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SAWTIMBER MARKETS AND BUSINESS CYCLES IN THE FINNISH SAWMILLING INDUSTRY

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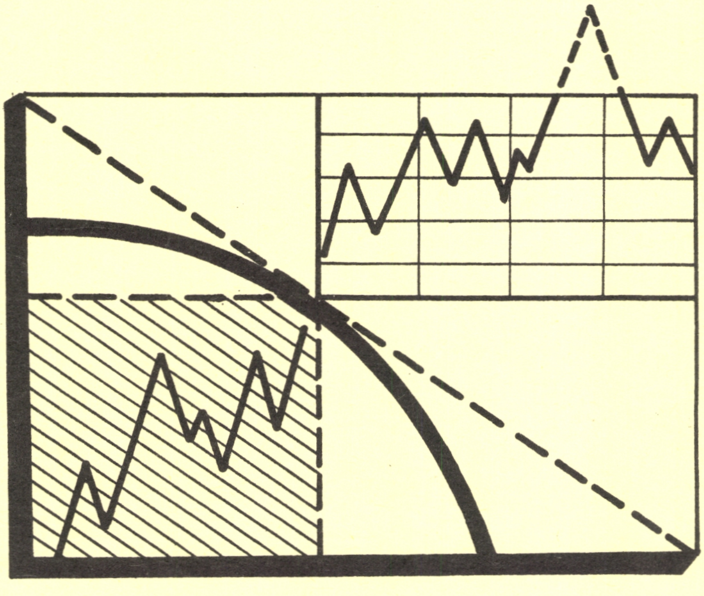

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SAWTIMBER MARKETS AND BUSINESS CYCLES IN THE FINNISH SAWMILLING INDUSTRY

Results of a preliminary study

This paper is an abridged version of KUULUVAINEN, JARI 1981. Sahateollisuuden suhdannevaihtelut ja sahatukin markkinat Suomessa, esitutkimus (Business cycles in the sawmilling industry and the sawtimber markets in Finland, preliminary study). Kansantaloustieteen laudatur-tutkielma. University of Helsinki. 89 p. (in Finnish).

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KUULUVAINEN, JARI. 1982. Sawtimber Markets and the Business cycles in the Finnish Sawmilling industry. Metsäntutkimuslaitoksen tiedonantoja 63. 1-37.

ASBSTRACT: The paper examines Business cycles in the sawmilling industry and in the sawtimber markets using relative changes of selected variables and gross correlation analysis. Based on the results of this time series analysis, a preliminary econometric model for the sawtimber markets in Finland is constructed and estimated using single equation estimation and ordinary least squares. The model consists of three demand equations (demand for production, and two equations explaining behaviour of the sawtimber stocks), and the supply equation for sawtimber. The estimations of demand and stock equations are considered satisfactory, while the supply equation behaves poorly. The results of estimations and the reasons for the poor behaviour of the supply side of the model are shortly discussed. An outline is given of the study´s continuation.

1. BACKGROUND OF THE STUDY

The purpose of this study is to formulate a theoretically justified model in order to describe and explain the functioning of the sawtimber markets in Finland. We feel that the microfoundations of the behaviour of the roundwood markets has gained all too little attention in Finland so far. An example of the growing interest to this type of approach is the recent article by Ollonqvist (1980) dealing with stumpage prices, price expectations and transportation costs of roundwood and their effect on the profitability of the forest industry firm. The article by Ollonqvist and the econometric study of sawtimber markets by Korpinen (1979) raised up the important problem of the expected prices and their effect on supply and demand for timber. In spite of the difficulties in measuring the expectations in empirical models, their role should at least be theoretically discussed. The singnificance of expected prices has been noticed earlier in different contexts (e.g. Sivonen 1965 p. 49 and Nissilä 1978, p. 14). The explicit consideration of them was initiated by Korpinen (1979). His specification of the price expectations of the private forest owners is based on the "return to normal" hypotheses. The stumpage price of the previous period (t-1) is, in his model, assumed to describe the normal level. Specification is therefore greatly simplified and the price expectations of the sawmilling industry firms are not considered. Ollonqvist, on the other hand, considers representative price taking, forest industry firm producing one homogeneous product and using as input homogeneous wood raw material and labour. He comes to the conclusion that the stumpage price has different effects on the profitability of the firm depending on whether the price expectations of the forest owners are based on past development of stumpage price alone or on the development of the export price.

Important topic of the study of economic cycles in the sawmilling industry is the speed of the transmission of the business cycles from export markets to the roundwood markets. Measuring the lengths of the lags has been handicapped by the lack of monthly and quarterly time-series data. Only semi-annual data is available from the roundwood markets. Nevertheless, an empirical study of business fluctuations is bound to be unsatisfactory without explicit examination of the lags, even though theory gives very little background to this kind of a study.

It has been suggested that decisions concerning raw material stocks are reinforcing the relative fluctuations in economic activity of the Finnish roundwood markets (Palo 1974). The role of the stocks in the Finnish roundwood markets has not so far been systematically studied. The empirical question related to "inventory cycles" is how to measure the demand and supply. Traditionally, the volume of the commercial fellings has been used to describe the demand-supply situation at the roundwood markets and the volume of shippings to describe the demand-supply situation at export markets. However, when using semi-annual, quarterly or monthly data both of these time-series contain a possibility of systematic error when used to measure supply and demand. In this work, therefore, the purchases of sawtimber and the export sales of lumber will be used instead. The former has been collected with sample from the basic data on forest taxation and the latter has been obtained directly from the archives of the Finnish Sawmill Owners´ Association.

The purpose of this project is to construct a sawtimber market model to study the transmission of business cycles from export lumber markets through the sawmilling industry to the Finnish sawtimber markets. The international transmission of business fluctuations, and their effect on the balance of payments and on employment, are not included in the study. Also, the domestic consumption of lumber and the demand for sawtimber in the other branches of the forest industries are not examined. In this paper a preliminary sawlog market model and some experimental estimations of the model are presented.

