IMPORTS OF PULPWOOD AND PRICE DISCRIMINATION: A TEST OF BUYING POWER IN THE SWEDISH PULPWOOD MARKET

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ABSTRACT

The Swedish pulp and paper industry's ability to exert monopsony power is tested both with a conjectural variation model, which parameterizes the firms' expectations about other firms' behavior, and with a model that estimates country-specific effects and effects of currency fluctuations on import prices. We use industry data for the 1970–1993 period and find only weak evidence of market power, in spite of the apparent lack of competition.

Keywords: conjectural variation, generalized Leontief, market power, monopsony, oligopsony, profit function.

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INTRODUCTION

We use a data set from 1970–1993 including major exporters of pulpwood to Sweden during this time, to estimate the Swedish' pulp and paper industry's market power over the suppliers of pulpwood. In doing so, we make use of two strands of the economics literature.

The first is the "New Empirical Industrial Organization" (NEIO), which aims at parametric estimation of market power using price and quantity data only, often applied to a single industry. This is in contrast with the earlier IO literature which focused on cross-industry studies of concentration and profitability and relied on accounting cost data.

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The second is a literature that tries to empirically test for imperfect competition in export markets. Knetter (1989) has suggested a technique for assessing the existence of market power, using a reduced form single equation. He models the export price of a good to a specific market as a function of the exchange rate, a country-specific dummy and a time dummy. If the international markets for this good were perfectly competitive, then the exchange rate and the country dummy should have no effect on the price. On the other hand, if the exchange rate and the country dummy affect the price, this suggests that the market is characterized by imperfect competition. Pick & Park (1991), Yerger (1996) and Alexius & Vredin (1996), among others, have employed the same technique on other markets. In all of these papers, the perfect competition hypothesis was rejected. However, Knetter suggested an alternative explanation for the effect of the exchange rate on prices: that variations in the exchange rate induce shifts of demand or supply. Buongiorno & Uusivuori (1992) argue that if the "law of one price" holds, i.e. if in the long run export prices of all commodities are the same across each pair of countries, then the apparent effects of exchange rates on prices are likely to have such other causes.[1] Using co-integration methods, Buongiorno and Uusivuori find that the law of one price does indeed hold for a sample of pulp and paper exports from the U.S.

An early example of the NEIO-literature is Appelbaum (1982), who estimated a (conjectural variation) parameter representing the market power exerted by the firms of an industry. The possibility of identifying such a parameter without the use of accounting data is clearly discussed by Bresnahan (1982) and Lau (1982). Empirical methods for estimating the parameter have been developed by, e.g., Atkinson & Kerkvliet (1989). Applications to the pulp and paper industry include Bernstein (1992), Bergman & Brännlund (1995), Murray (1995) and Yerger (1996). The structure of the pulp and paper industry motivates the estimation of mono*psony* power, instead of the monopoly-power parameter estimated in most of the empirical literature.

[1] Alternatively, the law of one price holds if, in the long run, one of the prices is a linear function of the other price, for each pair of prices.

The Swedish pulp and paper industry is highly concentrated. The four largest firms use 75 percent, and the seven largest firms 95 percent, of the pulpwood. Furthermore, most of the largest firms coordinate their purchases in jointly owned purchasing companies.[2] The production of pulp (6 percent of world production in 1994) and paper (3 percent of world production) in Sweden is approximately half of that in Canada. The turnover of the Swedish-owned industry, however, is comparable to that of the Canadian-owned industry, or almost 25 billion USD. About half of the turnover stems from subsidiaries located abroad. (Yearbook of Forest Statistics.)

Between 1973 and 1987, the pulp and paper industry were able to coordinate their investments with the help of the Building and Construction Act, which regulated investments in the pulp and paper industry during this period. The Act gave the firms in the industry influence over their competitors' investments.

Since 1906, when the Swedish pulp and paper industry was prohibited from acquiring forest land, it has owned 25 percent of the forest area. In 1994, however, this figure rose to 40 percent, when most of the state-owned forest was transferred to a state-owned producer of pulp and paper, which subsequently was partly privatized, although with the state retaining a majority of the shares. In 1965 the industry regained the right to acquire forest land. Half of the forest land is owned by private forest owners, while 55–60 percent of all domestic wood supply comes from private owners. During the last three or four decades, 40 to 50 percent of the private wood supply has been sold with the Forest Owner's Association acting as an intermediary. In the 1960s and early 1970s, the Association integrated forward into the pulp and paper and sawmill industries. In 1975, its cooperatives accounted for 15–20 percent of total production. The recession following the first oil crisis forced the Forest Owner's Association to shut down or sell half of its industrial capacity.

Clearly, the industry has the upper hand in the price negotiations with the Forest Owner's Association. There

[2] These were recently banned by the Swedish Antitrust Authorities under the new and stricter 1993 Competition Law. The purchasing companies are currently being restructured as transport optimization joint ventures.

have been concerns that the industry uses imports of pulpwood to exert downward pressure on the price, and reports of import prices far higher than the prevailing domestic prices. This would suggest price discrimination. However, Figure 1 shows that the average cost of imported pulpwood has not deviated much from the industry's total average cost of pulpwood (i.e., including both domestic and imported wood; no disaggregation into species and chips are made).

Before 1975 the trade in pulpwood across the Swedish border was small and balanced; since 1975 imports have accounted for 10–20 percent of the pulp and paper industry's input. The sudden increase coincides with what appears to be a downward shift in domestic supply (see Figure 2 below).

