Error-correction Models in the Demand for Finnish Paper Exports to the United Kingdom

Susanna Laaksonen,
Anne Toppinen & Jari Kuuluvainen

METSÄNTUTKIMUSLAITOKSEN
TIEDONANTOJA 536

The Finnish Forest Research Institute
Research Papers 536

Error-correction Models in the Demand for Finnish Paper Exports to the United Kingdom

Susanna Laaksonen,
Anne Toppinen & Jari Kuuluvainen

METSÄNTUTKIMUSLAITOKSEN TIEDONANTOJA 536
Metsien käytön tutkimusosasto

The Finnish Forest Research Institute
Department of Forest Resources
Research papers 536

Helsinki 1994

Laaksonen, S., Toppinen, A. & Kuuluvainen, J. 1994. Error-correction Models in the Demand for Finnish Paper Exports to the United Kingdom. Metsäntutkimuslaitoksen tiedonantoja 536. 30 p. The Finnish Forest Research Institute, Research Papers 536. ISBN 951–40–1406–5. ISSN 0358–4283.

The present paper investigates the demand for Finnish printing and writing paper (excluding newsprint) in the United Kingdom. Empirical demand equations based on the Armington export demand model are derived. Using quarterly data from the U.K. foreign trade statistics and the techniques of modern time series analysis, both the short- and long-run adjustment of Finnish exports of coated and uncoated printing and writing paper are examined. No seasonal cointegration is detected. The data-generating process determining the Finnish exports of the two paper grades is somewhat different. For coated paper, the relative price does not seem to be cointegrated with Finnish exports to the U.K. or with total imports. However, the series for imports from Finland and total imports seem to be cointegrated. On the other hand, for uncoated paper the relative price seems to have an effect both in the long-run and in the short-run. The out-of-sample forecasting performance of the short-term error-correction models is tested and it turns out to be reasonably good for both paper grades.

Keywords: export demand, Armington model, paper, cointegration

Publisher: Finnish Forest Research Institute Department of Forest Resources, project KT 3011-9
Approved by: Aarne Reunala 16.12.1994
Authors' address: The Finnish Forest Research Institute, Unioninkatu 40 A, FIN-00170 HELSINKI (internet: slaakson@nature.Berkeley.edu, Anne.Toppinen@metla.fi, Jari.Kuuluvainen@metla.fi)

Acgknowledgements:

We wish to thank Riitta Hänninen, Lauri Hetemäki and Mikko Tervo for helpful comments on earlier versions of the study and Malcolm Waters for checking the language. All remaining errors are naturally our own.

TABLE OF CONTENTS

1. INTRODUCTION

About 40 per cent of Finland's export income is derived from forest industry exports. The pulp and paper industry accounts for over 80 per cent of the export income of the forest industry. Forest industry products are exported mainly to Western European markets, the United Kingdom being the most important export market.

According to the FAO's capacity forecasts, printing and writing paper capacity will grow faster than consumption in Europe in the 1990s. This will lower capacity utilization unless new market shares can be gained outside the traditional marketing area. Therefore, it is important to understand what determines export demand for and market shares of paper products.

A number of studies were carried out in the 1970s and 1980s on the demand for exports of pulp and paper products. The Armington approach was used e.g. by BUONGIORNO (1978), who examined the income and price elasticities of the demand for paper and paperboard, and by CHOU and BUONGIORNO (1982), who studied the demand for American forest products in the EEC market. BRÄNNLUND et al. (1982) examined the market shares of Swedish pulp, paper and sawnwood in Europe. This study was extended by CARLEN et al. (1984), who focused on market shares of Swedish pulp and paper. BAUDIN and LUNDBERG (1987) developed a model for describing the long-run demand for paper and paperboard.

In spite of the importance of pulp, paper and paperboard in Finland's exports, there have been only a few Finnish studies of the demand for these products. HAVUKAINEN (1976) examined the exports of Finnish pulp and paper to the United Kingdom and developed a simultaneous equation model of demand and supply. VOLK (1983) modelled the exports of Finnish printing and writing paper to the United Kingdom and Germany. HÄNNINEN (1986, 1989, 1993) used the Armington approach in her studies of the demand for Finnish sawnwood and plywood exports, as too did LAAKSONEN-LISKI (1993) for Finnish pulp and paper exports to the United Kingdom and Germany.

The aim of this paper is to examine the long- and short-run effects of relative prices on the demand for Finnish paper exports and the changes that have occurred in market shares. The time series properties of the data and cointegration of the time series used are explicitedly tested, which has not been done before in Finnish studies. The demand equations for coated and uncoated printing and writing paper are estimated on the basis of Armington export demand model. Finally, the forecasting properties of the equations are discussed.

The results indicate that even in short-term forecasting it is important to take into account the adjustment towards long-run equilibrium and the fact that the data-generating processes for even fairly similar products may display significant differences.

2. EXPORT DEMAND

Studies of foreign trade have shown that elasticities of substitution provide a good means of investigating the demand for a particular commodity from a specific country of origin in relation to the demand for the same commodity produced in other countries. The Armington approach (1969) is commonly used for this purpose. Products are distinguished by kind and country of origin and thus the same products (e.g. uncoated paper, coated paper) from different countries are assumed to be imperfect substitutes. The Armington model has certain restrictions. First, to be able to use a collapsed production function, the marginal rates of substitution between any two products from different countries of origin must be independent of the quantities demanded of all other products. Second, the quantity index functions are linearly homothetic and homogenous functions, *i.e.* market shares depend only on relative prices in the market and not on the size of the market itself (ARMINGTON 1969).

Import demand is determined in a separable two-step procedure. This makes the allocation of purchases among products from different countries independent of the decision concerning allocation between other products. In the first stage of the Armington approach the importer decides how much of a particular commodity to import.

