Pellervon taloudellisen tutkimuslaitoksen työpapereita

Pellervo Economic Research Institute Working Papers

N:o 47 (June 2001)

EXPORT PRICE AND EXCHANGE RATE EFFECTS IN ROUNDWOOD MARKETS OF FINLAND, SWEDEN AND AUSTRIA*

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Helsinki June 2001

ISBN 952-5299-41-4
ISSN 1455-4623

*The Wood Wisdom –forest sector research programme for financial support for carrying out this study. Valuable comments and suggestions for developing the manuscript by professor Pekka Ilmakunnas, professor Jari Kuuluvainen and managing director Vesa Vihriälä

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Hänninen, R. & Toivonen, R. & Toppinen, A. 2001. EXPORT PRICE AND EXCHANGE RATE EFFECTS IN ROUNDWOOD MARKETS OF FINLAND, SWEDEN AND AUSTRIA. Pellervo Economic Research Institute Working Papers No 47. 36 p. ISBN 952-5299-41-4, ISSN 1455-4623.

ABSTRACT: In this study, price transmission from forest product export markets to roundwood markets is analysed in the three largest exporting countries of the EU (Finland, Sweden and Austria) and the two largest destination markets (the UK and Germany). The results confirm that roundwood price development is tied to the price development in forest product markets. However, changes in sawnwood or newsprint export prices have not been carried through proportionally to national roundwood prices. Results from annual data for the period 1975-97 indicate no evident differences between the export countries in price transmission. Changes in export prices have reflected in the Finnish roundwood market to an approximately equal extent as in the Swedish roundwood market. Differences were, however, found between the two wood assortments in roundwood markets. The effects of export prices on roundwood prices were greater for pulpwood than for sawlogs. Using monthly data available for Austrian and Finnish sawlog markets, we found an indication of a closer linkage between Austrian and German prices than those for the Finnish sawlog market during 1986-97.

Keywords**:** roundwood, newsprint and sawnwood markets, price fluctuations, business cycles

Hänninen, R. & Toivonen, R. & Toppinen, A. 2001. METSÄTEOLLISUUS-TUOTTEIDEN VIENTIHINTOJEN JA VALUUTTAKURSSIEN VAIKUTUS PUUMARKKINOILLA SUOMESSA, RUOTSISSA JA ITÄVALLASSA. Pellervon taloudellisen tutkimuslaitoksen työpapereita n:o 47. 36 s. ISBN 952-5299-41-4, ISSN 1455-4623.

TIIVISTELMÄ: Tutkimus tarkastelee hintavaihteluiden välittymistä metsäteollisuus-tuotteiden vientimarkkinoilta raakapuumarkkinoille. Vertailussa on kolme EU:n merkittävää metsäteollisuustuotteiden vientimaata, Suomi, Ruotsi ja Itävalta, ja kaksi merkittävintä vientimarkkina-aluetta, UK ja Saksa. Tulokset vahvistavat aiempaa tietoa siitä, että raakapuun hintakehitys on selvässä yhteydessä metsäteollisuustuotteiden hintakehitykseen. Sahatavaran tai sanomalehtipaperin hintamuutokset vienti-markkinoilla eivät kuitenkaan välity raakapuumarkkinoille täysin sellaisinaan eli yhden suhteessa yhteen. Tuotteiden hintamuutokset vientimarkkinoilla välittyvät kuitenkin jotakuinkin samalla tavoin raakapuumarkkinoille kaikissa tarkastelluissa kolmessa eri vientimaassa (vuositason tarkastelu jaksolla 1975-1997). Erityisen samalla tavoin hintamuutokset välittyivät Suomen ja Ruotsin puumarkkinoille. Sen sijaan tukki- ja kuitupuun välillä havaittiin eroa siinä, kuinka lopputuotteiden hintamuutokset välittyivät näiden puutavaralajien hintoihin: Vuositasolla lopputuotteiden hinnat vaikuttivat voimakkaammin kuitupuun kuin tukkipuun hintaan. Tarkasteltaessa kuukausihintoja vuosilta 1986-1997 havaittiin, että Itävallan tukki- ja Saksan sahatavaramarkkinoiden hintakehitys oli tiiviimmässä yhteydessä toisiinsa kuin Suomen tukki- ja Saksan sahatavaramarkkinat. Ruotsista ei kuukausittaisia tukkihintoja ollut käytössä.

Avainsanat: raakapuu, sanomalehtipaperi, sahatavara, hintavaihtelut, talouden syklit

CONTENTS

1. INTRODUCTION

Large fluctuations in the forest products industries and roundwood markets have been of concern to both industry and to wood sellers in timber markets. Both prices and quantities are rather volatile. However, it is not clear how fast and to what extent fluctuations in roundwood markets are related to the world market demand and price changes of forest products. This study investigates the transmission of price fluctuations from forest products export markets to roundwood markets in Finland and competitor countries.

Information on the nature of price transmission between product prices and input prices is useful in planning both at the industry and at the factor market levels, for example, in helping roundwood market participants to develop strategies for responding to future price changes. It is also important in forest sector modelling and forecasting at the aggregate market level. Price linkages are of particular interest in the current economic integration in Europe. More precisely, from the Finnish point of view, there might be differences in the price transmission between Finland and its main competitor countries in Europe. If exchange rates play an important role in price transmission, roundwood market prices may be affected by the introduction of the euro.[1]

The present study examines price transmission to Finnish, Swedish and Austrian roundwood markets originating in their main export countries, the UK and Germany. Sawlogs and pulpwood are analysed separately due to apparent differences in the industrial end uses of these wood assortments. In the export markets, newsprint represents an end product of the pulp and paper industry and sawnwood of the wood products industry. The empirical analysis use two data sets, the contents of which are dictated by the availability of the data. The annual data cover the period from 1975 to 1997. Monthly data cover the period from January 1986 to December 1997 and only include data only for Finnish and Austrian sawlog markets.
The use of monthly data in the analysis was seen necessary in order to study dynamic features of price relations.

Historically, the effect of export price changes on roundwood prices could be assumed to be relatively large in Finland. The Finnish price negotiation of roundwood market participants used export prices as a basis for their price recommendations up to late

[1] Currently, Finland and Austria belong to the European monetary union while Sweden has remained outside. In the longer term, it is likely that the euro will fundamentally impact on the pricing patterns of forest products, especially on the use of the Swedish Krona in European sawnwood markets. However, we concentrate here on assessment of the current situation as it is reflected in historical data, and this potential change is not considered in this study.

1990s, when the negotiations gradually ended. However, the elasticity of roundwood price with respect to export price may differ depending on the roundwood assortment. The larger cost share of wood raw material in sawnwood production than in paper production suggests greater elasticity for sawlog than for pulpwood. For example, in Finland the respective stumpage cost shares were estimated to be 34 per cent in the woodworking industry and 10 per cent in the pulp and paper industry in 1998 (FFSEO, 2000). On the other hand, a larger export share of paper production compared with sawnwood production implies greater elasticity for pulpwood than for sawnwood in the three exporting countries.

Despite many interesting issues related to price transmission in the forest products industry, there have been few previous econometric studies of linkages between product and factor markets in different countries. A common way to investigate price linkages has been to form a simple two-variable model including product export price and domestic roundwood price. This is a potential approach in the case where production of forest products is exported to world markets for the most part. If roundwood has a large cost share in the final product, the price of roundwood may be determined mainly by product export prices. However, in some cases (e.g. the paper industry) technical development may improve the industry’s ability to pay for roundwood, which changes the long-run relationship between roundwood and product price.

The simple two-variable model mentioned above was used, for instance, by Forsman and Heinonen (1989a). They applied error correction models estimated by the OLS method. The inclusion of exchange rate in their model (1989b) to separate exchange rate and product price effects on roundwood prices improved the behaviour of the model. However, the exchange rate variable was not statistically significant. According to the results, Finnish and Swedish stumpage prices can be explained rather well by forest products export prices during 1963-1986.

In the Finnish model, the annual changes in the export prices of wood industry products had a one-to-one effect on the price of sawlogs. For the price of pulpwood, the elasticity was greater than one indicating a stronger response. This was interpreted as being due to the reduced need for pulpwood in the paper industry production processes as a result of technological change. The results for Sweden were not as clear as those for Finland. The results of Pitkäjärvi (1996) that were estimated by Johansen’s co-integration method (Johansen 1995) indicated a roughly one-to-one relationship between changes in Finnish export prices (sawnwood, paper) and domestic wood (sawlog, pulpwood). Simple relationships between product and factor prices estimated by co-integration methods are also commonly used in the analysis of price transmission in other economic sectors, e.g. the oil industry (Gjolberg & Johnsen 1999) and agriculture (Goodwin & Holt 1999).

Other methods for analysing price linkages include partial price equations (i.e. inverted demand functions) for a factor in question and larger static equilibrium market models. In Haynes (1977) and Merrifield and Haynes (1984), for example, price linkages were analysed in the U.S. Pacific Northwest lumber and plywood industries using an equilibrium-market model and OLS. This approach is, however, problematic in modelling dynamic interrelationships between the markets. Co-integration methodology was used by Toppinen (1998) for studying the adjustment in the Finnish sawlog market applying a demand and supply model. In a long-term equilibrium relation, the effect of sawnwood export price on sawlog price was slightly above one (1.15), while in the short term the effect was not significantly different from zero.

So far, comparative studies on price transmission from export markets to different countries' roundwood markets are largely lacking. This study aims at filling at least a part of this gap by estimating simple price relationships, including product export price, roundwood price and exchange rate. The analysis of specific countries and products allows us to compare price transmission by roundwood assortment in Finnish, Swedish and Austrian roundwood markets. It also gives information on possible differences in export price transmission from Germany and the UK to the exporters prices of roundwood.

