Exchange Rate Changes and the Finnish Sawnwood Demand and Price in the UK Market

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This paper examines the long-run influence of exchange rate changes on the Finnish sawnwood price in the United Kingdom (UK) using quarterly data for the period 1978–1994. The degree of influence was measured by a pass-through coefficient (PT) obtained from a markup pricing relation of a system model. The model, which included export demand and price equations, was estimated with the cointegration method of Johansen. The results indicated a large PT, which means that exchange rate changes are reflected almost proportionately in Finnish export price expressed in pounds sterling. Thus, the Finnish price of sawnwood in pounds has lowered as a result of depreciation of the Finnish markka (FIM). This has improved Finnish competitiveness and market share in the UK. Appreciation of the FIM has had the opposite effect. It seems that Finnish exporters have made use of depreciations and devaluations of the FIM to maintain and increase their market shares but not necessarily their markups. For Finland, which is in the process of joining the European economic and monetary union (EMU), knowing the size of the PT is also important in assessing the economic impact of membership.

Keywords exchange rate, export demand, Johansen's cointegration method, pass-through, sawnwood price, United Kingdom
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1 Introduction

This study examines the effects of exchange rate changes on Finland's sawnwood exports to the United Kingdom (UK), which is a major market for Finnish sawnwood. In 1996 the UK accounted for 18 percent of Finland's sawnwood exports (Facts and Figures 1997). Exchange rate effects are analysed by a demand and supply model for Finnish sawnwood exports. The focus of the study is on the exchange rate pass-through (PT), i.e. the percentage change in export prices associated with a one percent change in the exchange rate.

If the exchange rate has a small effect on foreign currency prices, currency realignments should not have much effect on exports. Previous results are scanty for forest products, but they indicate that trade flows of forest products (measured in quantities) have not been very sensitive to exchange rate variations (Buongiorno et al. 1988). Also Uusivuori and Buongiorno (1990) found no long-run relationship between exchange rates and quantities of paper exports from Finland and Sweden to the USA. For Finland, which is in the process of joining the EMU, the magnitude of the exchange rate effect is important in assessing the economic impact of membership. In the EMU, it will no longer be possible to improve competitiveness by manipulating the exchange rate. Estimates of the degree of pass-through are also informative as to market competition, which is important in modeling trade flows.

The pass-through concept can be defined as the extent to which a change in a country's nominal exchange rate induces a price change in terms of the foreign currency. The magnitude of the pass-through also reflects the extent of market competition. For example, in perfect competition, export prices in foreign currency do not change as a result of a devaluation (revaluation) of the exporter's currency. In this case, Finnish exporters' prices in FIM would increase (decrease), their markup margins would increase (decrease) and the PT would be zero. On the other hand, in imperfect competition Finnish exporters could change their foreign currency prices when the exchange rate changes. If exchange rate fluctuations were partly reflected in foreign currency prices and partly in FIM prices, PT would be between zero and unity. If PT is unity, Finnish exporters lower (raise) their foreign currency export prices pro rata to a devaluation (revaluation) of the FIM

Pass-through has not been extensively studied for forest products trade, although it has been analyzed for trade in many other commodities and for aggregate imports and exports (see e.g. the survey Menon 1995). PT is found to vary widely by industry (e.g. Feenstra et al. 1996), which means that it is necessary to study pass-through at the commodity level. Most of the few studies analyzing the PT for forest products deal with the USA. For example, there are very few results for Finnish exports. In the study of Vesala (1992) PT for export prices of Finnish paper manufactures was found to be between 0.66 and 0.69 for western Europe and between 0.16 and 0.30 for the USA. According to Vesala, the smaller PT for the USA is due to the large US domestic market, in which the Finnish share is much smaller than in Europe. Other studies have also found that prices of several commodities imported to the USA only slightly reflect changes in exchange rates (e.g. Yang 1997).

Uusivuori and Buongiorno (1991) estimated PT for US forest products exports to Europe and Japan. Pass-through was incomplete in most of the product categories. However, in lumber exports to Japan, PT was high: from 0.79 to 1.04, depending on the species. Also in the study of Menon (1993a), who estimated PTs for Australian imports, wood products had a relatively high PT (0.80), while for paper and board the PT was 0.45. The earlier results indicate that PT is higher for wood industry products than for paper products. However, exact conclusions about the size of the PT for forest products are difficult to draw, because studies are scarce and they concern only a few products and countries.

