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ROUNDWOOD PRICE CO-MOVEMENT IN AUSTRIA, FINLAND AND SWEDEN

Ritva Toivonen
Anne Toppinen
Tapio Tilli

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ABSTRACT: With globalisation of economy and deepening economic integration of Europe, the need for information on the functioning of international roundwood markets has increased. This study presents a simple empirical testing of the law of one price (LOP) on the spatial roundwood markets formed by Austria, Finland and Sweden, using annual delivery prices of pine and spruce sawlogs and pulpwood from 1980 to 1997. There is quite high positive correlation between prices in all three countries, in particular for pulpwood prices. The law of one price seems to hold between Finnish and Swedish roundwood markets. Instead, clear price co-movement between Austria and the two Nordic countries could not be detected. Overall, the study provides new insights into common behaviour of roundwood markets in the EU, and in particular suggests that the Finnish wood markets have impacted on the development of Swedish markets. Thus, shocks affecting Finnish roundwood prices should eventually get carried to the Swedish wood prices. Moreover, shocks affecting the Nordic pulpwood markets get eventually carried also to the Austrian wood markets. The study concludes that European roundwood markets can be characterised already at least somewhat international, on the basis of the degree of co-movement of prices between the three countries analysed. However, the on-going economic integration in Europe will probably further deepen integration also on the roundwood markets.
Key words: Roundwood markets, roundwood assortments, market integration, Europe, the Nordic countries

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TIIVISTELMÄ: Tiedontarve koskien kansainvälisiä puumarkkinoita kasvaa jatkuvasti samalla, kun talous ja metsäteollisuus globalisoituvat. Etenkin Euroopan taloudellinen integraatiokehitys lisää tätä tiedontarvetta Euroopan tasolla. Tässä tutkimuksessa testataan Itävallan, Suomen ja Ruotsin puumarkkinoiden keskinäistä integroituneisuutta aikavälillä 1980-1997. Nämä kolme maata kattavat lähes puolet EU:n talousmetsien pinta-alasta. Puutavaralajeittaiset vuositason keskihinnat korreloivat melko vahvasti kaikkien kolmen maan välillä. Etenkin kuitupuun hintojen korrelaatiot olivat suhteellisen korkeita. Tulokset myös yhden hinnan lain testauksesta viittaavat siihen, että Suomen ja Ruotsin puumarkkinat ovat kohtalaisen selvästi integroituneita. Sen sijaan näiden kahden Pohjoismaan ja Itävallan puumarkkinoiden integroituneisuus ei ollut yhtä selkeä. Lisäksi ulkoisten shokkien aiheuttamat vaihtelut näyttävät siirtyvän Pohjoismaiden kuitupuumarkkinoilta Itävallan puumarkkinoille. Pohjoismaiden kesken vaikutussuunta on lähinnä Suomen puumarkkinoilta Ruotsiin. Kaikkiaan kansallisten puumarkkinoiden toiminta Euroopassa ainakin nyt tutkittujen kolmen maan osalta vaikuttaa tulosten perusteella olevan jo nyt kohtalaisesti sidoksissa toisiinsa ja voidaan puhua ainakin jossain määrin kansainvälisistä, eurooppalaisista puumarkkinoista. Tosin talouden yleisen integraation eteneminen edelleen syventänee myös puumarkkinoiden kansainvälistymistä.
Avainsanat: Puumarkkinat, puutavaralajit, markkinoiden integraatio, Eurooppa, Pohjoismaat

CONTENTS

1. INTRODUCTION

1.1 Background and purpose

Background

Roundwood market integration within Europe has become a topical issue especially since Finland, Sweden and Austria joined the European union (the EU) in 1995. The membership of these three countries doubled the forest area of the EU (to the level of about 130 million hectares) and made the union net exporter of forest industry products.

The European monetary union (EMU) will further deepen the economic integration. Common money will make it somewhat easier to compare prices in different countries and thereby enhances international competition in roundwood markets (e.g. Hetemäki et al. 1997; Toivonen 1997a). Hence, due to the generally deepening economic integration in Europe, roundwood markets in different countries will become increasingly open for the international competition.