(1) $$X = X(Y, P, P_0, Z),$$

where
X = *total imports of the product*
Y = *importers' national income*
P = *import price of the product*
P_0 = *prices of all other products*
Z = *other explanatory variables.*

In the second stage the importer decides how to allocate the commodity imports among different suppliers:

(2) $$X_i = X_i(X, P_1, \ldots, P_n, Z),$$

where
X_i = *total imports of the product*
P_j = *price of the product from country j, j=1...n*
Z = *other explanatory variables.*

The quantity index function X_i is a constant elasticity of substitution (CES) function, in which the elasticities of substitution between all pairs of products are identical and constant. It is also assumed that each country's market share changes only in response to changes in relative prices (homotheticity). Under the Armington assumptions, the following export demand equation can be derived from the quantity index function for a single supplier, e.g. Finland

(3) $$x_i = \beta_i^{\sigma}(p_i/p)^{-\sigma}x,$$

where
x_i = *consumer country's imports from Finland*
x = *consumer country's total imports of the product*
β_i = *constant*
p_i = *price of the product from country i*
p = *average price of the product in the consumer country*
σ= *constant elasticity of substitution*

(ARMINGTON 1969, ALSTON et al. 1990, VOLK 1983) Equation (3) is used in this study to examine the demand for Finnish exports of printing and writing papers.

3. DATA AND ESTIMATION PROCEDURE

31. Data of the study

We examine separately coated and uncoated printing and writing paper, which together account for 70 per cent of forest industry exports from Finland to the United Kingdom[1]. Homogenous product groups are required in order to obtain meaningful substitution elasticities between supplier countries. Both data series consist of 72 quarterly observations from the period 1975–1992. A description of the sources of the time series can be found in Appendix A and more details in LAAKSONEN-LISKI (1993). For uncoated paper, interpolated observations were substituted for 7 outlier observations in the late 1980's that were due to obvious errors in trade statistics. Logarithmic transformations of the original series are used throughout the study.

32. Properties of the time series

The properties of the time series are examined prior to estimation. This examination is important because whether time series are stationary or not has an implications for the validity of statistical inference and for the modelling strategy to be chosen. A stationary process has a mean and variance that do not change through time and the covariance between values of the process at two time points will depend only on the distance between these time points and not on time itself, *i.e.* mean of $X_t = \mu$, variance of $X_t = \sigma_x^2 < \infty$ and $\text{cov}(X_t, X_{t-\tau}) = \lambda_\tau$. If these assumptions do not hold, *i.e.* the variable is not stationary, shocks to it will have permanent effects (GRANGER and NEWBOLD 1986). In this study the stationarity of the time series is examined by computing autocorrelation functions and autoregressive processes and by applying augmented Dickey-Fuller (ADF)

---

[1]Perhaps a better approach from the end user's point of view would have been to divide printing and writing paper into wood-contained (mainly magazine paper) and wood free (fine paper) grades. The U.K. trade statistics do no allow such distinction, however.

and Cointegrating Regression Durbin-Watson (CRDW) tests. The ADF test has the following equation

$$(4) \qquad \Delta y_t = \mu + \gamma^* \gamma_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta y_{t-j} + \varepsilon_t$$

and it can be estimated by OLS. The null hypothesis of a unit root is $\gamma^*=0$. (DICKEY et al. 1986) The test equation for CRDW is

$$(5) \qquad y_t = c + \varepsilon_t$$

and it too can be estimated by OLS. The null hypothesis is that the DW-test statistics of the equation is zero, in which case the series has a unit root. Thus we seek DW statistics high enough to reject the proposition that it is actually zero. For testing the trend-stationary alternative hypothesis a deterministic trend can be included in equation (4). (ENGLE and GRANGER 1987) The critical values are obtained from BHARGAVA (1986).

Because the data consists of quarterly observation, we also test for seasonal integration. OSBORN et al. (1988) define a time series to be integrated of order (d,D) if the series is stationary after first-differencing d times and seasonally differencing D times. ENGLE et al. (1989) define seasonal integration of a series by using seasonal filter. A variable is seasonally integrated of orders d_0 and d_s ($SI(d_0, d_s)$), if

$$(6) \qquad (1-L)^{d_0} S(L)^{d_s} = \Delta^{d_0} S(L)^{d_s} x_t$$

is stationary. S(L) transforms the variables to moving sums. For quarterly data $S(L)=1+L+L^2+L^3$. A zero frequency unit root is described by 1-L and the seasonal frequency unit roots are described by S(L). The properties of seasonally integrated series are quite similar to the properties of ordinary integrated processes. They have a long memory so that shocks last forever and may change permanently seasonal patterns. They have variances which increase linearly since the start of the series and are asymptotically uncorrelated with processes with other frequency unit roots. A seasonally integrated series may also have a deterministic seasonal component that can be large and cause the slow drifting of series (e.g. HYLLEBERG et al. 1990).

In this study we test seasonal integration by using the Hylleberg-Engle-Granger-Yoo (HEGY) stationarity test, which essentially tests the existence of unit roots in the polynomial representation of quarterly data. The HEGY(π) test can be carried out using the following equation,

(7) $\varphi^*(B)y_{4t} = \pi_1 y_{1t-1} + \pi_2 y_{2t-1} + \pi_3 y_{3t-2} + \pi_4 y_{3t-1} + \varepsilon_t$, ,where

(8) $y_{1t} = (1 + B + B^2 + B^3)x_t = S(B)x_t$

(9) $y_{2t} = -(1 - B + B^2 - B^3)x_t = x_{t-1} + x_{t-3} - x_{t-2} - x_t$

(10) $y_{3t} = -(1 - B^2)x_t = x_{t-2} - x_{t-4}$

(11) $y_{4t} = (1 - B^4)x_t = x_t - x_{t-4}$

The equation (7) can be estimated by OLS. The overall null hypothesis is $H_0{:}X_t \sim I(0,1)$. There will be no seasonal unit roots if π_2 and either π_3 or π_4 are different from zero.This requires the rejection of the hypothesis that $\pi_2 = 0$ and a joint test for the hypothesis that either π_3 or $\pi_4 = 0$. The joint hypothesis can be tested using the F-statistic. For there to be no unit roots at all, every π_i must be different from zero (see e.g. ENGLE *et al.* (1993) for the derivation of the test). Critical values are from ENGLE *et al.* (1987).

33. Modelling cointegrated time series

Two series are said to be cointegrated with a cointegrating vector α if the series are integrated of the same order (for example of order one) but the linear combination of the time series is already stationary. If $\alpha' x_t = 0$ is interpreted as a long-run equilibrium, cointegration implies that deviations from equilibrium are stationary, with finite variance, even though the series themselves are nonstationary and have infinite variance (ENGLE and GRANGER 1987). HYLLEBERG *et al.* (1990) further point out that if there is seasonal cointegration, but it is ignored, then a misspecified error-correction model will result, leading to inferior forecasting and long-run interpretation.