Based on the earlier models for Finnish sawnwood exports to the UK (e.g. Hänninen 1986, Tervo et al. 1988, Hänninen 1994) and studies that test arbitrage in UK sawnwood imports (Hänninen 1998), it can be assumed that the PT is relatively large. The assumption is also supported by the structure of UK sawnwood imports, which is dominated by four large supplier countries, i.e. Finland, Sweden, Canada and Russia.

The analysis of the present study is based on a structural multivariate model formulated for Finnish sawnwood exports to the UK. The model consists of an export demand equation and a markup price equation. In earlier studies simultaneous multivariate models have not been applied in analyzing pass-through in forest products markets and they have rarely been applied in other commodities markets (see however Rockerbie 1992, Menon 1993a, 1993b, Kongsted 1996). Previously used models have usually been bivariate, with a price variable being regressed on an exchange rate (e.g. Knetter 1989, 1993, Pick and Park 1991, Uusivuori and Buongiorno 1991).

Multivariate approaches based on the markup concept have also been applied, but these applications have been single equation models (e.g. Dornbusch 1987, Hooper and Mann 1989, Athukolara 1991, Athukolara and Menon 1994, 1995, Hung et al. 1993). The present study uses the Johansen (Johansen 1988, Johansen and Juselius 1990 and 1992) multivariate cointegration method for nonstationary data for estimation purposes. This allows for the estimation of a model system, unlike the traditional Engle and Granger (1987) procedure.

The findings indicate that PT is large, which means that in the long-run changes in the exchange rate (FIM/pound sterling) are almost completely reflected in Finnish prices as measured in pounds. Thus, for example, depreciations and devaluations of the FIM have improved Finnish competitiveness and market share by lowering the relative Finnish price in the UK market.

2 Model

In the present study, a theoretical model is formed to describe Finnish sawnwood exports to the UK. The model includes a demand equation and a price equation. An estimate for the exchange rate pass-through (PT) is obtained from the price equation. The same type of model construction has earlier been applied by Kongsted (1996) in modeling Danish manufacturing exports.

The model is constructed on the assumption that competition between supplier countries is imperfect in UK sawnwood imports. Thus, the elasticity of substitution model describing demand for goods from different origins is used to describe the export demand for Finnish sawnwood. The derivation of the export demand assumes a two-stage optimization of a representative sawnwood importer in the UK. First, costs are minimized subject to the expenditure on a good (e.g. sawnwood) and, secondly, this expenditure is allocated optimally between the products from different countries of origin. Thus, the export demand for Finnish sawnwood can be represented as

$$X_f = b_f^{\,\eta} X_o \, (P_f / P_o \, ER)^{\eta} \tag{1}$$

where X_f and P_f are the Finnish quantity (1000 m^3) and nominal unit price of sawnwood exports (FIM/m^3) to the UK market, X_o and P_o are the respective quantity and price (£/m^3) of competitors' sawnwood, ER is the nominal exchange rate (FIM/£), b_f is a constant and η is the elasticity of substitution (assumed to be constant). After logarithmic transformation of the variables in (1), the export demand relation becomes

$$x_f = -\eta \, (p_f - p_o - er) + x_o + c + \varepsilon \tag{2}$$

where lower-case letters denote logarithmic values of the corresponding upper-case letters in equation (1), c is a constant term and ε is a disturbance term. The symbol η is the price elasticity of demand and equation (2) is homogenous of degree zero in the nominal variables. In this elasticity of substitution model (2), the change in the relative quantities demanded is assumed to be proportional to the change in the relative price of exports.

An equation for Finnish sawnwood price is based on a markup model that has earlier been applied in the estimation of pass-through e.g. by Dornbusch (1987), Hooper and Mann (1989), Athukolara (1991), Athukolara and Menon (1995), Hung et al. (1993). In deriving the price equation, it is assumed that a representative Finnish exporter firm produces exclusively for an imperfectly competitive UK market, employs constant-returns-to-scale technology and unit production cost, C_f. The firm maximizes profit by taking the competitors' price and the supply of competitors' sawnwood as given and by setting the price in FIM, P_f, as a constant markup over unit production costs, C_f. With X_f denoting export quantity, the exporter's profit, V_f, is defined as

$$V_f = (P_f - C_f) \, X_f \tag{3}$$

Profit maximization yields

$$P_f = C_f \, \eta \, / \, (\eta - 1) \tag{4}$$

where η is the price elasticity of demand. According to Hung et al. (1993), a more general case, in which competitors' prices determine the exporter's price, can be presented by using the concept of a variable markup. Then, a variable markup can be defined by assuming that the coefficient η depends partly on price competitiveness in the export market. Competitiveness can be described as the relative price $(P_o\,ER)/P_f$, where $(P_o\,ER)$ is the competitors' price in the terms of exporter's currency (ER = FIM/£). Thus, the price elasticity of demand is