A look at the institutions of Swedish forestry suggests that the industry has substantial market power over the sellers of wood, while a comparison of domestic prices and prices of imported wood suggests otherwise. Attempting to resolve this puzzle, the aim of this paper is to estimate the oligopsony power using industry data for the Swedish wood pulp and paper industry. The findings of Bergman & Brännlund (1995) lend some support to the notion that the industry has market power vis-à-vis the supplier of pulpwood, although the results indicate that the market power may have varied over the years. The current paper uses a more recent data set. Another important difference is the inclusion of the market for imported wood. The results in-

TABLE 1. IMPORTS OF PULPWOOD IN 1000 m^3FUB, ANNUAL AVERAGES OVER THE PERIODS.

	Imports from							
Period	Norway	Denmark	Finland	FSU	Germany	Poland	UK	Holland
60-64	174	0	513	0	0	0	0	0
65-69	97	0	136	0	0	0	0	0
70-74	101	12	244	88	116	0	0	0
75-79	200	259	139	217	838	281	26	4
80-84	348	308	523	213	652	438	348	18
85-89	469	345	452	1282	1370	632	187	22
90-93	518	263	127	1395	937	231	45	3

Source: SOS Trade Statistics. FSU=(Former) Soviet Union.

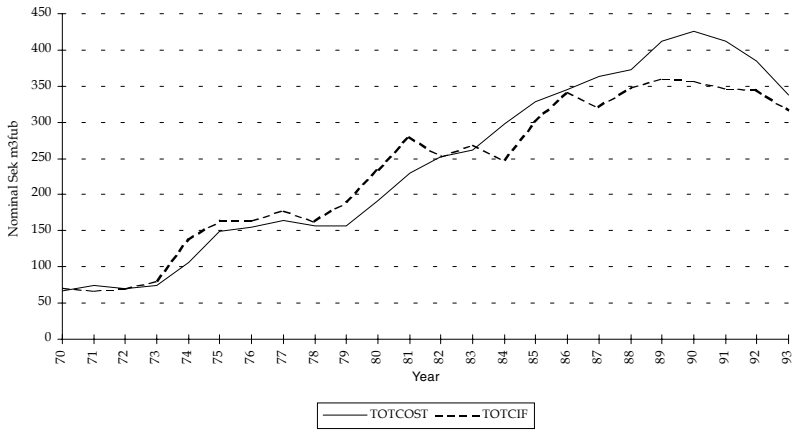

FIGURE 1. TOTAL COST AND COST OF IMPORTS.

Source: SOS Industry and Yearbook of Forest Statistics, various years. Domestic price (TOTCOST) is approximated with the average cost of all pulpwood at the factory, including imports. Import prices, IMPCOST are measured as CIF-prices plus 10 percent to account for unloading and transport costs. m^3fub means cubic meter solid volume excluding bark.

dicate that the Swedish domestic market for pulpwood is competitive, but for the imports the results are somewhat mixed.

IMPORTS AND MARKET POWER

The most important suppliers of pulpwood to Sweden are the Baltic Sea states, although imports from countries as far away as Chile occasionally occur. Table 1 shows the evolution of import volumes from the most important suppliers.

As can be seen in Table 1, the major exporters in recent years are Germany and the FSU (former Soviet Union). In the 1960's only Norway and Finland exported significant amounts of pulpwood to Sweden. One explanation for this increase in trade with new partners in the 1970s is falling bulk transport costs (Lundgren, 1996). Another explanation may be that because of increased concentration, the industry has become more prone to use imports to exert market power.

The average unit value of imports, hereafter referred to as the CIF-price, is closely correlated to the domestic price, whether this is measured as the domestic list price or as the average pulpwood cost at the factory (see Figure 1). One

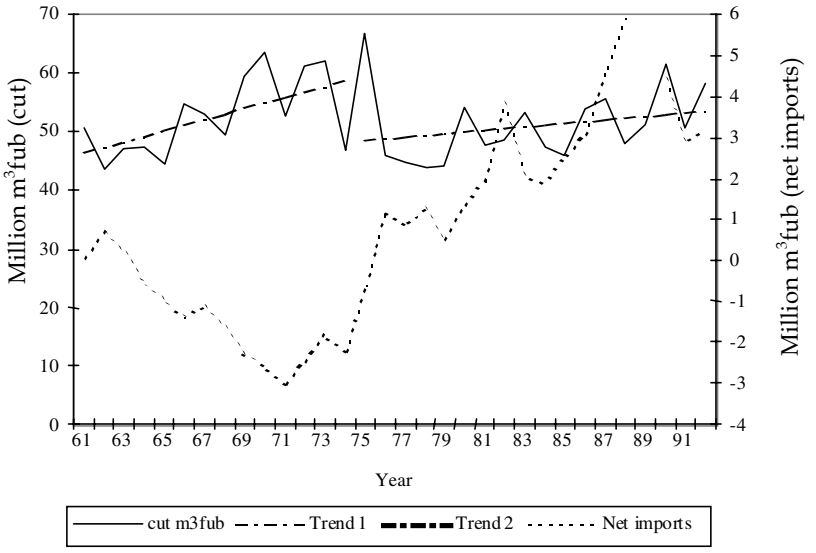

FIGURE 2. QUANTITY ROUNDWOOD CUT IN SWEDEN AND NET IMPORTS 1961–1992, TRENDS ADDED.

Source: Yearbook of Forestry Statistics 1996. m³fub means Cubic metre solid volume excluding bark.

should also note that according to our measures, since the early 1980's, the average CIF-price has been lower than the cost of domestic pulpwood at the factory. However, note that we are comparing average prices, while we should study prices at the margin. The correlations between CIF-prices, cost at factory and the list prices are presented in Table 2.

