 3). This class is analyzed by a given vector of explanatory variables X_k, by predicting the probabilities.

Then follows the analysis to explain the selling/cutting frequency class Y_2. The first task is to drop out the observations of the class Y_1, after which the data contains only those observations that belong to classes Y_2-Y_5. Then the dependent variable must be constructed, again in the 1-0 form. Alternative 1 is now "has sold less seldom than every third year" and alternative 0 is "has sold every third year or more often". After the analysis of this selling frequency class the observations belonging to Y_2 are dropped out and the next dependent variable is formed in 1-0 form for the class Y_3 and so on (see figure 1).

FIGURE 1: Estimation procedure in the binary sequential model



*) Observations belonging to this selling frequency are dropped out before the next estimation.

**) This is the data in the next estimation.

The main features of this estimation procedure are, therefore the right formulation of the dependent variable and the partitioning of the data. Let us now write the probability that a given forest owner belongs to some selling frequency class in a more formal way. Let us assume that the vector of the explanatory variables and coefficients is given by $X_k b_k$ and let F denote the logistic distribution function, then we can write the conditional probabilities of forest owners to belong to some of the selling frequency classes as follows.

$$P_1(Y_1 = 1) = F(b_{1k}X_k)$$

$$P_2(Y_2 = 1) = (1 - F(b_{1k}X_k))F(b_{2k}X_k)$$

$$P_3(Y_3 = 1) = (1 - F(b_{1k}X_k))(1 - F(b_{2k}X_k))F(b_{3k}X_k)$$

$$P_4(Y_4 = 1) = (1 - F(b_{1k}X_k))(1 - F(b_{2k}X_k))(1 - F(b_{3k}X_k))F(b_{4k}X_k)$$

$$P_5(Y_5 = 1) = (1 - F(b_{1k}X_k))(1 - F(b_{2k}X_k))(1 - F(b_{3k}X_k))(1 - F(b_{4k}X_k))$$

The probabilities of the sequential binary model are conditional on the first phase of the procedure. Therefore, one cannot directly say anything about the selling frequency probabilities, only the direction of effects of various variables and their statistical significance can be stated. The last class becomes a residual class which cannot be analyzed. Therefore one must always decide from which class to start.

The interpretation of the coefficients b_k is the usual one: if the coefficient b_k of the k'th variable X_k is positive, then the probability of belonging to the selling frequency class in question is increasing. However, the coefficient does not directly measure the quantitative effect of the change in the explanatory variables X_k, because the effect of their change depends on the level of other variables. The statistical significance of the explanatory variables is measured by the t-test statistics and the significance of the model is measured by the likelihood ratio test.

3. The data, variables and hypotheses

The data used here has been collected from a population which comprises private nonindustrial forest holdings with the minimum of 5 hectares forest land located in rural communes of Finland in 1971. A two stage sampling covering the whole of Finland was applied, and the data consisted of 878 observations (see Järveläinen 1974). Some information was missing in a few variables. We replaced them by the means of these variables.

3.1. The dependent variables

We use two different but related dependent variables in our models. Because our data does not contain direct information about the cutting decisions, we use **tree marking** as a proxy for the cuttings in the conventional binary model. In our opinion tree marking is not a bad proxy for the cutting decision, although some precaution necessary: there may exist a time difference between tree marking and cutting, for example because of waiting for higher timber prices.

The dependent variable in the sequential model is the **cutting/selling frequency.** The selling frequency classes are based on information given by forest owners, not on actual observed behavior. This is, of course, a weakness. It is usually thought that forest owners may not estimate correctly their past cuttings; for example in low selling frequency classes they may underestimate their selling frequencies. In addition the explanatory variable called "the period of ownership" may rank some very new owners to low selling frequencies although they may have a high selling frequency. However, this mainly concerns the class "has never sold" and the observations belonging to that class are dropped out for later estimations. For these two reasons one must be careful with this variable, although it is difficult to say in what way the results will be biased.

3.2. The explanatory variables

Our hypotheses about the effects of the variables are mainly the same as in the literature, we will state them briefly and gather the expected signs in the following table.