Because the following terms will be used without further definition, they are presented below in chronological order, asumming that at a certain point of time there is a change in export sales and in roundwood purchases.

Sawmilling industry	Roundwood markets
Export sales (- sales price)	Purchases of sawtimber (- stumpage price)
↓	↓
Production	Stocks of standing timber
↓	↓
Lumber stocks	Commercial fellings
↓	↓
Export shippings (-export price)	Stocks at roadsides (-delivery price)
	↓
	Transportation
	↓
	Stocks at factory (- factory price)
	↓
	Production

2. TIME-SERIES ANALYSIS

2.1. Relative changes

The examination of the relative changes revealed some interesting observations (see also APPENDICES 1 - 4). Firstly, relative changes in the volume of the export sales of lumber were considerably stronger than relative changes in the volume of the purchases of sawtimber in the roundwood markets. Therefore, the hypotheses that fluctuations get stronger while moving from secondary to primary production is, in this case, rejected. On the other hand, fluctuations in shippings and production are weaker than in purchases of sawtimber and in commercial fellings. Further, the relative changes in volume both in the roundwood markets and in export markets are considerably stronger than the relative changes in the prices. Table 1 presents the standard deviation and the minimum and maximum values of the logarithmic differences of the time series describing the economic activity in the sawmilling industry and in the lumber markets.

Table 1. Standard deviations of the logarithmic differences of the variables from the sawmilling industry and sawtimber markets. The differences are calculated from semi-annual data smoothed with two-term gliding sums.

$$\text{log diff.} \qquad \log\left(\frac{Y_t}{Y_{t-1}}\right) \cdot 100$$

Variable	standard dev.	min	max
Lumber export price in real terms	7	- 23 (1975, II)	22 (1974, I)
Lumber export sales	38	- 179 (1974, II)	97 (1975, II)
Lumber export deliveries	10	- 28 (1975, I)	19 (1976, I)
Lumber production	7	- 19 (1975, II)	16 (1976, II)
Sawtimber, stumpage price in real terms	11	- 19 (1975, II)	38 (1974, I)
Sawtimber, purchases (private non-industrial forests)	25	- 91 (1965, II)	74 (1976) II)
Sawtimber, commercial fellings	11	- 26 (1975, I)	23 (1976, II)
Sawtimber, stocks	12	- 21 (1975, II)	31 (1973, II)

2.2. Cross-correlation analysis

In this section the relationships between lumber export markets, the sawmilling industry in Finland and the roundwood markets are examined using cross-correlation functions. (Data is semi-annual. When possible results are compared to cross-correlation functions calculated from quarterly or monthly data.)

Strong negative correlation emerges between unlagged export sales and the unit value of the shippings (= export price). There is, however, a positive correlation between these two when export sales are lagged by three periods. It therefore seems that price adjustments are considerably slower than quantity adjustments (APPENDIX 5a). The long lag can be partly explained by the time difference between sales and shippings. The unit value is recorded at the date of delivery. However, if actual sales prices are used (monthly sales prices are available from 1970 - on wards) the lag of one year remains.

The strongest positive correlation between export shippings and export sales arises when sales are lagged by one period, and between production and sales when sales are lagged by two periods. The relationship between shippings and sales seems logical, but the lag between production and sales is amazingly long. It means that changes in the export sales cause the strongest reaction in production only after half to one year. When using quarterly data, the lag is three quarters (APPENDIX 5b).

The changes in export sales are transmitted to the roundwood markets in one year. The strongest positive correlation between export sales and purchases of sawlogs occurs when export sales are lagged by two periods (= one year). The lag between export sales, stumpage prices and stocks of sawtimber is even longer (from one to one and a half years). It seems, therefore, that instead of buying raw material before hand based on expected development in sales, the sawmilling industry is adjusting sawtimber purchases according to earned export incomes from already realized sales and production. The income effect from export sales would therefore have a stronger effect on raw material purchases than the anticipated sales. The reason for this behaviour also partly rests in the taxation of profits and undervaluation regulations of stocks. Further, in the roundwood markets quantities are adjusting faster than prices. The correlation between stumpage price and purchases is strongest when purchases are lagged by one period (APPENDICES 6 and 7).

The central problem of the present study is the role of the raw material stocks in the business cycles of the roundwood markets. When comparing export sales and sawtimber purchases the relative changes are stronger in sales. However, the production of lumber and the lumber prices are fluctuating considerably less than purchases of sawtimber and stumpage prices. Is the reason for the strong fluctuations in prices and quantities solely the strongly fluctuating export sales (= income); or do the inventory decisions and price speculations play a role in the development of business cycles in the roundwood markets?

When comparing production volume with the stocks at roadsides and at the factories, there is strong positive correlation between unlagged series. The peak of the cross-correlation function is wide, however, and the strongest correlation occurs when the end-of-period stocks follow production by half a year (production lagged by one period). Correlation between stocks of standing timber and production are strongest when comparing unlagged series. However, stocks of standing timber should be compared with commercial fellings. It can be assumed that the dependence between them is of the same character as between production and the stocks alongside roads and at factories. In this case, also, correlation was strongest when comparing unlagged series. (APPENDIX 8).

Also of importance is the dependence between export and stumpage prices, price expectations, and their bearing on inventory decisions. Positive correlation between prices (stumpage and export) and stocks of standing timber is strongest when the beginning-of-period stocks and the same period prices are compared. The possibility of price expectations affecting the invetory decisions remains.