2. THE METHODS AND DATA

2.1 Econometric price equations

Simple price relationships between product export price, roundwood price and exchange rate are estimated here. It is assumed that forest industries in Finland, Sweden and Austria act in competitive export markets for forest products. The theory of derived demand assumes that increased activity in the end-use sector causes the prices of forest industry products to rise. This will consequently increase the price of the factor inputs (e.g. roundwood) used in production as their demand increases. In competitive output markets, a relative devaluation of exporting country's currency increases export price in its own currency, improving mark-up margins and thereby exporting opportunities. Rising volumes will eventually have a positive effect on factor prices, which means that a devaluation also benefits roundwood sellers.

Previous studies, e.g., Ronnila and Toppinen (2000), have found little statistical evidence for oligopsony power in Finnish roundwood markets. The cost share of roundwood is assumed large enough, so that the price of roundwood is affected by export prices. Although the assumption of competitive export markets may be a simplification of real market situation, where products may have qualitative differences and there are long-term contracts between suppliers of paper products (see e.g. Hänninen 1998), it can be justified with our main focus on analysing price linkages in the markets rather than studying market structures.

In our model, the exporter's price change (in the exporter's home currency) is actually divided into two components: the exchange rate effect and the world market price effect as in, for example, Forsman and Heinonen (1989b). The empirical roundwood price equation for the exporter country and roundwood assortment in question can be presented in a logarithmic form as

$$pw_t = a_o + \underset{(+)}{a_1 px_t} + \underset{(+)}{a_2 er_t} + u_{t,} \qquad (1)$$

where *pw* is the unit price of roundwood (sawlog, pulpwood) in the exporter's domestic currency, *px* is the exporter's price for a forest industry product (sawnwood, pulpwood) in the destination market's currency (Germany, the United Kingdom) and *er* is the bilateral exchange rate of the exporters (e.g., FIM/GBP for the UK and FIM/DEM for Germany). As mentioned above, the theory of derived demand implies that both the effect of product price *(px)* and exchange rate *(er)* on wood price *(pw)* can be assumed to be positive in the long-term equilibrium.

Equation (1) is estimated by OLS when annual data is analysed by also allowing lagged levels in the models. In the estimation, three hypotheses are tested by restricting the regression coefficients. If the fluctuations of export price pass fully through to the roundwood price, their relationship is proportional. A proportional relationship between two variables also indicates that they are co-integrated, i.e., they have a long-term economic equilibrium relationship. First, the ability to restrict the coefficient of export price to unity is tested in (1):

Hypothesis 1: $a_1 = 1$

Second, it is tested whether wood price is solely a function of export price expressed in the currency of the destination country (in GBP or DEM). If exchange rate changes play no separate role in wood price determination, the coefficient (a_2) of *er* can be restricted to zero:

Hypothesis 2: $a_2 = 0$

In the model (1), the exporter’s price change (in the exporter's home currency) is divided into the exchange rate effect and the world market price effect. Finally, it is tested whether wood price is a function of export price expressed in the exporter’s home currency (FIM, SEK, and ATS):

Hypothesis 3: $a_1 = a_2$

Monthly sawlog price models of Austria and Finland are estimated using Johansen’s (1988, 1995) co-integration analysis (see Appendix 1). In Johansen’s method, the above hypotheses are tested by restricting the coefficients of the co-integration vector respectively.

2.2 Time series data

The annual data covers the period from 1975 to 1997 in newsprint, sawnwood and roundwood prices, which gives us 23 observations. Monthly data covers the period from January 1986 to December 1997, including Finnish and Austrian sawnwood prices in Germany and the two exporters’ domestic sawlog prices, which gives us 144 observations. The data of the study is summarized in *Appendix 1*.

Our data for product export prices are obtained from the customs statistics of the United Kingdom (CSO) and Germany (Statistiches Bundesamt). Unit values of imports to the

UK and Germany from the three supplier countries are used as representative prices of forest products (coniferous sawnwood: CN 44710 with unit value/m^3, newsprint: SITC641.1 for the UK and CN4801 for Germany with unit value/tn). The bilateral exchange rates (FIM/GBP, FIM/DEM, SKR/GBP, SKR/DEM, ATS/GBP, ATS/DEM) are obtained from the Statistics of the Bank of Finland.

Finnish roundwood prices are for the non-industrial private forest owners (NIPFs), which currently account for about 80% of the total market volume. For Finnish monthly wood prices we used both *stumpage and delivery* prices for coniferous sawlogs and spruce pulpwood (FIM/m^3) as obtained in the Finnish Statistical Yearbook of Forestry. At the annual level, only stumpage prices were used, since delivery prices were not available for the whole period. Although the use of stumpage market data may weaken the comparability of our results, they are more representative of the market, currently accounting for over 80% of the total Finnish market.

In Sweden, delivery prices for spruce sawlogs and pulpwood are used to represent wood prices. Swedish data are from the Swedish Forestry Statistics (Skogsstyrelsen, statistical service June/1999), and represent prices of roundwood from all forest owner groups' forests. However, until 1995, Swedish price statistics were based on price lists and thus did not include information on the possible premiums paid in addition to the list price. The system of collecting the price information was changed in 1995. From this year on the Swedish statistics should reflect the actual average price level better than earlier.

For Austria, our empirical analysis is more limited than for Finland and Sweden due to differences in forest industry production. For Austria, we did not estimate pulpwood price equations because of the small quantity of newsprint production and exports. Levels of trade to individual European countries were so low that using unit values as a proxy for prices would be subject to a high degree of randomness. Second, since Austrian sawnwood exports to the UK are very small, we estimated the Austrian sawlog price equation for the German sawnwood price only. The price data of Austrian wood assortments are based on statistics from the Austrian Statistical Office. The price statistics of spruce sawlogs are the quality class B II prices and represent sales for all ownership categories.

3 MARKETS FOR ROUNDWOOD AND FOREST INDUSTRY PRODUCTS

The structure of roundwood markets in all three countries is quite similar. At least half of the forest land is owned by small non-industrial private forest owners (NIPFs) (see Table 1; for more information on the structure of roundwood markets, see Rämö et al., 2001). However, there are some specific differences in the relative proportions of the owner categories. In Sweden, the industry's share of forest ownership is 39 per cent. This indicates that the Swedish forest industry is not as dependent on the selling behaviour of NIPF owners as the Finnish and Austrian industries.

Table 1. Forestry and the forest industry in Austria, Finland and Sweden.

	Finland	Sweden	Austria
Forest and other wooded land/ share of land area %	23 mill. ha 75%	28 mill. ha 68%	3.9 mill. ha 46%
Forest ownership of land area	NIPF 62% State 25% Forest Industry 9%	NIPF 50% State 2% Forest Industry 39%	NIPF and other private 82% State 15% Forest Industry -
Industrial roundwood harvests, 1997	52 mill. m^3	60 mill. m^3	15 mill. m^3
Production of sawn wood, 1997 (export share %)	10.7 mill. m^3 (71%)	15.5 mill. m^3 (70.3 %)	8.3 mill. m^3 (58%)
Production of paper and paperboard, 1997 (export share %)	12.1 mill. tons (89%)	9.8 mill. tons (85%)	3.8 mill. tons (90%)
Use of industrial roundwood, 1997	64.5 mill. m^3	64.5 mill. m^3	16.8 mill. m^3

Sources: Finnish statistical yearbook of forestry 1998, Skogsstatistisk årsbok 1998 (Sweden), Eurostat 1998, ÖSTAT 1999, FAO Yearbook of forest products 1997, Skogsstyrelsen 1999, * Sweden: roundwood m^3 without bark

In Finland, felling in forests owned by companies and the state has fluctuated counter-cyclically to balance the material needs of the industry. On the demand side, the roundwood market in all three countries is mainly covered by a few large companies.

In Sweden, newsprint is the most important paper grade accounting for about 40 per cent of paper industry exports (Pulp and Paper International 1998). In Finland and Austria, the respective share of newsprint was 14 per cent in 1997. Sawnwood is the main forest industry product in Austria, where production of newsprint has been negligible in the 1970s and 1980s, but has been increasing over the 1990s due to new investments for production capacity.

An evident feature in the structure of exports from the three supplier countries is the growth of Swedish exports of both newsprint and sawnwood during the period of 1973-97 (Figure 1). Finnish newsprint exports show no increase at all, while the annual export growth from Sweden has been 4 per cent. Exports from Austria have started to increase just after 1984. The reason behind the stagnation of Finnish export development is that Finland has replaced newsprint with higher quality paper grades in production. As compared to newsprint exports, the growth of sawnwood exports from all three supplier countries has been low, averaging 1-2 % annually. Growth has been highest during the 1990s due to the decreased supply from Russia and Canada to the European sawnwood markets.