TABLE 2. CORRELATION OF PULPWOOD "PRICES".

	Average Cost at Factory	Domestic List Prices	CIF Price (unit value)
AC at Factory	1		
List Price	0.74	1	
CIF Price	0.87	0.67	1

Sources: SOS Industry, Yearbook of Forest Statistics, various years.

As a first step, we estimate the following equation to test for imperfect competition:

$$\ln w_{it} = \theta_t + \gamma_i + \beta_i \ln s_{it} + u_{it}, \quad (1)$$

where w_{it} is the price per unit of wood imported from country i at time t in Swedish Kronor (SEK), θ_t is a time effect, γ_i is a country effect, s_{it} is the price of country i's currency at time t, and u_{it} is the disturbance term. This is the monopsony version of Knetter's (1989) proposed specification for the monopoly case. If the market were perfectly competitive, then we would expect all γ_i and β_i to be zero, assuming that the marginal value products of wood from different countries are equal. If the supply elasticities are constant over time, but competition imperfect, then γ_i may vary across markets, but all β_i should be zero. Finally, under imperfect competition and non-constant elasticity of supply both γ_i and β_i may be non zero. We have tested this for the eight countries that are included in our study, using the nominal exchange rate. The exchange rates of the FSU and Poland were for most of this period not determined in free markets. We argue that they anyway to some extent reflect the economic conditions. Estimation results are shown in Table 3.

TABLE 3. COUNTRY AND EXCHANGE RATE EFFECTS ON THE CIF-PRICE. *Sample period is 1974–1993. All exchange rates are expressed as the export market's currency per SEK. Prices are CIF average, nominal SEK. Data sources: see data section below. Time effects not reported.*

	Exchange Rate	t-stat	Country Dummy	t-stat
Norway	–1.67	–2.18		
Finland	–2.73	–4.58	–0.79	–3.96
Denmark	–1.17	–2.53	0.078	0.68
Germany	0.04	0.17	0.03	0.09
FSU	0.03	1.13	0.13	1.20
Poland	–0.00	–0.17	–0.00	–0.00
UK	0.88	1.72	2.06	1.71
Holland	0.06	0.14	0.19	0.45
F=11.41	R^2adj.=0.70			

As can be seen, the exchange rate parameter is significant in three cases: Norway, Finland and Denmark. A significant exchange rate parameter suggests a non-constant elasticity of supply. Consider a depreciation of the foreign (exporting country's) currency relative to the domestic (importing country's) currency. The price faced by exporters then increases. If this causes supply elasticities to change, then the optimal import price, possibly set by the Swedish importers, will change. In other words, changes in the exchange rate may cause changes in the import price. The interpretation of that parameter is, for example, that if the Finnish currency becomes weaker compared with the Swedish, (i.e., the FIM/SEK rises) this results in a lower price for Finnish pulpwood imported to Sweden. It is interesting to note the fact that all the Nordic countries exhibit an elasticity of the CIF-price with respect to the exchange rate that is lower than –1. Surprisingly enough, in the case of the UK, a change in the exchange rate is more than offset by a rise in the export price in British Pounds, which means that a weaker Pound coincides with higher prices on wood imported from the UK.

The country specific effects suggest that Finnish pulpwood is less costly compared with Norwegian pulpwood (the reference country). The 'conventional wisdom' that Swedish pulpwood buyers prefer not to compete with the Finnish pulpwood industry, in order to reduce competition in domestic markets, accords with our results.

A CONJECTURAL VARIATION MODEL

Following Appelbaum (1982), Atkinson & Kerkvliet (1989), and others, we use a dual representation of the production structure. Thus, we estimate input demand and output supply instead of the production (or profit) function. In contrast to, e.g., Atkinson and Kerkvliet, we simultaneously estimate the input supply functions. If these latter functions are not also estimated, then the monopsony hypothesis can be rejected either because of competitive behavior, or because the input supply curves are highly elastic. In order to separate these two effects, input demand and input supply must be estimated simultaneously (or we must use prior information on input supply elasticities).

In the Appendix, we make a number of formal assumptions and derive the equations to be estimated. In short, we assume that inputs (pulpwood, labor and energy) are homogeneous, that competition in the pulpwood market is possibly imperfect, that other inputs are bought on competitive markets, that firms maximize profits, and that all firms have equal conjectural elasticities.[3] We then derive the input demand and output supply equations to be estimated by applying Hotelling's lemma on an industry profit function. This gives the output supply:

$$\frac{\partial \pi^*}{\partial p} = q(p, z, w_1 s_1, t) \tag{2}$$

and the input demand:

$$-\frac{1}{s_i}\frac{\partial \pi^*}{\partial w_i} = R_i(p, z, w_1 s_1, t) \tag{3}$$

$$-\frac{\partial \pi^*}{\partial z_i} = x(p, z, w_1 s_1, t) \tag{4}$$

where π is the profit function, p and w are the (actual) prices of pulp and pulpwood, z is the price vector of other inputs, ws is the shadow price of pulpwood, index 1 (i) refers to the home country (country i), q is pulp output, R is demand for pulpwood, x is demand for other inputs and t is time.

In addition, we make a conventional specification of the pulpwood supply in market i as:

$$w_i = w_i(R_i, y_i) \tag{5}$$

where y is a vector of exogenous variables that shift pulpwood supply.

Estimation of the system consisting of Equations (2) to

[3] A firm's conjectural elasticity is a measure of how much that firm expects market demand to change when it changes its own demand. See the Appendix for a definition.