$$\eta = \eta((P_o\,ER)/P_f) \qquad (5)$$

From (4) and (5), the pricing behavior of a profit maximizing exporter can be described as a variable markup over the unit cost:

$$P_f = \phi\,C_f \qquad (6)$$

The variable markup, ϕ, depends on the relative price and may be approximated as

$$\phi = \phi((P_o\,ER)/P_f) = \phi'((P_o\,ER)/P_f)^{\theta} \qquad (7)$$

where $\theta\,(\geq 0)$ is the relative price elasticity of the markup. The constant markup is obtained if $\theta = 0$ and $\phi' = \eta/(\eta - 1)$. The second equality in (7) comes from the log-linear approximation of the nonlinear function ϕ. Substituting (7) into (6) and taking a logarithmic transformation, a relation for the price of Finnish sawnwood in the UK market is obtained:

$$p_f = \delta + (1 - \gamma)(er + p_o) + \gamma c_f + u \qquad (8)$$

where $\gamma = 1/(1 + \theta)$, $0 < \gamma \leq 1$, $\delta = \ln\phi'/(1 + \theta)$ is a constant, and u is a disturbance term that captures all other factors. The other symbols are the same as above. Lower-case variables denote logs of the corresponding upper-case variables. The export price, p_f, is homogenous of degree zero in the exchange rate and competitors' prices, and the equality restriction is imposed on the coefficients of p_o and er in the estimation.

The degree of exchange rate pass-through (PT) can be derived as the absolute value of the exchange rate elasticity of export price measured in foreign currency (e.g. Kongsted 1996). From equation (8) we obtain

$$\mathrm{PT} = -(\partial(p_f - er)/\partial er) = \gamma, \qquad 0 < \mathrm{PT} \leq 1 \qquad (9)$$

If $\gamma = 0$, then the exchange rate affects the Finnish price in FIM (equation 8) and thus the changes in er (FIM/£) are absorbed by the variable markup. This means that Finnish exporters do not pass through changes in the exchange rate to their export prices in pounds, i.e. PT = 0, which indicates perfect competition and the existence of the law of one price in the market.

If $\gamma = 1$, Finnish export prices in FIM, p_f, are proportional to production costs, c_f, and PT = 1. This indicates that Finnish exporters fully pass through er changes to their export prices in pounds and keep the markup constant. This indicates imperfect competition in the market. Between the above extremes ($0 < \gamma \leq 1$) we have incomplete pass-through. In this case, changes in er are reflected partly in FIM-denominated and partly in foreign currency-denominated export prices.

The model used in the study may naturally be affected also by factors other than those included in the model. If production costs include an important imported component, it is evident that the degree of pass-through will be less than one, even if $\gamma = 1$. In the Finnish sawnwood industry, inputs are for the most part of domestic origin, which suggests that this effect is not very important.

3 Estimation of the Model

3.1 The Data

During the period studied, the FIM fluctuated widely with respect to the pound sterling (graph 1C in Appendix 1). Moreover, the exchange rate regime was revised several times. The FIM was fixed with respect to other currencies in the years 1978–1992. However, the value of the FIM was changed by specific decisions of the Finnish government, being revalued in 1979, 1980 and 1989 and devalued in 1978, 1982, 1991 and 1992. Revaluations can be seen as declines and devaluations as rises in the graph (1C). During the fixed exchange rate period, the value of the FIM was measured by a currency index that included the currencies of Finland's most important trading partners, until June 1991. After this, the FIM was unilaterally linked to the ECU basket until September 1992 and then allowed to float until October 1996.

The development of the exchange rate (graph 1C) can be divided into three subperiods. The period of depreciation, 1978–1980, was followed by a long period, 1981–1990, during which the FIM appreciated by about 22 per cent. In the years 1990–93 the FIM again depreciated by about 26 per cent with respect to the pound sterling. The same subperiods can also be distinguished in the development of the other variables. A comparison of the graphs (1B, 1C, 1D, 1F) indicates that FIM depreciations have lowered the relative Finnish price in pounds and increased export quantities and Finnish market share in the UK. FIM appreciations have had the opposite effects.