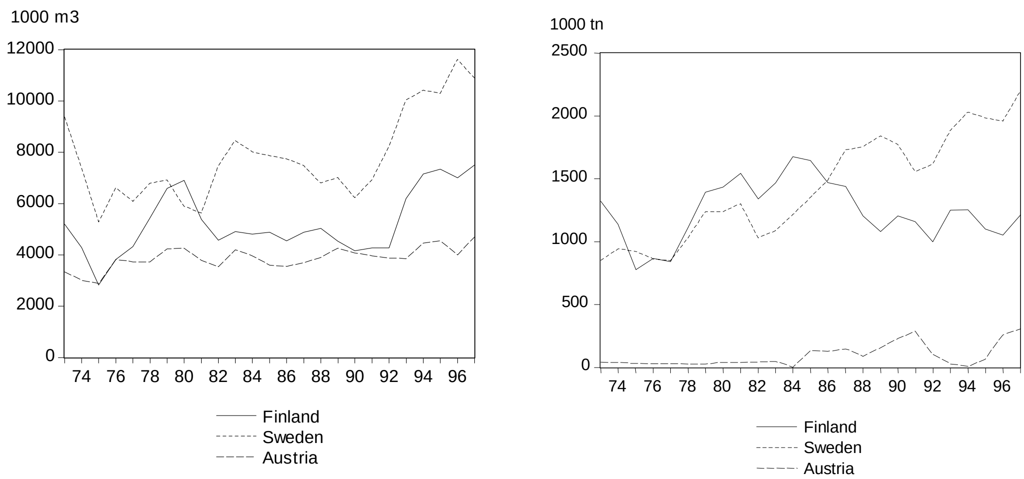

Figure 1. Sawnwood (left) and newsprint (right) exports from Finland, Sweden and Austria in the years 1973–1997.

The annual nominal price development of forest products has fluctuated considerably, with an increasing trend up to 1990, after which the trend has in most cases turned downwards (Figures 1-4 *Appendix 3*). A relatively strong similarity can be found in nominal price development between the exporters' domestic roundwood prices and foreign currency export prices in the UK and German market, at least up to 1990. After this year the trends of roundwood and product price development differ, especially in the case of Finnish and Swedish sawlogs and sawnwood (Figures 1-2, *Appendix 3*). This indicates a relatively high degree of price transmission between product markets and roundwood markets up to 1990, after which the connection seems to have weakened.

Exchange rate changes appear unlikely to have affected price transmission in the Austrian sawlog market. The development of the Austrian shilling with respect to the

Deutsche mark has been stable since the beginning of 1980s with no annual fluctuations (*Appendix 4*). With respect to the Deutsche mark, Finnish and Swedish currencies show an upward (depreciating) trend. Compared to the graphs of Finnish and Swedish nominal export prices, the exchange rates show a counter-cyclical development (Figures 2-4, *Appendix 3*). This indicates that during the currency depreciation the exporters' foreign currency prices for forest products have decreased, while during the currency appreciation they have increased. The present study examines how strong the relationships between the prices and exchange rates have been and whether price transmission differs between sawlog and pulpwood markets.

Monthly sawlog and sawnwood prices indicate high covariation and no significant lead-lag relationships between the Finnish or Austrian roundwood market and German sawnwood markets (Figure 2). Correlations between nominal sawlog and sawnwood prices are positive and high, but slightly higher in Austria (0.84) than in Finland (0.77). A relatively strong similarity can be found in price development between the two market levels, with a tendency for decreasing prices. Interestingly, sawlog prices in Finland correlate negatively (-0.88) with the exchange rate, while in Austria the correlation between sawlog prices and exchange rates is practically zero. Fluctuations in Austrian and Finnish sawlog prices are relatively uniform, and with only a slightly lower correlation (0.73) than between the two exporters' sawnwood prices in the German market (0.79). This suggests that European markets are at least somewhat integrated at both the market levels (see also Toivonen et al. 2000).

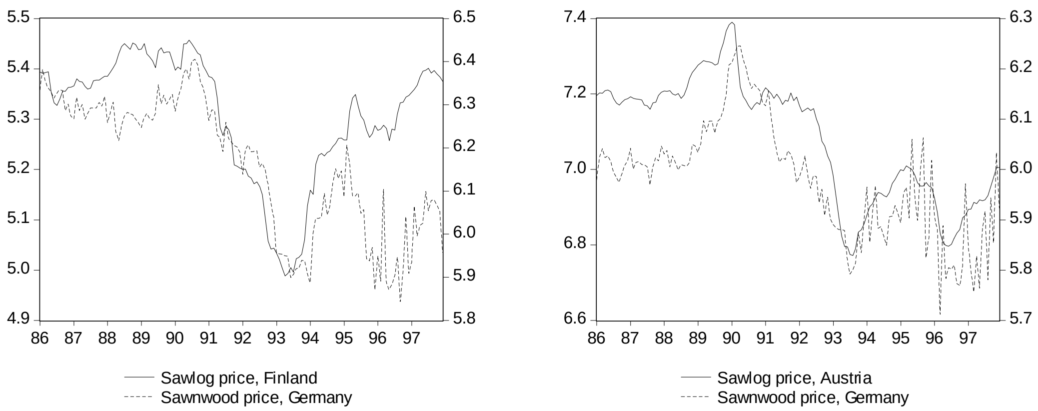

Figure 2. Finnish and Austrian sawlog prices compared with sawnwood export prices in Germany from January 1986 to December 1997.. Logarithms of nominal monthly prices in national currencies.

4 ESTIMATION RESULTS FOR WOOD PRICE MODELS

4.1 Testing time series properties of annual data

Before estimating the annual roundwood price models, stationarity of the data was analysed using the Augmented Dickey-Fuller (ADF) unit root tests, and lags from 0 to 2. If the variables are nonstationary, i.e., they are not constant in means and variance over time, a "spurious regression" problem may arise.[2] Inferences can, however, be made if the variables of the model are co-integrated.[3] In this study the ADF tests indicate that almost all the variables are nonstationary. Therefore, the residuals of the models were tested for stationarity using ADF –tests.[4] However, even the ADF test results are not always straightforward to interpret (e.g., Maddala and Kim 1998). For instance, for finite samples it is not necessarily possible to draw conclusions on whether a series is stationary. This is why graphs of the series are also used in this study to interpret the ADFtest results.

The ADFtest results for two test specifications (constant and constant & trend included) are presented for the variables in Table 1 (*Appendix 5*), with one lag in the test equation. The test values obtained their highest t-values at one lag in all cases. The ADF test with only a constant included (Table 1, *Appendix 5*) accept the null hypothesis of nonstationarity for all variables except for the Finnish exchange rate (FIM/GBP). Furthermore, most of the graphs describing price data show clear upward trends indicating nonstationarity (*Appendix* 3). However, in Figure 2, the Swedish sawnwood price in Germany, and in Figure 4, the Finnish and the Swedish newsprint prices in Germany could be stationary. The test with constant & trend indicates that the Finnish newsprint price and the exchange rates (FIM/DEM and SEK/DEM) are trend stationary

[2] In this case the interpretation of the results is difficult, because the conventional *t or F* statistics calculated for such regressors do not follow standard distributions (e.g. Banerjee *et al.* 1993).
[3] According to Granger (1981), nonstationary variables may form stationary linear combinations (the variables are co-integrated).
[4] Due to the problems with ADF testing, a better way to estimate models with nonstationary variables would be the Johansen's co-integration method (1995). This is, however, not possible for our annual data because of too few observations.

4.2 Annual pulpwood price models 1975-1997

Results for estimated roundwood price equations are first presented for pulpwood. Residual autocorrelation of the models is examined using the DW (Durbin Watson) test which measures first order serial correlation. A more general LM test (Lagrange multiplier test, valid for models with lagged dependent variables) measuring higher order autocorrelation was also applied. The null hypothesis of the LM-test (using Breausch-Godfrey LM test statistics, Godfrey 1988) is that there is no serial correlation up to lag order *p*[5]. Here, *p* for annual data is chosen to be 2.

The coefficients for the Finnish and the Swedish pulpwood price equations are shown in Table 2 for the UK product price data, and in Table 3 for the German product price data. In the left-hand side column for each country are the results for Model 1, representing the unrestricted price equation (1) from section 2 where price and exchange rate effects are separated from each other. Restriction of the price effect to equal one (i.e. direct price proportionality between product import price and factor price, (*px*=1) and the model where exchange rate effect is restricted to zero (*er*=0) are the additional hypotheses (H_1 and H_2) to be tested.

Model 2, in the right-hand side column for each country, presents the restricted model, where the joint equal coefficient for prices and exchange rates is estimated (H_3). A null hypothesis (H_3) where the joint effect is restricted to *px*=*er*, is shown in the bottom line of each table.

[5] The highest order of *p* that might describe the serial correlation should be specified.

Table 2. Results for pulpwood price equations, newsprint import price in the UK market, 1975-1997.

	Finland		Sweden	
	Model 1	Model2 (H3)	Model 1	Model 2(H3)
Constant	-0.34	-0.34	-2.01	-2.00
	(-0.23)	*(-2.31)*	*(-2.58)*	*(-2.63)**
Newsprint price	1.02**		0.87**	
	(6.70)	1.01**	*(5.42)*	0.90**
Exchange rate	-0.54	*(5.32)*	0.97*	*(9.61)*
	(-1.16)		*(2.77)*	
R2	0.71	0.55	0.80	0.81
DW	0.78	0.54	0.85	0.85
LM-2nd order-test	P=0.04	P=0.00	P=0.02	P=0.02
H1: px=1	P=0.89		P=0.44	
H2: er=0	P=0.26		P=0.01	
H3:px=er	P=0.00		P=0.84	

T-statistics are in parenthesis below coefficients, where * (**) indicates rejection of the null hypothesis at the 5% (1%) level. Probability values at the bottom of the table are for the Wald test rejecting the null hypothesis given in the column on the left.

Table 3. Results for pulpwood price equations, newsprint import price in the German market, 1975-1997.