(5) will provide us with an estimate of θ_1, the underlying market-structure parameter. The estimation will also give us an estimate of the supply elasticities on the different markets, γ_i. From the equality:

$$w_1(1+\theta_1\gamma_1) = w_1 s_1 = w_i s_i = w_i(1+\theta_i\gamma_i) \tag{6}$$

it follows that all θ_i can be estimated if we know all w_i and γ_i. Equation (6) imposes the restriction that the shadow price of pulpwood is equal across countries. Oligopsony power is measured by the product of θ and γ.

EMPIRICAL SPECIFICATION

We assume that firms use wood (r), labor (x_l), energy (x_e), and capital (K) as inputs. The inputs of labor and energy (corresponding to x in the previous section), and wood, are variable, while capital is fixed. Thus, the model should be interpreted as a short-run model. We assume that the markets for pulp, labor, and energy are competitive, i.e., that the price of pulp (p), the wage rate (z_l), and the price of energy (z_e) are parametric to the (Swedish) pulp industry.

We specify the behavioral profit function for the pulp industry as a Generalized Leontief (GL) profit function, which is a so-called flexible-form profit function. This means that it is a second-order differential approximation to an arbitrary profit function (Chambers, 1988). However, in order to save degrees of freedom, our specification is not flexible with respect to technical change. The profit function is given by:

$$\pi^*\left(p,z,w_1(1+\theta_1\gamma_1)K\right) = (1+g)^t\left[\sum_{a=p,l,e,w}\sum_{b=p,l,e,w} K\beta_{ab}y_a^{1/2}y_b^{1/2} + \sum_{a=p,l,e,w}\beta_a y_a\right] \tag{7}$$

where $y_p = p$, $y_l = z_1$, $y_e = z_e$, and $y_w = (1+\theta_1\gamma_1)w_1$. Since the Hessian of a profit function is symmetric, we require that $\beta_{ab} = \beta_{ba}$. A fundamental property of the profit function is homogeneity of degree one in prices — this is satisfied by Equation (7). In addition, we allow the profit function to be homogeneous of degree one in the fixed factor. This is the case if $\beta_{ab} = 0$ for a=p,l,e,w. (Bergman & Brännlund,

1995.)[4] Using Hotelling's lemma, Equations (2) to (4), on Equation (7) we obtain:

$$q = \sum_{a=p,l,e,w} \beta_{pa}(1+g)^t K\left(\frac{y_a}{y_p}\right)^{1/2} + \beta_p(1+g)^t \tag{8}$$

$$-x_l = \sum_{a=p,l,e,w} \beta_{la}(1+g)^t K\left(\frac{y_a}{y_l}\right)^{1/2} + \beta_l(1+g)^t \tag{9}$$

$$-x_e = \sum_{a=p,l,e,w} \beta_{ea}(1+g)^t K\left(\frac{y_a}{y_e}\right)^{1/2} + \beta_e(1+g)^t \tag{10}$$

$$-r = \sum_{a=p,l,e,w} \beta_{wa}(1+g)^t K\left(\frac{y_a}{y_w}\right)^{1/2} + \beta_w(1+g)^t \tag{11}$$

The GL profit function has the property that its derivatives, with respect to prices, are linear in the parameters. However, when one of its inputs is traded in a non-competitive market, as in this case, the function becomes nonlinear in the parameters.

To estimate the inverse of γ_i, namely the supply elasticity, we need to specify the forest owners' supply of wood. The specification of the Swedish forest owners' decision problem is very conventional. We also estimate a "foreign" residual supply of pulpwood. Data availability allowed us to include for example cutting cost in the Swedish supply of pulpwood, but not in the foreign supply. We represent the domestic supply of pulpwood as a log-linear function:

$$\ln R_1 = \gamma_{10} + \frac{1}{\gamma_{1w}}\ln(w_1)\gamma_{1l}\ln(I_1) + \gamma_{1c}\ln(C_1), \tag{12}$$

where I_1 is forest inventory and C_1 is harvesting cost.

We assume that the foreign forest owners' supply of

[4] Bergman (1993) shows how the GL profit function should be specified, with or without homogeneity in a fixed factor, in order for it to be a flexible form that is homogeneous in prices.

pulpwood is represented by the log-linear function:

$$\ln R_i = \gamma_{i0} + \frac{1}{\gamma_{wi}} \ln(w_i) \gamma_{ir(t-1)0_{it-1}} \qquad (13)$$

where R_{it-1} is imports from country i in period $t-1$.

The full model to be estimated is given by Equations (6) and (8) to (13). Two versions of the model will be considered: one in which the conjectural elasticity parameter q is zero and one in which q is constant over time.

DATA

The data we use are annual observations from 1970 to 1993, collected from Official Statistics of Sweden: Manufacturing (SOS Industry) and from the Yearbook of Forest Statistics. The data of the exporting countries are found in the FAO Yearbook of Forest Products. The countries used in the study are Holland, UK, the FSU, Denmark, Norway, Finland, Germany and Poland.

The price of pulp is the price of bleached sulfate pulp. Wood input is measured as the consumption of wood raw material at the pulp mills minus wood chips and other wood residuals used. The domestic pulpwood price used is the total cost of pulpwood at the factory divided by the quantity used. The price of imported pulpwood is the total CIF paid at the border divided by the imported quantity plus 10 percent to account for unloading costs and costs for transport from the harbor to the pulp plant. Labor cost per hour is calculated as the total labor cost divided by the numbers of hours worked, plus the social costs paid by the employer. The price of energy (electric power) is derived in the same manner (total cost divided by total quantity).