It seems that exchange rate changes have affected Finnish competitiveness and market share by changing the Finnish price in terms of pounds, while the markup has remained relatively constant. Comparison of the markup on production costs ($p_f - c_f$) and the exchange rate, *er*, indicates that exchange rate fluctuations have not had much of an impact on the markup. The markup series is relatively stationary up to 1990. After 1990, when FIM was devalued two times by large percentages, the markup jumped up to a higher level (graph 1E). It is possible that the markup absorbed a larger part of the exchange rate change in the 1990s than in the 1980s. If this is true, PT has decreased in the 1990s. It is also likely that the markup increased partly as a result of a decrease in production costs. Finnish prices of sawlogs decreased by about 30 percent due to the recession in the Finnish economy in the years 1990–93. Exchange rates and prices of products and inputs seem to have been much more turbulent in the 1990s than earlier, which makes it difficult to draw conclusions.

The data used in this study were seasonally unadjusted, quarterly, and covered the period from 1978 to 1994. Finnish and competitors' prices of sawnwood were described by import unit values of sawnwood to the UK (£/m^3) based on CIF figures (CIF includes cost, insurance and freight). The Finnish price in pounds was converted into FIM, p_f, at the nominal exchange rate. The competitors' price, p_o, is a (quantity-share) weighted unit price of imports (£/m^3) from Sweden, Canada and Russia. Competitors' import quantity, x_o, is the sum of UK imports from these three countries. Data on quantities and values of sawnwood (SITC 248.2-3) imports were taken from the Overseas Trade Statistics of the United Kingdom (CSO) for the years 1978–1990 and from the intra- and extra-EU trade statistics (European Commission) for the rest of the observations.

The exchange rate variable, *er* (FIM/£), was the nominal quarterly average. Price observations for the period 1990:1–1994:4 were transformed using the £/ECU rate. Both exchange rates were obtained from International Monetary Fund (IMF) statistics. Production costs of Finnish sawnwood, c_f, were described by the production price index (1990 = 100, manufacture of wood and furniture), which was obtained from the Bulletin of Statistics (Statistics Finland). The use of the production price index as a proxy for the domestic cost of the sawnwood industry may cause uncertainty in the testing of PT, but it is used because proper cost variables are not available. Another possibility would have been to describe the production costs by the price of rawmaterial. Quarterly time series for prices of sawlogs are however available only from year 1985, which would make the estimation period too short.

3.2 Estimation Method

The cointegration estimation of the model comprising Equations (2) and (8) involves a vector of six time series. Provided that the data is cointegrated, it may be possible to identify two cointegration vectors the coefficients of which describe the long-run equilibrium relationships implied by equations (2) and (8).

The present study uses Johansen's cointegration method (Johansen 1988, 1995), which is suitable for the estimation of nonstationary data. The main advantage of Johansen's method compared to the earlier alternative multivariate methods (e.g. Engle and Granger 1987) is that it makes it possible to estimate and identify multiple cointegration vectors. In more complex cases than the two-variable case, there may exist up to $p - 1$ (p denotes the number of variables) cointegration vectors. The earlier methods do not solve this problem. When a cointegration relationship was identified, it was assumed to be unique. This need not be true in a multivariate case. Johansen's method provides a log-likelihood ratio test statistic for determining the number of cointegration vectors in the data.

If there exist more than one cointegration vector linking the variables together, the relationship estimated by the Engle-Granger method will be invalid. The relationship may simply represent complex linear combinations of all the cointegration vectors. Johansen's method, unlike the Engle-Granger procedure, also accommodates short-run dynamics in the cointegration regression. This helps to reduce biases and improves efficiency in using the information content of the data in the estimation. Johansen's method also enables testing of several economic hypotheses by means of linear restrictions in the same cointegration framework.

The stationarity of the variables was not tested separately prior to the analysis, as would be the case e.g. if the Engle and Granger (1987) method had been used. The property that unit vectors can be cointegration vectors in Johansen's model means that one can include in the cointegration analysis $I(1)$ or $I(0)$ variables provided they are economically meaningful (Johansen 1995, p. 74). By including a stationary variable in the vector of variables, X, one adds an extra cointegration vector, i.e. an extra dimension in cointegration space.

The analysis of the present study starts by estimating an unrestricted statistical VAR model including all six variables. The method of Johansen (1988) and Johansen and Juselius (1990) uses a statistical model that is a p-dimensional VAR process of order k, where p is the number of variables. The VAR model can be formulated as

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + ,..., + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi x_{t-k} + \mu + \Phi D_t + \varepsilon_t, \quad t = 1,...,T \tag{10}$$

where Δx_t is an I(0) vector of the six first-differenced variables. In the VAR model the constant term, μ, can be restricted to cointegration space so as to represent the absence of a linear trend in the data. However, in the present study a linear time trend was assumed to exist in the data and thus the constant term was not restricted. D_t is a seasonal dummy and k is the lag length. Introducing a sufficient number of lags usually produces a well-behaved error term NID(0,Ω). $\Gamma_1,...,\Gamma_{k-1}$ and $\Pi = - I + \Pi_1 + \Pi_2 +,...,+ \Pi_k$ are coefficient matrices and ε_t is a vector of error terms assumed to be normally and independently distributed with expectation zero and variance matrix Ω.