	Finland		Sweden	
Constant	-1.80	-3.65	-1.30	-2.50**
	(-0.55)	*(-1.73)*	*(-0.89)*	*(-3.58)*
Newsprint price	0.77		0.79**	
	(1.71)	1.04**	*(3.81)*	0.96**
Exchange rate	1.07**	*(3.85)*	0.25	*(11.21)*
	(3.88)		*(0.99)*	
R2	0.37	0.39	0.85	0.85
DW	0.55	0.52	1.24	1.23
LM 2nd order-test	P=0.00	P=0.00	P=0.11	P=0.10
H1: px=1	P=0.62		P=0.32	
H2:er=0	P=0.00		P=0.00	
H3:px=er	P=0.46		P=0.36	

T-statistics are in parenthesis below coefficients, where * (**) indicates rejection of the null hypothesis at the 5% (1%) level. Probability values at the bottom of the table are for the Wald test rejecting the null hypothesis given in the column on the left.

In general, the explanatory power of the pulpwood price models (1) was moderate, ranging from 0.37 to 0.85 for Sweden and Finland (Tables 2 and 3). The simple behavioural price relation was incapable of explaining all features in pulpwood price development as also reflected in relatively low Durbin-Watson coefficients for first order residual autocorrelation. The LM test for second order serial correlation indicates problems of residual autocorrelation in all equations, except for Sweden in the German data.

The estimation results for Model 1 in most cases show statistical significance and the coefficients are of the right sign except for the Finnish exchange rate in the UK data. The residual ADF tests for the unrestricted models with a constant (Table 2, *Appendix* 5) indicate stationarity for Finnish pulpwood models in the UK and Germany. With a trend included in the test, the residual of the Swedish model in the German data is also stationary. Sweden obtained very low test values in the UK data, indicating nonstationarity of residuals and problems in interpreting the results. However, according to Figure 1 (see *Appendix 6a*), this residual also seems stationary.

Next, it was tested whether the coefficient of export price can be restricted to unity (H1). The null hypothesis H1 was accepted, indicating that newsprint export price development (expressed in the destination market currency) has been the primary determinant over exchange rates for Swedish and Finnish pulpwood prices. However, the exchange rates also matter somewhat in the pulpwood price determination; the Wald test for hypothesis H2 (er = 0) was rejected in all models except for the Finnish pulpwood model in the UK.

Model 2 represents hypothesis H3, with a restricted joint coefficient for product price and exchange rate (H3: px = er). In all models, except for the Finnish model in Germany, the equality of export price and exchange rate coefficients was accepted. This indicates the importance of newsprint export price in pulpwood price determination (in the exporter's home currency: FIM, SEK, ATS). For Finnish models, coefficients were in the same range, about unity in Germany and in the UK. In addition, for Swedish models, newsprint price effects were close to unity. This indicates, that pulpwood prices have changed proportionally with respect to changes in the exporters' newsprint prices in both export markets.

The price coefficients were statistically significant in all estimations of Model 2, but the residual autocorrelation (see LM test results) were present in the models. The residual ADF tests for Model 2 with a constant (Table 2, Appendix 5) indicate stationarity only for the Finnish model in Germany. The ADF test-value is especially low for Swedish Model 2 in the UK, indicating problems in the interpretation of the results. The graphs of the series (see Figures 1-2, *Appendix 6a*), however, imply that all the residuals of Model 2 could be stationary.

In addition to these static regression models, dynamic versions were also estimated, with annual one-period lagged dependent and independent variables and specifications including deterministic trends accounting for technical change. The results did not appear to behave statistically better than the static models, and are not reported.

4.3 Annual sawlog price models 1975-1997

In Tables 4 and 5, estimation results are presented for ten sawlog price models. Explanatory power of the models ranged from 0.30 to 0.88. The estimation results for sawlog models show statistical significance, and the coefficients have the theoretically right signs. The LM test indicates less problems of residual autocorrelation for the sawlog models than for the pulpwood models reported in the previous chapter.[6]

The residual ADF tests for Model 1 with a constant and a trend indicate stationarity for the Finnish model in Germany (Table 2, *Appendix 5*). The Swedish model in the UK and the Austrian model in Germany have very low ADF test values, which makes the interpretation of their results problematic. However, the graphs of the residuals of all the specifications of Model 1 again indicate stationarity (Figures 1-2, *Appendix 6b*).

Hypothesis H1 tests whether the elasticity coefficient of sawnwood export price, expressed in the destination market currency, can be restricted to unity. The null of H1 was rejected in most cases (in the UK, and for Sweden also in Germany, Tables 4-5). Hence, the export price effect on sawlog prices seems smaller than that on pulpwood.

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[6] Autocorrelation is present only in the Swedish Model 2 for Germany, at the 3% level (LM test).

Table 4. Results for sawlog price equations, sawnwood import price in the UK market, 1975-1997.

	Finland		Sweden	
	Model 1	Model 2 (H3)	Model 1	Model 2 (H3)
Constant	0.42	-0.25	0.88	0.77
	(0.39)	*(-0.38)*	*(2.05)**	*(2.04)**
Sawnwood price	0.77**		0.73**	
	(7.84)	0.78**	*(7.72)*	0.68**
Exchange rate	0.48	*(8.15)*	0.55*	*(12.89)*
	(1.21)		*(2.21)*	
R2	0.74	0.75	0.88	0.88
DW	1.38	1.29	1.18	1.16
LM 2nd order-test	P=0.39	P=0.34	P=0.22	P=0.20
H1: px=1	P=0.03		P=0.01	
H2: er=0	P=0.24		P=0.04	
H3: px=er	P=0.45		P=0.57	

T-statistics are in parenthesis below coefficients, where * (**) indicates rejection of the null hypothesis at the 5% (1%) level. Probability values at the bottom of the table are for the Wald test rejecting the null hypothesis given in the column on the left.

Table 5. Results for sawlog price equations, sawnwood import price to German markets, 1975-1997.

	Finland		Sweden		Austria	
	M 1	M 2 (H3)	M 1	M 2 (H3)	M 1	M 2 (H3)
Constant	-2.89*	-0.26	1.74	0.23	-16.57	1.17
	(-2.08)	*(-0.37)*	*(1.58)*	*(0.54)*	*(-132)*	*(0.58)*
Sawnw. Price	1.26**		0.49*		0.60*	
	(5.23)	0.78**	*(2.65)*	0.76**	*(2.20)*	0.75**
Exchange rate	0.55**	*(7.75)*	0.81**	*(12.56)*	10.29	*(2.90)*
	(3.89)		*(11.79)*		*(1.54)*	
R2	0.77	0.73	0.88	0.88	0.35	0.30
DW	1.16	0.91	1.12	0.82	1.45	1.27
LM2ndorder-test	P=0.39	P=0.05	P=0.13	P=0.03	P=0.59	P=0.44
H1: px=1	P=0.30		P=0.01		P=0.16	
H2: er=0	P=0.00		P=0.00		P=0.14	
H3: px=er	P=0.05		P=0.15		P=0.17	

T-statistics are in parenthesis below coefficients, where * (**) indicates rejection of the null hypothesis at the 5% (1%) level. Probability values at the bottom of the table are for the Wald test rejecting the null hypothesis given in the column on the left.

The separate coefficients of exchange rates in Models 1 were statistically significant in most cases. The Wald test for H2 (er = 0) was rejected in all models, except for the Finnish model in the UK and the Austrian model in Germany. This indicates that the exchange rates are also important in determining sawlog prices. Although the statistical behaviour of the sawlog models is better than that of the pulpwood models, these simple models evidently cannot capture all the important features of price determination.

Model 2 with hypothesis H3 represents the restricted joint coefficient for sawnwood export price and exchange rate (H3: px = er). The equality was not rejected in any model. This indicates the importance of sawnwood export price in sawlog price determination (in the exporter's home currency: FIM, SEK, ATS). Finnish sawnwood price coefficients were 0.78 in the UK and Germany, Swedish coefficients were 0.68 and 0.76, respectively, and the Austrian coefficient was 0.75 in Germany. The magnitudes of the price coefficients were close to each other indicating no clear differences between exporting or destination countries.

All the price coefficients for sawlog Model 2 were statistically significant in both export markets. The residual ADF tests for Model 2 with a constant rejected nonstationarity at the 5% level for the Finnish models in the UK and in Germany (Table 2, *Appendix 5*). It was also rejected by the test with a trend for the Swedish model in Germany. Very low ADF test values were again obtained for the Swedish and the Austrian Models 2 in Germany. However, the graphs of residuals indicate nonstationarity only for the Austrian sawlog model.

For the sawlog prices, dynamic versions with annual one-period lagged variables were also estimated (specifications including deterministic time trends), but the results did not appear to behave statistically better than using concurrent static models. Therefore the results are not reported here.

4.3 Sawlog price models with monthly data 1986-1997

Johansen's co-integration analysis (Johansen 1995) was performed for price transmission from the German sawnwood market to Finnish and Austrian sawlog markets. The co-integration estimation is based on Equation (1) including three variables:

(2) $x_t = [\, pw \; px \; er]$,

where *pw* is the Finnish or Austrian sawlog price in FIM or ATS, respectively, *px* is the Finnish or Austrian export price of sawnwood to Germany in DEM and *er* is the bilateral exchange rate FIM/DEM or ATS/DEM. Provided that the data are co-integrated, it is possible to identify at most two co-integration vectors, the coefficients of which describe the long-term equilibrium relationships implied by Equation (1).

Prior to co-integration analysis, non-stationarity of individual time-series was tested using Augmented Dickey-Fuller tests (Dickey and Fuller 1979). According to test results in Table 6, variables appeared to be integrated with an order of one with the exception of the Austrian-German exchange rate series, which is possibly stationary. When using Johansen's co-integration method, however, the inclusion of both stationary and nonstationary time series in the model is not a problem, since a stationary time series should show up as an additional co-integration vector in the model.

