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DYNAMIC MODELS OF THE ROUNDWOOD MARKET IN FINLAND

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ABSTRACT

We contribute to the discussion of the reasons why the supply of roundwood has lagged behind the growth of forests since the early 1970s. Our dynamic models of the roundwood market provide some evidence that the very low level of the real interest rate is an important reason for the sluggishness of fellings in private forests.

TIIVISTELMÄ

1970-luvun alkupuolelta lähtien hakkuut ovat jääneet huomattavasti jälkeen valtakunnallisesta hakkuusuunnitteesta. Tutkimuksessa saatujen empiiristen tulosten mukaan reaalikoron alhainen taso on ollut merkittävä syy hakkuiden vähäisyyteen. Lisäksi tulosten mukaan näyttäisi siltä, että kantohintojen muutokset ovat yhtä suuria kuin vientihintojenkin.

CONTENTS

1 INTRODUCTION

There has been an ongoing discussion on the insufficiency of cuttings in Finnish and Swedish forests. In Finland, it has been argued that potential stumpage revenue and labour income will be lost unless the forest industry expands its capacity. By contrast, the industry itself claims that the insufficient utilisation of forests as sources of raw material is due to the fact that private forest owners refuse to sell their trees at competitive prices. Export prices are mainly exogenous to the Finnish forest industry and, therefore, the profitability of exports is strongly affected by developments in production costs.

The discrepancy between cuttings and allowable cut started to widen at about the same time as the real interest rate was at a historically very low level (Figure 1). Overcapacity in the forest industry, especially as regards sawmills, may be based on miscalculations concerning the availability of timber, on the one hand, and on low interest costs, on the other hand. In this paper we try to discuss both of these issues by considering the significance of the real interest rate for roundwood sales decisions.

Some empirical research has been done on the causes of the frictions in the wood market. At the aggregate level, an interesting dependence is that between sales of roundwood and stumpage prices. This relationship has been investigated in several earlier studies, e.g. Kuuluvainen (1982, 1986), Kuuluvainen et al. (1988), Korpinen (1981) and Tervo (1986). They have estimated simultaneously the levels of demand for and supply of roundwood. Only a few of the Finnish studies include the real interest rate as an explanatory variable. At the theoretical level, and even in those empirical studies in which the real rate is included, this variable has not usually been found to have any real significance (see e.g. Ovaskainen 1987). A rise in the interest rate should increase the supply of wood and decrease the demand for it in the short term.

A model is used here to determine the aggregate supply for and prices of sawlogs and pulpwood in Finnish private-owned forests.[1] We are interested in the largely neglected research area of the short-term dynamics of the forest market. Stumpage prices are explained here directly by export prices using a difference model in error correction form. We assume that the forest industry is a price taker in both input and output markets. As this seems to be roughly the right assumption we use single equation methods in modelling fellings. The model of fellings is explicitly dynamic in that we take into account the intertemporal choice of the forest owner. Sales in previous periods have an effect on sales in the current period. Most earlier studies have been estimated in level form, whereas our specification is in difference terms. Our basic model is very compact in order to avoid the problems arising from the lack of degrees of freedom and the simultaneity of explanatory variables. We used annual aggregate data from 1957 to 1986. When using such a short time series and crude data, it is useful to concentrate on only a few economic relationships.

[1]As two-thirds of all forests (measured by growth) are privately owned, it is particularly important to identify the determinants of transactions in the private sector.

2 THE MODELS

The theory of the roundwood market mainly concerns long run developments. Much less attention has been paid to the short-run behaviour of buyers and sellers in the roundwood market (see, however, Johansson and Löfgren, 1985). Decision-making by agents in short-run empirical models has seldom been thoroughly studied; rather, estimation has been based on crude assumptions. It is especially difficult to derive theoretical short-run models which are also consistent in the long run. This is because in the short term a rise in the interest rate has a positive effect on the supply of timber whereas in the long run the effect is indeterminate. We also adopted a rather pragmatic approach in this study. However, our approach differs from that of most other empirical studies in that we introduced the dynamics of market developments in an explicit way.