In (10) the level terms capture the long-run steady state relationships and the first-difference terms show the short-run dynamics. Π is the matrix of long-run coefficients of the lagged levels. It can be decomposed into a matrix of loadings, α, and a matrix of cointegrating vectors, β, i.e. $\Pi = \alpha\beta'$. If x_t is I(1), i.e. integrated of order one, the components of x_t are cointegrated. The number of cointegration vectors that exist among the variables is determined by estimating the rank of the matrix Π. Johansen's method (Johansen 1988) formulates two likelihood ratio tests for the cointegration rank, r, from which the trace test is applied here. The trace test for testing that there are at most r cointegration vectors in the set of p variables is defined as

$$\text{Trace } (r) = -T \sum_{i=r+1}^{p} ln\left(1 - \lambda_i\right) \tag{11}$$

where T is the number of observations and the λ_i's are the smallest squared canonical correlations (eigenvalues). When the number of cointegration relations, r, is determined it is possible to test hypotheses on the long-run matrix, $\Pi = \alpha\beta'$. The present study tests restrictions on the β_{ij} coefficients. In the Johansen framework these tests are conducted under the hypothesis

$$\beta = H\varphi \text{ or } \Pi = \alpha\varphi' H' \tag{12}$$

where H is a $(p \times s)$ matrix, φ is a $(s \times r)$ matrix and $r \le s \le p$. Restrictions, s, are defined by φ, and r is the number of cointegration vectors. The exclusion test (excluding a variable from a cointegration relation) was performed in order to identify the economic long-run relation as being that represented in equations (2) and (8). The testable null hypothesis for exclusion of a variable was $\beta_{ij} = 0$. Homogeneity between Finnish export price, p_f, and the other nominal variables was tested by restricting the respective coefficients accordingly. Finally, the markup relationship was tested by examining if the coefficient of c_f could be restricted to unity.

4 Results

4.1 Cointegration of the Empirical Variables

The cointegration estimation was based on the VAR(4) model given by equation (10), with six equations ($p = 6$) for the period 1978–1994. The lag length, k, of the VAR model was determined by the Schwarz (SC) and Hannan-Quinn (HQ) information criteria, using likelihood ratio tests. Starting from $k = 5$ (see Doornik and Hendry 1994, p. 287), a reduction of the VAR from $k = 5$ to $k = 4$ was accepted. Because the reduction from $k = 4$ to $k = 3$ was rejected, $k = 4$ was used for further modeling.

The diagnostic tests on the residuals of the VAR(4) model are presented in Table 1, and they support the model with $k = 4$. Autocorrelation of the residuals was examined using the F-form of the Lagrange Multiplier (LM) test, which is valid for systems with lagged dependent variables. The null hypothesis of no serial autocorrelation was accepted at the 5 percent level. Heteroskedasticity was tested using the F-form of the LM test against 4th order autoregressive conditional heteroskedasticity. The null hypothesis of no heteroskedasticity was accepted at the 5 percent level. Normality of the residuals was tested by means of the Doornik-Hansen test (Doornik and Hendry 1994) and the null hypothesis of normality was accepted for all the equations. Also the corresponding vector tests for the equation system accepted normality and indicated no autocorrelation. For further details and references concerning these tests, see Doornik and Hendry (1994).

The results of the cointegration estimation of the VAR(4) model indicate that $r = 2$ (Table 2). According to Johansen's trace test, the hypotheses of $r = 0$ and $r \leq 1$ can be rejected. Thus two cointegration vectors are accepted at the 5 percent level. The eigenvectors (β_j) and their weights (α_j) obtained from the cointegration estimation of model (10) are shown in Table 3. Of the six eigenvectors, the first two relations (β_1 and β_2) are most highly correlated with the stationary part of the process Δx_t corrected for the lagged values of the differences. Thus, β_1 and β_2 are the two cointegration vectors determined by the model (Johansen 1995). They are normalized by the coefficients of Finnish export quantity, x_f, and Finnish export price, p_f.

The normalized vectors of loadings, α_j, are

Table 1. Misspecification tests for the residuals of the VAR(4) model.