According to GRANGER (1988), if a pair of series is cointegrated, then there must be Granger causation in at least one direction. Essentially, the

Granger causality testing (e.g. GRANGER & NEWBOLD 1986) involves using F-tests to determine whether lagged information on a variable, say X, contributes in a statistically significant way to explaining Y in the presence of lagged Y. The procedure is also applied in the opposite direction from Y $\Rightarrow$ X. If causation proceeds in both directions simultaneously there's feedback between the variables.

In this study the appearance of cointegration is tested by the Engle-Granger cointegration test (ENGLE and GRANGER 1987) and the Johansen cointegration test (JOHANSEN 1988). The equation for the Engle-Granger cointegration test is in bivariate case

(12) $$y_t = \alpha x_t + c + \varepsilon_t$$

The equation can be estimated by OLS. The null hypothesis is that CRDW=0, *i.e.,* if, after running cointegrating regression, the residuals are non-stationary, the CRDW will approach zero. Thus, the test indicates cointegration if the DW-statistics is large enough (ENGLE and GRANGER 1987). Cointegration is also tested with residual ADF-test test, with similar procedure than that was done with individual time series.

The Johansen cointegration test (JOHANSEN 1988, JOHANSEN & JUSELIUS 1991) provides a method for testing the number of cointegrating vectors. This is important because the Engle-Granger two-step estimation method is applicable only when there is exactly one cointegrating vector in the system. The starting point of the Johansen procedure is unrestricted VAR:

(13) $$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + \mu + \Psi D_t + \varepsilon_t, t = 1, \ldots T$$

where the rank of matrix Π determines the number of cointegrating vectors. The constant term μ and seasonal dummies D in (1) can be excluded for simplicity. After selecting the order p of autoregression, the residual of the above equation is saved. In the second phase, another regression for z_{t-1} on its lagged differences is estimated and the residuals saved. Third, the squares of the canonical correlations δi between the above-mentioned two residuals are calculated. The trace test[2] for testing the rank of. Π is:

$$(14) \quad -2\ln(q) = -T\sum_{i=r+1}^{p}\ln(1-\hat{\lambda}i^2)$$

H_0 is that the rank $(\Pi) \leq r$ and the H_1 hypothesis is that the number of cointegrating vectors is larger than r. Two special cases might occur. When all series of vector z_t are stationary, the matrix Π has full rank p. When no cointegration exists between the variables z_t, the matrix Π has zero rank. It should be noted that Johansen's ML estimator estimates the cointegration space spanned by cointegrating vectors and not the individual vectors themselves.

34. Estimation procedure and diagnostic tests

The export demand equations are estimated using OLS. The validity of the models is tested using the standard diagnostic tests – the Jarque-Bera test for normality, the Box-Pierce and the LM test for serial correlation of any order and the ARCH test for autoregressive conditional heteroskedasticity in error processes.

The LM test is based on an auxiliary regression, in which the residuals from the original regression are regressed on the original explanatory varibles augmented with a specified amount of lagged variables. The ARCH test is based on the regression of squared residuals on lagged, squared residuals. The White test is used to check for violations against the assumption that error terms are homoskedastic and independent of regressors and the test is based on the regression of the squared residuals from the original regression on the same variables as in the original regression augmented with the squared values of the original variables.

---

[2] Another version of the trace test statistic is the maximal eigenvalue test with an explicitly stated alternative hypothesis of the number of cointegrating vectors (Johansen 1988). It is not discussed here, because we are only interested here in making sure that one cointegrating vector really exists and that the use of the EG 2-step estimation is valid.

The RESET test for linearity (correct functional form) is also computed by augmenting the original regression with a specified number of fitted values from the original regression. The recursive tests for parameter constancy and recursive residuals are also reported. For a detailed description of the tests, see e.g. GREENE (1993)

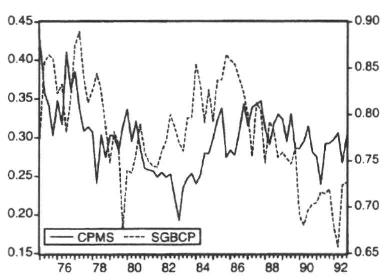
4. EMPIRICAL RESULTS

41. Paper markets in the United Kingdom

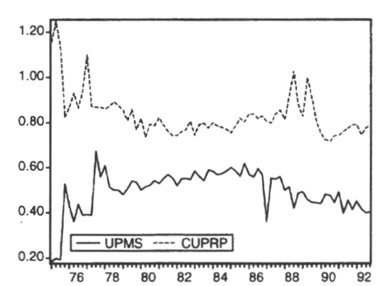
Finnish exports of coated printing and writing paper have risen faster than those of other paper grades. The average annual growth rate for exports to the United Kingdom in the period 1975–92 was 14 per cent. Finland's market share was about 20 per cent at the end of the period. Both Finnish market share and the relative price display a weak downward trend during the period studied.

Figure 1. Finnish market share and relative price for a) coated b) uncoated printing and writing paper in the U.K. Time series for total imports and Finnsih exports in c) coated and d) uncoated paper, 1975–92.

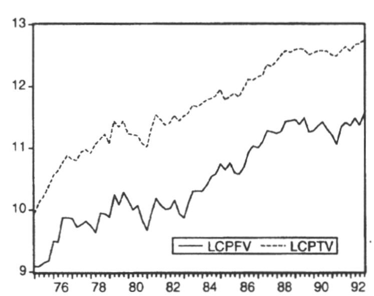
a)



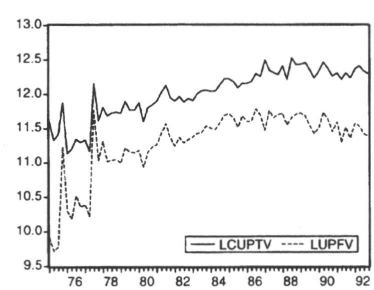
b)



c)



d)



Finland's market share to the United Kingdom for uncoated printing and writing paper is about 40 per cent. Finnish exports increased by 7–8 per cent annually during the period studied, while total imports grew by 5–6 per cent. The market share rose slightly during the period, and relative prices of Finnish exports decreased towards the end of the period. However, if one excludes the observations for 1975, no clear trend is discernible in the market share.