The analysis starts by estimating an unrestricted VAR model (Equation A2 in *Appendix 2*) for each exporter that includes three variables. In the Austrian data, a two-lag model with an unrestricted constant was sufficient to remove residual autocorrelation, and no inclusion of seasonal dummies was necessary. Trace-test results (Equation A3 in *Appendix 2*) from co-integration analysis for the Austrian model (Table 7) indicate two co-integration vectors at the 1% level. As mentioned above, based on the Augmented Dickey Fuller unit root tests, the Austrian-German exchange rate series could be stationary in levels.

Table 6. Augmented Dickey-Fuller unit root tests of individual monthly time series, constant and trend included (number of lagged differences in equation denoted by N).

	Levels of time series	1st difference of time series
Finland:		
Sawlog stumpage price	-1.09 (N=1)	-7.78** (N=0)
Sawlog delivery price	-0.68 (N=0)	-11.32 (N=0)
Sawnwood price in Germany	-2.30 (N=1)	-11.08** (N=1)
Exchange rate, FIM/DEM	-1.67 (N=1)	-7.50** (N=0)
Austria:		
Sawlog price	-2.53 (N=1)	5.48** (N=0)
Sawnwood price in Germany	-2.02 (N=2)	-12.79** (N=1)
Exchange rate, AUT/DEM	-9.59** (N=0)	-14.03** (N=1)

* (**) denotes rejection of the null hypothesis of nonstationrity at the 5% (1%) level

Table 7. Results from co-integration analysis in the Austrian model. Trace test values are those with degrees of freedom correction.

Null hypothesis H_0:r≤I	Eigenvalues λ_i	λ trace statistics T(I)	95% c. values C (i)
r = 0	0.28	65.97*	29.7
r ≤ 1	0.12	20.52*	15.4
r ≤ 2	0.02	2.78	3.8

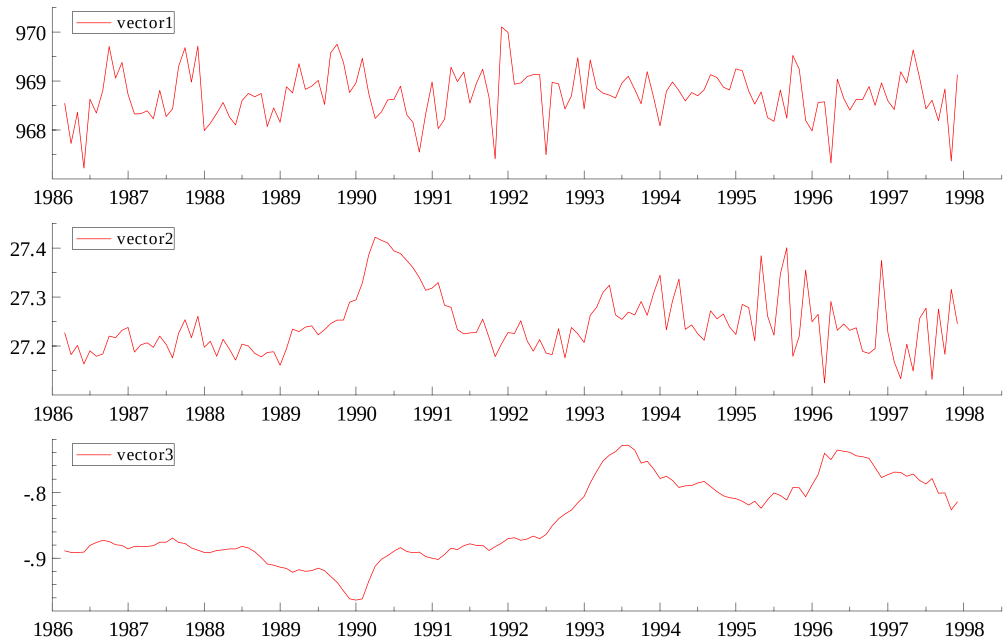

Figure 5. Co-integration vectors for the Austrian model.

Graphs of co-integrating vectors in Figure 5 also indicate that there may indeed be two stationarity relationships in the data, while the third relationship looks more clearly like nonstationarity. The α and β coefficients of the unrestricted co-integration estimation are not presented here.

When the number of co-integration relations is determined it is possible to test hypotheses on the long-term matrix, $\Pi=\alpha\beta'$. The role of exchange rate with price proportionality between exporters sawlog prices (in FIM or in ATS) and sawnwood prices in either domestic currencies or in DEM as

H1: [1 –1 *]
H2: [1 * 0]
H3: [1 $\beta_{21}=\beta_{31}$]

by imposing restrictions on the β-coefficients of the co-integration vector where * denotes that the respective coefficient is not restricted at all.

In testing the economic hypothesis in the Austrian model under *r = 2*, exchange rate was assumed to be weakly exogenous in the model, since it is clearly determined outside the wood products sector. We will assume that there are two co-integrating vectors β_{1i} and β_{2i}, one of which is a stationary exchange rate series while the other captures the long-term sawnwood-sawlog price relationship. The null hypothesis of stationarity of exchange rate under $r = 2$ was tested and it cannot be rejected in β_1 (Table 8, Hypothesis 0). However, in testing the proportionality between two prices in the β_2 vector (Hypothesis 1), the restriction is rejected according to the LR test statistic. Instead, Hypothesis 2, when the exchange rate effect excluded, and Hypothesis 3, where it is restricted to equal the price effect, are not rejected by the data. However, we obtain a coefficient for sawnwood price of 1.62, which indicates no long-term price proportionality between sawlog prices and sawnwood prices.

Table 8. Results from testing the hypotheses in the Austrian model.

	0[1]	***H1***	***H2***	***H3***
	β_1: [0 0 1]	β_1: [0 0 1] β_2: [1 -1 *]	β_1: [0 0 1] β_2: [1 $-\beta_{12}$ 0]	β_1: [0 0 1] $\beta_{22} = \beta_{23}$
β2 vector	Free	1 –1 7908	1 –1.62 0	1 –1.62 –1.62
LR statistic	1.60	9.48	0.03	0.03

In the Finnish sawlog price model, two-lag VAR model specification with unrestricted constant was sufficient to remove residual autocorrelation, and no inclusion of seasonal dummies was needed. However, residual terms of the VAR do not behave as well as in the Austrian model and our results are therefore subject to higher uncertainty. Results from co-integration analysis for Finland do not suggest such close long-term movement as was found in the Austrian model (Table 9), since Johansen's trace test statistics indicate only one co-integration vector in data at the 5 per cent level as compared with two vectors in the Austrian case. Moreover, graphs of co-integrating vectors (Figure 5) indicate that the first relation most clearly shows mean reverting behaviour, indicating one stationary equilibrium relationship in the market.[7] The α and β coefficients obtained from the unrestricted co-integration estimation are not presented here. In the Finnish model, we do not impose a restriction for requiring weak exogeneity of the exchange rate. Historical evidence suggests that there could have been be a linkage between

[7] Another model was estimated for Finland using stumpage prices instead of delivery price, but there was no statically significant evidence for co-integration in the model. The result suggests a behavioural difference between price determination in these two roundwood market segments in Finland, which merits further analysis.

economic performance in the forest industry and the past macroeconomic policy up to the beginning of the 1990s in Finland.

Table 9. Results from co-integration analysis in the Finnish model.

Null hypothesis H_0: r ≤ I	Eigenvalues λ_i	λ trace statistics T(I)	95% c. values C (i)
r = 0	0.11	30.88*	29.7
r ≤ 1	0.07	14.30	15.4
r ≤ 2	0.02	3.76	3.8

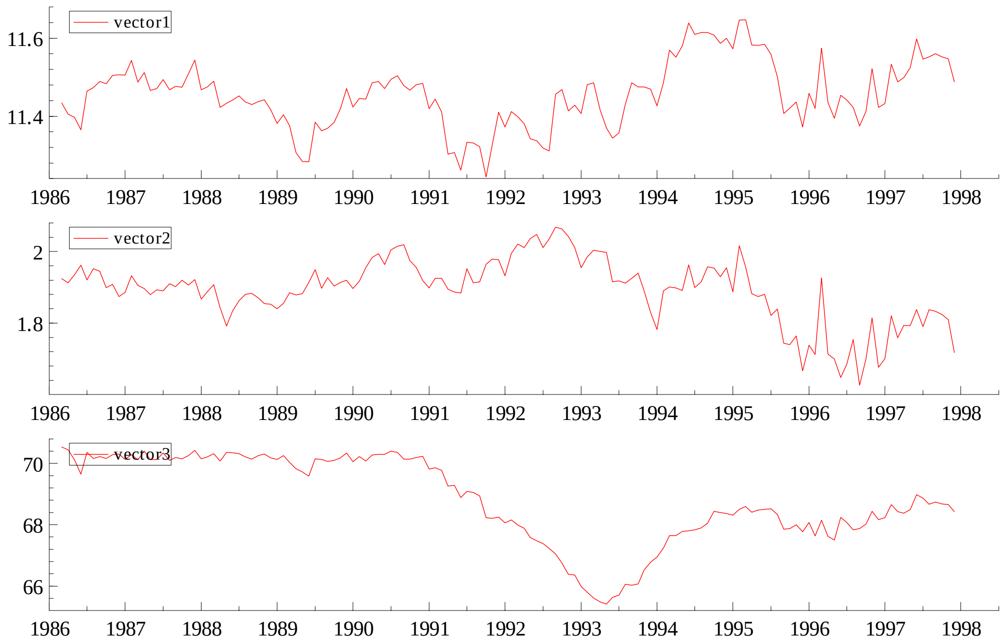

Figure 6. Co-integration vectors for the Finnish model.