A problem with the data is that the capital stock in the pulp industry is not available on a time series level. There exists data on capacity utilization, from which production capacity can be calculated. This is in turn used as a proxy for the capital stock. The data on standing timber is taken from the Yearbook of Forest Statistics. Exchange rates are from International Financial Statistics, IMF.

TABLE 4. REGRESSION RESULTS.
The table presents NL3SLS estimates of pulp supply, pulpwood demand and domestic and foreign pulpwood supply parameters respectively. Market power is assumed to be Zero. t-ratios within parenthesis.*

Pulp Supply		Pulpwood Demand		Domestic Pulpwood Supply		Foreign Pulpwood Supply	
Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient
β_{pp}	0.33 (5.13)	β_{ww}	−1.08 (−6.21)	γ_0	557456 (0.61)	γ_0	0.03 (0.64)
β_{pw}	−0.021 (−1.72)	β_{wp}	−0.021 (−1.72)	γ_{PRICE}	0.22 (1.37)	γ_{CIF}	1.23 (3.01)
β_{pl}	−0.012 (−1.69)	β_{wl}	0.65 (3.15)	γ_{COST}	−0.33 (−2.55)	γ_{Rt-1}	0.88 (9.94)
β_{pe}	0.65 (2.25)	β_{we}	−1.16 (−0.12)	γ_{INVENT}	−0.42 (−1.81)		
Time	1.018 (2.40)						
DW	0.83		0.85		1.31		1.83
R^2	0.58		0.23				

* A model with a non-homogeneous fixed input did not change the results or parameter values significantly.

EMPIRICAL RESULTS

We have tried a number of alternative specifications. Primarily, we are interested in estimating q, the conjectural elasticity, as a measure of market power. In some regressions we estimate this parameter without restrictions, in some we add the restriction that it should be non-negative and for comparison we have estimated our set of four[5] equations with q set to zero.[6] The results obtained with the latter restriction are shown in Table 4. Unfortunately, the β parameters have no direct interpretation, while the γ variables can be interpreted as elasticities.[7] Previously we found

[5] Simultaneous estimations of all six equations yields similar results, although the t-statistics deteriorate. Since the time series are short, we have chosen to estimate only the four most crucial functions.

[6] The restriction imposed by Equation (6) has a degenerated solution when the expressions within parentheses are zero. This solution is achieved when $\theta_1=-1/\gamma_1$ and $\theta_i=-1/\gamma_i$. Besides the theoretical reasons for not allowing a negative θ, this is another reason for forcing θ to be positive.

[7] However, point estimates of demand and supply elasticities can be obtained by differentiating Eqs. (13) to (16) with respect to own prices and evaluating at, e.g., the sample mean of the variables, although the statistical significance of these estimates cannot be derived. Since, in addition to this, our results are not very robust, we have chosen not to report elasticities.

TABLE 5. REGRESSION RESULTS.
NL3SLS estimates of pulp supply, pulpwood demand and domestic and foreign pulpwood supply parameters. Market power estimated. t-ratios within parenthesis.

Pulp Supply		Pulpwood Demand		Domestic Pulpwood Supply		Foreign Pulpwood Supply	
Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient
β_{pp}	0.36 (5.42)	β_{ww}	−1.07 (−6.06)	γ_0	559803 (0.62)	γ_0	.036 (0.64)
β_{pw}	−0.05 (−1.06)	β_{wp}	−0.05 (−1.06)	γ_{PRICE}	0.23 (1.44)	γ_{CIF}	1.24 (3.03)
β_{pl}	−0.013 (−1.96)	β_{wl}	0.03 (2.06)	γ_{COST}	−0.33 (−2.56)	γ_{Rt-1}	0.88 (9.96)
β_{pe}	0.67 (2.47)	β_{we}	0.12 (0.21)	γ_{INVENT}	−0.42 (−1.84)		
				θ_{DOM}	−0.19 (−1.31)	$\theta_{iIMPORT}$	−1.04 (−2.29)
Time	1.018 (2.29)						
DW	1.01		0.79		1.35		1.69
R^2	0.60		0.27				

some evidence that the Swedish industry has market power only in the Nordic market. For this reason, we have used imports from the Nordic countries only as an alternative measure of imports in some regressions. [8]

Despite the fact that the sample size is small, a relatively large number of the parameters are significantly different from zero. The price elasticity of domestic supply is estimated to be 0.2, indicating a fairly inelastic supply. The foreign supply is more elastic, with an estimated supply elasticity of 1.23. This suggests that price discrimination between the two markets is possible. The domestic supply is estimated to be inversely related to the inventory of forests in Sweden, whereas the prior belief is a positive relation. Clearly, a better specification of foreign supply of pulpwood would be desirable. The time variable, which in some sense represents technology, indicates a productivity growth slightly below 2 percent.

[8] A test designed where we divided foreign supply into Nordic and 'Others', could not converge, if we estimated them jointly (not reported here).

Earlier evidence indicates that the price elasticity of the Swedish pulpwood supply is rather small (Brännlund, 1988, and Bergman & Brännlund, 1995). Bergfors, Bergman & Hultkrantz (1989) give some initial evidence to an elastic supply of imported pulpwood, confirmed by the present study, although our estimate is considerably below theirs.

In the estimates reported in Table 5 we impose the restriction that the shadow prices should be equal between the domestic and the international pulpwood market.

Compared to Table 4, the changes in parameter values are small. A puzzling result is that the estimated qs are negative. *A priori* we would expect the *q*s to be positive. Theoretically, a value larger than 1 is possible but theory rules out negative values. Therefore, we tried to estimate our system of equations with the qs restricted to be non-negative.[9] The results are reported below (Table 8).