Roundwood markets are inherently dynamic by nature (if you sell everything today you will have nothing to sell tomorrow). Our model is also very compact compared to many other empirical studies. As we had only yearly data, we were able to save degrees of freedom by focusing on only a few explanatory factors. The error correction method applied also saved degrees of freedom.

The most obvious way to investigate price relationships in roundwood markets is to study export prices. Finnish forest products are mostly exported to world markets by competing firms. If firms are price-takers in both markets and roundwood has a large cost share (as in sawmills), then the price of roundwood is determined mainly by export prices. The simple stumpage price equation then takes the logarithmic form

$$(1) \qquad \Delta P_{i,t} = a_{1i}\, \Delta PX_{i,t} + a_{2i}\, \frac{P_{i,t-1}}{PX_{i,t-1}} + e_{i,t}$$

where P = stumpage price

i = s, p s = saw logs p = pulpwood

PX = export price

Δ = difference operator

Equation (1) is an error correction model (ECM) of roundwood prices. The effect of the second term in (1) is that in the long run roundwood and export prices do not deviate from each other. In the short run, stochastic shocks can change the relationship between these prices.

If e_t is white noise and $a_1 = 1$, stumpage prices are determined in the world markets for forest products. Therefore the long run demand curve is horizontal and single equation-methods can be used to estimate sales of roundwood.

Modelling the supply side of the roundwood market is more complicated. The forest-owner's decision to sell now or later is intertemporal by nature and may depend on many factors, some of which are sociological rather than economic. This is a reflection of imperfections in the market, which make supply decisions dependent on preferences (see, for example, Loikkanen et al, 1986). Regulation of the roundwood market may also effect the behaviour of forest owners. However, it is assumed here that the effects of regulation and non-economic factors are not significant in aggregated data. Our annual data does not offer an opportunity to formulate expectations on future stumpage prices, and this is clearly a problem.

Important questions for the potential seller of roundwood are the following: How much roundwood to supply and at what prices? What is the opportunity cost, i.e. the interest rate? The model can therefore be formulated as follows:

$$\text{(2)} \qquad \Delta Q_{i,t} = b_{0i} + b_{1i}\, \Delta P_{i,t} + b_{2i}\, \frac{Q_{i,t-1}}{S_{t-1}} + b_{3i}\, R_t + e_t$$

where
Q = fellings
i = 1, p
S = planned fellings in private forests (allowable drain)
R = real interest rate

Model (2) explicitly takes into account the fact that extensive fellings in the previous period reduce potential sales in the current period. It is assumed that the level of real interest rates contributes positively to the change in fellings.[2] The rise in stumpage prices is expected to increase fellings.

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[2]The famous Faustmann cutting rule states that a rise in the interest rate increases fellings in the short run but reduces them in the long run. Thus, our model is not consistent with the Faustman rule in the very long run.

3 EMPIRICAL RESULTS[3]

Stumpage prices

Stumpage prices can be explained rather well by export prices. The relationship between these variables becomes closer when the period of estimation covers the years 1969 to 1986 (see Table 1). In the 1980s, a price agreement system linking stumpage prices with export prices has been one reason for this development.

TABLE 1 Stumpage prices, estimation results

No.	Dependent variable	Explanatory variables		Period	$\bar{R}^2$	DW
	ΔP_1 (saw logs)	ΔPX_1	$(P_1-PX_1)_{-1}$			
1.		0.928 (6.08)	-0.278 (1.86)	1957 - 86	0.424	1.69
2.		1.114 (6.23)	-0.425 (2.16)	1969 - 86	0.614	2.28
	ΔP_k (pulpwood)	ΔPX_k	$(P_k-PX_k)_{-1}$			
3.		1.064 (5.38)	-0.126 (1.58)	1957 - 86	0.41	1.1
4.		1.347 (0.99))	-0.426 (4.56)	1969 - 86	0.83	1.6

The symbols of variables are as in (1). The numbers in parentheses are t-values.

The stumpage price of logs behaves as expected. The change in export prices has an approximately one-to-one effect on the price of logs.

[3]For the data, see Appendix.