3. THE TIMBER MARKET MODEL

3.1. Demand for stumpage to produce lumber

The demand for sawtimber is derived from the demand for lumber. The capital input can be taken as given in the short run. The production function of the sawmilling industry is typically an input-output production function ex post. The relationship between rawmaterial (sawtimber) and the output (lumber) is linear and approximately fixed, also ex ante. Changing the input-output relationship in the sawmilling industry is possible only by changing the relationship between the side-products (e.g. chips) and the end product (lumber). The production function with rawmaterial as the only limiting factor, is therefore

(3.1.1) $$Y = \frac{1}{\alpha} x$$

Y = production (m^3)
x = rawmaterial (m^3)
α = input coeficient

It is assumed that a representative firm has limited market power both at its end-product and at its raw material markets. The assumption at the end-product market is justified by the fact that quantities are fluctuating considerably more than prices. At the raw material markets, on the other hand, the number of sellers is large compared to the amount of buyers. Also in the roundwood markets, prices have fluctuated less than quantities. Although the above assumptions are disputable, they are used as working hypotheses in the study. From the profit function of the representative firm

(3.1.2) $\Pi = P(Y)Y - q(x)x,$

where

Π = profit

P = lumber price

q = stumpage price

we obtain the equilibrium condition:

(3.1.3) $MR = q(x)/P(\frac{x}{\alpha}) = (1+\eta)/[\alpha(1+\theta)] = MC,$

where

$$\eta = \frac{\partial P/\partial Y}{P/Y} \text{ and } \theta = \frac{\partial q/\partial x}{q/x}$$

The profit maximizing monopolistic behaviour assumed by the above equilibrium condition can, however, be regarded as a long term phenomenon. It would also seem realistic to assume that the monopolistic features are most relevant if the sawmilling industry in Finland as a whole can be thought of as having a common pricing policy, or at least some cooperation in pricing. However, when considering a single enterprise and its market behaviour in the short run, the representative firm is probably close to a price-taker desiring some minimum acceptable profit for it to continue production. In figure 1 this model means an immediate increase in production from $\bar{Y}$ to Y_1, when demand shifts from D_1 to D_2. At this production level, however, MC > MR, prices adjust over time and the production falls back to Y_2.

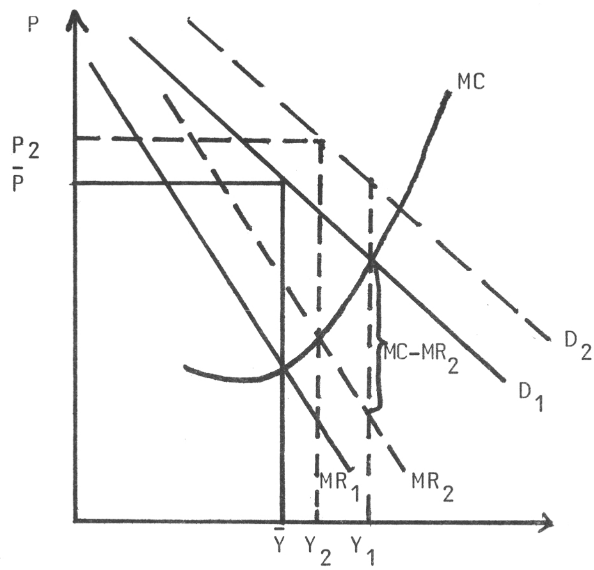

Figure 1. Adjustments to demand changes in the short ($\bar{Y} \rightarrow Y_1$) and in the long run ($Y_1 \rightarrow Y_2$).

In the short run therefore the changes in the demand for lumber directly alters the production volume and the demand for sawtimber for production, so that

(3.1.4) $\Delta S = \Delta Y = \frac{1}{\alpha} \Delta x$,

where

ΔS = the change in sales.

In this case, the demand for sawtimber for production is simply a linear function of production

(3.1.5) $x_t^D = c_0' + c_1' Y_t + u_t$

If production is assumed to possess linear dependence on export sales (ES), the demand function can be written

(3.1.6) $x_t^D = c_0 + c_1 ES_t + u_t$

Function (3.1.6) has to be studied further, because a short run price-taker, desiring at least a minimum profit, is not necessarily a profit maximizing monopolist in the long run.

However, a factor demand function of the type 3.1.5 is also derivable from slightly different assumptions. If we take Leontief-technology and assume a profit maximizing price-taker, the derivate property of the cost function will produce factor demand functions of the type 3.1.5. In this case, the input demand is conditional and production level has already been fixed by some other considerations (see e.g. Varian 1978, p. 32).

3.2. Raw material stocks

Because of technical delays in getting the purchased timber from the forest to the factory and, for example, because of uncertainties in the functioning of the roundwood markets and in weather conditions, it is necessary for the sawmilling industry to have stocks of roundwood. These stocks can be divided in three major components. Purchased but unharvested timber forms the stocks of standing timber. After commercial fellings, the timber is transported to the roadside stocks and to the factories. In this study the standing timber stocks are examined separately from the stocks alongside roads and at factories.

The stocks of standing timber are of special interest. This is for two major reasons. First, the allowed maximum storing time is from 2 to 3 years depending on agreement between the buyer and the seller. Secondly, in practice, the only cost involved in holding standing timber stocks is the opportunity cost of the investment. Of course, a certain amount of standing timber stocks is necessary in order to avoid stock-outs and to cover delays in production and shipments.

The factors affecting inventory decisions can be considered as follows. As an example, a two period case for a firm having limited market power at input markets is considered. Again Leontief production technology with one raw material input (x) and one product (Y) is assumed. The production during this (Y_{t-1}) and the coming (Y_t) period is assumed to be given. The firm is a profit maximizing price-taker at end-product markets and the sales price of this period (P_{t-1}) is given. The price expectation for the coming period is following some adaptive process based on previous realized prices. The stumpage price during this period is assumed to be a function of the roundwood demand. The expected stumpage price for the coming period is, however, a function of the expected sales price. The profit function of the firm for two periods is

