TESTING FOR OLIGOPSONY POWER IN THE FINNISH WOOD MARKET

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ABSTRACT

In this study we test for oligopsony power of the pulp industry over the Finnish pulpwood and wood chip markets. Following Bergman and Brännlund, we apply duality to derive a factor demand system from which the markdown of the pulpwood market price from the value of its marginal product is statistically estimated. Our empirical estimates assuming constant market power suggest that the pulpwood market in Finland has on the average been competitive during the period 1965–94. However, some evidence is found that wood chips purchased from sawmills have been priced below the value of their marginal product. This result is intuitively plausible due to the lack of countervailing power of the sawmilling industry as compared to suppliers of roundwood in the pulpwood market.

Keywords: oligopsony power, pulp industry, pulpwood market, wood chips.

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INTRODUCTION

In recent decades both stumpage prices and wood quantities in the Finnish roundwood market have fluctuated widely over the business cycle. Between 1978 and 1991 the stumpage prices were subject to nationwide collective bargaining system including representative organisations of the forest industry and private forest owners to set price recommendations for each felling season. Due to developments in the economic environment, more precisely the new competition law in 1992 and the Finnish membership in the EU in 1995, this negotiation system was prohibited. The market is characterized by a pronounced structural asymmetry, i.e. a small number of wood buyers in contrast to the over 300 000 nonindustrial private forest owners. Buyer concentration has increased due to mergers and acquisitions in the forest industry, especially in the last decade.

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Currently the three largest buyers dominate both the pulpwood and sawlog markets. The sawlog market is however characterized by a competitive fringe of numerous small sawmills.

Due to a small number of wood buyers, the Finnish wood market can be suspected of being imperfectly competitive. In spite of this, most econometric models of Finnish sawlog and pulpwood markets assuming competitive behaviour have described the market quite well (see e.g. Kuuluvainen *et al*. 1988, Hetemäki & Kuuluvainen 1992, Toppinen & Kuuluvainen 1997), although direct empirical evidence on testing the competitive market assumption is by and large nonexistent. In this paper we aim to fill this gap by modelling the Finnish pulpwood market as an oligopsony, *i.e.* a market with few buyers and many sellers.

In an oligopsony wood market, the buyer side may have market power over the suppliers of wood, resulting in a wood price level lower than that in a competitive wood market. Consequently, the wood buyers would gain a positive markup (or actually markdown, since we are dealing with an input market distortion) with the value of the marginal product for wood exceeding its market price. If buyers act collectively as a purchasing cartel, the market could even function as a monopsony. If there is oligopsony power in the pulpwood part of the market, it could mean a welfare transfer from suppliers of wood to pulp industry. It could also have an effect on the sizes of different wood using industries.

The contribution of this paper is the explicit testing of a potential deviation from competitive pricing in the wood input markets of Finnish pulp industry. We use the method that was introduced by Appelbaum (1979, 1982) and that was further developed by Atkinson & Kerkvliet (1989) and Bergman & Brännlund (1995) to account for oligopsonistic competition in input markets. Following Bergman and Brännlund we apply duality to derive a factor demand system from which the markdown of the wood price from the value of its marginal product is statistically estimated. The estimated factor demand system is based on a flexible functional form. In this respect, the paper can also be seen as an extension of Hetemäki's (1990) factor demand model for the Finnish pulp and paper industry, in which the wood input price was treated as an industry parameter. It should be noted that since we deal with the aggregate market and annual time series data, our results can say nothing about possible deviations from competitive wood pricing at the local level or over time periods shorter than a year.

Theoretical Background and Previous Studies

The theoretical framework for this study has been presented in the industrial organization literature (see e.g. Tirole, 1988). Before the 1980s, the dominant approach was the structure-conduct-performance paradigm (SCPP), which tried to establish a direct link from industry structure to conduct, so that the level of competition could be implied by an industry's structural features. However, the SCPP was criticized later on because the relationship between industry structure and conduct is not unambiguously predicted by the theory of imperfect competition, e.g. high concentration in an industry does not necessarily imply noncompetitive behaviour. With the current methodology of the new empirical industrial organization (NEIO), the existence of market power can be studied more rigorously than before.