Several other factors may also lead to increasing integration of forest products markets and roundwood markets. One argument for the increasing integration of roundwood markets is the occurred globalization and consolidation of forest industries during the 1990s. This development is clearly evident within the pulp and paper industry, but the process has reached also the mechanical wood processing industry during the latter part of the 1990s. Also, development of information technology continuously improves availability of international market information, which may cause prices to fluctuate similarly on competitive spatial roundwood markets even without large physical arbitrage. These changes within the wood-using industry and its operating environment may cause tightening linkages between roundwood markets in different countries.

More specifically, producers of fairly homogenous forest industry products compete on the economically integrated European markets. Demand shocks on these markets get carried to the roundwood markets of the various exporting countries, such as Austria, Finland and Sweden. As a consequence of factor price equalization, co-movement of roundwood prices in the exporting countries with similar roundwood resources and market structures can be expected to occur if market conditions do not markedly differ from the perfect competition.

On the other hand, small segmented markets are less likely to be perfectly competitive than geographically and physically larger markets. Therefore, a few arguments also

justify the assumption of spatially segmented roundwood markets in Europe[1]. Quantities of international trade of roundwood are relatively small between the EU member countries. In addition, different structure of national markets may segment roundwood markets as institutional and legal environment vary between European countries. Lastly, there are differences in roundwood quality as the geographical distance increases and also the climate conditions differ between countries.

However, so far the integration of the European roundwood markets has raised only moderate interest among forest economists (see, however, Thorsen 1996 and Nyrud 1999 on the Nordic timber markets). Therefore, it is difficult to assess what the current extent of the roundwood market integration in Europe is. This information is, however, needed before impacts of the European economic integration or other factors on the roundwood markets can be assessed. Information on the interactions between national wood markets helps also in modeling of the European roundwood markets and in predicting price development. If European roundwood markets are highly integrated then a single model could be sufficient for modeling purposes. Instead, if the markets are highly segmented, understanding of the behavioral relations in geographically distinct roundwood markets requires more disaggregated approach.

Purpose

The purpose of this study is to describe roundwood markets and their development in Austria, Finland and Sweden. In addition, empirical analysis is carried out on roundwood market integration, as measured by co-movement of annual wood prices. The analysis covers the period from 1980 to 1997.

In the empirical analyses we disaggregate the roundwood markets by wood species and assortments. Disaggregation of data is necessary since each wood assortment has its different end-uses, and demand and supply conditions in sawnwood and pulp/paper markets may differ considerably from each other, so also demand between wood assortments is different from each other[2]. Also demand and supply conditions in sawnwood and pulp/paper markets may differ considerably from each other. Thus aggregating the wood assortment specific data might lead to a loss of information and

[1] For example Nyrud (1999) suggests though that the whole Europe could be seen as a single roundwood submarket within the world scale. However, also he sees it possible that Europe is further divided into smaller submarkets.

[2] Pulpwood and sawlogs are substitutes to each other asymmetrically; sawlogs can be used in producing pulp but the use of pulpwood in producing sawnwood is more limited. However, it can be observed that the average sizes of saw logs have diminished at least in Finland and Austria from the eighties to the end of nineties. This means that to some extent wood which was previously used as pulpwood is nowadays qualified suitable for sawmilling industry.

even yield biased results. The analysis concentrates on softwood assortments only, since coniferous species are dominant in the forest resources within all three countries.

1.2 Comparison of roundwood markets in Austria, Finland and Sweden[3]

The more similar structural characteristics the spatial roundwood markets exhibit, the more likely it is that prices do not fluctuate independently from each other, i.e. that the markets are integrated. Austria, Finland and Sweden share several similar characteristics related to roundwood markets. All three countries are mainly producers of coniferous (pine and spruce) logs and pulpwood. The size of roundwood markets is about the same in Finland and Sweden (see Table 1), while the Austrian roundwood market is clearly smaller. At least half of the forests in all countries is owned by private non-industrial forest owners (NIPF-owners). Industrial wood demand is mainly covered by a few large companies. Demand is more concentrated on pulpwood markets than on log markets in all three countries (see Toivonen 1997b). All the three countries are major importers of roundwood even in global scale. In contrast, roundwood trade between these countries is small.