TABLE 1: The expected effects of variables on the cutting frequency

Variable	expected sign of coefficient
exogenous **income**	-
residence at the holding	+
the holding is **owned** by one person or family	+
location of the holding (Northern Finland zero case)	+
area of **forest land**	+
continuity of ownership	+
period of ownership	-
area of **cultivated land**	-
ownership type: **nonfarmer** (farmer zero case)	-
price expectations*	
- price is rising	-
- price is declining	+
(constant price is zero case)	

*) Variable is used in the conventional binary model only.

An exogenous income is supposed to decrease cuttings and the selling frequency, because of a lowered need to finance consumption plans by cuttings, therefore the area of cultivated land also has the same effect. Residence at the holding increases knowledge about cutting possibilities and the expected sign is positive. If a person or a family owns the holding time lags caused by administrative procedures will diminish and cutting probability increases. Compared with Northern Finland, other parts of the country have better growth conditions therefore the sign is positive. Greater forest land areas mean greater cutting possibilities, a positive sign.

The continued ownership[1)] of the holding is supposed to increase cuttings and the selling frequency. If, instead, the owner is going to leave the holding, the bequest motive lead him to abstain from cuttings. A short period of ownership is supposed to increase the cutting probabilities, because of the financial needs of the new owners.

If the prices of timber are expected[2)] to rise the owner is supposed to wait until the price has risen to its peak before selling: the expected sign is negative. When the prices are expected to decline owners are supposed to try to sell their timber before the price reaches the bottom, the expected sign is positive.

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1) The question asked was the following: Do you think that the holding will be in the ownership of your family during your life time?

2) The question asked was the following: How do you think the price of timber will change in the future compared with the price of other goods? Will it rise, remain constant or decline?
This variable is used in the conventional binary model only.

4. Estimation and the results

In this chapter we will report the results of both our models. The usual binary model is of secondary interest and therefore will be reported very briefly (see Appendix 1, tables 1-3). However, this chapter will largely concentrate on the results of the sequential binary model (see Appendix 2, tables 4-12).

4.1. The conventional binary model

The results of the conventional binary model are in accordance with some basic findings of earlier studies. Especially, farmers seem to sell their timber more often than nonfarmers. The variables "owning", "residence" and "area of forest land" received significant coefficients and their effects were in accordance with the hypotheses. The price expectations variable was of special interest, because we have not seen such a variable in other studies. However, it was not statistically significant, although the coefficients received expected signs. Lastly, it must be stated that we did not get any definite results for farmers and nonfarmers separately.

4.2. The sequential binary model

Before presenting the results some remarks must be made. In the data there was one observation belonging to the class "cannot tell his selling frequency". This observation was dropped out. The five selling frequencies, mentioned above, had to be combined into four classes by uniting the classes "has sold every third year" and "has sold every second year" because of the low number of observations of nonfarmers in these two classes (and it still remained too low).

The presentation of the results is quite a complicated task, because we have three times three models to report. The precise results are given in Appendix 2, tables 4-12. We have compiled three tables by stating the sign of coefficients and the statistical significance (tables A,B and C). For the sake of readability and clarity we will concentrate here only on the main results.

It can be seen from the tables A-C that the variables of location, forest land area and owning behave mainly according to the hypotheses and the coefficients are mostly significant. The area of cultivated land behaved slightly better than in conventional models. The nonsignificance of the sign of the residence variable was a surprise. The exogenous income behaved mainly according to the hypothesis. The results are also in line with those of conventional binary models.

One of the most interesting questions in this sequential binary model was the possible difference in the selling frequency between farmers and nonfarmers. Farmers constituted the zero case in the estimation and the sign of nonfarmers was supposed to be positive at least for low selling frequencies.

The signs of the coefficients are positive in each class, but statistically significant only in class (2) ("has sold less seldom than every third year"). Actually, the result is quite reasonable. What, for example, would be a special reason for nonfarmers to abstain completely from cutting? On the other hand, the selling frequency class (3) ("has sold every third or second year") is slightly above the mean of selling/cutting frequencies in this data. So, the result indicates the lower propensity of nonfarmers to enter the roundwood market. In addition, the sequential model shows the relevant range of lower cutting propensity.

The results of the sequential binary model are very interesting with respect to the variables of continuity of ownership and the period of ownership. Here we may have something that has not been so clearly pictured in the conventional binary models.