In NEIO, the degree of competition is typically analysed via the estimation of conjectural elasticities. These elasticities are computed as

$$\varepsilon^i = \frac{\partial Q}{q^i}\frac{\partial q^i}{Q} \tag{1}$$

where Q denotes industry output (or demand for oligopsonistic input) and q^i is the output (input) of i'th firm. ε^i measures the firm's expectation of the industry output change in response to its output change or alternatively, it can be simply interpreted as an index of market power. A comprehensive structural model for estimating the degree of market power in oligopolistic markets was introduced in Appelbaum (1982), and this method can be applied to input markets as well.

Numerous empirical applications of estimation and testing of market power can be found. Bresnahan (1989) and Slade (1995) provide surveys of these studies. Examples of studies that consider market power in output markets are Appelbaum (1982) and Bernstein & Mohnen (1991) for manufacturing industries, and Schroeter (1988) and Schroeter & Azzam (1990) for agricultural product markets. Input market distortions are considered e.g. by Just & Chern (1980), Bergman & Brännlund (1995), and Murray (1995), of which the latter two consider wood markets. Applications involving both input and output markets include Atkinson & Kerkvliet (1989) for the U.S. electrical utility industry, Wann & Sexton (1992) for the California food industry, and Bernstein (1992) for the Canadian forest industries.

Bergman & Brännlund (1995) tested the oligopsony hypothesis for the Swedish pulpwood market, and their empirical results suggested a noncompetitive pulpwood market. Estimates of a strongly time-varying conjectural elasticity term in Bergman and Brännlund indicated an unstable cartel situation with phases of industry cartel under weak pulp markets and perfect competition under strong pulp markets.

Murray (1995) studied market power in both the pulpwood and sawlog markets in the U.S. He used a more restrictive approach modelling wood as a quasi-fixed factor, so that the shadow prices of the wood input could be estimated from a flexible-form profit function. His results suggested that the U.S. pulpwood market as a whole is more oligopsonistic than the sawlog market, although both markets were closer to perfect competition than to monopsony. In contrast to the two above-mentioned wood market studies, Bernstein (1992) accounted for capital adjustment costs in the Canadian sawmill and pulp and paper industries. Competitive behaviour was not rejected in any of the input or output markets of sawnwood or paper products.

THE MODEL AND ECONOMETRIC SPECIFICATION

Let us consider an individual firm in an n-firm oligopsonistic industry. Following notation in Bergman & Brännlund (1995), we write the twice continuously differentiable production function of firm i as

$$q^i = f\left(x_m^i, \tilde{x}^i\right), \tag{2}$$

where q^i is the firm's output quantity, $\tilde{x}^i$ is a vector of inputs with a parametric price vector $\tilde{w}$, and x_m^i is the input of factor m which is used only by the firm and its rivals. Assume that for input m the industry faces an inverse supply function

$$w_m = w_m\left(x_m, y\right), \tag{3}$$

where w_m is the price, x_m is supply ($\partial w_m/\partial x_m > 0$), and y a vector of exogenous variables affecting the supply. In equilibrium, the supply x_m equals the industry's demand for that input. Let us assume that the firm maximizes its profit by choosing inputs x_m^i and $\tilde{x}^i$. Denoting the output price by w_p, the problem of firm i is:

$$\mathrm{Max}_{x_m^i, \tilde{x}^i} = w_p f\left(x_m^i, \tilde{x}^i\right) - w_m\left(x_m, y\right) x_m^i - \tilde{w}^T \tilde{x}^i, \tag{4}$$

where the superscript T represents vector transposition.