Equation	Tests for the residuals and the standard errors			
	Autocorrelation F_{AR} (4,32)	Heteroskedasticity F_{ARCH} (4,28)	Normality $\chi^2_N(2)$	Standard errors σ_e
$\Delta(x_f)$	0.97[0.44]	0.02[1.00]	0.05[0.98]	0.16
$\Delta(p_f)$	1.96[0.12]	0.33[0.86]	2.00[0.37]	0.05
$\Delta(er)$	0.44[0.78]	0.22[0.93]	0.99[0.61]	0.04
$\Delta(c_f)$	1.14[0.36]	0.48[0.75]	4.01[0.13]	0.01
$\Delta(p_o)$	2.14[0.10]	0.14[0.97]	0.77[0.68]	0.07
$\Delta(x_o)$	0.69[0.60]	0.34[0.85]	0.32[0.85]	0.12
System:	VF_{AR} (144,48) = 1.10[0.36]		$V\chi^2_N$ (12) = 9.98[0.61]	

Note: Values in square brackets are marginal significance levels.

Table 2. Results for the cointegration rank test.

Null hypothesis H_0: $r \le i$	Eigenvalues λ_i	λ trace statistics T(i)	95% critical values C(i)
$r = 0$	.56	122.9 *	94.20
$r \le 1$	.36	70.83 *	68.50
$r \le 2$	.29	42.23	47.20
$r \le 3$	.22	20.69	29.70
$r \le 4$	.06	4.88	15.40
$r \le 5$	.02	1.18	3.80

Note: * indicate rejection of the null hypotheses implying that the rank is 2.

Table 3. Normalized eigenvectors, β_j, with corresponding weights, α_j, obtained from the unrestricted cointegration estimation.

Variables	Eigenvectors					
	β_1	β_2	β_3	β_4	β_5	β_6
x_f	1.00	0.44	–0.03	0.83	–0.41	–0.81
p_f	–6.75	1.00	–0.48	1.50	–0.82	–0.25
e_r	–4.49	0.57	1.00	–2.35	0.97	2.29
c_f	8.90	–0.72	0.26	1.00	–0.22	0.21
p_o	–0.89	–1.26	0.38	–2.16	1.00	–0.32
x_o	–2.30	0.50	0.27	–1.15	0.06	1.00
Variables	**Weights**					
	α_1	α_2	α_3	α_4	α_5	α_6
x_f	–0.05	–0.09	–0.29	0.26	0.24	0.11
p_f	0.05	–0.03	0.16	–0.17	–0.10	0.01
e_r	–0.01	–0.02	–0.52	–0.06	–0.03	0.01
c_f	–0.01	0.04	0.05	–0.02	–0.01	0.00
p_o	–0.04	–0.04	0.57	0.14	–0.11	0.03
x_o	0.16	0.15	0.10	0.32	0.06	0.05

Symbols: x_f = Finnish quantity, p_f = Finnish price (FIM), er = exchange rate (FIM/£), c_f = Finnish unit cost, p_o = competitors' price in pounds sterling and x_o = competitors' quantity.

presented under the β_j vectors in Table 3. The α_{ij}'s represent the weights with which the error-correction terms enter each equation and they indicate the average speed of adjustment toward the estimated equilibrium state. A low coefficient indicates slow adjustment, while a high coefficient indicates rapid adjustment. Table 3 shows that the loadings of the two cointegration vectors (β_1 and β_2) are rather low.

4.2 Long-run Exchange Rate Pass-through

The two estimated cointegration vectors are tested with restrictions in order to identify the model system comprising export demand and price relations for Finnish sawnwood. The unrestricted cointegration vectors from Table 3 are

$$\beta_1: \; 1.00x_f - 6.75p_f - 4.49er + 8.90c_f - 0.89\,p_o - 2.30x_o \text{ and} \tag{13}$$

$$\beta_2: \; 0.44x_f + 1.00p_f + 0.57er - 0.72c_f - 1.26p_o + 0.50x_o \tag{14}$$

where, x_f and p_f are Finnish quantity and unit price (FIM/m$^{3)}$ of sawnwood exports to the UK and x_o and p_o are the respective quantity and price (£/m^3) of competitors' sawnwood. er is the exchange rate (FIM/£) and c_f is the unit cost of Finnish sawnwood output.

The first cointegration vector, β_1 (equation 13), was identified, as was equation (2), by excluding Finnish production cost (c_f) from the relation and assuming that the coefficient of x_o is β_{61} = –1. The exclusion of c_f was accomplished by restricting its long-run coefficient, β_{41}, to zero. The second cointegration relation, β_2 (equation 14), was identified, as was equation (8), by excluding Finland's and the competitors' quantity.

