Market Price for Forest Estates – Outline of a Mathematical Model

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Abstract

The main purpose of this research is to develop a model for calculating the market value of small-scale forest owner estates. Since the beginning of the 1990s the market prices for these estates have in Sweden differed markedly from the price development of timber. This is not logic if the yield of the timberland is the only variable related to the market price. In this paper we will differ between the monetary and the non-monetary parts of the market price for an estate. The monetary part depends on the state of the forest, for example standing volume and yield, and the roundwood prices. The non-monetary part depends on factors as sentimental reasons, attachment to the area, right of control" and pride of ownership. From a database based on data from brokers of forest estates that up to the date for the calculation have been sold are derived. Based on these data an average forest estate is constructed, i.e., an estate for which we know the forest area, standing volume per age class and market value. Based on a set of equations, value per age class j and m^3 is estimated. As the market value for the average estate is known and the production value has been calculated the non-market value can be calculated as the difference.

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INTRODUCTION

In the very beginning God created the world. He created darkness and light. He created water and land. Since that very day no land has been produced – possibly this is the reason why today market prices for agriculture and forestland are so high as they are?

Let us take Sweden as an example. During several decades the Swedish market for estates was controlled. A basic difference was made between inheriting and buying an estate. Estates that were bought needed a special permit and a calculated price was set by a public authority. Of course this meant that a true market value did not exist. The price on such a market will behave in a predictable way.

In the beginning of the 1990s with few exceptions the law was changed and a free market was established. The control came to an end. Figure 1 illustrates the price development after the change.

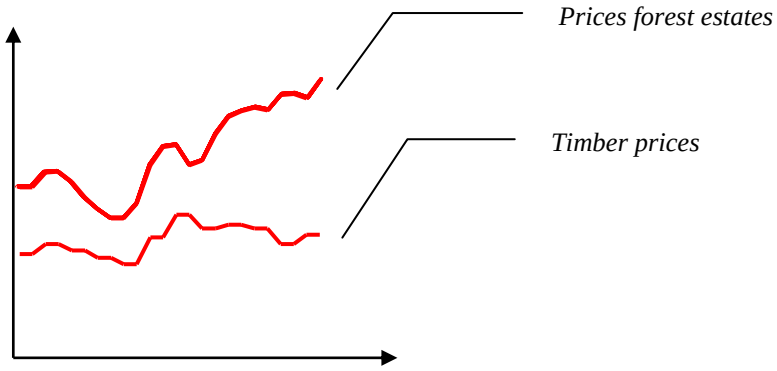

Figure 1. The prices for forest estates compared with prices for timber, the period 1989 - 2001. Source: Lantmäteriets Minienkät and Skogsbarometern LRF & Föreningssparbanken

As can be seen for the later part of the period the market prices for forest estates differ markedly from the price development of timber. This is not logic if the yield of the timberland is the only variable related to the market price. The price estimation models, which were used during the period of authority control, have obviously omitted some explanatory variables, something that has nothing to do with the yield of the timberland. We claim that the market price can be explained from two groups of variables: monetary and the non-monetary variables, respectively. Thus, in this paper we will differ between

- The monetary value
- The non-monetary value

The main purpose of this research is to develop a model for calculating the market value. For estimating the market value we will both calculate the non-monetary and the monetary values. Torbjörn Sundelin is doing the research as a Ph.D.-project.

It should be noted that our main interest is in timberland owned by non-industrial private forest owners or small-scale forest owners. We are not interested in why someone is willing to pay more than what is economically. However, we notice that one component – the non-monetary value – has a great influence on the price picture. In his thesis Lindeborg (1986) makes the same observation.

The monetary value

Calculation of the monetary value or the net present value is not an issue without problems. The reason for this is that the rotation period[1] in Sweden is between 70 – 130 years. The variation depends mostly on at which degree of latitude and from which distance to the sea level the timberland is situated.

In average, there is a change of estate owners every 15 – 25 years (Persson et al. 1983; Lönnstedt and Törnqvist 1990). An investment calculation, with a rotation period of 100 years, therefore will extend over about four generations of owners. This will have a major influence on the management of the estate. Besides, assumptions about timber prices, tax laws, catastrophes, etc will have a great influence on the result. An adequate question therefore is weather a calculation should extend over a rotation period or a shorter period?

During the years different models have been presented. Most of them are related to Faustman (1849). Theoretically it is an elegant model, which calculates the net present value (NPV) for a single rotation period. In spite of its elegance it has some weaknesses.

- It is for example extremely sensitive for the level of the interest rate. Small changes in interest rate cause huge differences in NPV.
- Besides inaccuracies in the description of the timberland will be accumulated during the rotation period and quite substantially influence the result.
- Finally, during a rotation period so much will change technically, economically and politically that most of the precautions that were valid at the time for the calculation cannot be regarded as constants during the period.