The optimality condition for profit maximization requires that the marginal product value of an input is equal to the perceived marginal cost of an input. For inputs with parametric price, this yields the equation

$$w_p \nabla_{\tilde{x}^i} f\left(x_m^i, \tilde{x}^i\right) = \tilde{w}. \tag{5}$$

Assume that the firm realizes that since its use of input m, x_m^i, forms an important part of the total demand for the input, x_m, its input decision has an impact on price w_m. Let us denote the supply elasticity of the input price $(\partial w_m/\partial x_m)(x_m/w_m)$ by γ. Firm i may also conjecture that its input decision affects its rivals' input decisions. Let us denote this conjectural elasticity $(\partial x_m/\partial x_m^i)(x_m^i/x_m)$ by θ^i. For a monopsonist, θ^i equals one, and for a firm that takes input price as given θ^i equals zero. Using the notation above, we can write the optimality condition for input demand x_m^i as

$$w_p \frac{\partial f}{\partial x_m^i} = w_m\left(1 + \theta^i \gamma\right). \tag{6}$$

Due to a lack of data on individual firms, we must make some restrictive assumptions to enable aggregation of the firms in order to perform our analysis using industry-level data. One possibility is to assume that θ^i is the same for all the firms, so that all the firms face identical marginal prices. On the other hand, if we assume that the marginal product of input m is the same for all the n firms in the industry, then Equation (6) implies that in equilibrium θ^i is the same for all the firms. We will make the former assumption, and denote the common conjectural variations parameter by θ. Using the equilibrium values for inputs and outputs, the industry shadow price variable profit function, Π, can be expressed as:

$$\begin{aligned}\Pi = w_p q\left(w_p, w_m(1+\theta\gamma), \tilde{w}\right) - \\ w_m(1+\theta\gamma) x_m\left(w_p, w_m(1+\theta\gamma), \tilde{w}\right) - \\ \tilde{w}\tilde{x}\left(w_p, w_m(1+\theta\gamma), \tilde{w}\right),\end{aligned} \tag{7}$$

where $q(\cdot)$ is the industry equilibrium output, and x_m and $\tilde{x}$ are the industry equilibrium inputs with (shadow) prices $w_m(1+\theta\gamma)$ and $\tilde{w}$ respectively. Applying Hotelling's Lemma in terms of shadow prices to Equation (7), the output supply and the negative of input demand equations for the industry can be solved respectively as

$$\frac{\partial \Pi}{\partial w_p} = q\left(w_p, w_w(1+\theta\gamma), \tilde{w}\right), \tag{8}$$

$$\frac{\partial \Pi}{\partial w_m(1+\theta\gamma)} = -x_m\left(w_p, w_m(1+\theta\gamma), \tilde{w}\right), \tag{9}$$

$$\nabla_{\tilde{w}} \Pi = -\tilde{x}\left(w_p, w_m(1+\theta\gamma), \tilde{w}\right). \tag{10}$$

In the econometric application we assume that the Finnish pulp industry uses two variable inputs, wood and labour, together with a quasi-fixed capital input in order to produce pulp, which is sold in competitive world markets. This framework allows for the possibility that the industry is not in long-run equilibrium. To account for technological change, time enters equations to be estimated as a fixed input. We based the model on a generalized Leontief (GL) profit function, which is a flexible functional form. This form allows us to avoid placing *a priori* constraints on the second derivatives of the profit function.

Let Z be an n-vector of the (quasi) fixed inputs and w^s an m-vector of *shadow* prices for output and variable inputs. The chosen GL specification for the industrial shadow price variable profit function, $\Pi(w^s,Z)$, is

$$\Pi\left(w^s,Z\right)=\sum_i^m\sum_j^m\beta_{ij}\left(w_i^s w_j^s\right)^{0.5}+\sum_i^n\sum_j^n\mu_{ij}Z_iZ_j+\sum_i^m\sum_j^n\phi_{ij}w_i^sZ_j, \tag{11}$$

where β_{ij}, μ_{ij}, ϕ_{ij}, as well as the parameters γ and θ in the shadow price of wood, are estimated. For symmetry of the profit function, we impose the restrictions $\beta_{ij}=\beta_{ji}$ and $\phi_{ij}=\phi_{ji}$. Applying Hotelling's Lemma on shadow prices to Equation 11, we obtain output supply equation q and input demand equations for variable factors x_i.