After a shock the difference between export and stumpage prices disappears very quickly, as the high value of the error correction parameter indicates. As there is no autocorrelation (the DW-statistic is close to 2) and the R^2 is rather high, export prices seem to determine the stumpage prices of logs satisfactorily. Moreover, it can be noticed that no dummy variables were used in this study whereas other studies use dummies for the "crazy years" (1975 - 76).[4]

The stumpage price of pulpwood is also well explained by the export prices of paper products, especially in the period 1969 - 86. In this shorter period, the R^2 receives a fairly high value and the DW-statistic is also satisfactory. In the short run, the stumpage price of pulpwood responds faster (elasticity over one) to export prices than does the price of logs. This can be explained by the fact that the need for roundwood in the production process has been reduced through technological advances. The pulp and paper industry has been able to pay higher prices for its raw material. However, the DW-statistic indicates that residuals may contain some information. To deal with this, we assumed that, if there are other variables explaining the price of pulpwood, this information must be evident in the price ratio between pulpwood and exports.

We restricted the coefficient of the export price to one and examined how investment in the pulp and paper industry affects this price ratio. The result

$$\frac{P_p}{PX_p} = \underset{(1.35)}{-\ 1.047} + \underset{(4.32)}{0.66}*(P_p/PX_p)_{-1} + \underset{(1.35)}{0.135}*(I + I_{-1})$$

$$\bar{R}^2 = 0.625 \quad DW = 1.204 \quad \text{period } 1962 - 86$$

[4]In principle we could have studied co-integration between export prices and stumpage prices. However, as current tests of co-integration and lag distributions based on annual data are weak, we did not find it necessary to use these tests in our study. Because of the lack of degrees of freedom, we did not estimate the distribution of lags explicitly.

where I_t = Investment in pulp and paper industry

gives some weak indication that domestic demand conditions have an effect on the price of pulpwood. However, this model is only preliminary and further research on this subject is needed. For example, if the stumpage price of pulpwood is predetermined because of lack of competition, as Brännlund et al. (1985) assume, it is difficult to explain stumpage prices of pulpwood. In our example above, the capacity of the paper and pulp industry adjusts very slowly to shocks. Therefore the profit maximizing stumpage price of pulpwood can be determined differently from export prices.

According to the results in Table 1, changes in export prices are passed through to stumpage prices within one year. The change in the exchange rate seems to increase stumpage prices at a one-to-one rate.

Fellings

Difference form models of fellings obtain a fairly good fit, despite data problems (see Table 2).[5] Stumpage prices and the real interest rate affect fellings positively. A one percentage point rise in the real interest rate increases fellings by 1 - 3 per cent. Note that the regression is made between the level of interest rates and the change in fellings. Therefore, the stock of forests adjusts slowly to the interest rate. As expected, the high level of fellings in the previous period hampers fellings in the current period.

There is some risk of simultaneity bias, however, in the fellings equations, particularly in the equation for pulpwood. To correct this bias we replaced stumpage prices by their estimate (2SLS). The results

[5]There are many measurement problems. Our data consist of fellings rather than sales. We use the allowable drain as a capacity variable (S_t) while logs and pulpwood should actually be modelled separately. An additional problem is how to measure the real interest rate. Here we have used the effective interest rate on government bonds (nominal rate deflated by the consumer price index). The interest rate is treated as a representative long-term rate.

did not change markedly, as can be seen by comparing equations 6 and 7 and 9 and 10 in Table 2.

TABLE 2 Fellings, estimation results

No.	Dependent variable	Explanatory variables				Period	$\bar{R}^2$	DW
	ΔQ_1	Constant	ΔP_1	$(Q_1-S)_{-1}$	R			
5.		-0.802 (4.29)	0.719 (3.37)	-0.535 (4.05)	0.013 (2.37)	1958 - 86	0.497	1.307
6.		-0.813 (4.29)	0.920 (4.19)	-0.573 (4.08)	0.032 (4.30)	1969 - 86	0.697	1.644
7.		-0.907 (4.29)	0.806 (3.60)	-0.630 (4.09)	0.033 (4.08)	1969 - 86	0.646	1.461
	ΔQ_k (pulpwood)		ΔP_k	$(Q_k-S)_{-1}$	R			
8.		-0.714 (3.74)	0.541 (3.36)	-0.505 (3.48)	0.012 (2.39)	1958 - 86	0.43	1.828
9.		-0.578 (3.74)	0.829 (5.05)	-0.380 (3.20)	0.027 (4.33)	1969 - 86	0.69	2.14
10.		-0.794 (4.27)	0.748 4.18)	-0.555 (4.02)	0.029 (3.93)	1969 - 86	0.61	2.19

The symbols of the variables are as in (2). The numbers in parentheses are t-values. Eqs. 6 and 9 were are estimated using estimated values of P_i from Table 1 (2SLS).