Hypothetically if the owner will not continue his ownership of the holding he will save his forests because of the bequest motive. Therefore the sign of the coefficients of variable continuity should be positive at least for low cutting frequencies, (alternative to continue is the zero case). Indeed the signs are positive in low selling frequencies and negative in the class (3), just as postulated. However, the statistical significance holds true only for class (3). Our conclusion is that the results give only weak support to the hypothesis concerning the influence of the bequest motive.

A short period of ownership (four years or less) was hypothesized to imply high selling frequencies. The results, however, are surprising. The coefficient of the variable received a positive and significant sign in class (1), and a negative and significant sign in the rest (with one exception). This was clearly contrary to the hypothesis. In addition, the results did not change when the classification was increased from 4 to 8 years.

What are the conclusions? Our conjecture is to combine this phenomenon with the earlier one: that most Finnish holdings are inherited and therefore the financial needs at the beginning of ownership are probably not as high as is usually thought. This is partly due to easy possibilities to obtain loans for the facilitating the inheritance (e.g. inheritance tax or payments to other heirs of in the family).

TABLE A: The selling frequencies: All owners

	selling (1)	frequency (2)	class (3)
Explaining variable	**coeff.**	**coeff.**	**coeff.**
income	+	+ (*)	-
owning by a person	- (*)	-	-
(company, heirs zero case)			
location:			
- Southern Finland	- (*)	- (*)	- (*)
- Western Finland	- (*)	- (*)	- (*)
- Eastern Finland	- (*)	- (*)	-
(Northern Finland zero case)			
continuity of ownership	+	+	- (*)
(continues zero case)			
period of ownership	+ (*)	- (*)	- (*)
(over 4 years zero case)			
owner is nonfarmer	+	+ (*)	+
(farmer zero case)			
forest land area (fa)			
- fa < 25 hectares	+ (*)	+ (*)	+ (*)
- 25 < fa < 50 hectares	+ (*)	+ (*	+ (*)
- 50 < fa < 100 hectares	+ (*)	+ (*)	-
- 100 < fa (zero case)			
area of cultivated land (ac)			
- ac < 5 hectares	-	+ (*)	+
- 5 < ac < 11 hectares	-	+	-
- 11 < ac < 17	-	+	-
- 17 < ac (zero case)			
Sample size	877	808	459
Mean of dependent variable	.079	.432	.573
Likelihood ratio test (14.d.f.)	111.6	153.6	79.0
(*) = significant at 95% level			
Proportion of correct predictions	92.59%	69.18%	69.72%

TABLE B: The selling frequencies: Farmers

Explaining variable	selling (1) coeff.	frequency (2) coeff.	class (3) coeff.
income	+	+	-
owning by a person	- (*)	-	- (*)
(company, heirs zero case)			
location:			
- Southern Finland	- (*)	- (*)	- (*)
- Western Finland	- (*)	- (*)	- (*)
- Eastern Finland	- (*)	- (*)	-
(Northern Finland zero case)			
continuity of ownership	+	+	-
(continues zero case)			
period of ownership	+ (*)	- (*)	- (*)
(over 4 years zero case)			
forest land area (fa)			
- fa < 25 hectares	+ (*)	+ (*)	+ (*)
- 25 < fa < 50 hectares	+ (*)	+ (*)	+ (*)
- 50 < fa < 100 hectares	+ (*)	+ (*)	-
- 100 < fa (zero case)			
area of cultivated land (ac)			
- ac < 5 hectares	-	+ (*)	-
- 5 < ac < 11 hectares	-	+	-
- 11 < ac < 17	-	+	- (*)
- 17 < ac (zero case)			
Sample size	686	646	398
Mean of dependent variable	.058	.384	.550
Likelihood ratio test (13.d.f.)	62.4	104.8	70.85
(*) = significant at 95% level			
Proportion of correct predictions	94.17%	68.89%	69.85%