In testing the economic hypothesis in the Finnish model using sawlog delivery prices, Hypotheses 1-3 are all rejected (Table 10). In testing H3, coefficients are also of implausible magnitude. So, even though the existence of the long-term equilibrium suggests that prices in sawnwood and sawlog markets move together over time, it appears impossible to find proportionality between prices in the two markets.

Table 10. Results for hypothesis tests in the Finnish model.

	H1 β_1: [1 –1 *]	***H2*** β_1: [1 * 0]	***H3*** $\beta_{12} = \beta_{13}$
β1 vector	1 –1 –0.02	1 –0.95 0	1 –1984 –1984
LR statistic	6.25	6.22	4.03

Dynamic error-correction models were then estimated for both countries where deviations from the long-term equilibrium prices were used as an additional explanatory variable in the conditional models for the sawlog prices (*Appendix 7*). The two countries differed from each other regarding the role of seasonal variation in the short-term models: there was no seasonality present in the Austrian sawlog price model while in the Finnish prices there was some seasonality present. We therefore included 11 seasonal dummies for the Finnish model and 3 of them were statistically significant according to t-statistics (excluded for brevity from the Table). In the Austrian model, with the prior evidence of stationarity of the exchange rate, this variable was excluded from the long-term relationship and only its possible short-term effect was allowed on sawlog prices. Both present and lagged differences were included in the model, and the specification presented in Appendix 7 was chosen according to the principle of parsimony.

To summarize the results, the model for the Austrian market provided a better degree of explanation of sawlog price variation than the Finnish model but the explanatory power of neither model was very high. The Austrian model was able to account for 40% of the variation in sawlog prices, the majority of which was as a result of information about lagged sawlog prices. Short-term effects of sawnwood price or the exchange rate were not different from zero. Monthly data frequency was found to be too short for the adjustment between prices in Austria as the error correction term was not significantly different from zero.

In the model for the Finnish sawlog market, the coefficient of determination was below 0.20 and thus the performance of the dynamic model was weaker than in Austria. In the short-term, sawnwood price had a small but positive effect and the exchange rate had a negative effect on sawlog price. In Austria, as in the Finnish model, the error-correction term was not statistically significant. Thus, it appears that a monthly frequency is too short a time for the adjustment between the product and roundwood markets to occur.

5 CONCLUSIONS

This study compared price linkages between roundwood markets of the three largest exporting countries of sawnwood and newsprint in the EU, i.e. Sweden, Finland and Austria, and the two largest consumer markets, the UK and Germany. Two different data sets were used in the analysis: annual data for the period 1975-1997, and monthly data for the period 1986-1997. Monthly data were only available for Austrian and Finnish sawlog markets.

Results using time series data for 1975-1997 indicate that there are some differences between forest products in how economic fluctuations impacting on forest product prices in export markets are transferred to roundwood markets. First, product prices, expressed in the exporters' currencies, have a clearer impact on roundwood prices than the bilateral exchange rates, as can be expected. However, exchange rates also seem to have importance in roundwood price determination. Second, the effects of product export prices on roundwood prices were larger for pulpwood than for sawlogs. One explanation for this is the larger export share of newsprint production compared with sawnwood production, in each of the three the exporting countries analysed.

On a monthly level, a close linkage was found between the Austrian sawlog market and the German sawnwood market. In other words, co-integration analysis indicated that in the long-term, sawlog prices in Austria and German sawnwood prices move together over time, but that the fluctuations in sawlog prices were not proportional to sawnwood prices. A long-term equilibrium relationship was also detected between Finnish sawlog delivery prices and German sawnwood prices, but again it was not a one-to-one relationship, even in the long term. This points out an interesting issue meriting further analysis: perhaps responses of wood price to product price increases differ from responses to product price decreases, even though this effect has been found to be small for agricultural commodities in general (von Craumol-Taubadel 1998).

No clear differences could be detected between the exporting and destination countries in price transmission to roundwood markets. Finnish sawnwood price coefficients were 0.78 in the UK and Germany, Swedish coefficients were 0.68 and 0.76, respectively, and the Austrian coefficient was 0.75 in Germany. The exporters' coefficients for newsprint prices/pulpwood prices were all close to unity.

The results for the whole period confirm that roundwood price development has been closely tied to price development in the forest product markets. However, visual inspection of the price series indicates a relatively high price uniformity between product markets and roundwood markets up to 1990. During the 1990s the connection seems to have weakened. In all three countries, one possible explanation for this is the ending of different types of price negotiation practices between roundwood market actors. Another potential reason may be the strong consolidation of the forest industry, especially during the 1990s. Overall, the results of this study are valuable when forecasting the development of wood markets, and in understanding the transmission of economic fluctuations from the export markets to roundwood markets. It is of interest to know that the fluctuations are transmitted quite similarly to the roundwood markets in all of these major competitor countries.

However, one should keep in mind that the statistical behaviour of many of the models of this study was not very good, and therefore the results need to be interpreted with some caution. On the other hand, it is natural that the simple models could not explain all features of price transmission from export markets to roundwood markets. Thus, further development is needed to take into account time series properties of the data, and also more aspects related to price transmission. For example, the degree of imperfect competition in export and roundwood markets affects price transmission, and deserves more attention in research. Structural changes in the estimation period are also possible, but were not analysed due to the limited number of observations. And finally, the question of asymmetrical price response deserves further investigation on wood markets.

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Appendix 1. Data.

Table 1. The data of the study.

Data/Exporters	**Roundwood prices by wood assortment**		**Export prices by product and destination country**			
	Spruce	Spruce	[2]Sawnwood		Newsprint	
	Sawlogs	Pulpwood	UK	Ger.	UK	Ger.
Annual, 1975-97:						
[1]Finland	X	X	X	X	X	X
Sweden	X	X	X	X	X	X
Austria (1980-97)	X	-	-	X	-	-
Monthly, 1986:1-1997:12						
Finland	X	-	-	X	-	-
Austria	X	-	-	X	-	-

Notes: [1] prices are for coniferous sawlogs, [2] prices are for coniferous sawnwood, Missing data is denoted by -

Appendix 2. Johansen's estimation method.

In Johansen's co-integration method (e.g., Johansen, 1995, p. 11), the co-integration rank is determined by estimating a two-dimensional VAR(*k*) model system:

$$x_t = A_1 x_{t-1} + ... + A_k x_{t-k} + \mu + \varepsilon_t, \quad t = 1,...,T, \qquad \text{(A1)}$$

where x_t is a vector of empirical variables, which are here the Finnish (Austrian) domestic sawlog price, sawnwood export price to Germany and bilateral exchange rate. Symbol μ is a vector of constant terms, k is the lag length (k = 1,...,N) and ε_t is a vector of error terms assumed to be NID(0,Ω). Equation (2) is re-parameterized in error-correction form (e.g. Johansen 1995, p.89) as:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi x_{t-1} + \mu + \Phi D_t + \varepsilon_t, t = 1, \ldots, T \qquad \text{(A2)}$$

where Δx_t is an I(0) vector and Γ_1,..., Γ_{k-1} and $\Pi = - I + \Pi_1 +,...,+ \Pi_k$ are coefficient matrices where Γ describes short-term dynamics of the process and Π is the matrix of long-term coefficients. The coefficient matrix Π can be decomposed into a matrix of loading vectors, α, and a matrix of co-integrating vectors, β, such that $\Pi = \alpha\beta'$. The constant term (μ) can be restricted to co-integrating space to represent the absence of linear trend in the data. Seasonal dummies (D) can be included in the analysis when monthly data is used.

The co-integration vectors define the stationary linear combinations (long-term relations) of the variables in x_t. The rank test of the Johansen procedure is used to define if there is a co-integration vector in the data. The trace test for testing that there are at most r co-integration vectors in the set of p variables is defined as

$$\text{Trace}(r) = -T \sum_{i=r+1}^{p} \ln(1-\lambda_i), \qquad \text{(A3)}$$

where T is the number of observations and the λ_i's are the smallest squared canonical correlations (eigenvalues). The null hypothesis $H_0 : r = r_0$ against $r_0 < r \leq p$.

Appendix 3. Summary graphs of the data

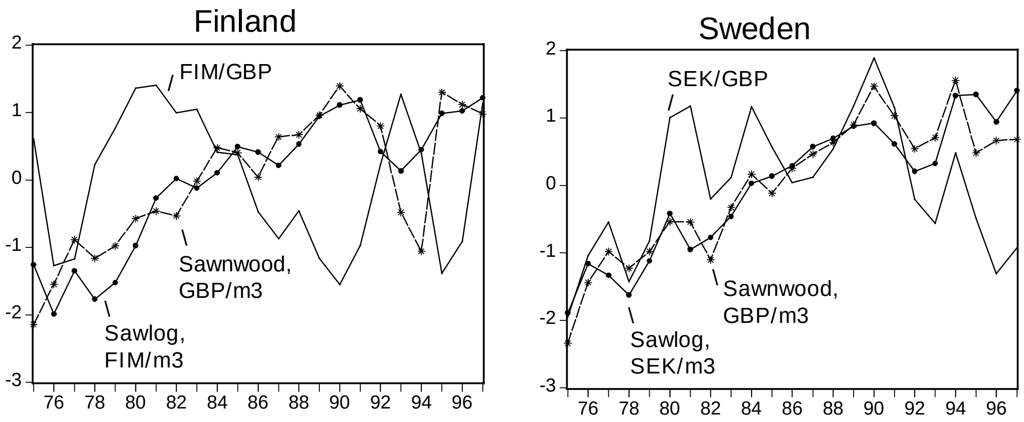


Figure 1. Finnish and Swedish domestic sawlog prices, unit values of sawnwood exports to the UK and exchange rates, 1975-97. Nominal values, normalized data.