$$q=\sum_j^m\beta_{qj}\left(w_j^s/w_q^s\right)^{0.5}+\sum_j^n\phi_{qj}Z_j, \tag{12}$$

$$-x_i=\sum_j^m\beta_{ij}\left(w_j^s/w_q^s\right)^{0.5}+\sum_j^n\phi_{ij}Z_j. \tag{13}$$

Assuming roundwood input to be freely adjustable, the model consists of Equation (12) for pulp output and Equation (13) for wood and labour input. Because our purpose was to test the pricing rule, the markdown term for the wood price $(1+\gamma\theta)$ was treated as a single parameter, χ, in our empirical model. The measure of actual oligopsony power, which can also be interpreted as the input market counterpart to the Lerner index, L, can be calculated from the estimate for χ as $\chi=1+\theta\gamma$ so that we get $L\equiv\chi-1=\theta\gamma$.

Note that if the factor demand system is estimated simultaneously with the wood supply equation (3), it is possible to separate the supply elasticity of wood price, γ, from the conjectural elasticity term, θ. Because of a lack of data, this procedure could not be used for modelling the supply of wood imports or wood chips coming from the sawmilling industry, of which both are important raw material sources for the Finnish pulp industry. For domestic pulpwood, simultaneous estimation of the supply elasticity was attempted, but due to the wrong signs for the pulpwood supply elasticity estimates, this approach could not be used. However, it is justifiable to assume that the supply elasticities of wood input are finite since earlier roundwood market studies suggest that the elasticity of the stumpage price of pulpwood with respect to supply (i.e., the inverse price elasticity) lies between one and two (e.g. Kuuluvainen *et al.*, 1988; Toppinen & Kuuluvainen, 1997). Therefore, an estimate for χ that is greater than one indicates deviation from competitive wood pricing.

Data

The model was estimated using annual data for Finland for the period from 1965 to 1994. The wood input of the pulp industry consists mainly of three different components; private nonindustrial forests, imported pulpwood and wood chips purchased from the sawmilling industry. Imports of pulpwood currently account for roughly one sixth of the total consumption of industrial roundwood in Finland. During the study period the average share of wood chips in total wood input for pulp production has been close to one fifth, and wood chips have been used both in mechanical and chemical pulp production. However, the market for wood chips is not well defined, as a major part of chips are obtained as a by-product from sawmills owned by the companies that also produce pulp. The availability of residual wood varies annually, depending on business conditions in the sawmilling industry, which do not always coincide with business cycles in the pulp industry. Moreover, wood chips do not allow for a long storage period before pulping, whereas the wood buyer in the pulpwood stumpage market can postpone felling up to two years after purchasing the wood. Although wood chips are close substitutes for roundwood, differences in the quality of two inputs in pulp production is an open question.

All the three types of wood, i.e. wood chips, domestic pulpwood and imported pulpwood, have their own unique price developments during the study period. The cost of domestic roundwood has always exceeded the price of wood chips, while price differences between domestic and imported pulpwood are less pronounced. Price difference between wood and chips may be due to the fact that the inputs are not perfect substitutes or that the inputs differ in other respects that may affect the price, e.g. availability and terms of trade. The differences may also be a sign of imperfectly competitive markets, with suppliers being in different positions in negotiating vis-a-vis over the prices of their products.

The domestic roundwood price that we used is the value of domestic pulpwood input in the pulp and paper industry divided by the domestic pulpwood quantity, i.e. the mill price. This pulpwood mill price consists of a rather highly variable stumpage price component and a relatively stable harvesting and transportation cost component. The unit price of imported pulpwood (CIF) is the value of imports divided by the quantity of imports. For wood chips, no actual prices were available. Therefore we used the recommended price for wood chips at Kotka harbour up to the year 1986 (from Hetemäki, 1990), and the price reported by a representative forest industry company thereafter. The firms in the forest industry are assumed to use market prices as a basis for their internal transfers of wood and chips. The low quality of the wood chip price data must be borne in mind when comparing results from alternative models.