It would be quite interesting to make an economic calculation of the red wood forest in California where the rotation period lasts for a couple of thousands of years (figure 2).

[1] Defined as the period between planting and at the moment when the sum of grows of volume and the grows of value are below the rate of interest.

Figure 2. General Sherman. Photo NPS

The non-monetary value

The NPV will certainly be directly effected by the prices of timber, the growth and the costs of forestry, but how will the non-monetary value develop? The value includes future expected values and sacrifices (Kalbro 1998). One question is therefore how the non-monetary value will change over time?

Studies for explaining the non-monetary value exist. Lindeborg (1986) shows that "the most important non-monetary motives for holding forest properties include sentimental reasons, attachment to the area, right of control" and pride of ownership. The same author (Lindeborg 1989) describes two methods for estimating a market value:

- statistic interference
- simulation of the market

Now and then it is possible to see calculations where the interest rate has been changed in order to include the non-monetary value to the NPV. This method does not have theoretical support. (Paulsson 2002) However, the main impression is that relevant methods and models for explaining the non-monetary value are lacking.

Why market value?

Felling reduces the market value while growth and forest management activities increase the value. Growth is an ongoing process while harvesting is performed irregularly. Given the influence of these variables and a dynamically calculated market value it is possible to optimize the economy. (Figure 3).

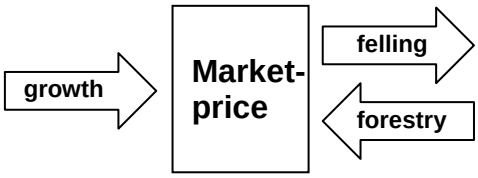

Figure 3. It is possible to optimize the economy only if the market value can be dynamically calculated

Production value is only generated by growth and revenue from felling. Both production value and revenue can be effected by different management activities. It should be stressed that felling transfers financial values from the "forest bank" to the financial values.

MATERIALS AND METHODS

Creation of a database

A fundamental aspect for estimations is a reliable database. For the time being such a database, with relevant and actual statistics of market prices and state of the forest for sold forest estates, does not exist. However, the information exists by the brokers but it is not collected. Thus a computer program is constructed which makes it possibly for the brokers to connect their PC:s to the university computer system. Our idea is to create such a database through promising that if they deliver data about sold forest estates they will receive information about an estimated market value for new objects. An option for the brokers is to up-date an old forest management plan. They can also print sales documents. The license for this program will be free. (As a start data from the National Forest Survey will be used, more about this in the next section.)

Definitions and assumptions

Length of period

In all businesses when making decisions and consequence analyses it is necessary to use planning period that is possible to survey. In this case we have chosen a period of ten years. Reasons for this is the Forest Act and the forest management plan have the same time horizon.

Management

If not in conflict with the Forest Act cuttings followed by regeneration activities will in the model be done in stands where the sum of increment and increased value added is less than the chosen interest rate.

Value of standing volume

An estimate of the value of the standing volume requires likely distributions of dimensions and adapting rules. In order to achieve this Sweden has been divided into a number of regions. For each region a number of typical stands have been identified. Statistics about these typical stands have been found from the *Swedish National Forest Inventory* Further more list of prices for each region is introduced and regularly updated.

Model

The Faustman formula calculates the net present value (NPV) for a rotation period as follows:

$$\mathbf{NPV} = \Sigma\, \mathbf{N_t / (1+i)^t} \qquad (n = 0, 1, \ldots, n) \qquad \mathbf{....(1)}$$

NPV = net present value
N_t = net cash flow in year t (R_t - C_t)
R_t = revenue in year t
C_t = expenditure year t
n = r = rotation length
i = discount rate

If we instead of a rotation period chose a possible surveying period of ten years the equation looks like:

$$\mathbf{NPV_{10}} = \Sigma\, \mathbf{N_t / (1+i)^t} \qquad (n = 0, 1, \ldots, 10) \qquad \mathbf{....(2)}$$

If by cuttings (compare with the section above about "Management") the value of the standing volume for a forest estate is transferred into money/capital the sum of the transferred capital and the remaining value of the standing volume will be equal to the value of the estate at the beginning of the period. If this value is called $\mathbf{W_0}$, the net from the cuttings $\mathbf{NPV_{10}}$ and the remaining value of the standing volume at the end of the period (year 10) $\mathbf{W_{10}}$ the following equation will be true:

$$\mathbf{W_0} = \mathbf{NPV_{10} + W_{10} / (1+i)^{10}} \qquad \mathbf{....(3)}$$

In next calculation step the total stumpage price value of the forest is estimated. This value will be directly proportional to actual roundwood prices for all values that have reached cutting age according to the Forest Act and the above stated economic criteria. Standing volumes that do not fulfil these criteria will receive the same price reduced by the interest for the remaining time to minimum age for harvest.