TABLE C: The selling frequencies: Nonfarmers

Explaining variable	selling (1) coeff.	frequency (2) coeff.	class (3) coeff.
income	+	+	-
owning by a person	-	+	+
(company, heirs zero case)			
residence at the holding	+	-	-
location:			
- Southern Finland	-	- (*)	+
- Western Finland	- (*)	- (*)	+
- Eastern Finland	- (*)	- (*)	+
(Northern Finland zero case)			
continuity of ownership	+	-	- (*)
(continues zero case)			
period of ownership	+ (*)	-	- (*)
(over 4 years zero case)			
forest land area (fa)			
- fa < 25 hectares	+ (*)	+ (*)	+
- 25 < fa < 50 hectares	+	+	+
- 50 < fa < 100 hectares	+	-	-
- 100 < fa (zero case)			
Sample size	191	162	61
Mean of dependent variable	.152	.624	.721
Likelihood ratio test (11.d.f.)	35.90	29.18	21.2
(*) = significant at 95% level			
Proportion of correct predictions	86.91%	61.73%	78.69%

5. Discussion

In this study we have analyzed the factors that affect the selling/cutting frequency of forest owners. It was executed by introducing a sequential binary model as a simplification to this multinominal problem. As far as we know, this econometric method has not been applied to the analysis of the selling frequencies before.

We estimated two models: a conventional binary and a sequential binary model in order to compare the results of both models. The dependent variable in the first model was "sell - not sell" dichotomy and the selling frequency constituted the dependent variable in the latter model. Actually, the cutting decision was approximated by tree marking and the selling frequencies based on the announcement of forest owners. This partly reduces the reliability of the results, although the nature of the possible bias cannot be predicted.

The results of the conventional binary model were in line with other studies. Especially, farmers sold their timber more frequently than nonfarmers. However, the results were not so informative compared with those of the sequential model.

The analysis of selling frequencies differs slightly from that of cutting probabilities during a given cutting year, because the cumulated past cutting behavior is now in question. Because of its nature, the sequential binary model handles the data in a much more detailed way than conventional binary models (partitioning procedure versus aggregative analysis) and therefore it also seems to give more information about the data.

The usefulness of the sequential binary model receives strong support in the following three conclusions. The first conclusion supports the results of the conventional binary models and the next two reveal some interesting points for further analysis.

First, our study of the selling frequecies shows that non-farmers have a lower propensity to enter the roundwood market than farmers. Our model also suggests what the relevant range of this propensity would be: the selling frequency class "has sold less seldom than every third year", which is just below the mean of the selling frequencies in the data (see Järveläinen 1974, 76).

Secondly, the model type we used allows the formation of a picture of the owners in each selling frequency class. For example the typical owner in the class "has never sold" either will not continue his ownership (i.e. is going to leave the holding as an inheritance to his children) or has owned the holding for a very short time. Exogenous income, nonfarmership and small area of cultivated land seem to be the characteristics of the owners in the class "has sold less seldom than every third year".

Thirdly, we want to stress a interesting connection between the continuity of ownership and the period of ownership variables. A short period of ownership strongly implies a high probability of belonging to the selling frequency class "has never sold". This provides information about the effects of the system of inheritance in Finland. If most holdings are inherited, the financial needs are not necessarily significant at the beginning of ownership. On the other hand, the continuity of the ownership variable is negative and significant in high selling frequencies. This seems to indicate the influence of the bequest motive of old owners. A full analysis of the effects of the system of inheritance system should, however, include many other additional factors, for example, the effects of inheritance taxation.

If this hypothesis about the effects of the system of inheritance is correct, it certainly has many intresting implications to the forest policy and to the discussion about the willingness of forest owners to sell their timber in the market. However, a further study and more recent data is needed for firmer conclusions.

Lastly, we want to compare the selling frequency and cutting decision as dependent variables and the respective models used in their analysis. In our opinion, these variables are closely related. However, the conventional cutting analysis makes it possible to combine the structural data with some of the market situation dependent variables, such as the price expectations, which is not possible in the analysis of the selling frequencies. These possibilities have not been used very much so far.

The analysis of selling frequencies requires the enlargement of model types towards multinominal models. They, and the simplified sequential binary models lead us to a more closer analysis of the factors affecting the cutting probability over time. In our opinion the sequential binary model has demonstrated its usefulness as a tool in the analysis of the cutting behavior.