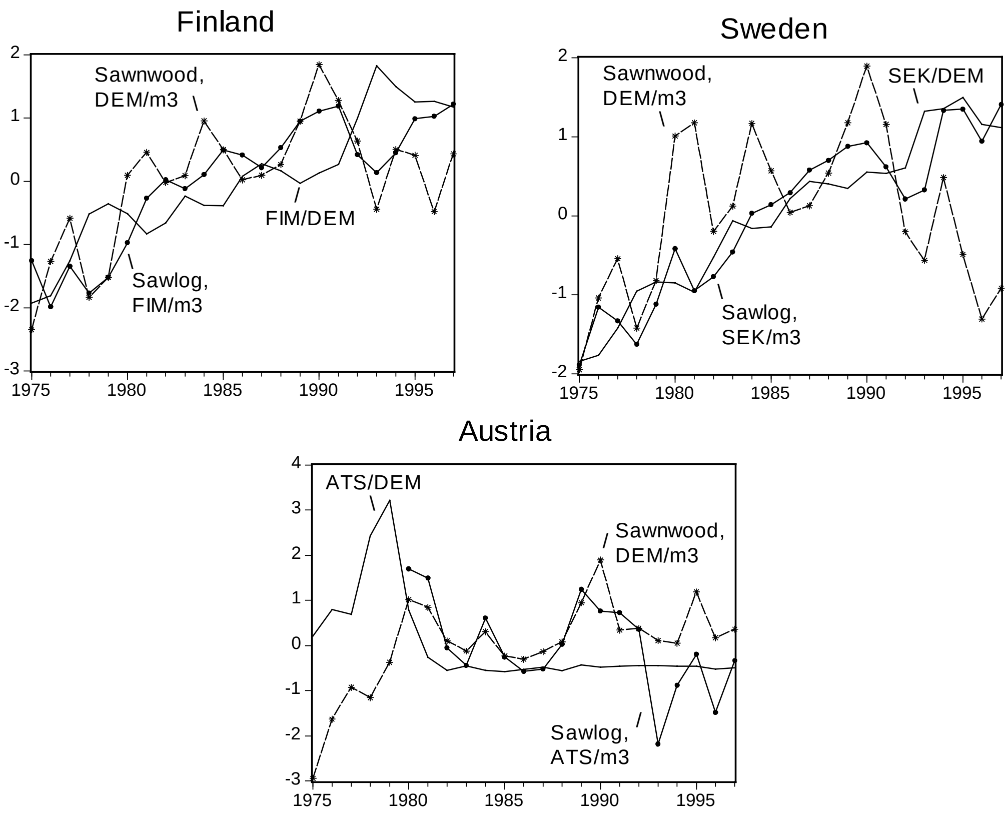


Figure 2. Finnish, Swedish and Austrian domestic sawlog prices, unit values of sawnwood exports to Germany and exchange rates, 1975-97. Nominal values, normalized data.

Appendix 3. Continued

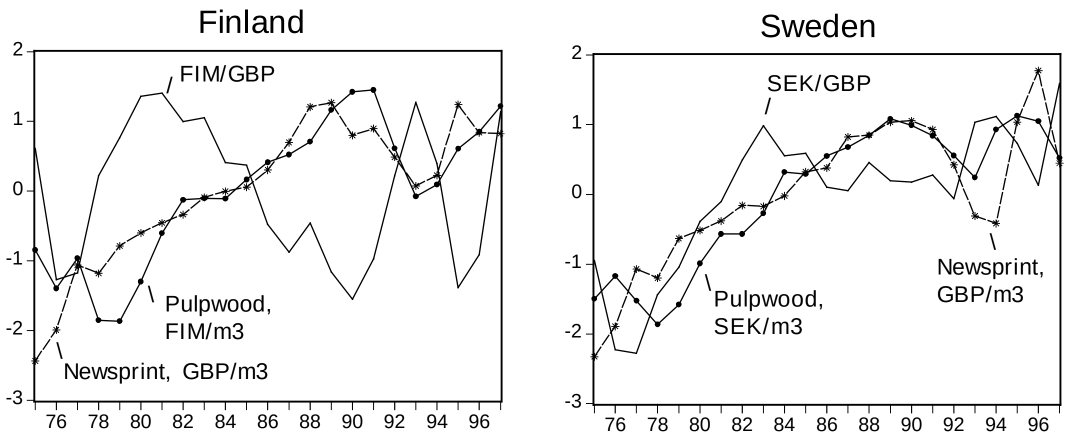


Figure 3 Finnish and Swedish domestic pulpwood prices, unit values of newsprint exports to the UK and exchange rates, 1975-97. Nominal values, normalized data.

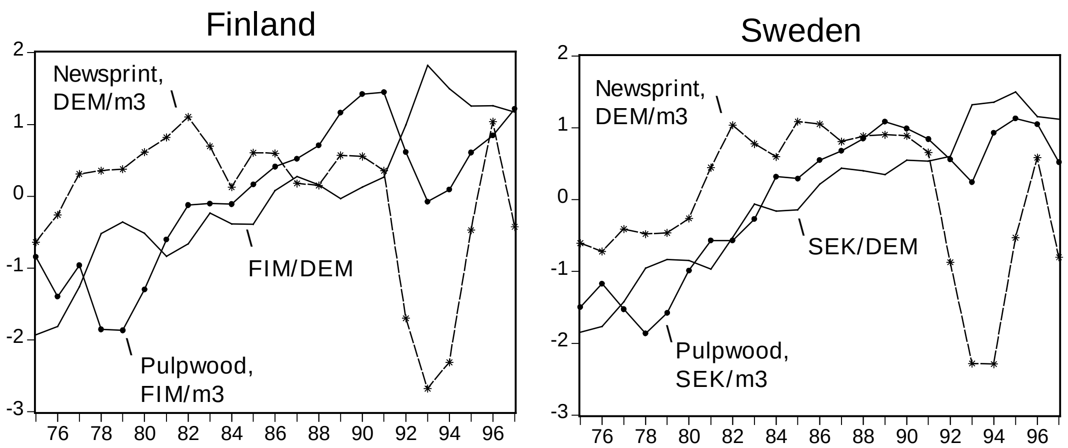
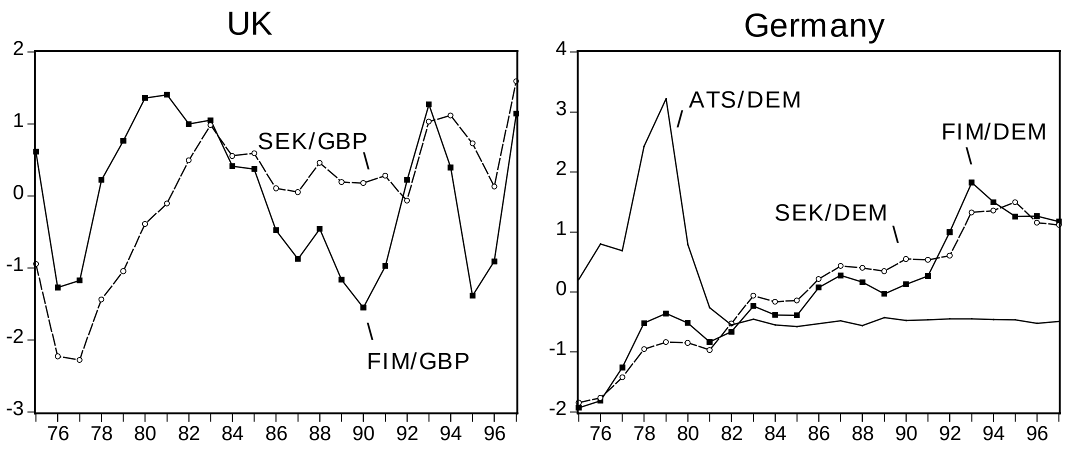


Figure 4 Finnish and Swedish domestic pulpwood prices, unit values of newsprint exports to Germany and exchange rates, 1975-97. Nominal values, normalized data.

Appendix 4. The exporters' exchange rates with respect to the currencies of the UK and Germany.



Appendix 5. Results for the ADF tests.

Table 1. Augmented Dickey-Fuller unit root tests for the levels of time series, one lag in test equation. * denotes the rejection of the null hypothesis of nonstationarity at the 5 % level, critical value with constant included is -3.02. With constant & trend included the 5 % critical value is -3.66.

Variable	**ADF test value Constant**	**ADF test values Constant & Trend**
Newsprint prices:		
Finnish price in the UK	-1.64	-1.62
Finnish price in Germany	-2.91	-4.41*
Swedish price in the UK	-2.18	-2.54
Swedish price in Germany	-2.51	-2.82
Pulpwood prices:		
Finnish price	-1.24	-2.60
Swedish price	-2.03	-1.33
Exchange rates:		
FIM/GBP	-3.44*	-3.53
SEK/GBP	-2.84	-2.81
FIM/DEM	-1.49	-4.25*
SEK/DEM	-1.57	-3.91
ATS/DEM	-1.77	-2.09
Sawnwood prices:		
Finnish price in the UK	-1.92	-2.68
Finnish price in Germany	-2.21	-2.52
Swedish price in the UK	-1.45	-1.78
Swedish price in Germany	-2.81	-2.59
Austrian price in Germany	-2.34	-2.57
Sawlog prices:		
Finnish price	-1.30	-2.03
Swedish price	-1.14	-3.12
Austrian price	- 2.35	-2.56

Appendix 5 continued.