In its simplest form the relationship price – age of the tree has the principle appearance shown in Figure 4.

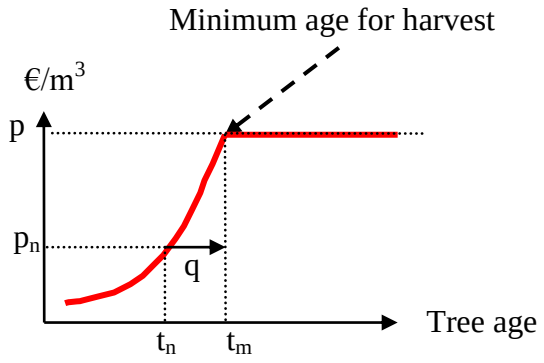

Figure 4. The timber price (p) per m^3 will be reduced according to remaining years to age of cutting.

The value of standing volumes that because of the economic criteria or the Forest Act cannot be cut are charged with a calculation rate estimated in the following way:

$$\mathbf{p_n} = \mathbf{p^* (1 + i)^{(-q)}} \quad t \le t_m \quad \textbf{….(4)}$$
$$\mathbf{q} = \mathbf{0} \quad t > t_m \quad \textbf{….(5)}$$

t = age of tree or stand
p = roundwood price per m^3
q = remaining years until minimum cutting age

Because of the proportional relationship between the value of stumpage volumes and the standing volume value the equation above can be written as:

$$\mathbf{w_j} = \mathbf{K^* p^* (1 + i)^{(-q)}} \quad t \le t_m \quad \textbf{....(6)}$$
$$\mathbf{q} = \mathbf{0} \quad t > t_m \quad \textbf{....(7)}$$

$$\mathbf{W_0} = \mathbf{w_j} * \Sigma \square\ \mathbf{v_{j,0}} \quad j = 1,2,...,12 \quad \textbf{....(8)}$$
$$\mathbf{W_{10}} = \mathbf{w_j} * \Sigma \square\ \mathbf{v_{j,10}} \quad \textbf{....(9)}$$

w_j = value per age class j and m^3
K = constant
j = age class
$v_{j,a}$ = total standing volume for age class j at age a

In the next calculation step the constant **K** will be estimated through iteration. Following this all values ($\mathbf{w_j}$) for the different age classes will be estimated.

Statistical calculation

Statistical treatment

From the database data for all forest estates that up to the date for the calculation have been sold are derived. Based on these data an average forest estate is constructed, i.e., an estate for which we know the forest area, standing volume per age class and market value. Based on the formulas presented above, parameter $\mathbf{w_j}$ is estimated. As the market value for the average estate is known and the production value has been calculated the non- monetary value (**U**) can be calculated as the difference:

$$\mathbf{M} = \mathbf{W + U} \quad \textbf{....(10)}$$

M_n = Market value, year n
U = Non-monetary value

Value estimate

For the estate under consideration we will first of all calculate the volume that is possible to fell during a ten-year period. The same procedure as above will be followed but this time when calculating the market value at the tenth year the estimated parameters will be used. Finally the non-monetary values will be calculated,

also by using parameters that have been estimated through the procedure described above.

The final result has to be adjusted. For example, how does the forest area effect the non-monetary value, access to the sea and lakes, combined livelihood from agriculture land etc.? For the moment we have no experience from these adjustments but through the database based on broker data we will gain enough knowledge for making these adjustments. Our hypothesis is that estates with a large forest area have a relative low non-market value per hectare because a limited number of possible buyers.

Nearness to economic wealth and population

Another dimension worth to study is the connection between the non-monetary value and economic wealth and population in the actual region. This is still another way for adjusting when calculating the non-monetary value and could therefore verify and maybe also increase the precision of the calculation.

One theory is that the non-monetary value (**U**) is proportional to the number of inhabitants in a region and inversely proportional to a function with the distance to that region.

$$U(pn) = P / f(d) \qquad \ldots (11)$$

P = population
d = distance

As all regions will influence the results, and will be summed up as follows

$$U(p) = C * \Sigma (P_i / f(d_i)) \qquad \ldots (12)$$

Population (P) could be replaced with **P * K** where **K** is the average income in the region, alternatively the average wealth. All different regions are compared to that region in Sweden that reaches the highest sum. Therefore the result could be presented as a percent of that value. The distance could be measured with the help of GIS-coordinates.

Comment

When enough sales have been received from the brokers a most valuable database has been established. The database will continuously be updated by new sales. During the first years the precision of the market estimates will improve. The database will also be an important contribution to the scientific community, maybe the most valuable contribution from this project.

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