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APPENDIX 1: THE RESULTS OF THE CONVENTIONAL BINARY MODEL

TABLE 1: The cutting probability, all owners

Explaining variable	coefficient	t-value
constant	- .6806	- 1.9634
income	- .0010	- 1.0090
owning by a person	.4892	2.3766
(company, heirs zero case)		
location:		
- Southern Finland	.3170	1.1828
- Western Finland	.5523	2.2164
- Eastern Finland	.2867	1.2012
(Northern Finland zero case)		
continuity of ownership	.0351	.2265
(continues zero case)		
period of ownership	.2189	.9483
(over 4 years zero case)		
owner is nonfarmer	- .5780	- 2.2863
(farmer zero case)		
forest land area (fa)		
- fa < 25 hectares	- 1.1306	- 4.7065
- 25 < fa < 50 hectares	- .4913	- 2.1425
- 50 < fa < 100 hectares	- .4998	- 2.1060
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	- .2848	- 1.0283
- 5 < ac < 11 hectares	.0158	.6941
- 11 < ac < 17	- .0489	- .2075
- 17 < ac (zero case)		
price expectations		
- price is declining	.2693	1.5624
- price is rising	- .1525	- .7577
- price is constant (zero case)		

Sample size 878
Mean of dependent variable .5524
Likelihood ratio test value 57.53 with 16 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 66.86%

TABLE 2: The cutting probability, farmers

Explaining variable	coefficient	t-value
constant	- .6652	- 1.6614
income	- .0004	- .1795
owning by a person	.3831	1.6659
(company, heirs zero case)		
location:		
- Southern Finland	.2161	.7136
- Western Finland	.5112	1.8248
- Eastern Finland	.0564	.2080
(Northern Finland zero case)		
continuity of ownership	.1296	.7550
(continues zero case)		
period of ownership	.1991	.7479
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	- 1.1304	- 4.1031
- 25 < fa < 50 hectares	- .5567	- 2.1538
- 50 < fa < 100 hectares	- .4504	- 1.7238
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	- .2343	- .7909
- 5 < ac < 11 hectares	.0790	.3268
- 11 < ac < 17	- .0094	- .0390
- 17 < ac (zero case)		
price expectations		
- price is declining	.3495	1.8387
- price is rising	.0138	.0615
- price is constant (zero case)		

Sample size 687
Mean of dependent variable .3382
Likelihood ratio test value 35.19 with 16 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 64.48%

TABLE 3: The cutting probability, nonfarmers

Explaining variable	coefficient	t-value
constant	- 1.8910	- 2.2306
income	- .0016	- 1.0359
owning by a person	1.0384	2.0039
(company, heirs zero case)		
residence at the holding	.0457	.1036
(residence elsewhere zero case)		
location:		
- Southern Finland	.7799	1.1208
- Western Finland	.7312	1.0929
- Eastern Finland	1.3170	2.1009
(Northern Finland zero case)		
continuity ownership	- .4135	- 1.0568
(continues zero case)		
period of ownership	.4653	.8959
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	- 1.0648	- 1.8647
- 25 < fa < 50 hectares	.1770	.3063
- 50 < fa < 100 hectares	- .7129	- 1.0229
- 100 < fa (zero case)		
price expectations		
- price is declining	.1269	.2923
- price is rising	- .8827	- 1.7466
- price is constant (zero case)		

Sample size 191
Mean of dependent variable .2251
Likelihood ratio test value 22.58 with 13. d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 76.96%

APPENDIX 2: THE RESULTS OF THE SEQUENTIAL BINARY MODEL

TABLE 4: The selling frequency: Has never sold, all owners

Explaining variable	coefficient	t-value
constant	- 3.1678	- 4.2290
income	.0009	.8678
owning by a person	- .6765	- 2.0998
(company, heirs zero case)		
location:		
- Southern Finland	- 1.7618	- 3.8237
- Western Finland	- 1.5313	- 3.6929
- Eastern Finland	- 1.6492	- 3.9505
(Northern Finland zero case)		
continuity of ownership	.3050	.9700
(continues zero case)		
period of ownership	2.0507	6.5671
(over 4 years zero case)		
owner is nonfarmer	.2512	.5376
(farmer zero case)		
forest land area (fa)		
- fa < 25 hectares	2.4086	3.7809
- 25 < fa < 50 hectares	1.9158	3.0051
- 50 < fa < 100 hectares	1.5478	2.4528
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	- .0178	- .0327
- 5 < ac < 11 hectares	- .4771	- .9960
- 11 < ac < 17	- 1.0446	- 1.6932
- 17 < ac (zero case)		