The pulp price is the quantity-weighted export price (FOB) of mechanical and chemical pulp. The measure of pulp quantity is the sum of the Finnish output of mechanical and chemical wood pulp. The labour input is the total number of working hours in the pulp industry provided by the Statistics Finland. This was not as such available for the years 1986–1994, as integrated pulp and paper production were aggregated in the Industrial Statistics for those years. Working hours in pulp production were separated from the total working hours in integrated pulp and paper production by extrapolating from past developments in the pulp and paper industry. Wage cost is the total sum of wages and social security costs in the pulp and paper industry divided by the total number of working hours.

The National Accounts provide an updated series for the net stock of capital for the aggregate of pulp, paper and paper products. We separated the capital stock for pulp from the total capital stock for the pulp, paper and paperboard industries, using share weights obtained from the respective (older) series of Industrial Statistics. Again, this method was only applicable up to the year 1985 and for the rest of the observations, the production capacity for pulp and paper was used as a reference for separating the net stock of pulp capital from the aggregate capital stock. Due to high correlation between the capital stock series for the pulp and paper industry and for the pulp industry exclusively, the choice between the two capital stock values does not make a difference in estimation.

Estimation Results

The model was estimated using Zellner's iterative seemingly unrelated regression method in a stochastic form with additive disturbance terms. We report four alternative estimations (Models A, B, C and Model A with dummy variables). In Model A imperfect competition is allowed in the pulpwood market, while in Model B it is allowed in the market for wood chips. To avoid having the markdown parameter χ (χ =1 + $\theta\gamma$) appear under the square root sign, we introduced the parameter for $\sqrt{\chi}$ and used its square as a parameter in our estimations.

In Model A it was assumed that the pulp industry uses all the wood imports and wood chips that are available to it in a given year and that it buys the additional wood from private forests. Hence the variable part of wood input is domestic roundwood, for which the wood from alternative sources is a perfect substitute. Domestic pulpwood price was used as the representative wood price in Model A. Then we estimated the same system using the wood chip price as a representative wood price (Model B). Here we assumed that the pulp industry purchases its pulpwood before it knows the quantity of wood chips available, and then buys the available wood chips from the sawmills.

In Table 1 most of the parameters in both models A and B were significant and the test statistics for the two models did not differ markedly. Many of the cross-price parameters were significant, which suggests that Leontief-technology (i.e linear equations with respect to input prices) is not a good description of the wood pulp industry at the aggregate level. In model A a significant estimate, 0.99, is obtained for $\sqrt{\chi}$, and the Wald test supports the restriction $\sqrt{\chi} = 1$ with high probability value (p = 0.97). Hence, the result can not reject the competitive pulpwood market if the wood price at the margin has been determined in the domestic pulpwood market. On the other hand, model B suggests that if industry buys wood chips at the margin, it marks down their price. The estimate 1.21 was obtained for $\sqrt{\chi}$, giving χ an approximate value of 1.47[1]. The obtained Wald-test probability value for restriction $\sqrt{\chi} = 1$ was lower (p = 0.19) than for pulpwood.

If the market has been competitive as suggested by model A, then the actual profits of the pulp industry coincide with the behavioural profit function, as shadow prices for variable inputs do not differ from observed prices in a competitive industry. We included shadow profit (Equation 11) in the equation system to check the sensitivity of the parameter estimates to the inclusion of the variable profit equation. The estimate for the variable profit was calculated from the price and quantity data, valuing the alternative wood inputs at their prices and estimating the model with c restricted to one (Model C). The results were very similar to those of the model A, as can be seen from Table 1.