(3.2.1)

$$\Pi_{t-1} + (1+i)^{-1}\Pi_t = \left[P_{t-1}Y_{t-1} + (1+i)^{-1}P_t^e Y_t^e\right] - q_{t-1}\,\alpha Y_{t-1} - (1+i)^{-1}q_t^e\,\alpha Y_t^e$$
$$+\left[(1+i)^{-1}\,q_t^e - q_{t-1}\right]\Delta I_t - rq_{t-1}\,\Delta I_t$$

where
- Π = profit
- i = discount rate
- P = sales price
- q = stumpage price
- e = expected ~
- ΔI_t = change in standing timber inventories ($I_t - I_{t-1}$)
- r = opportunity cost (interest from alternative investment
- α = parameter from production function

Term $[(1+i)^{-1}\,q_t^e - q_{t-1}]\Delta I_t$ on the right is the income or income loss caused by the change in stumpage price expected by the industry enterprise. In the following we assume that $i = 0$, so that $(1+i)^{-1} = 1$. Term $rq_{t-1}\Delta I_t$ gives the cost of the stock investment if the rate of profit from an alternative investment is r (cf. Klein 1950, 2 s. 15). Taking the derivate of the profit function with respect to the change in the stocks (ΔI_t), the equilibrium condition gives

$$(3.2.2) \qquad \frac{q_t^e - (1+r)q_{t-1}}{(1+r)\ \frac{\partial q_{t-1}}{\partial \Delta I_t}} = \Delta I_t \qquad \partial q_{t-1}/\partial \Delta I_t > 0$$

If $q_t^e < (1+r)\ q_{t-1}$, then the change in the stocks (ΔI_t) becomes negative and in the opposite case positive. A negative change in stocks cannot of course exceed the size of the beginning-of-period stocks. However, the change in stumpage price caused by the demand for raw material for stocks moderates the change in standing timber stocks caused by the expected and actual stumpage price level. Because of the term $\partial q_{t-1}/\partial \Delta I_t$, the change in the stocks cannot be solved directly from equation (3.2.2). Therefore, in the following function explaining the behaviour of the stocks only the signs of the parameters are taken from the above equilibrium condition.

Because the equilibrium condition (3.2.2) does not give the optimal size of the stocks of the standing timber, we have to go further. Following the flexible accelerator model, the optimal size of the beginning of period standing timber stocks relates to the level of planned production.

Because commercial fellings are the following stage in the utilization of standing timber stocks, it is natural to assume that their optimal size depends directly on planned commercial fellings (i.e. the acceleration principle: cf. Lovell 1960). Planned commercial fellings depend on the difference between the desired and actual level of the stocks alongside roads and at factories, (this question will be discussed further). It is assumed that a linear dependence exists between the planned commercial fellings (MH_t^e)and the desired level of the beginning-of-period standing timber stocks (I_t^{P*})

$$(3.2.3) \quad I_t^{P*} = e_1 + e_2 MH_t^e + v_t$$

According to equation (3.2.2), current stumpage price has negative correlation and expected stumpage price positive correlation with the stock change. When these results are included in the equation of the desired stock level, high current stumpage price decreases the end-of-period desired level of stocks, high expected sales price during next period increases it.

All previous factors affect the planned change in the stock level. However, unexpected changes in the commercial fellings during the current-period (e.g. weather conditions) tend to cause departures from the level of stocks suggested by the simple accelerator. There may, therefore, be a tendency for stocks to fall below the desired level when commercial fellings are increasing ($\Delta MH_{t-1} = MH_{t-1} - MH_{t-2} > 0.$) and vice versa. Equation (3.2.3) then has the form

$$(3.2.4) \quad I_t^{P*} = e_0 + e_1 MH_t^e - e_2 \Delta MH_{t-1} - e_3 q_{t-1} + e_4 P_t^e + v_t$$

Coming-period sales price describes the export price expectations of the sawmills. Here it is assumed (see above) that stumpage price expectations are based on the expectations of the export sales prices. Even if this connection does not exist, next period export price in this equation is justified because the expected rise in end-product price suggests higher raw material stocks (increased poduction) and vice versa.

However, the actual stock investment is only a fraction of that required if stocks were able to adjust to equilibrium level instantly. This is reflected by the equation including the adjustment coefficient ξ

$$(3.2.5) \quad I_t^P - I_{t-1}^P = \xi(I^{P*}_t - I_{t-1}^P) + u_t; \quad 0 < \xi \leq 1$$

Substituting the desired inventory level equation (3.2.4) to (3.2.5) yields

$$(3.2.6) \quad I_t^P = \xi e_0 + \xi e_1 MH_t^e - \xi e_2 \, \Delta MH_{t-1} - \xi e_3 q_{t-1} + \xi e_4 P_t^e + (1-\xi) I_{t-1}^P + (\xi v_t + u_t)$$

As stated earlier commercial fellings are assumed to depend on the actual and desired level of stocks at roadsides and at factories. Desired level of the beginning-of-period stocks, on the other hand, depends on the planned production during that period. Unplanned changes in stocks are again due to unexpected changes in production. Using the above flexible accelerator model we obtain, for stocks at roadsides and at factories,

$$(3.2.7) \quad I_t^T = a_0\delta + a_1\delta Y_t^e - a_2\delta\Delta Y_{t-1} + (1-\delta)I_{t-1} + (\delta v_t + u_t).$$

Because these types of roundwood stocks are a technical link in the process of delivering the raw material to the factories, prices are not assumed to affect the stock investment at this stage.

3.3. Sawtimber supply from private forests

In this study the main emphasis is on the effect of stumpage price, and the price expectations of the private forest owners, on the supply of sawtimber. The expectations act as shifters of the short run supply function. If stumpage prices are expected by the sellers to rise during the next period, the supply curve during the current-period is shifted upwards i.e., supply decreases at a given price level. Decreasing price expectations, on the other hand, increase supply and the supply curve is shifted downwards. (This result holds for competitive factor markets, and has not yet been extended to the markets where the buyer acts as a monopolist.) From the point of view of the business cycles it is evidently important whether the buyers and sellers base their price expectations on the same variables and whether the expected prices go in the same or different directions.