42. Properties of the time series

The autocorrelation functions of all the time series except the relative price of uncoated printing and writing paper indicate that the series may be integrated of order one. According to the autoregressive processes, all the time series except the relative price for uncoated paper follow a first-order autoregressive (AR(1)) process (Appendix B).

The time series for total imports, imports from Finland and the relative price for coated paper are normally distributed. The time series for Finnish exports of uncoated paper to the United Kingdom is skewed and the relative price of uncoated paper has a few extreme outliers, leading to the rejection of the normality hypothesis. This may cause problems in interpreting the stationarity test results. According to the HEGY test, none of the variables is seasonally integrated (Appendix C).

The results of the stationarity tests are reported in tables 1 and 2. According to ADF-test, imports of uncoated paper from Finland and the respective relative price may be stationary, and if the trend is allowed total imports of both paper grades also seem to be stationary. ADF and CRDW give contradictory results for the relative price of coated paper, which might be stationary according to the CRDW tests.

However, especially in the case of uncoated paper, nonnormality of the time series may affect the stationarity test results. On the other hand, if series are in fact integrated the order of integrations is at most one, as all series are stationary in first differences.

Table 1. Results of normality and ADF tests. C in parentheses (c) indicates the ADF test equation with a constant and (t) the test equation with a constant and trend.

Variable		χ^2_N	ADF for ln c	ADF for ln c, t	ADF for Δ
Imports from Finland/coated	CPFV	4.48	–1.33	–3.10	–4.58***
Total imports/coated	CPTV	3.21	–2.27	–3.98**	–9.56***
Relative price/coated	CPRP	2.13	–2.59	–3.41	–8.25***
Imports from Finland/uncoated	UPFV	47.66	–3.77***	-4.76***	–8.75***
Total imports/uncoated	UPTV	7.48	–2.57	–6.13***	–14.94***
Relative price/uncoated	UPRP	65.04	–4.11***	4.20***	–9.93***

The critical value for χ^2_N at the 5 % level and 2 degrees of freedom is 5.99. *** = significant at the 1 % level ** = significant at 5 % level * = significant at the 10 % level

Table 2. Results of CRDW and CRDW (t) tests.

Variable		CRDW for ln	CRDW for Δ	CRDW (t) for ln
Imports from Finland/coated	CPFV	0.04	2.31**	0.36
Total imports/coated	CPTV	0.02	2.22**	0.37
Relative price/coated	CPRP	0.38**	2.28**	0.58**
Imports from Finland/uncoated	UPFV	0.43**	2.93**	0.91**
Total imports/uncoated	UPTV	0.33	3.01**	1.35**
Relative price/uncoated	UPRP	0.49**	2.33**	0.66**

The critical value for the CRDW-test at the 5 % significance level and 70 observations is 0.37 and for CRDW (t) 0.48 (Bhargava 1986).

Granger-causality tests are performed to obtain evidence on possible causal relationships between variables. Further, if the series are in fact cointegrated, it should be possible to detect Granger-causality between them at least in one direction. With four lags, the results indicate causality for coated paper only from Finnish imports to the relative price. For uncoated papers one-sided causality is found between all three variables, and thus cointegration is possible, in spite of the ADF and CRDW tests.

Table 3. Granger-causality tests using 4 lags.

Causality X ⇒ Y	F-statistic	Causality Y ⇒ X	F-statistic
CPFV ⇒ CPTV	1.23	CPTV ⇒ CPFV	1.98
CPFV ⇒ CPRP	4.99**	CPRP ⇒ CPFV	1.54
CPTV ⇒ CPRP	1.57	CPRP ⇒ CPTV	1.45
UPFV ⇒ UPTV	3.03**	UPTV ⇒ UPFV	0.94
UPFV ⇒ UPRP	0.81	UPRP ⇒ UPFV	2.94**
UPTV ⇒ UPRP	0.90	UPRP ⇒ UPTV	2.85**

Table 4. Results of the Johansen cointegration test (r = hypothesized number of cointegrating relations).

Variables	H_0: r	λ	LR value	Critical values (1/5/10 %)
LCPFV LCPTV LCPRP	0	0.144	20.46	(35.65 / 29.68 / 26.79)
	≤1	0.010	9.77	(20.04 / 15.42 /13.34)
	≤2	0.004	2.54	(6.65 / 3.76 / 2.82)
LUPFV LUPTV LUPRP	0	0.430	49.4***	(35.65 / 29.68 / 26.79)
	≤1	0.092	10.60	(20.04 / 15.42 /13.34)
	≤2	0.055	3.91	(6.65 / 3.76 / 2.82)

In spite of the fact that the time series for imports of coated paper from Finland and the respective relative prices were not necessarily stationary according to the ADF and CRDW tests, the Johansen cointegration test (table 4) did not detect cointegration for total imports, imports from Finland and relative price of coated paper. The LR test statistics falls below the 10 % critical value. However, total imports and imports from Finland seem to be cointegrated, and their linear combination turns out to be stationary[3]. The test results are robust for different assumptions concerning the data, *i.e.* intercept and/or linear trend.

[3] The Johansen-test actually finds a cointegrating vector, if a price variable is excluded.

For uncoated paper, contrary to the above pre–estimation stationarity tests, the hypothesis of one cointegrating relationship in the time series is accepted by the Johansen cointegration test. Again the result is robust for the use of intercept and/or trend in test equation. Thus, we conclude that the series are in fact integrated with a unique cointegrating vector, in spite of the ADF and CRDW tests.

43. Export demand models

431. Coated printing and writing paper

4311. Results for the long-run model

In spite of the fact that the Johansen cointegration test did not support cointegration for coated paper, we also estimated the Engle-Granger cointegration regression for coated paper, i.e., the long-run model for U.K. imports of coated paper from Finland.