Table 2. Augmented Dickey-Fuller unit root tests for the residuals of the annual models. One lag in test equation. * denotes the rejection of the null hypothesis of nonstationarity at the 5% level, critical value is -3.03 with constant included. The 5% critical value with constant and trend included is -3.68.

MODELS	**ADF test value Constant**	**ADF Constant & trend**
Pulpwood price models		
Finnish model 1, the UK	-3.53*	-4.66*
Finnish model 2 , the UK	-2.65	-2.64
Swedish model 1, the UK	-1.72	-2.78
Swedish model 2, the UK	-1.78	-1.72
Finnish model 1, Germany	-3.07*	-3.08
Finnish model 2, Germany	-3.30*	-3.59
Swedish model 1, Germany	-2.98	-3.85*
Swedish model 2, Germany	-2.90	-3.12
Sawlog price models		
Finnish model 1, the UK	-2.89	-4.83
Finnish model 2 , the UK	-3.18*	-3.04
Swedish model 1, the UK	-1.65	-2.47
Swedish model 2, the UK	-0.91	-3.39
Finnish model 1, Germany	-2.45	-2.74
Finnish model 2, Germany	-3.29*	-3.37
Swedish model 1, Germany	-1.96	-2.75
Swedish model 2, Germany	-2.90	-5.19*
Austrian model 1, Germany	-1.73	-3.21
Austrian model 2, Germany	-1.71	-1.71

Appendix 6a. Graphs of the residuals for the unrestricted and restricted pulpwood price models.

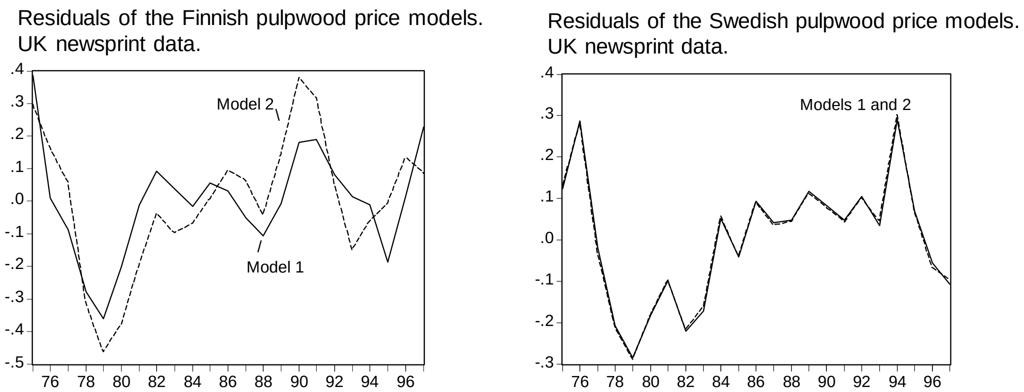


Figure 1. Finnish and Swedish pulpwood price models, 1975-1997. UK newsprint data.

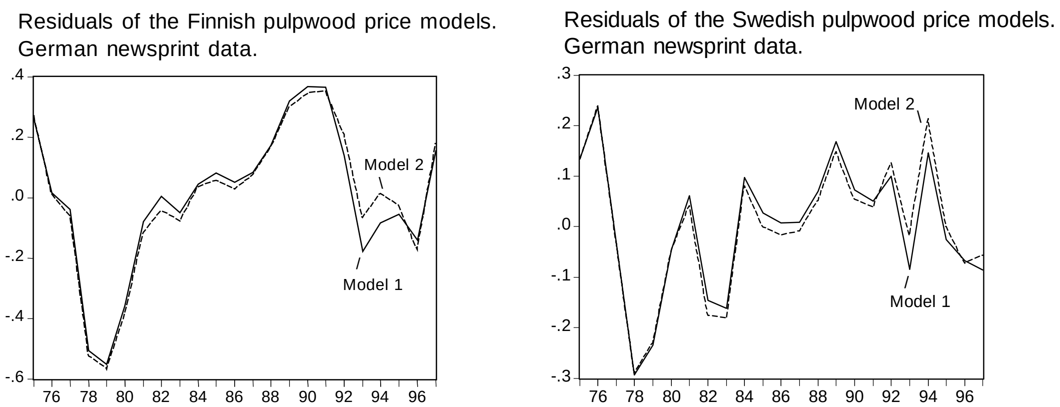


Figure 2. Finnish and Swedish pulpwood price models, 1975-1997. German newsprint data.

Appendix 6b. Graphs of the residuals for the unrestricted and restricted sawlog price models.

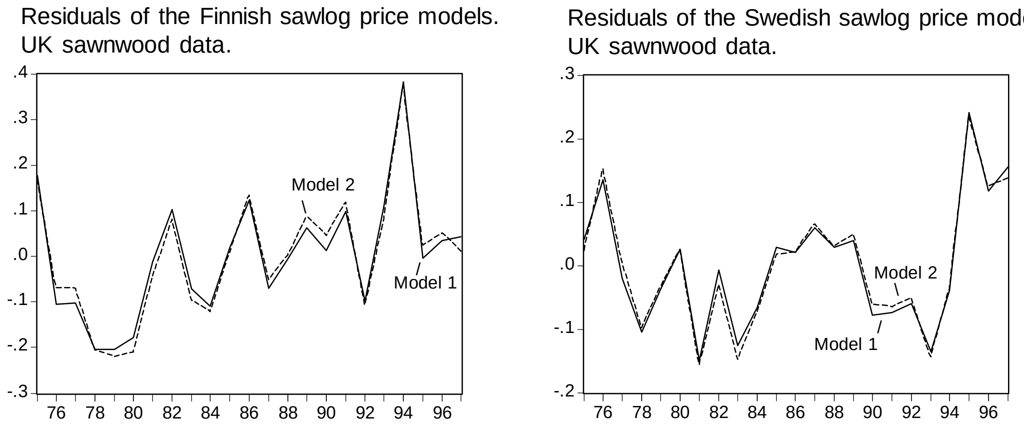


Figure 1. Finnish and Swedish sawlog price models, 1975-1997. UK sawnwood data.

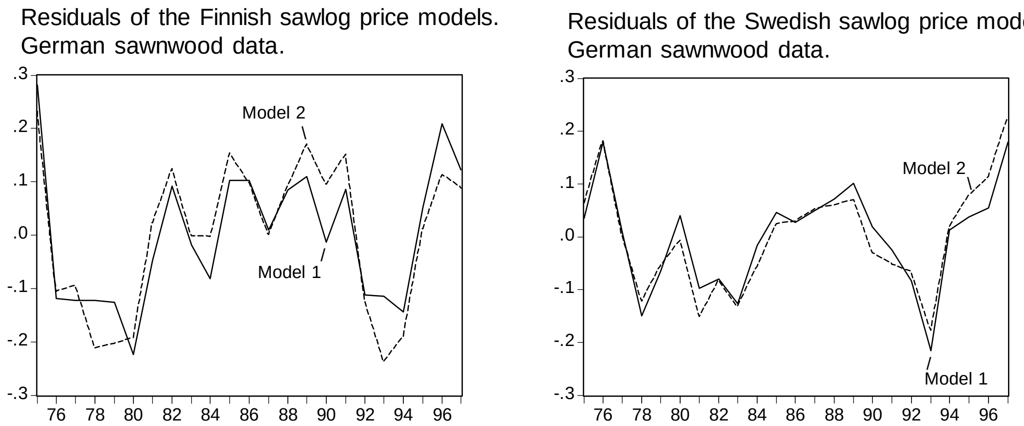


Figure 2. Finnish and Swedish sawlog price models, 1975-1997. German sawnwood data.

Appendix 6b. continued.

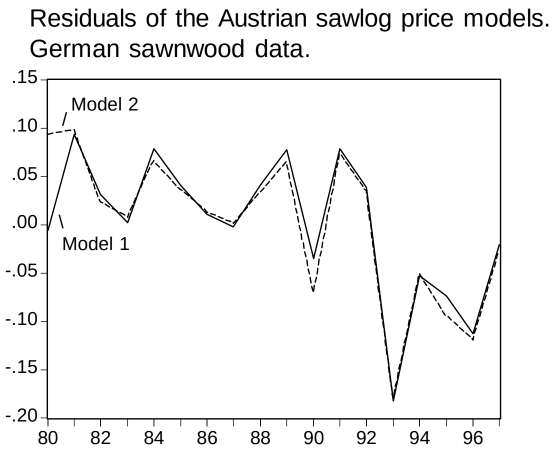


Figure 3. Austrian sawlog price models, 1980-1997. German sawnwood data.

Appendix 7. **Results for the dynamic sawlog price models, where D denotes first differences of variables and ECT is the error-correction from co-integration regression.**

Explanatory variables	Austria	Finland
Constant	-0.04	-0.13
	(-0.93)	*(-0.54)*
D(sawnwood price) $_t$	0.04	0.08*
	(1.53)	*(1.96)*
D(exchange rate) $_t$	1.60	-0.24*
	(1.49)	*(-2.31)*
D(sawlog price) $_{t-1}$	0.64**	-
	(9.54)	
D(sawnwood price) $_{t-1}$	-	0.06
		(1.46)
ECT $_{t-1}$	-0.01	0.01
	(-0.92)	*(0.58)*
Seasonal dummies	No	Yes
R2	0.42	0.17
RSS	0.03	0.05
Autocorrelation DW	2.10	2.30
Autocorrelation LM(7th order-test)	1.15	1.38