When the above restrictions and the homogeneity assumption required by economic theory were tested for the demand and price relations, the test rejected this structure (structure I in Table 4). The homogeneity of the equations in the nominal variables p_f, c_f and (p_o + er) implies that the coefficients of p_o and er should be equal and that the coefficient of c_f should equal the difference between the coefficients of p_f and er in the cointegration vectors. However, the coefficients of the unrestricted equation (13) in particular indicate that homogeneity does not necessarily hold. Thus testing was continued by applying structure II (Table 4), where the homogeneity restriction is applied only in the price equation.

The structural form (II) is accepted. The type of demand equation (1) applied in the present

Table 4. Tests for the restrictions on the unrestricted cointegration vectors β_1 and β_2 under r = 2.

Variables/ LR-tests	Restricted and normalized demand (β_{i1}) and price (β_{i2}) relations (i = 1,...,6; j = 1,2)					
	(I) $\beta_{5j} = \beta_{3j}$ and $\beta_{31} = -\beta_{21}$, $\beta_{41} = 0$, $\beta_{61} = -1$, $\beta_{12} = 0$, $\beta_{62} = 0$, $\beta_{42} = -(\beta_{22} + \beta_{32})$		(II) $\beta_{31} \neq -\beta_{21}$, others unchanged		(III) Mark-up: $\beta_{42} = 1$, others unchanged	
	β_{i1}	β_{i2}	β_{i1}	β_{i2}	β_{i1}	β_{i2}
x_f	1.00	0.00	1.00	0.00	1.00	0.00
p_f	2.13	1.00	1.57	1.00	2.44	1.00
er	–2.13	–0.04	–6.16	–0.08	–6.56	0.00
c_f	0.00	–0.96	0.00	–0.92	0.00	–1.00
p_o	–2.13	–0.04	–6.16	–0.08	–6.56	0.00
x_0	–1.00	0.00	–1.00	0.00	–1.00	0.00
LR	χ^2 (1/4 4) = 14.62*		χ^2(1/4 3) = 6.84		χ^2(1/4 5) = 7.63	

Notes: 1) Symbols: x_f = Finnish quantity, p_f = Finnish price (FIM), er = exchange rate (FIM/£), c_f = Finnish unit cost, p_o = competitors' price in pounds sterling and x_o = competitors' quantity.
2) * indicates rejection of the restricted model structure.

study is not often tested for homogeneity in earlier applications. The homogeneity condition has usually been satisfied simply by expressing the exporter's and competitors' prices in a common currency in the form *PF/PO*. Because the price relation fulfills the restrictions and produces the PT estimate, the estimation is continued by restricting it further.

In the accepted structure (II), the price relation β_2 resembles the markup pricing relation with $\gamma = 1$ (Table 4). The coefficient of unit cost, c_f, is close to unity (–0.92), while the coefficients of the exchange rate (er) and competitors' price (p_o) are close to zero. Finally, the markup assumption was tested by restricting the price relation accordingly. The resulting structure (III) is also accepted by the test and the final long-run equilibrium relations can be presented as

$$\beta'_1: \ 1.00x_f = -2.44\, p_f + 6.56(er + p_o) + 1.00x_o \text{ and} \tag{15}$$

$$\beta'_2: \ 1.00p_f = +\, 0.00(er + p_o) + 1.00c_f \tag{16}$$

where the symbols are the same as above. Because the demand equation failed the homogeneity test, interpretation of its coefficients is problematic. However, the signs of the own-price and exchange rate elasticities of Finnish sawnwood export demand are consistent with the economic theory. Moreover, the magnitude of the price elasticity (–2.44) is between the earlier estimated results of Hänninen 1994 (–1.71, estimated from annual data, 1976–90) and of Tervo et al. 1988 (–3.1, estimated with Almon polynomials, 1–12 lags from quarterly data, 1966–85). The relatively large elasticity of the exchange rate (6.56) implies a large effect of exchange rate on Finnish sawnwood exports to the UK.

The restricted price relation (16) representing markup pricing, with $\gamma = 1$, indicates that Finnish sawnwood export price in FIM is proportionate to production cost and the effect of the exchange rate on the FIM price is very small (zero). Thus, exchange rate pass-through is large. A large pass-through coefficient indicates that exchange rate changes are reflected almost pro rata in the Finnish export price in pounds sterling.