(15) $$\ln CPFV = c + a_1 \ln CPTV + a_2 \ln CPRP + e,$$

where e is the error term. The MacKinnon test statistic for cointegration is above the one per cent critical value and CRDW-test supports also cointegration hypothesis. The coefficient of the relative price has a wrong sign with an absolute value close to zero. We conclude that it is not possible to extract the long-run effect of the relative price of Finnish coated paper on Finnish exports to Great Britain from the present data set.

However, imports from Finland and total imports seem to be cointegrated and the relative market share (lnCPTV - lnCPFV) is in fact stationary. Subsequently, instead of using the Engle-Granger two-step estimation procedure for the short-run model, we include (lnCPFV-lnCPTV) and the constant term in the short-run model, following e.g. BANERJEE et al. (1993).

Table 5. Results for Engle-Granger cointegration estimations for coated paper.

Variable	Coefficient	STD error	t-value
C	-0.81	0.28	-2.86
ln CPTV	0.97	0.03	35.93
ln CPRP	0.11	0.28t	0.41
R^2	0.96	F(3,68)	894.97
DW	0.58	J-B	2.78
EG: TV, FV, RP	–3.94	EG: FV, TV	–3.85

ADF-test MacKinnon critical values for three variables are –4.5 ***, –3.86** and –3.54*. For two variables the critical values are –4.05***, –3.42** and –3.10*. For CRDW-test critical value 0.39 from ENGLE & GRANGER (1987) is used.

4312. Results for the short-run model

The following short-term error-correction equation for U.K. imports from Finland is estimated [4].

(15) $$\ln D1CPFV = c + a_1 \ln D1CPTV + a_2 \ln D1CPRP + a_3(\ln CPFV - \ln CPTV)_{t-1} + e_t,$$

where e_t is the normally distributed error term. The estimation results for equation (15) are given in table 6. The model fit can be seen in figure 2 and the recursive coefficient estimates and residuals in figure 3.

Statistically the short-term model, including the constant term, behaves well and passes all the diagnostic tests. The coefficient of total exports is one. Thus, the Armington hypothesis seems to hold in the short-term. The relative price has a negative elasticity of 0.5 with the probability of 5.8. The Chow F-test indicates acceptable out of the sample forecasting performance. Further evidence is provided in figure 3, which shows that

[4] For quarterly data, deterministic seasonality was ruled out, because seasonal dummies for both paper grades turned out to be insignificant. This could also explain estimation problems when using the same data in seasonal (i.e. fourth) differences (c.f. Laaksonen & Toppinen 1994).

the model is able to predict the turning points in the time series rather well.

Table 6. Results for the error-correction model estimations for coated paper.

Variable	Coefficient	STD error	t-value
C	–0.36	0.10	–3.60
Δ CPTV	1.0	0.11	9.10
Δ CPRP	–0.51	0.26	–1.93
CPMS(–1)	–0.29	0.08	–3.57
R^2	0.59	F(3,68)	34.66
DW	2.34	JB	0.07
BP(χ^2(12))	19.78	LM(χ^2(4))	1.04
ARCH(χ^2(4))	1.24	White(χ^2(4))	0.13
RESET (F(1,71))	1.77	Chow (F) 89Q1–92Q4	0.71

Critical values for tests above:

$\chi^2(4)=9.49$ $\chi^2(12)=21.03$ F(1,71)=4.30 F(3,68)=2.74

Figure 2. Actual and fitted values of the dependent variables in long-run and short-run models for coated paper.

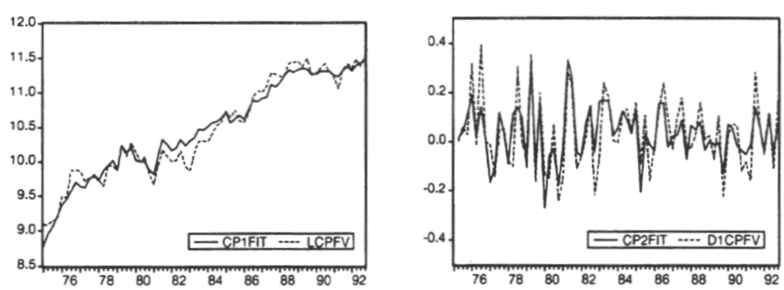
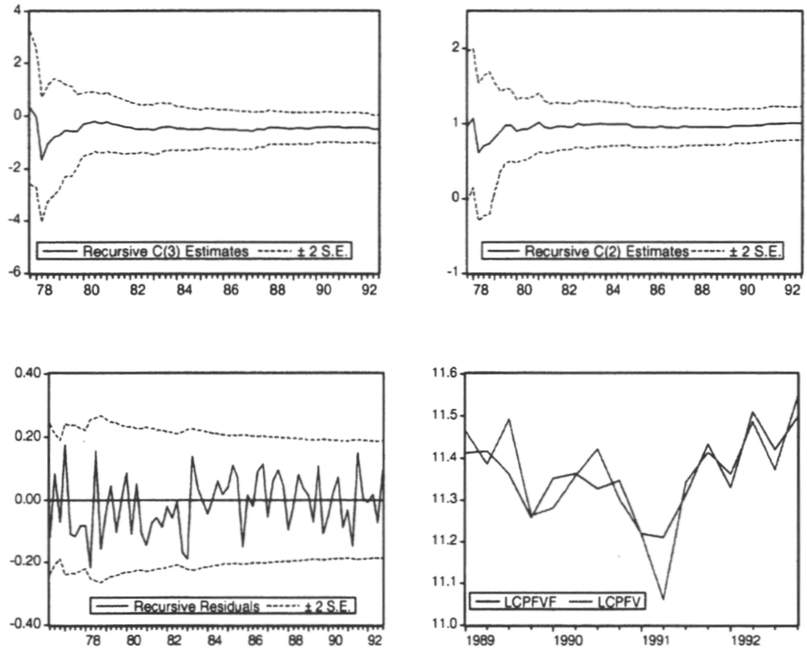


Figure 3. Recursive coefficients of total imports and relative price, recursive residuals and static one step ahead forecast.