Table 3 suggested that the Swedish industry primarily has market buying power in the Nordic market. Therefore, Tables 6 and 7 present the estimation results when imports from the Nordic countries is the measure of import.

Table 6 shows, first, a much lower supply elasticity in the Nordic market (0.60) than for all imports (1.23). Second, the Swedish price elasticity of supply increases from 0.22 to 0.32. A fundamental condition for price discriminating behavior is that the elasticity with respect to price differs between markets. Since the two supply functions (the Swedish and the 'residual supply') are not estimated using the same variables, they should be compared with caution. Still, to some extent this result supports the possibilities of market power. Table 7 reports the result of the estimation of market power in the Swedish and Nordic 'residual supply' case.

As in the earlier estimations of market power, the *q* parameters have negative signs. Taken at face value, the negative *q*'s suggest that firms may even be paying prices above the competitive level. The estimates are close to the degenerate solution (see note 6). To control for the possibility that this is the cause for these paradoxical results, we have esti-

[9] See also note 6.

TABLE 6. REGRESSION RESULTS.
NL3SLS estimates of pulp supply, pulpwood demand and domestic and Nordic pulpwood supply parameters. t-ratios within parenthesis.

Pulp Supply		Pulpwood Demand		Domestic Pulpwood Supply		Foreign Pulpwood Supply	
Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient
β_{pp}	0.41 (4.78)	β_{ww}	−1.13 (−6.18)	γ_0	$0.26*10^7$ (0.57)	γ_0	.60 (0.77)
β_{pw}	−0.026 (−1.82)	β_{wp}	−0.026 (−1.82)	γ_{PRICE}	0.32 (1.95)	γ_{CIF}	.60 (1.51)
β_{pl}	−0.0073 (−1.82)	β_{wl}	0.51 (2.17)	γ_{COST}	−0.42 (−3.18)	γ_{Rt-1}	0.76 (7.20)
β_{pe}	0.59 (1.85)	β_{we}	4.20 (0.41)	γ_{INVENT}	−0.65 (−2.59)		
Time	1.016 (2.24)						
DW	0.83		0.91		1.45		2.04
R^2	0.57		0.46				

TABLE 7. REGRESSION RESULTS.
NL3SLS estimates of pulp supply, pulpwood demand and domestic and Nordic pulpwood supply parameters. Market power estimated. t-ratios within parenthesis.

Pulp Supply		Pulpwood Demand		Domestic Pulpwood Supply		Foreign Pulpwood Supply	
Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient
β_{pp}	0.52 (3.81)	β_{ww}	−0.34 (−0.60)	γ_0	$0.23*10^7$ (0.55)	γ_0	.60 (0.77)
β_{pw}	−0.48 (−1.81)	β_{wp}	−0.48 (−1.81)	γ_{PRICE}	0.41 (2.38)	γ_{CIF}	.60 (1.51)
β_{pl}	−0.0029 (−0.024)	β_{wl}	0.023 (0.58)	γ_{COST}	−0.44 (−3.08)	γ_{Rt-1}	0.76 (7.20)
β_{pe}	0.67 (1.98)	β_{we}	0.02 (0.02)	γ_{INVENT}	−0.67 (−2.56)		
				θ_{DOM}	−0.41 (−2.37)	$\theta_{iIMPORT}$	−0.55 (−1.44)
Time	1.013 (1.93)						
DW	0.87		0.77		1.43		2.04
R^2	0.49		0.29				

TABLE 8. REGRESSION RESULTS.
NL3SLS estimates of pulp supply, pulpwood demand and domestic and total pulpwood supply parameters. Market power estimated, forcing θ to be positive. t-ratios within parenthesis.[*]

Pulp Supply		Pulpwood Demand		Domestic Pulpwood Supply		Foreign Pulpwood Supply	
Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient	Parameter	Coeffcient
β_{pp}	0.37 (5.45)	β_{ww}	−1.03 (−5.85)	γ_0	547278 (0.62)	γ_0	.041 (0.64)
β_{pw}	−0.02 (−2.04)	β_{wp}	−0.02 (−2.04)	γ_{PRICE}	0.17 (1.11)	γ_{CIF}	1.21 (2.98)
β_{pl}	−0.014 (−1.98)	β_{wl}	0.63 (3.00)	γ_{COST}	−0.30 (−2.35)	γ_{Rt-1}	0.88 (9.97)
β_{pe}	0.84 (3.07)	β_{we}	−3.42 (−0.34)	γ_{INVENT}	−0.40 (−1.75)		
				θ_{DOM}	0.00 *(see fn. 6)*	$\theta_{iIMPORT}$	0.09 *(see fn. 6)*
Time	1.016 (2.49)						
DW	0.69		0.82		1.29		1.70
R^2	0.52		0.21				

[*] We forced the θ's to be positive by estimating the square root of each respective θ. Then the θ's are calculated by squaring the estimated parameter thus making θ positive. Due to the transformation the θ's change distribution. The original values of the parameter estimate were (with t-ratios within parenthesis) for the domestic variable 0.027 (0.097) and for the 'foreign' variable 0.09 (2.00).

mated the system without Equation (6), separately for Swedish and foreign supply. This results in a positive but insignificant θ for domestic supply and a negative and almost significant θ for foreign supply.

Table 8 reports the results when the θ parameters are restricted to be non-negative. Now the estimated supply elasticity is higher in the Nordic market and lower in the domestic market than before. The restriction causes substantial changes in the pulpwood demand parameters.