We made some preliminary attempts to take expectations into account in the model (not reported here). Stumpage prices in the next period (rational expectations) did not have any explanatory power at all. Lagged stumpage prices had some weak effect (insignificant) in both equations but a positive one on fellings of pulpwood and a negative one on logs. It is remarkable that farmers' income did not have any explanatory power at all on fellings in this kind of model. Furthermore, contrary to the general belief, fellings of pulpwood were not affected by fellings or prices of logs.[6]

All in all, our simple models fit the data rather well. The high R^2 and a DW-statistic close to two indicate that the models are satisfactory. The results are preliminary, however, and much work still needs to be done. More detailed data on the structure of sales would help in answering many of the open questions.

Comparing our results with those of other Finnish studies is rather difficult because of the different approach applied by us. Tikkanen and Vehkamäki (1987) and Korpinen (1980) have studied saw log markets using static simultaneous models. Both studies indicate a positive relationship between sales (of fellings) and the real interest rate.[7]

Korpinen (1981) finds a small positive long run relation between stumpage prices of saw logs and fellings whereas Tikkanen and Vehkamäki (1987) do not find such a relationship. Tervo (1986), who explains the total supply of roundwood, restricts the long-run price effect to zero. Our results indicate that the positive price effect on fellings lasts for many years in pulpwood markets. This result indicates that the price elasticity of pulpwood is positive.

The other empirical models mentioned above do not have a clear mechanism which would adjust the stock of forests back to normal after extensive fellings.[8]

In our error correction model of fellings we used a variable, the level of fellings relative to the allowable drain, which may be biologically optimal but not economically profitable. The choice of fellings variables is also an area where further research is needed.

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[6]These unreported results are available from the authors on request.

[7]Korpinen approximated the real interest rate by changes in consumer prices.

[8]Even our method of modelling the inherent dynamics is incomplete since the stock of timber in forests is a function of the real interest rate.

4 CONCLUSION

The aim of this study was to identify the relationship between stumpage prices and export prices, on the one hand, and the effect of the real interest rate on timber sales, on the other hand. The theoretical background was that forest industry firms are price-takers both in output and in input markets. The econometric models we used were very basic difference equations.

Stumpage prices are closely linked to export prices. The link was especially clear after the major devaluation in 1967. The price of saw logs varies at a one-to-one rate with the export prices of the forest industry. The price of pulpwood covaries with the export prices of the pulp and paper industry. The short-run response of pulpwood prices to export prices is greater than one.

The results presented here are not robust enough to state anything quantitatively about the claimed insufficiency of investment in the forest industry. Our models do, however, indicate that the forest industry can obtain more pulpwood only at increasing cost. On the other hand, the rise in the real interest rate seems to increase the supply of roundwood in the short term. It is possible that even though the very low real interest rate after the first oil crisis explained some of the frictions in timber sales, factors other than purely economic ones also contributed to sales decisions (see, for example, Järveläinen, 1988).

Although the dynamic models of fellings presented in this paper are still incomplete, the results are at least promising. Stumpage prices, fellings in the previous period and the real interest rate explained changes in fellings rather well. The estimated stumpage price elasticity has a value which is in line with the findings of other empirical studies. The low (negative) real interest rate may be an important reason for the low level of fellings in private forests since the beginning of the 1970s.