In this preliminary study the adaptive expectations formula presented by Nerlove (1958) is used.

$$q_t^e - q_{t-1}^e = \lambda(q_{t-1} - q_{t-1}^e) \quad ; 0 < \lambda \leq 1 \qquad (3.3.1)$$

q_t^e = expected price for period t,

q_{t-1}^e = expected price for period t-1

q_{t-1} = actual price during period t-1

λ = adjustment coefficient

Only the stumpage price and expected stumpage price are assumed to affect the supply, thus

$$(3.3.2) \quad x^s_{t-1} = b_0 + b_1 q_{t-1} + b_2 q^e_t + u_{t-1} \quad ; \; (\partial x^s / \partial q^e) < 0.$$

For estimation, the supply function can be derived from equation (3.2.2) by solving q^e_t, lagging by one period and substituting q^e_t and q^e_{t-1} in (3.3.1) to get

$$(3.3.3) \quad x^s_{t-1} = \lambda b_0 + (b_1 + (b_2 \lambda))\, q_{t-1} + b_1(\lambda - 1) q_{t-2} + (1-\lambda) x^s_{t-2}$$

$$+ (u_{t-1} + (\lambda - 1) u_{t-2})$$

The problem with the formulation of (3.3.3) is that the connection between long and short run supply is unclear. To be precise, it only gives the direction of change in supply caused by the relation between actual and expected price. When using (3.3.3) in estimations it must be assumed that the optimal rotation period has been determined, so that, for example, long run supply agrees with the sustained yield principle, (for discussion see e.g. Samuelson 1976, Ollonqvist 1981). The final optimal felling time is determined by the short run fluctuations of the stumpage price. Empirical estimations of the equation such as (3.3.3) easily give misleading results if markets are dominated by demand, which is clearly the case in the roundwood markets, or if there exists some structural or other factors affecting the supply (in the short or in the long run).

4. ESTIMATIONS

4.1. Single equation estimation

Each equation of the model was first estimated using ordinary least squares with the correction for serial correlation (APPENDIX 9). Elasticities were assumed constant over time, because of a relatively short study period (1962 - 1978) and logarithmic levels were used (semi-annual data, two-term moving sums).

According to preliminary estimations (equation 3.1.6), export sales lagged by 2 periods explained about 94 percent of the volume of sawtimber purchases from private forests. It therefore seems that the replacement of raw material follows its consumption in the production process. The determining factor in the demand is the solvency provided by the export incomes. Purchased timber is coming to the production process via stocks and at least part of it is going to stay in stocks for more than one observation period. Therefore the definition of equation (3.1.6) is somewhat misleading, because it is in fact the total demand (for production and for stocks). However, for the time being the theoretical framework fails to take this into account.

The coming-period production, along with the acceleration principle of the stocks at roadsides and at the factories, explain the level of these types of stocks rather well (equation 3.2.8). When the change in the stocks was used as the dependent variable the adjusted coefficient of determination decreased, but the regression coefficients and the T-values remained the same.

The equation for the standing timber stocks also behaved rather well. Positive serial correlation was weak and ρ did not differ significantly from zero. Unfortunately, only coming-period export price (price expectations) and the lagged endogeneous variable had clearly significant coefficients. Further the change in commercial fellings had a coefficient with the wrong sign. This is probably due to the long observation period (semi-annual data). The change in commercial fellings was assumed to measure unexpected changes and therefore to cause deviations from the stock level suggested by the simple accelerator. When the observation period is long enough industry has time to react to the changes and the sign of the variable changes from negative to positive. When changes in commercial fellings were left out of the equation the remaining variables prossessed significant coefficients with the signs suggested by theory.

In the supply equation all coefficients have correct signs and are statistically significant. However, the absolute value of the elasticity of the price expectations (b_2) is unrealistically large when compared with the elasticity of the current stumpage price. The same holds if b_1 and b_2 are interpreted as long-run (as is often done) and the estimated coefficient of q_t and q_{t-1} are interpreted as the short-run elasticities. In a steady state, these results suggest that supply is a decreasing function of the stumpage price. With certain assumptions, the supply function may become backward bending (see Löfgren et al. 1981). The compensated own-price effect must, however, be positive. The problem with the supply specification in question is that it does not identify the other factors affecting the supply, but lumps all these effects onto the coefficients of prices and lagged endogenous variables. The poor estimation results are also due to the demand effects, because the quantity changed in the roundwood markets is clearly determined by the demand.

4.2. Simultaneous equation estimation

Because the simultaneous equation is at a preliminary stage, the results of the estimations are not presented in detail. Nevertheless, some remarks are in order. The stumpage price is determined by the interaction of supply and demand. Therefore two-stage least squares was used to estimate the demand-supply model formed by the equations (3.1.6), (3.2.7), (3.2.9) and the equilibrium condition $x_t^S = x_t^D + \Delta I_t^p$. The model was estimated with the method suggested by Fair (1970)[1], except for equation (3.1.6), where ordinary least squares with the correction for serial correlation was used.

The coefficients remain approximately the same as in the single-equation estimations. Only the coefficients in the supply equation gain slightly larger absolute values. The problems which arose in the single-equation estimations

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1) Fair has shown that to obtain consistent estimates in the case of first order serially correlated errors, at least lagged dependent and independent variables must appear as instruments. If the model is

(1) $AY + BX = U$ and

(2) $U = RU_{-1} + E$

with normal assumptions of E, then the estimation of the first equation of (1)

(3) $y_1 = -A_1Y_1 - B_1X_1 + u_1$

requires $y_{1_{-1}}$, $Y_{1_{-1}}$, X_1 and $X_{1_{-1}}$ in the instrument list.

remained. This suggests that the model is so far unable to identify the demand and supply factors correctly. Specially the supply equations is seriously disturbed by the strong influence of the demand on quantities changed. Also for example the adjustment speed of 30 percent of the difference between actual and desired stock levels during 6 months seems too low. It may however be that the adjustment to desired stock level is in reality quite slow. This however is not because the industry is aiming at slow adjustment but rather because of the rigidities in timber supply.