To sum up, we find no support for the notion that the imported pulpwood is used to exercise monopsony power in the domestic market. We find some evidence that Nordic supply differs from the rest of the world, but this cannot be confirmed when market power is estimated.

CONCLUSION AND DISCUSSION

The aim of this study was to test whether Swedish pulpwood buyers exercise oligopsony power or not. Regressing import prices on exchange rates and country dummies, we find some initial evidence of market power. Buongiorno and Uusivuori (1992) have demonstrated one way in which to proceed from this point: to confront the data with a test for the "law of one price". We have chosen instead to test for market power directly, using a conjectural variation model in combination with a dual representation of the production structure. We assume that the shadow prices are equal for all markets and impose this as a restriction on the system. This appears to be a critical restriction, but follows from profit maximization.

We are not able to reject the hypothesis of a competitive market, neither in the domestic pulpwood market nor in the international market. The domestic supply has an estimated own price elasticity between 0.17 and 0.41, which is in accordance with supply price elasticities found in earlier studies. The world supply function (in reality a residual supply function) has an estimated own price elasticity that lies between 0.60 and 1.24. This difference is a necessary but not sufficient condition for price discrimination between markets. The market power estimate rejects the hypothesis of market power in three different estimations. Inconsistent with economic theory, the sign of the market power estimate coefficient was negative (when estimated freely). Therefore we tried to force this estimate to be non-negative. The coefficient then became virtually zero, suggesting a perfectly competitive market.

We suggest a few explanations for our results. One important objection to our model is the specification of foreign supply of pulpwood. Our specification may not give an accurate estimate of the foreign price elasticity of supply. Second, one may venture the explanation that the Swedish firms are not acting rationally, i.e. they are paying to much for the domestic supply. It follows that we would have to discard the assumption of profit maximizing firms. However, we tend to believe that firms *will* approach a profit maximizing behavior over time. Third, we use average prices to estimate the market power although the relevant prices are the prices on the margin. If average

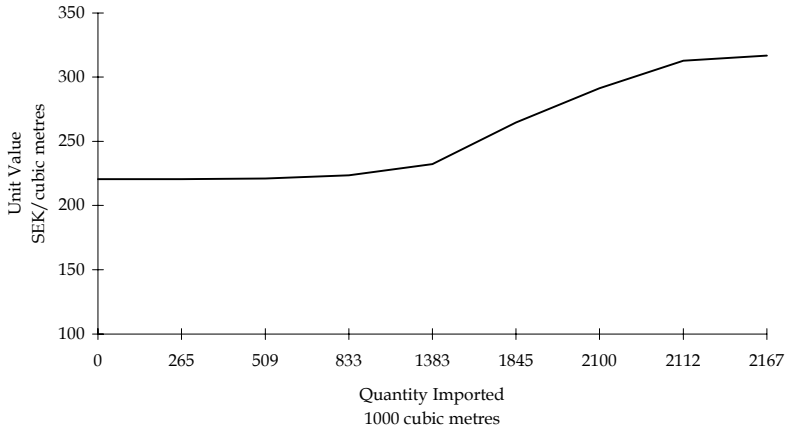

FIGURE 3. PRICES OF IMPORTS TO SWEDEN FROM EIGHT COUNTRIES 1983.
Source: Yearbook of Forestry Statistics 1984 and 1985. m^3fub means Cubic metre solid volume excluding bark. The countries used in the study are Holland, UK, the FSU, Denmark, Norway, Finland, Germany and Poland.

prices are proportional to marginal prices this would be an innocuous approximation. However, assume that the difference between the average and marginal import prices are bigger than the difference between the domestic average and marginal prices. Then we would systematically underestimate the price on the margin for imported pulpwood. To further explore this idea we plotted the imported quantities against the CIF unit value, thus creating a foreign pulpwood "supply" curve (see Figure 3).

One of the conclusions from Figure 3 is that the average import price may differ significantly from the marginal price. Although this is likely to be true also for domestic supply, some of our results may be due to measurement problems. Having pointed out these caveats we still believe our results carry some interest.

In Table 3 there is some evidence of market power in the pulpwood trade with the Nordic countries, especially the trade with Finland. This suggests that Swedish and Finnish buyers keep out of each others 'territories.' Therefore, we tried to estimate market power in the domestic market and in the rest of the Nordic countries. The estimation, shown in Table 7, rejects the hypothesis of market power.

Our results are somewhat contradictory, but the main conclusion is that we find no strong evidence of pulpwood prices below the competitive level. This contradicts the apparent lack of competition in the market, but accords, not surprisingly, with statements from the industry. Although a richer international data set would strengthen the power of this empirical assessment of market power, we believe the present study to be a first step in evaluating price discrimination between domestic and foreign pulpwood markets.

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APPENDIX

Assume that we have an industry in which N firms produce a homogenous good, pulp, using two different kinds of homogeneous inputs, r and x. Alternatively, r and/or x could be seen as vectors of inputs. The state of technology is assumed to be a function of time, t. Firm j's output is then:

$$q_j = f\left(r_j, x_j, t\right) \tag{A1}$$

where $f(\cdot)$ is a twice continuously differentiable production function. Input (vector) x_j represents inputs that are used in other industries (labor, energy et cetera), while r_j is an input that is used to produce this particular good only (pulpwood). Thus, we assume that each firm takes the price of x as given, while the

price of r depends on the quantity purchased. Pulpwood can be bought from M different countries, including the home country which is represented by index 1. Let w_{ij} be the price paid by firm j for pulpwood imported from country i. Assuming that all firms pay the same price in a given market makes index j redundant. Firm j's total purchase of pulpwood is the sum of purchased quantities over all markets, *i.e.*,