432. Uncoated printing and writing paper

4321. Results for the long-run model

The long-run model for uncoated paper is of similar form as the one experimented with coated paper. The estimation results are given in table 7. The coefficient of total imports is positive and unity according to Wald's test. The elasticity of U.K. imports from Finland with respect to the relative price is −1.4, indicating elastic import demand in the long-run. However, because of nonstationarity, the estimated t-values are not consistent with the standard probability values and therefore the significance of coefficients according to t-values is undetermined[5]. The coefficient of the relative price, *i.e.* the substitution elasticity, is negative, as expected. The fact that the residuals are not normally distributed may bias parameter estimates. However, the residuals appear to be stationary

[5] Considerably higher t-values are suggested instead of the standard normal values of approximately 2 (Greene 1993, p.560).

according to the ADF-test[6] and CRDW-test, which suggest cointegration. According to the MacKinnon test statistics, the time series for uncoated printing and writing paper appear to be cointegrated at the 1 per cent risk level, supporting the Johansen cointegration test results.

Table 7. Results for Engle-Granger cointegration estimations for uncoated paper.

Variable	Coefficient	STD error	t-value
C	–1.41	0.80	–1.77
ln UPTV	1.04	0.07	15.28
ln UPRP	–1.40	0.22	–6.37
R^2	0.86	F(3,68)	225.65
DW	0.77	J-B	
EG: FV, TV, RP	–4.64		

For critical values, see table 5.

4322. Results for the short-run model

Because series for uncoated paper appear to be cointegrated with a unique cointegrating vector, we can use the Engle-Granger two-step estimation. The coefficients of the error-correction model with the lagged residual from the cointegration estimation above are presented in table 8.

The statistical performance of this error-correction model is not as good as that for coated paper. No residual autocorrelation is found. The Jarque-Bera test, however, provides evidence against normality of the residuals because of extra kurtosis and a few outliers. The ARCH test shows that there is no heteroscedasticity in the residual term. The high test value from the RESET test indicates some problems in the linear functional form.

The estimation problems may partly be due to a structural change that has occurred during the late 1980s according to the Chow test. Unfortunately, we were not able to find an interpretation for it. Structural change can be seen in the recursive coefficients for total imports, which

[6] ADF-test value for testing the residual term was –4.61 with 1 % critical value was –3.89.

show a steep drop in 1986-87. In spite of these problems, all the variables in the regression have significant t-values, although their nonnormality gives some cause for concern. The fit is 0.85, better than for coated printing and writing paper.

The coefficients have the same sign as in the long-run model with a negative coefficient for the error-correction term. However, the coefficient of total imports is not unity in the short-run (the value of Wald test statistics is around 15!). Thus, for uncoated paper the Armington hypothesis of constant market share seems to hold in the long-run, but not in the short-run. In the short-run import demand seems to be inelastic with respect to price, as indicated by the elasticity of –0.9. The lagged residual from the long-run model has a coefficient estimate of –0.39 indicating the adjustment speed to long-run equilibrium[7].

Table 8. Short-run model for uncoated paper model.

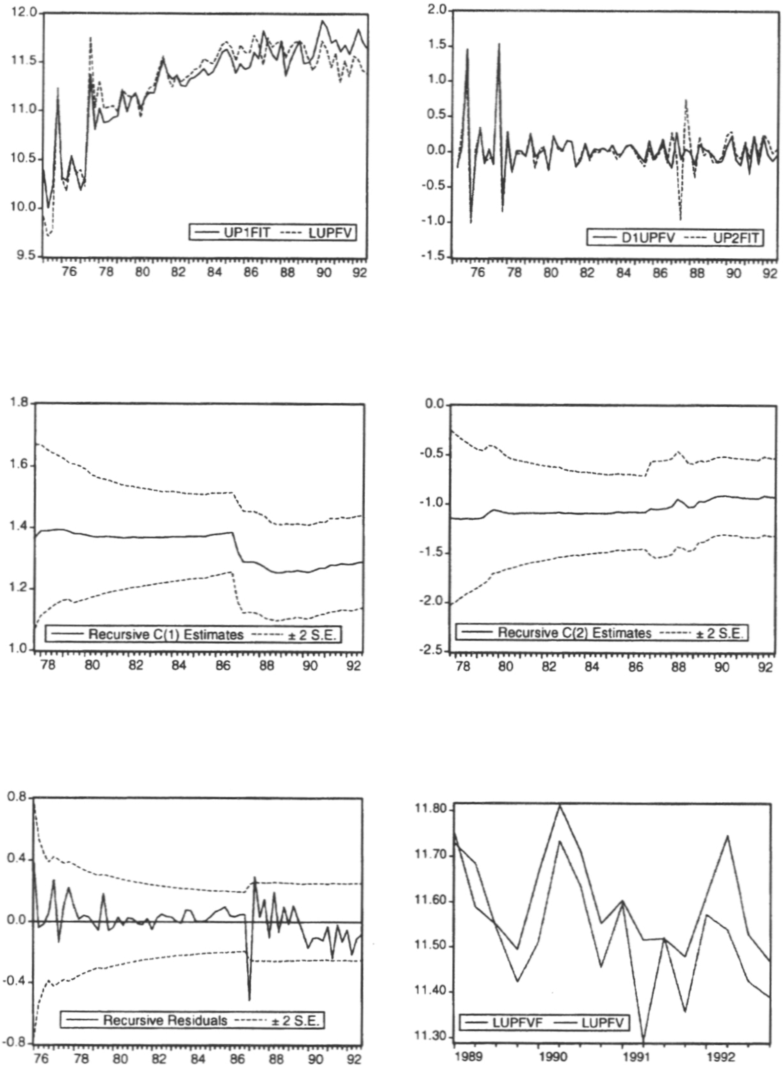
Variable	Coefficient	STD error	t-value
Δ UPTV	1.29	0.08	17.16
Δ UPRP	–0.92	0.20	–4.70
ECT(-1)	–0.39	0.09	–4.52
R^2	0.85	F(3,68)	197.36
DW	2.46	JB	48.77
BP(χ^2(12))	16.72	LM(χ^2(4))	2.24
ARCH(χ^2(4))	1.15	White(χ^2(4))	3.37
RESET	12.39	Chow (F)	0.87
(F(1,71))		89Q1–92Q4	

Critical values for tests above, see table 6:

Again, the Chow F-test indicates a rather good out-of-the-sample forecasting performance, which can also be seen from figure 4.

[7] When the error-correction model was estimated in vector error correction applying Johansen's method (results not reported here), the error correction term received a value of –0.52, somewhat higher than with the two-step estimation method.