Institutional environment in roundwood markets differs somewhat between the countries. Even though membership in the European union has resulted in abandoning the centralized price negotiation systems between roundwood buyers and sellers, some differences remain in wood trade due to country-specific traditions. Most importantly, roundwood is mainly sold as delivered to roadside in Austria and Sweden while in Finland stumpage sales cover over 70 per cent of the wood sales from private forests. In Sweden, several different roundwood sales systems are used, and it is difficult to exactly determine the share of stumpage and delivery sales.

Austria, Finland and Sweden are major exporters of forest industry products to Western Europe. Domestic product markets in each country are relatively small. Thus markets for forest industry products are, roughly speaking, common to the three countries focused in the study. When producers of forest industry products compete with their products on the economically integrated European markets, the demand shocks on these markets get carried to the roundwood markets of the various exporting countries. Linkages between the roundwood markets of the three countries of this study are thus possible through the common forest industry products markets, even in the absence of large trade of wood between Austria, Sweden and Finland.

[3] A more detailed description of the development of roundwood markets in Austria, Sweden and Finland will be presented in a separate report.

Furthermore, Sweden and Finland are neighboring countries with relatively low inter-country transportation costs, fairly similar harvesting costs and fairly good availability of market information. Therefore, it is more likely that markets between these countries are integrated than those between Nordic countries and Austria. Based on relative significance of different markets, it can be assumed that the larger markets in Finland and Sweden are more likely to have impacts on price development in the smaller Austrian markets than vice versa (see e.g. Thorsen 1998).

Table 1. Forestry and 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 47 %
Forest ownership	NIPF 62 % State 25 % Forest Industry 9 %	NIPF 50 % State 2 % Forest Industry 39 %	NIPF and other private 85 % State 15 % Forest Industry n.a.
Industrial roundwood harvests, 1997*	52 mill. m^3	60 mill. m^3	15 mill. m^3
Sawn wood production, 1997 (export %)	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 %)	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
Roundwood imports, 1997	8,4 mill. m^3	7,6 mill. m^3	7,6 mill. m^3

* In Sweden roundwood is measured as m^3 under bark. In general, there are some differencies in the measurement of volume of stems in the three countries.

** Use of roundwood does not necessarily equal with imports and harvests due to exports and use of reserves of harvested wood.

Sources: Finnish Statistical yearbook of forestry 1998, Skogsstatistisk årsbok 1998 (Sweden), Eurostat 1998, ÖSTAT 1999, FAO Yearbook of forest products 1997, Skogsstyrelsen 1999.

2 TESTING MARKET INTEGRATION WITH EMPIRICAL DATA

The Concept of The Law of One Price

In the perfect markets, two regions belong to the same competitive market if the local prices of homogenous products differ exactly by the transportation costs between these regions. This definition is known as the “law of one price (LOP)“ between regions or countries.

If the law of one price holds between several regions (countries), the long-run market equilibrium price in one region equals the price in another region, when expressed in the same currency. The equilibrium can be written in the form of:

(1) $P_{it}=a + b*P_{jt}$

where *a* represents transaction costs and *b* is one, i.e. roundwood prices *P* at each moment of time *t* are equal in two regions. If transaction costs are allowed and exist, then *a* may be different from zero. In the case of roundwood markets, transaction costs include marketing costs of wood and the costs of market information seeking as well. However, the major part of these costs are formed by transportation costs.

If *b=1*, any changes in prices in two regions should be equal. A stable long-run equilibrium relationship between prices on two regions is called here as the “weak LOP“. In the absolute form of LOP, it may be assumed that there are no transaction costs (see e.g. Buongiorno & Uusivuori 1992), and therefore *a* should be zero and *b* equal to one.

Thus, the law of one price is based on the argument that, in the long run, arbitrage is not profitable between regions because prices on the various local markets are the same excluding transaction costs (Sexton et al. 1991). But also spatial oligopoly could cause regional prices to fluctuate similarly (e.g. Faminow & Benson 1990). Therefore it is not possible to draw inferences on the market competition based on price behavior alone, and co-movement of prices is not a sufficient indication about high efficiency of markets either. In reality, only probably few commodities are absolutely homogenous in geographically distinct area and the conditions of perfectly competitive markets are rarely completely fulfilled. Therefore inferences about market efficiency based on comparisons of regional prices need to be done with caution.