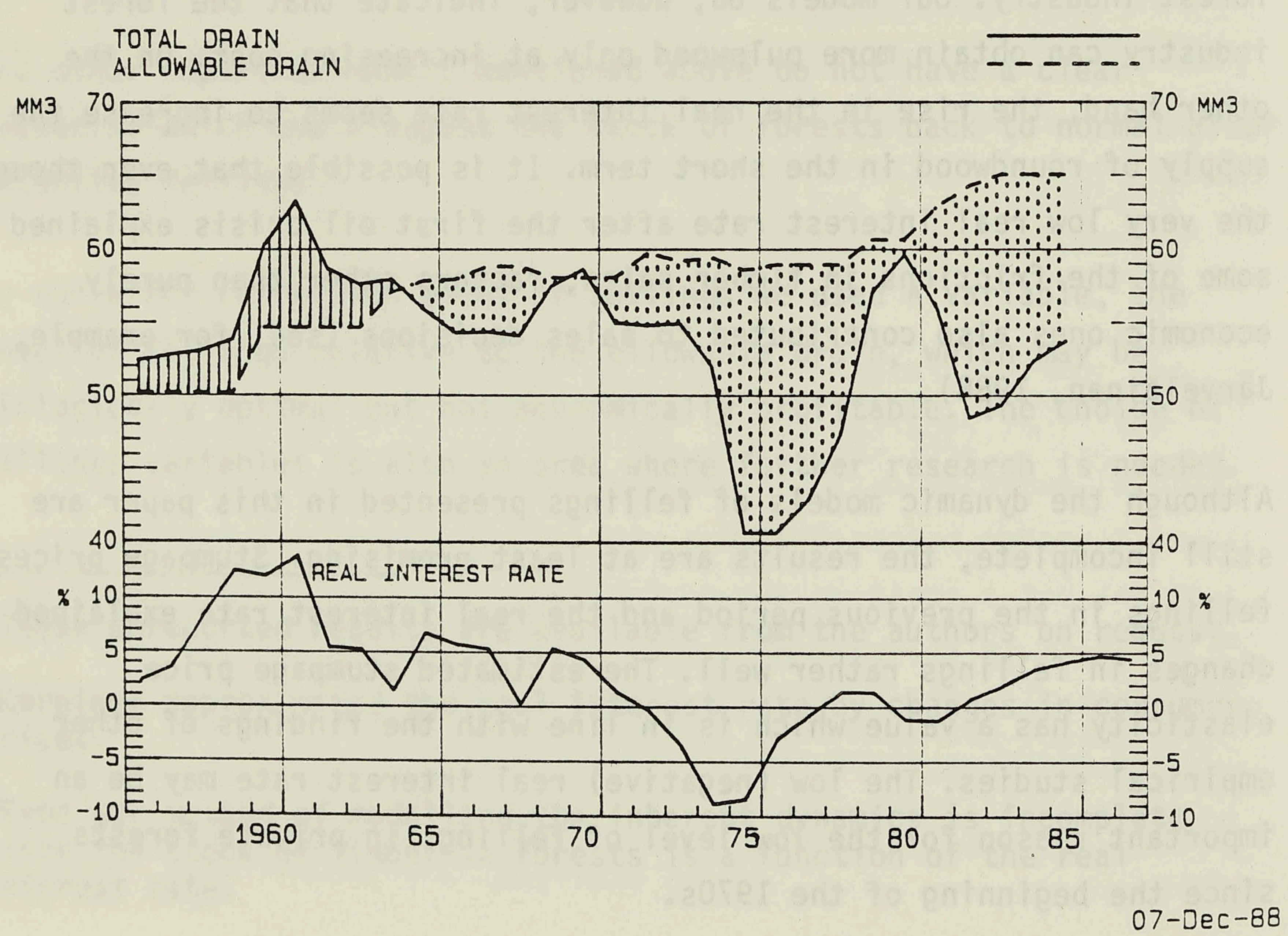
APPENDIX

DATA

The Finnish Forest Research Institute provided us with data on fellings and stumpage prices. The price index of pulpwood and saw logs was calculated using value weights, in a similar fashion as for the unit value indices in foreign trade. Export prices in the forest industry were taken from customs statistics from 1964 onwards and from Saralehto and Vajanne (1981) from 1956 to 1964. We used aggregate unit values of exports separately for the wood industry and the pulp and paper industry. Investment in the pulp and paper industry was described by gross fixed capital formation in the National Accounts.

Figure

FELLINGS AND ALLOWABLE DRAIN OF ROUNDWOOD



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