5. FURTHER WORK

Because of the preliminary stage of the study, the discussion of the results of the estimations and their implications is omitted. The following stage of the study will be a slight reformulation of the theoretical model. The basic structure will remain, but on the industry side the demand for production and for stocks will be integrated and dealt with simultaneously. Also, the goals of the representative firm will be more precisely formulated. The argumentation concerning the demand factors affecting the economic activity in the sawtimber markets will therefore be given greater precision.

In the present model the supply of roundwood is on an ad hoc basis, and is causing identification problems in the estimations. In the next stage of the study the supply of roundwood will be more firmly linked to the goals of the representative non-industrial forest owner. The changes in the structure of the private forest ownership and the effect of forest owners general income level on the supply of timber will be also taken into consideration. It seems that, besides the demand factors, the lack of other supply factors is causing the problems in estimations of the present model.

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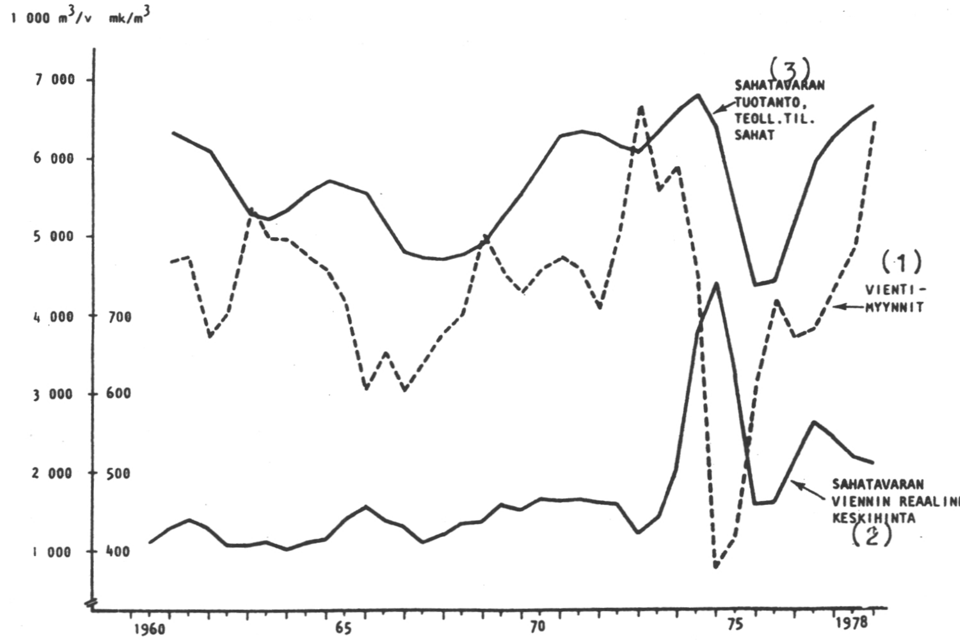
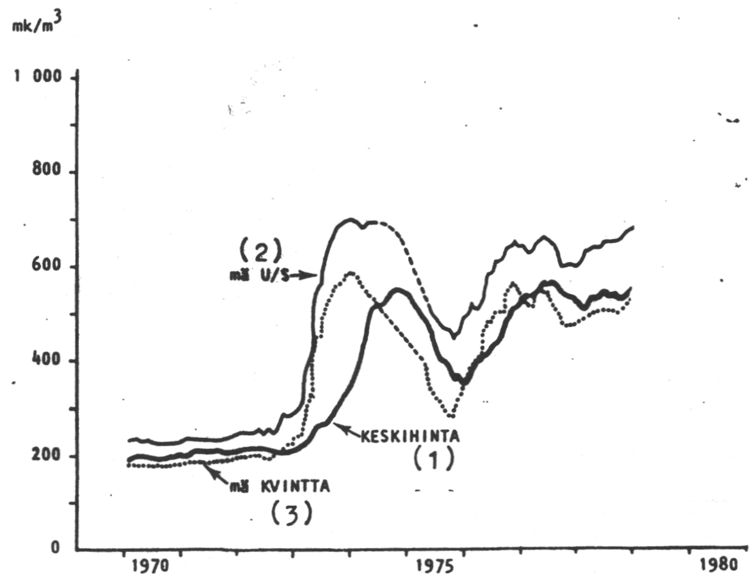
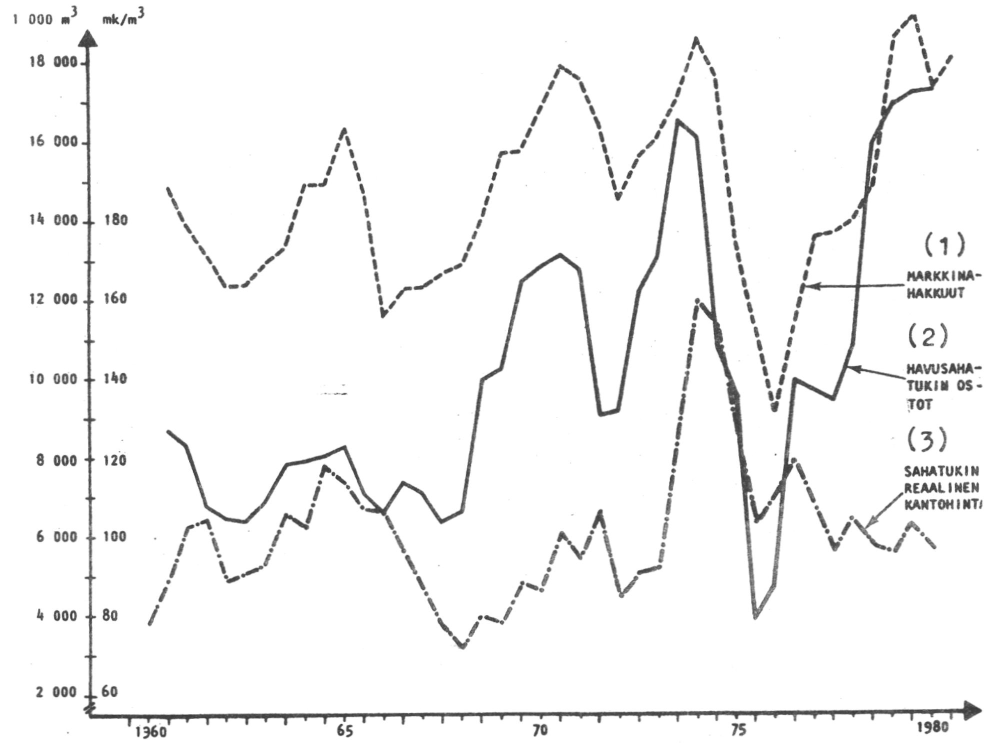
Appendix 1. Export sales (1) and production (2) of lumber 1960 - 1978, semi-annual data, two-term gliding sums; and a~~b~~verage export price of sawn timber (= the unit value of the shippings) (3), semiannual data 1960 - 1978