5 Conclusions

The study examined the long-run exchange rate pass-through (PT) for the Finnish price of sawnwood in the UK market by estimating a demand and price equation system. The data were quarterly and covered the years 1978–1994. Johansen's cointegration method, which is suitable for analyzing nonstationary data, was used in the estimation. The main advantage of Johansen's method in this study is that it allows for the estimation and identification of a system model, unlike the traditional Engle and Granger (1987) procedure. It also accommodates short-run dynamics in the cointegration regression, which helps to reduce biases. Johansen's method also enables testing of several economic hypotheses by means of linear restrictions in the same cointegration framework.

According to Johansen's rank test, two cointegration vectors were determined among the variables. These vectors were restricted in order to identify them with the theoretical export demand and price relation. The restrictions were accepted in both cointegration vectors, but in the export demand relation (15) the assumption of price homogeneity did not hold. Thus, the coefficients of the demand equation are problematic to interpret. However, the price and exchange rate elasticities were of the expected signs and the magnitude of the price elasticity was consistent with the earlier estimated results (Hänninen 1994 and Tervo et al. 1988). The elasticity of the exchange rate estimated from the demand equation was relatively large, implying a large effect for the exchange rate on Finnish sawnwood exports to the UK. The result does not agree with the earlier studies, which indicate that the trade flows of forest products are not very sensitive to the exchange rate variations (Buongiorno et al. 1988 and Uusivuori and Buongiorno 1990). The previous results are however scanty and they concern exports to the US market.

The responsiveness of trade flows to exchange rate changes is connected with the magnitude of PT. For example, a low PT indicates that trade flows remain relatively insensitive to exchange rate changes (Menon 1995). Thus, the abovementioned results of Buongiorno et al. (1988) and Uusivuori and Buongiorno (1990) indicate low PT for exports to the USA. Several studies have estimated low PTs (e.g. Yang 1997) for U.S. imports of many commodities. This indicates that trade flows directed to US market have not been very sensitive to exchange rates.

The pass-through coefficient obtained from the restricted price equation (16) was close to unity (0.92) and it could be further restricted to one. This means that exchange rate pass through in Finnish sawnwood price expressed in pounds sterling has been large. The result is consistent with the relatively large exchange rate elasticity obtained from the demand equation. However, the lack of proper data on sawnwood production costs may have compromised the measurement of PT.

Several earlier findings for forest industry products indicate relatively large PTs with the exception of US imports. For example, Uusivuori and Buongiorno (1991) estimated PT to be between 0.79 and unity for US lumber exports to Japan. According to Menon (1993a), PT was 0.80 for Australian imports of wood products and 0.45 for paper products. The results of Vesala (1992) showed that PT for the export prices of Finnish paper manufacturers varied between 0.66 and 0.69 in western Europe and between 0.16 and 0.30 in the USA.

A large PT for Finnish sawnwood exports means that variations in exchange rates are almost completely passed through to the foreign currency prices in the long-run and the markup is kept unchanged. For example, depreciations and devaluations of the FIM have lowered the relative Finnish price and improved competitiveness and market share in the UK. Because prices expressed in foreign currency change as a result of an exchange rate change, a large PT also implies imperfect competition. Also in this respect, the results are consistent with earlier results implying imperfect competition and rejection of the law of one price for UK sawnwood imports (Hänninen 1998).

The resulting large PT indicates that Finnish sawnwood exporters have made use of devaluations to increase their market shares and export quantities but not necessarily their profit margins. If EMU is realized and Finland joins, the possibility of using exchange rate policy to improve Finnish competitiveness and market share will disappear. Even outside the EMU, the scope for national exchange rate policy would be reduced (Hetemäki et al. 1997). Hence, other means must be found to adjust to future disturbances caused by demand and price decreases in the world market.

One way to improve Finnish competitiveness during recessions could be to adjust production costs. However, a rapid adjustment is problematic due to the relatively long-term price contracts that exist in the Finnish input markets. Hence, it is also necessary to differentiate Finnish products, for example via customer orientation, established customer relationships and by product planning. Because PT seems to be higher for wood industry products than for paper products, according to the earlier results, the sawnwood industry may have more difficulty than the paper industry in adjusting to the EMU environment.

For further research, the short-run dynamics of exchange rate changes vis-à-vis Finnish sawnwood prices would provide a useful and interesting challenge. Earlier studies of pass-through indicate that price adjustment does not necessarily happen immediately (Dornbusch 1987). The pass through effects could also be examined with respect to other forest products and other currencies, for example the Swedish krona, which has played an important role in western European sawnwood trade, particularly in the 1990s.

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Appendix 1. Quarterly time series data in logarithms covering the period 1978–1994.