The own- and cross-price elasticities were calculated at the mean of the variables for Models A–C. All the models gave roughly similar elasticities, of which those of Model C are given in Table 2. All the own-price elasticities were consistent with the theory since they were positive for pulp output and negative for variable inputs. All the elasticities were less than one, i.e. rather small in absolute terms. For example, the estimated own-price elasticity for pulpwood demand was –0.25 and the price elasticity of pulp supply was 0.15. Labour input was found to be a complement for wood input, in contrast to Hetemäki (1990), which found

[1] It is worth recalling that the low quality of wood chip price data may have an effect on this result (Model B).

Table 1. Regression Results.

This table presents parameter estimates for alternative iterative seemingly unrelated regression models. (t-values in parentheses on the right to the coefficients and Durbin-Watson statistics below coefficients of determination). The subscripts are: q for pulp, l for labor, w for wood, T for technological change, and K for capital.

	Equations			
	Pulpwood price A	Residual wood price B	Pulpwood price C	Pulpwood price A + Dummy variables
Parameters	Imperfect competition χ=free	Imperfect competition χ=free	Perfect competition χ=1	Imperfect competition χ=free
$\sqrt{\chi}$	0.99 (6.53)	1.21 (7.51)	–	1.17 (15.56)
β_{qq}	6.75 (6.40)	5.96 (9.28)	5.90 (10.79)	8.36 (8.39)
β_{ll}	−29.87 (−5.50)	−20.12 (−4.23)	−27.42 (−5.53)	−27.67 (−5.45)
β_{ww}	−9.89 (−1.98)	−12.50 (−3.71)	−4.48 (−1.53)	−0.28 (−0.06)
β_{ql}	−2.36 (−4.48)	−3.29 (−4.95)	−2.43 (−4.64)	2.59 (4.92)
β_{wl}	7.16 (4.75)	9.22 (5.57)	6.71 (4.64)	6.05 (4.35)
β_{qw}	−4.96 (−2.46)	−3.29 (−3.95)	−5.27 (−8.36)	−8.96 (−4.47)
D_{75q}	–	–	–	−1.97 (−6.04)
D_{76q}	–	–	–	−1.71 (−5.47)
D_{77q}	–	–	–	−1.76 (−5.77)
μ_{TT}	–	–	−4.75 (−2.88)	–
μ_{TK}	–	–	0.00 (4.28)	–
ϕ_{qK}	0.00 (0.16)	0.00 (0.12)	0.00 (1.66)	0.00 (2.61)
ϕ_{qT}	0.14 (5.11)	0.15 (5.66)	0.12 (4.75)	0.10 (5.64)
ϕ_{lK}	−0.00 (−7.13)	−0.00 (−7.34)	−0.00 (−7.80)	−0.00 (−7.25)
ϕ_{lT}	1.04 (10.26)	0.90 (10.07)	1.03 (11.05)	1.01 (10.58)
ϕ_{wT}	−0.55 (−4.39)	−0.63 (−5.26)	−0.44 (−3.97)	−0.33 (−4.44)
ϕ_{wK}	−0.00 (−0.22)	−0.00 (−0.36)	−0.00 (−1.85)	−0.00 (−2.66)
D_{75w}	–	–	–	8.28 (6.24)
D_{76w}	–	–	–	7.44 (5.86)
D_{77w}	–	–	–	7.11 (5.72)
Equation: Π				
Adj. R2	–	–	0.79	
(DW)	–	–	(0.59)	
Equation: Q				
Adj. R2	0.78	0.78	0.77	0.93
(DW)	(0.58)	(0.63)	(0.53)	(1.09)
Equation: $-X_W$				
Adj.R2	0.73	0.72	0.71	0.92
(DW)	(0.58)	(0.62)	(0.52)	(1.14)
Equation: $-X_L$				
Adj. R2	0.97	0.97	0.97	0.97
(DW)	(0.70)	(0.91)	(0.66)	(0.68)

TABLE 2. ELASTICITIES.

This tabel presents elasticities for model C, calculated at the mean of the variables.