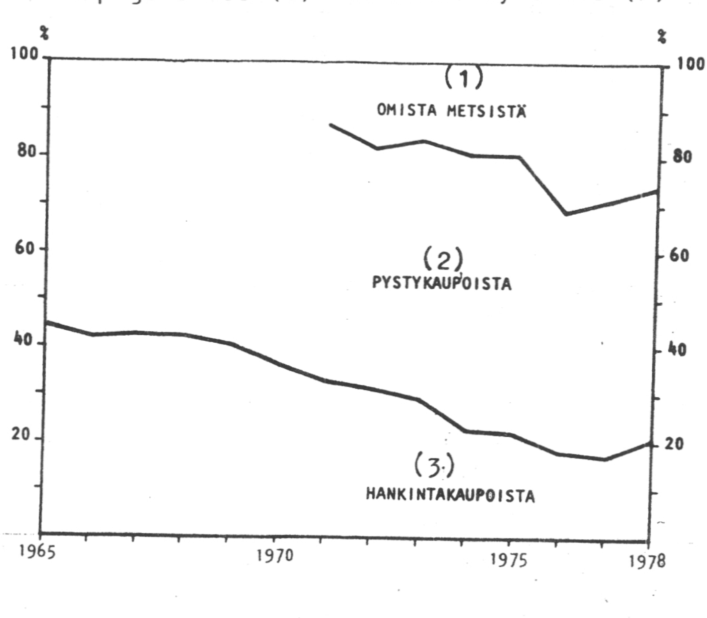
Appendi~~x~~ 2. Average sales price of Finnish lumber (1), UK sales price of pine U/S (2) and pine grade V (3), 1970 - 1980 monthly data.



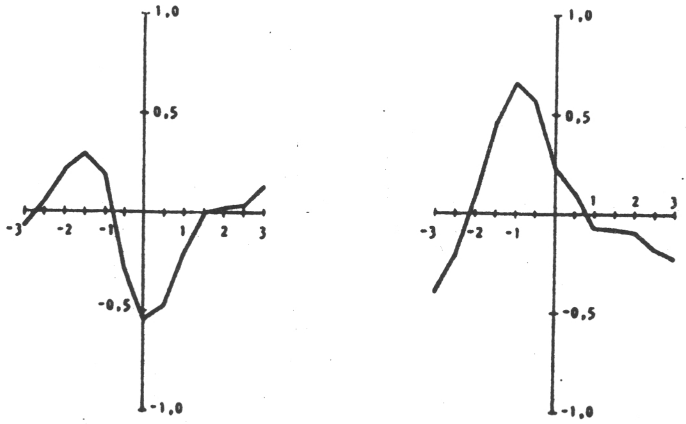
Appendix 3. Commercial fellings of sawtimber (1) and purchases of sawtimber from private non-industrial forests (2) 1960 - 1978, two-term gliding sums, and stumpage price in real terms (3) (semi-annual data).



Appendix 4. Commercial fellings from industries' forests (1), stumpage sales (2) and delivery sales (3)



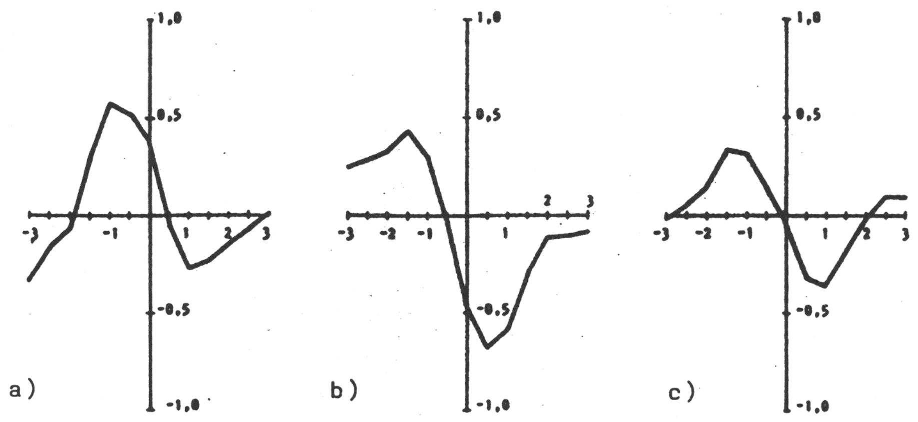
Appendix 5. The cross-correlograms between export sales of the lumber (x) and export price (average price in real terms) and sawntimber production. $r = f(x_t, y_{t-k})$.



a) y = real average export price of lumber (unit value)

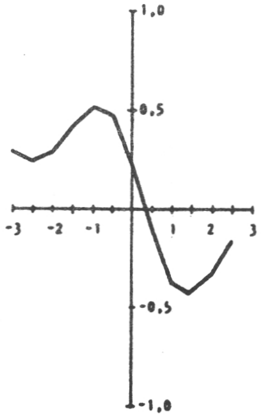
b) y = the production of lumber

Appendix 6. The cross-correlograms between export sales (x) and the purchases of sawtimber, stumpage prices and total stocks.