Sample size 877
Mean of dependent variable .0787
Likelihood ratio test value 111.56 with 14 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 92.59%

TABLE 5: The selling frequency: Has never sold, farmers

Explaining variable	coefficient	t-value
constant	- 3.2527	- 3.2534
income	.0015	.2891
owning by a person	- .8623	- 2.1343
(company, heirs zero case)		
location:		
- Southern Finland	- 2.1002	- 3.3901
- Western Finland	- 1.7284	- 3.2282
- Eastern Finland	- 1.7434	- 3.2878
(Northern Finland zero case)		
continuity of ownership	.4933	1.1696
(continues zero case)		
period of ownership	2.1560	5.3270
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	2.6328	3.0416
- 25 < fa < 50 hectares	2.2456	2.6385
- 50 < fa < 100 hectares	1.6888	2.0154
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	- .0440	- .0701
- 5 < ac < 11 hectares	- .5760	- 1.0654
- 11 < ac < 17	- 1.1409	- 1.7658
- 17 < ac (zero case)		

Sample size 686
Mean of dependent variable .0583
Likelihood ratio test value 62.43 with 13 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 94.17%

TABLE 6: The selling frequency: Has never sold, nonfarmers

Explaining variable	coefficient	t-value
constant	- 2.7329	- 2.5923
income	.0006	.4498
owning by a person	- .3905	- .7070
(company, heirs zero case)		
residence at the holding	.0793	.1508
(residence elsewhere zero case)		
location:		
- Southern Finland	- 1.3684	- 1.9140
- Western Finland	- 1.3902	- 2.0313
- Eastern Finland	- 1.6858	- 2.3533
(Northern Finland zero case)		
continuity of ownership	.0272	.0561
(continues zero case)		
period of ownership	1.9606	3.6859
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	2.1120	2.2034
- 25 < fa < 50 hectares	1.4766	1.5185
- 50 < fa < 100 hectares	1.4525	1.4547
- 100 < fa (zero case)		

Sample size 191
Mean of dependent variable .1518
Likelihood ratio test value 35.90 with 11 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 86.91%

TABLE 7: The selling frequency: Has sold less seldom than every third year, all owners

Explaining variable	coefficient	t-value
constant	- 1.1168	- 3.0391
income	.0027	2.3575
owning by a person	- .0062	- .0286
(company, heirs zero case)		
location:		
- Southern Finland	- .8211	- 2.8334
- Western Finland	- 1.2776	- 4.6361
- Eastern Finland	- 1.0021	- 3.8864
(Northern Finland zero case)		
continuity of ownership	.1230	.7523
(continues zero case)		
period of ownership	- 1.0260	- 3.4764
(over 4 years zero case)		
owner is nonfarmer	1.0999	4.0736
(farmer zero case)		
forest land area (fa)		
- fa < 25 hectares	2.0869	7.6681
- 25 < fa < 50 hectares	1.0409	3.9063
- 50 < fa < 100 hectares	.6361	2.3063
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	.7329	2.5104
- 5 < ac < 11 hectares	.1677	.6548
- 11 < ac < 17	.1568	.5926
- 17 < ac (zero case)		

Sample size 808
Mean of dependent variable .4319
Likelihood ratio test value 153.61 with 14 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 68.18%

TABLE 8: The selling frequency: Has sold less seldom than every third year, farmers

Explaining variable	coefficient	t-value
constant	- 1.4166	- 3.2056
income	.0039	1.6876
owning by a person	- .0931	- .3694
(company, heirs zero case)		
location:		
- Southern Finland	- .6593	- 1.9842
- Western Finland	- 1.2545	- 3.9379
- Eastern Finland	- .8751	- 2.9228
(Northern Finland zero case)		
continuity of ownership	.1556	.8499
(continues zero case)		
period of ownership	- 1.0960	- 3.0352
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	2.2945	6.9218
- 25 < fa < 50 hectares	1.2447	3.8766
- 50 < fa < 100 hectares	.8850	2.7373
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	.8128	2.5406
- 5 < ac < 11 hectares	.2014	.7272
- 11 < ac < 17	.1772	.6446
- 17 < ac (zero case)		

Sample size 646
Mean of dependent variable .3839
Likelihood ratio test value 104.83 with 13. d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 69.89%

TABLE 9: The selling frequency: Has sold less seldom than every third year, nonfarmers