Figure 4. Models for uncoated paper: long-run model, short- run model, recursive coefficients and residuals of short-run model and static one-step ahead forecast.



5. CONCLUSIONS

The results of this paper indicate the importance of inspection of the time series properties and the examination of both long- and short-run adjustment when studying the import demand for different products. In particular the Engle-Granger two-step estimation was found to be justified for uncoated paper, but for coated paper neither Engle-Granger test nor Johansen's trace test indicated cointegration between the price and quantity series. Therefore, we were unable to produce the long-run elasticity U.K. imports of coated papers from Finland with respect to price. However, the performance of the short-term import demand model was improved by including the relative market share as an error correction term. Its' coefficient was –0.29, indicating a rather sluggish adjustment. The Armington hypothesis was accepted for coated paper in the short- run.

For uncoated paper a unique cointegrating vector was detected and the Engle-Granger two-step model was estimated, although pre-estimation unit root tests indicated stationarity. The Armington hypothesis was accepted in the long- run but not in the short-run. The error correction term, *i.e.* the speed at which the model adjusts to long-run equilibrium is –0.39, indicating that approximately that percentage of a disequilibrium was corrected in one quarter. The adjustment speed is moderate, the model adjusts to long-run equilibrium in less than three quarters.

Because imports from Finland are cointegrated with total imports for both paper grades, it should be relatively easy to forecast fluctuations in imports from Finland if total imports of the consumer country are known. Thus, in order to be able to forecast imports (exports) from Finland, a model for the total imports of a consumer country is required.

REFERENCES:

ALSTON, J. M., CARTER, C. A., GREEN, R. & PICK, D. 1990. Whither Armington Trade Model. American Journal of Agricultural Economics, vol. 72, nr. 5, p. 455-467.

ARMINGTON, P. S. 1969. A theory of demand distinguished by place of production. IMF Staff Papers XVI (1), p. 159-177.

BANERJEE, A., DOLADO, J., GALBRAITH, J. & HENDRY, D. 1993 Cointegration, Error.Correction and the Economic Analysis of Non-stationary Data. Oxford University Press. 320 p.

BAUDIN, A. & LUNDBERG, L. 1987. A world model of the demand for paper and paperboard. Forest Science, vol. 33, nr. 1, p. 185-196.

BHARGAVA, A. 1986. On the theory of testing for unit roots in observed time series. Review of Economic Studies LIII, p. 369-384.

BRÄNNLUND, R., LUNDBERG, L. & WIBERG, A. 1982. Determinants of Swedish market shares for pulp, paper and sawnwood in Europe. Swedish University of Agricultural Sciences, Department of Forest Economics, Report nr. 36.

BUONGIORNO, J. 1978. Income and price elasticities in the world demand for paper and paperboard. Forest Science, vol. 24, nr. 2, p. 231-246.

CARLÉN, O., LUNDBERG, L. & WIBERG, A. 1984. Determinants of Swedish market share of pulp and paper in the Common Market. In: Tervo, M. & Selby, A. (eds.), Metsäntutkimuslaitoksen tiedonantoja 141. p.69-79.

CHOU, J. J. & BUONGIORNO, J. 1982. Demand for United States Forest Prodicts in the European Economic Community. Wood and Fibre Science, vol. 16, nr. 2, p. 158-168.

DICKEY, D. A., BELL, W. R. & MILLER, R. B. 1986. Unit roots in time series models: Tests and implications. The American Statistician, vol. 40, p. 12-26.

ENGLE, R. F. & GRANGER, C. W. J. 1987. Cointegration and error correction: Representation, estimation and testing. Econometrica, vol. 55, nr. 2, p. 251-276.

ENGLE, R. F., GRANGER, C. W. J. & HALLMAN, J. J. 1989. Merging short- amd long-run forecasts - an application of seasonal cointegration to monthly electricity sales forecasting. Journal of Econometrics, vol. 40, p. 45-62.

ENGLE, R. F., GRANGER, C. W. J., HYLLEBERG, S & LEE, H. S. 1993. Seasonal cointegration: The Japanese consumption funktion. Journal of Econometrics, vol. 55, p. 275-298.

GRANGER, C.W.J. 1988. Causality, Cointegration and Control. Journal of Economic Dynamics and Control. Vol 12. pp. 551–559.

GRANGER, C. W. J. & NEWBOLD, P. 1986. Forecasting econometric time series. Academic Press, Inc. New York. 333 p.

GREENE, W. H. 1993. Econometric Analysis. 2. ed. Macmillan. New York. 791 p.

HAVUKAINEN, L. 1976. Suomen selluloosan ja paperin vienti Isoon-Britanniaan vuosina 1958-72. Moniyhtälömallin sovellutus. Metsäntutkimuslaitoksen julkaisuja 87 (6) s. 1-65. (in Finnish)

HYLLEBERG, S., ENGLE, R. F., GRANGER, C. W. J. & YOO, B. S. 1990. Seasonal integration and cointegration. Journal of Econometrics, vol. 44, p. 215-238.

HÄNNINEN, R. 1986. Suomen sahatavaran vientikysyntä Länsi-Euroopassa vuosina 1962-1983. Summary: Demand for Finnish sawnwood exports in western Europe, 1962-1983. Folia Forestalia 657. The Finnish Forest Research Institute. Helsinki. 25 p.

HÄNNINEN, R. 1989. Länsi-Euroopan vanerimarkkinat ja vanerin kysyntä Suomesta vuosina 1961-1986. Kansantaloudellisen metsäekonomian laudaturtutkielma. University of Helsinki. 67 p. (in Finnish)

HÄNNINEN, R. 1993. The effect of relative price variations on the sawnwood imports to the United Kingdom from Finland. Licentiate thesis in forest products marketing. University of Helsinki. 108 p.

JOHANSEN, S. 1988. Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, vol 12, p. 231-254.

JOHANSEN, S. & JUSELIUS, K. 1990. Maximum likelihood estimation and inference on cointegration – with applications to the demand for money. Oxford Bulletin of Economics and Statistics. Vol 52. pp. 169–210.