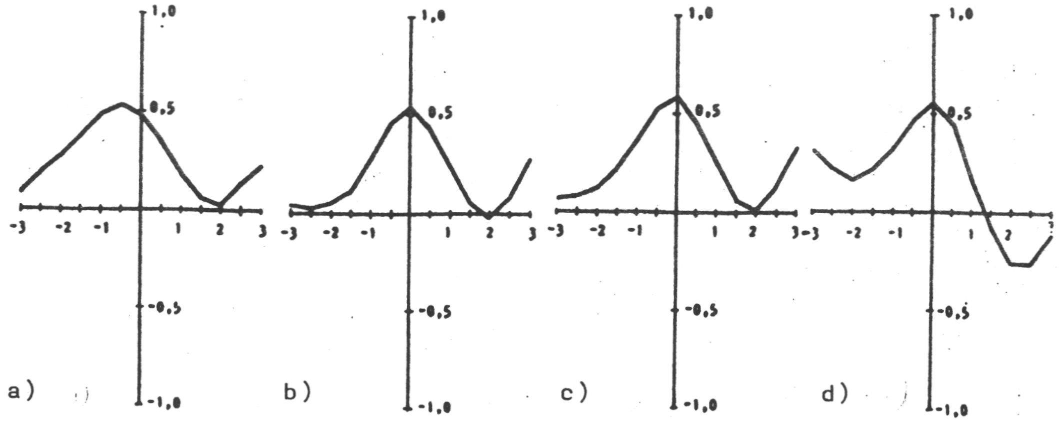
a) y = purchases of sawtimber
b) y = stumpage price of sawtimber
c) y = total stocks of sawtimber

Appendix 7. The cross-correlogram between the purchases of the sawtimber and the stumpage price in real terms.



x = the purchases of sawtimber
y = the real stumpage price

Appendix 8. The cross-correlograms between the production of the lumber (x) and different types of stocks and the cross-correlogram between commercial fellings (x) and the stocks of the standing timber.



(a) y = the stocks at roadsides and at factories
(b) y = the stocks of standing timber
(c) y = the total inventories
(d) x = commercial fellings
y = the stocks of standing timber

APPENDIX 9.

The timber market model was estimated in the levels of logarithms, using seasonally adjusted semiannual data from the first half of 1962 to the first half of 1978.

Results of ordianry least squares: The correction for serial correlation was made assuming that disturbances display first order serial correlation: $u_t = e_t + \rho u_{t-1}$. T-statistics are given in brackets under the regression coefficients. $\bar{R}$ is the adjusted coefficient of determination, DW the normal Durbin-Watson statistics, h is the statistics suggested by Durbin in case of a endogenous lagged variables among the explanatory variables (values greater than 1.67 suggest the presence of serial correlation) and ρ is the coefficient of serial correlation.

Demand for use in production

$$(3.1.6)\quad \ln x_t = \underset{(7.4)}{4.82} + \underset{(6.7)}{.51} \ln ES_{t-2} \qquad \bar{R}^2 = .94 \; ; \; \rho = \underset{(6.8)}{.78} \qquad DW = 1.98$$

x = purchases of sawtimber
ES = export sales of lumber (the two period lag is obtained from gross-correlation functions)

Stocks at roadsides and at factories

$$(3.2.8)\quad \ln I_t^T = \underset{(-.10)}{-.22} + \underset{(1.8)}{.45} Y_t^e - \underset{(-.9)}{.35} \Delta Y_{t-1} + \underset{(2.8)}{.60} I_{t-1}^T \; ;$$

$$\bar{R}^2 = .98 \; ; \; DW = 1.80 \; ; \; \rho = \underset{(2.7)}{.46} \; ; \; h = 1.00$$

$$\ln \Delta I_t = \underset{(-.10)}{-.22} + \underset{(1.8)}{.45} Y_t^e - \underset{(-.9)}{.36} \Delta Y_{t-1} - \underset{(-2.8)}{.40} I_{t-1}^T$$

$$\bar{R}^2 = .18 \; ; \; DW = 1.81 \; ; \; \rho = .46 \; ; \; h = .91$$

I^T = stocks alongside roads and at factories
Y = production
ΔY = change in production
ΔI^T = change in stocks

Appendix 9 continued

Stocks of standing timber

(3.2.7) $\ln I_t^P = -7.65 + .40 \ln MH_t^e + .37 \ln \Delta MH_{t-1} + 1.18 \ln P_t^e$
(-2.2) (1.4) (.9) (1.8)

$-.32 \ln q_{t-1} - .71 \ln I_{t-1}$
(-.9) (6.1)

$\bar{R}^2 = .84$ DW = 1.91

$\rho = .15$ h = .35

$\ln \Delta I_t^P = -7.65 + .40 \ln MH_t^e + .37 \ln \Delta MH_{t-1} + 1.18 \ln P_t^e$
(-2.2) (1.4) (.9) (1.8)

$-.32 \ln q_{t-1} - .29 \ln I_{t-1}$
(-9) (2.5)

$\bar{R}^2 = .29$ DW = 1.91 $\rho = .15$ h = .35

I^P = stocks of standing timber
MH = commercial fellings
P = export unit value (in real terms)
q = stumpage price
ΔI = change in inventories

Supply from private forests

(3.2.9) $\ln x_t^s = 5.70 + 1.09 \text{ Ln } q_t - 1.43 \ln q_{t-1} + .56 \ln x_{t-1}$

$\bar{R}^2 = .62$; DW = 1.8

$\rho = .081$ h = .6
(.42)

x_t^s = purchases of sawtimber from private forests

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