$$r_j = \sum_i r_{ij} \ .$$

Let the inverse supply function on market i facing the industry be given by:

$$w_i = w_i\left(R_i, y_i\right) \tag{A2}$$

where

$R_i = \sum_j r_{ij}$ is the sum of all Swedish firms' purchases from market i,

y_i is a vector of exogenous variables that shift pulpwood supply, and $\frac{\partial w_i}{\partial R_i} \geq 0$. Firm j's maximization problem is then:

$$\max_{x_j, r_{1j} \ldots r_{mj}} \pi_j = pf\left(x_j, \sum_i r_{ij}, t\right) - zx_j - \sum_i w_i\left(R_i, y_i\right) r_{ij}, \quad j = 1 \ldots, N, \tag{A3}$$

where p is the exogenous price of the final product and z is the exogenous price (vector) corresponding to x. The first order conditions for profit maximization are:

$$p\frac{\partial f}{\partial r_{ij}} = w_i\left(1 + \theta_{ij}\gamma_i\right), \quad i = 1, \ldots, M; j = 1, \ldots, N, \tag{A4i}$$

$$p\frac{\partial f}{\partial x_j} = z, \quad j = 1, \ldots, N, \tag{A4ii}$$

where

$$\theta_{ij} = \left(\frac{\partial R_i}{\partial r_{ij}}\right)\left(\frac{r_{ij}}{R_i}\right)$$

is the conjectural elasticity of firm j in market i with respect to buyers from country 1, and

$$\gamma_i = \left(\frac{\partial w_i}{\partial R_i}\right)\left(\frac{R_i}{w_i}\right)$$

is the inverse supply elasticity in market i of imports to Sweden (where $i \neq 1$ for imports, $i = 1$ is domestic supply). Each firm wants to equate marginal revenue with perceived marginal cost in each market. It appears reasonable to assume that the marginal product of pulpwood bought on different markets is the same, i.e., that for any j,

$$p\frac{\partial f}{\partial r_{ij}}$$

is equal for all i. Profit maximization and Equation (A4i) then imply that, for any j, $w_i(1+\theta_{ij}\gamma_i)$ is equal for all i. In other words, the shadow price of pulpwood must be equal on all markets for a given firm.

If $\theta_{ij} = 1$ for all i and all j, then we have a pure monopsony in all markets,

and if $\theta_{ij} = 0$ for all *i* and all *j*, then all markets are perfectly competitive. Cournot behavior implies that

$$\frac{\partial R_i}{\partial r_{ij}} = 1 .$$

In the domestic market, where only the domestic firms are assumed to operate, θ_{1j} is then the input share of firm *j*; in the other markets θ_{ij} would be firm *j*'s share of imports from country *i* to country 1.

The monopsony version of the Lerner index of monopoly power will be:

$$L_{ij} = \frac{VMP_{ij} - w_i}{w_i} = \frac{p\partial f / \partial R_i - w_i}{w_i} = \theta_{ij}\gamma_i \qquad \text{(A5)}$$

The degree of oligopsony power in the industry is the weighted sum of (A5). We have only access to aggregated data; in order to proceed, we assume that all firms have equal conjectural elasticities on a given market.* From Equation (A5) it is then clear that the firms behave as if they optimized against shadow prices $w_i s_i = w_i(1+\theta_i\gamma_i)$, where $s_i = 1+\theta_i\gamma_i$. We can now define the industry shadow, or behavioral, profit function as:

$$\begin{aligned}\pi^* &= pq(p,z,ws,t) - zx(p,z,ws,t) - \sum_i w_i s_i R_i(p,z,ws,t) \\ &= pq(p,z,ws,t) - zx(p,z,ws,t) - w_1 s_1 \sum_i R_i(p,z,ws,t) = \pi^*(p,z,w_1 s_1,t)\end{aligned} \qquad \text{(A6)}$$

where $ws = (w_1, w_2, ..., w_M)(s_1, s_2, ..., s_M)'$ are the vectors representing the pulpwood shadow prices. According to the argument following Equation (A4), $w_1 s_1 = w_2 s_2 = ... = w_M s_M$. Therefore, we only have to use one of the shadow prices in the reduced form profit function. The output-supply function is given by $q(\cdot)$, and the inputs-demand functions by $x(\cdot)$ and $R_i(\cdot)$.

Applying Hotelling's lemma, the industry output-supply function is:

$$\frac{\partial \pi^*}{\partial p} = q(p,z,w_1 s_1,t), \qquad \text{(A7)}$$

and the input demand functions are:

$$-\frac{1}{s}\frac{\partial \pi^*}{\partial w_i} = R_i(p,z,w_1 s_1,t) \qquad \text{(A8)}$$

$$-\frac{\partial \pi^*}{\partial z_i} = x(p,z,w_1 s_1,t) \qquad \text{(A9)}$$

Note that π^* is equal to the actual profit function p if s_1=1. Estimation of the system consisting of equations (A2), (A7), (A8) and (A9) will provide us with an estimate of θ_1, the underlying market-structure parameter. The estimation will also give us an estimate of the supply elasticities on the different markets, γ_i From the equality:

$$w_1(1+\theta_1\gamma_1) = w_1 s_1 = w_i s_i = w_i(1+\theta_i\gamma_i) \qquad \text{(A10)}$$

it follows that all θ_1 can be estimated if we know all w_i and γ_i. Oligopsony power is measured by the product of these two parameters, i.e., by the Lerner index.

* See, e.g, Bergman & Brännlund (1995).