Explaining variable	coefficient	t-value
constant	1.3967	1.7751
income	.0022	1.6564
owning by a person	.4064	.9134
(company, heirs zero case)		
residence at the holding	- .3536	- .8175
(residence elsewhere zero case)		
location:		
- Southern Finland	- 2.1865	- 2.9347
- Western Finland	- 2.0007	- 2.7565
- Eastern Finland	- 2.3022	- 3.2720
(Northern Finland zero case)		
continuity of ownership	- .1205	- .3129
(continues zero case)		
period of ownership	- 1.0247	- 1.7945
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	1.5610	2.8249
- 25 < fa < 50 hectares	.5375	.9520
- 50 < fa < 100 hectares	- .2519	- .4078
- 100 < fa (zero case)		

Sample size 162
Mean of dependent variable .6235
Likelihood ratio test value 29.18 with 11 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 61.73%

TABLE 10: The selling frequency: Has sold every third or second year, all owners

Explaining variable	coefficient	t-value
constant	1.1348	2.5046
income	- .0012	- .6752
owning by a person	- .5307	- 1.8840
(company, heirs zero case)		
location:		
- Southern Finland	- .9956	- 2.4993
- Western Finland	- .7522	- 2.0644
- Eastern Finland	- .2339	- .6751
(Northern Finland zero case)		
continuity of ownership	- .5027	- 2.2973
(continues zero case)		
period of ownership	- 1.0262	- 3.0706
(over 4 years zero case)		
owner is nonfarmer	.6068	1.5656
(farmer zero case)		
forest land area (fa)		
- fa < 25 hectares	2.0822	5.5916
- 25 < fa < 50 hectares	1.1533	3.8423
- 50 < fa < 100 hectares	- .0877	- .2924
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	.0149	.0369
- 5 < ac < 11 hectares	- .4458	- 1.4337
- 11 < ac < 17	- .5788	- 1.8636
- 17 < ac (zero case)		

Sample size 459
Mean of dependent variable .5730
Likelihood ratio test value 78.97 with 14 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 69.72%

TABLE 11: The selling frequency: Has sold every third or second year, farmers

Explaining variable	coefficient	t-value
constant	1.4678	2.9366
income	- .0015	- .5257
owning by a person	- .6875	- 2.2093
(company, heirs zero case)		
location:		
- Southern Finland	- 1.3638	- 3.1321
- Western Finland	- 1.0846	- 2.7450
- Eastern Finland	- .3599	- .9672
(Northern Finland zero case)		
continuity of ownership	- .4154	- 1.7753
(continues zero case)		
period of ownership	- .7287	- 1.9779
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	2.2433	5.4815
- 25 < fa < 50 hectares	1.2221	3.7096
- 50 < fa < 100 hectares	- .8425	- .2591
- 100 < fa (zero case)		
area of cultivated land (ac)		
- ac < 5 hectares	- .0918	- .2177
- 5 < ac < 11 hectares	- .6247	- 1.9092
- 11 < ac < 17	- .6609	- 2.0756
- 17 < ac (zero case)		

Sample size 398
Mean of dependent variable .5503
Likelihood ratio test value 70.85 with 13 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 69.85%

TABLE 12: The selling frequency: Has sold every third or second year, nonfarmers

Explaining variable	coefficient	t-value
constant	1.2647	.6468
income	- .0034	- 1.2561
owning by a person	.0313	.0344
(company, heirs zero case)		
residence at the holding	- .6218	- .5486
(residence elsewhere zero case)		
location:		
- Southern Finland	1.5466	.9598
- Western Finland	1.7510	1.0975
- Eastern Finland	.6959	.4679
(Northern Finland zero case)		
continuity of ownership	- 1.9055	- 2.0983
(continues zero case)		
period of ownership	- 2.7749	- 2.4891
(over 4 years zero case)		
forest land area (fa)		
- fa < 25 hectares	2.2762	1.4775
- 25 < fa < 50 hectares	2.2024	1.7764
- 50 < fa < 100 hectares	- .0101	- .0094
- 100 < fa (zero case)		

Sample size 61
Mean of dependent variable .7213
Likelihood ratio test value 21.20 with 11 d.f.
Critical t-test value at 95% level 1.96
Proportion of correct predictions 78.69%

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