Equations	Pulp price	Wood cost	Labor cost	Capital stock	Technical change
Pulp supply	0.15	–0.12	–0.03	0.20	0.27
Wood demand	0.32	–0.25	–0.07	0.27	0.27
Labor demand	0.29	–0.27	–0.03	0.48	–0.66

that labour was a substitute for pulpwood. According to semi-elasticity estimates for technical change, it was found to be wood using and labour saving in the Finnish pulp industry, while in Hetemäki (1990) it was found to be roundwood saving and labour using.

The models however suffer from residual autocorrelation, as indicated by the Durbin-Watson statistics. There is also a problem with the unexplained variation in the wood demand equation, which seems to arise mainly from the wide price and quantity fluctuations in the mid-1970s (1975–77). During this period pulp production and wood consumption plummeted at very high price levels for both pulp and pulpwood. Using separate dummies for these years in model A, residual autocorrelation was reduced as indicated by the rise in Durbin-Watson statistics (see Table 1). Most interestingly, the inclusion of dummies increased the markdown term in the model A, where χ received a significant estimate of 1.37.

In our models, potential markdown was assumed to be constant over the examined time horizon, which is a restrictive assumption. Unfortunately, our experiments using the time-varying markdown parameter, consisting of exogenous variables of the pulpwood model system as in Bergman & Brännlund (1995) produced theoretically incorrect values for markdown, i.e. χ was systematically below one.

Concluding Remarks

In this paper deviations from competitive pricing of wood were tested using a flexible functional form of factor demand system for the aggregate Finnish pulp industry in

1965–94. Our empirical estimates suggest that the Finnish pulpwood market has on average been competitive during the period. There is, however, some indication that wood chips purchased from the sawmilling industry have been priced below the value of their marginal product. Provided that pulpwood and wood chips are substitutes, this result is qualitatively evident *ex ante* since the price of wood chips has been constantly lower than the price of pulpwood. However, due to residual autocorrelation left in the models and to the fact that the results were sensitive to having all data points of the observation period included, one must be cautious with the conclusion regarding the degree of competition in the pulpwood market. One possible reason for residual autocorrelation in models with rather high explanatory power is nonstationarity of individual time series. Augmented Dickey-Fuller unit root tests (Dickey & Fuller, 1979) also indicate that at least two endogenous variables of the system, i.e. pulpwood and pulp quantity, may in fact be nonstationary. Unfortunately, cross-equation restrictions make it difficult to accommodate nonstationarity and possible cointegration in a flexible functional form factor demand model. This approach remains, however, as a possible way to extend this research (see also Aiginger et al. 1995).

Although the strong asymmetry of the Finnish pulpwood market suggests imperfect competition, our results in favour of a competitive market or weak oligopsony power are nevertheless plausible. As concluded by Bergman (1993) for the Swedish roundwood markets, the input market counterpart of the so-called Coase conjecture (Coase, 1972) offers an explanation for the wood market pricing. If wood buyers cannot commit themselves not to change the price in the future, the sellers of wood can postpone their decisions to sell and wait until the price eventually rises. Thus the stable market equilibrium in fact converges to the level where the actual wood price equals the value of the marginal product of input, i.e. to the competitive market price. This reasoning is even more suitable to the Finnish pulpwood market than to the Swedish one: the forest industry owns 40 % of the forest area in Sweden while the respective share in Finland is only 9 %, making the Finnish forest industry far more dependent on the nonindustrial private wood supply. Also previous studies on the Finnish wood markets have indicated that price expectations play a crucial role in explaining the forest owner's timber selling behaviour. On the other hand, the signs of imperfect competition in the wood chips market can be explained by the lack of countervailing power of independent sawmills as compared to suppliers of pulpwood.

ACKNOWLEDGEMENTS

We thank for useful discussions with Lauri Hetemäki, Pekka Ilmakunnas, Markku Kallio, Jari Kuuluvainen, and Markku Ollikainen. Financial support from the Academy of Finland is acknowledged. The usual disclaimer applies.

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