LAAKSONEN-LISKI, S. 1993. Suomalaisen selluloosan ja paperien vientikysyntä Isoon-Britanniaan ja Saksaan. Master's thesis in forest products marketing. University of Helsinki. 76 p. (in Finnish)

LAAKSONEN, S. & TOPPINEN, A. 1994. Export demand for Finnish pulp and papers to the United Kingdom and Germany. Proceedings of the Biennial Meeting of the Scandinavian Society of Forest Economics. Scandinavian Forest economics. No. 35. pp. 218–229.

OSBORN, D., CHUI, A., SMITH, P. AND BIRCHENHALL, C. 1988. Seasonality and the Order of Integration for Consumption. Oxford Bulletin of Economics and Statistics, 50, 4. pp. 361–377.

VOLK, R. 1983. A model for Finnish exports of printing and writing paper to the United Kingdom and Germany. PTT:n raportteja ja artikkeleita, nr. 29. Espoo.

APPENDIX A.

Construction of time series

Variable		CN codes in trade statistics
Import of coated papers from Finland	CPFV	1975-88 641.21
Total import of coated papers	CPTV	1988- 641.21, 641.25, 641.26,
Relative price of coated papers	CPRP	641.27, 641.29
Import of uncoated papers from Finland	UPFV	1975-88 641.22
Total import of uncoated papers *)	UPTV	1988- 641.33, 641.32, 641.33,
Relative price of uncoated papers *)	UPRP	641.34, 641.79, 642.42

*) The following observations were substituted by their interpolated values: 75Q2, 75Q3, 87Q1, 87Q3, 88Q2, 89Q1 and 89Q3.

Source: Business Monitor - Overseas Trade Statistics of United Kingdom. Central Statistical Office. London.

APPENDIX B.

Autocorrelation functions of time series.

Variable lag	1	2	3	4	5
LCPFV	0.94	0.88	0.83	0.78	0.73
ΔCPFV	-0.16	-0.09	-0.02	0.04	-0.00
LCPTV	0.93	0.88	0.82	0.78	0.73
ΔCPTV	-0.12	-0.02	-0.04	0.25	-0.18
LCPRP	0.81	0.68	0.60	0.52	0.50
ΔCPRP	-0.18	-0.19	0.04	-0.14	0.05
LUPFV	0.73	0.64	0.55	0.58	0.52
ΔUPFV	-0.47	-0.00	0.01	0.03	-0.02
LUPTV	0.78	0.73	0.72	0.67	0.63
ΔUPTV	-0.47	-0.08	0.15	-0.09	0.04
LUPRP	-0.06	0.01	0.06	-0.02	-0.01
ΔUPRP	-0.53	-0.02	0.09	-0.05	-0.01

Autoregressive processes of time series.

Variable lag	1	2	3	4	5
LCPFV	0.79	0.06	0.07	0.07	-0.02
LCPTV	0.78	0.09	0.02	0.30	-0.21
LCPRP	0.69	-0.06	0.23	-0.13	0.18
LUPFV	0.29	0.18	0.11	0.13	0.09
LUPTV	0.35	0.16	0.22	0.06	0.09
LUPRP	-0.01	-0.08	0.06	-0.02	-0.00

APPENDIX C.

Results from HEGY test:

Variable/ aux.	t: p_1	t: p_2	t: p_3	t: p_4	F: p_3 p_4	F: p_4 p_3
ln CPFV:						
-	2.46	-2.11**	-2.10**	-0.02	17.54***	
I	-0.33	-2.08**	-2.08**	-0.02	14.86***	22.86***
I, SD	-0.38	-3.48**	-4.83***	-3.53***	16.49***	
I, Tr	-0.62	-2.02**	-2.02**	-0.11	13.91***	17.09***
I#, SD, Tr#	-2.96	-4.17***	-6.13***	-3.20***	21.47***	
ln CPTV:						
-	2.61	-2.62**	-3.95***	-0.20	33.00***	
I	-1.19	-2.58**	-3.90***	-0.33	27.08***	30.47***
I, SD	-1.70	-3.74**	-5.29***	-4.01***	25.00***	
I, Tr	-0.97	-2.41**	-3.74***	-0.28	25.00***	23.22***
I#, SD, Tr#	-3.36*	-3.84***	-5.92***	-3.54***	26.13***	
ln CPRP:						
-	0.59	-1.64*	-1,59*	-2.46**	16.03***	
I	-1.64	-4.89***	-4.86***	-2.34**	21.28***	15.16***
I, SD	-1.61	-4.84***	-4.86***	-2.24**	11.91***	
I, Tr	-1.31	-4.91***	-3.68***	-2.33**	13.97***	11.52***
I, SD, Tr	-1.94	-4.81***	-4.85***	-2.21**	10.59***	
UPFV:						
-	0.66	-2.24**	-4.83***	3.31	13.56***	
I#	-3.68***	-4.65***	-5.42***	2.68	18.56***	8.91**
I#, SD	-4.69***	-3.83***	-4.07***	2.00	12.00***	
I#, Tr	-1.99	-4.39***	-5.26***	2.76	16.31***	6.59**
I, SD, Tr	-1.83	-4.62***	-5.15***	2.62	12.22***	
UPTV:						
-	0.98	-4.42***	-6.18***	0.04	19.06***	
I#	-2.57**	-2.82***	-3.53***	1.04	14.48***	4.48**
I, SD	-1.15	-4.39***	-6.04***	0.09	8.22**	
I#, Tr#	-2.97	-4.67***	-6.46***	-0.00	14.46***	4.62**
I#, SD, Tr#	-2.93	-4.67***	-6.34***	-0.01	8.83**	
UPRP:						
-	-2.62**	-5.12***	-6.30***	0.07	24.96***	
I#	-4.56***	-5.02***	-6.75***	0.46	25.39***	10.99***
I, SD	-4.47***	-4.98***	-6.73***	0.46	14.48***	
I, Tr	-0.87	-0.92	-1.04	0.38	10.09***	8.58**
I, SD, Tr	-4.62***	-5.05***	-6.76***	0.39	13.06***	

# indicates that the auxiliary variables are significant (t-value over 2,00)

* = significant at least at 10 % level,** = at least at 5 % level, *** = at least at 1 % level

Helsinki 1994
Yliopistopaino
Pikapaino

ISBN 951–40–1406–5
ISSN 0358–4283