It should be noted that even in the integrated markets, regional prices may fluctuate independently from prices in other locations as long as the price variations are less than

the transaction costs between two locations. If local price changes exceed transaction costs, then arbitrage between two markets becomes profitable. On competitive and spatially integrated markets this should have an impact in supply and demand in other regions, too. Thus in the integrated markets, arbitrage holds in the long run, while in the short run local prices may move differently depending on local demand, supply and other factors (e.g. Sexton et al. 1991), such as lags in publication of market information.

In reality, only probably few commodities are absolutely homogenous in geographically distinct areas. Thus the conditions of perfectly competitive markets are rarely completely fulfilled. Therefore inferences about market efficiency based on comparisons of regional prices need to be done with caution.

Although trade between two regions may provide information about the limits of geographical markets of a commodity, the extent of the geographical markets can be empirically analyzed more accurately by means of observing price behavior within the various local markets than by analyzing trade flows (e.g. Stigler & Shervin 1985). Prices are seen as the best single variable to reflect market development since supply and demand are directly reflected in prices.

Correlation and single-equation regression of price series were among the earliest statistical methods used for testing market integration (e.g. Stigler & Sherwin 1985; Barrett 1996). The use of correlation analysis only can be criticised because correlation between two price series may be merely a product of common exogenous trend, however. Therefore more sophisticated methods for analyzing market integration were developed during the 1980s and 1990s, based on co-integration between time series (e.g. Engle & Granger 1987; Johansen 1988, 1995; Ravallion 1986).

In addition, combining price data with data on transaction costs is suggested to be used as supportive information (e.g. Barrett 1996). However, it is usually difficult to find accurate information on transaction costs, and these have been excluded from many econometric studies about market integration as either stable or small cost factor.

Possible weaknesses of statistical analyses of aggregate price data in analyzing market integration could be also reduced by combining price data with microeconomic data of the traders (Barrett 1996). Detailed information about the spatial markets is thus important in interpreting the results of statistical analyses of market integration.

Applications on Forest Sector

There are relatively few studies analyzing the LOP on roundwood markets and even on forest products markets. Roundwood market integration between the Nordic countries has been earlier studied by Thorsen et al. (1996) who tested co-integration on roundwood markets between Danish and the other Nordic countries, Germany and the U.S.A. Their results suggested co-integration between Denmark, Norway, Sweden and even the USA on the markets for coniferous logs. The period for the time series data varied from country to country, but it mostly covered a period from early 1950s to early 1990s.

Later Thorsen (1998) continued studies on international roundwood markets, using data for the period 1951–1991 and performing cointegration analysis. He used spruce sawlog prices (delivery) from Sweden, Norway and Denmark but coniferous (average price for spruce and pine) sawlog stumpage price from Finland, and found statistical evidence for the assumption that the spruce (coniferous) saw log markets in the Nordic countries are integrated.

Thorsen´s results were in accordance with the assumption that larger markets are exogenous to smaller markets; Finnish and Swedish prices were exogenous to Norwegian and Danish prices. In addition, Finnish prices were found to be most clearly exogenous to prices in other countries. Recently, also Nyrud (1999) tested co-integration between the Norwegian and international roundwood prices. Studies on regional roundwood prices for Finland include the studies of Toppinen and Toivonen (1998) and Tilli et al. (1999).

On forest product markets, for example Uri and Boyd (1990), Jung and Doroodian (1994) and Murray and Wear (1998) have studied integration of the US lumber markets. Buongiorno and Uusivuori (1992) tested the LOP in US exports of pulp and paper products. Hänninen (1998) tested the law of one price on United Kingdom´s softwood lumber import markets and Hänninen et al (1997) on the UK and German newsprint markets. In addition, Jung et al. (1997) used co-integration approach in analyzing information contents of composite forestry price series.

Methods of Analysis

In this study, as the first phase of the analysis, we perform pairwise correlations of the level price series within each wood assortment of each of the three countries. This provides a preliminary outlook on the potential linkages between country specific price

series. Positive and statistically significant correlation coefficients fairly close to one support the existence of linkages between the markets.

However, as mentioned earlier, correlation might be caused also by concurrent but independent shifts in supply and demand, thus resulting in spurious (artificial) co-movement of prices instead of actual market integration (e.g. Sexton et al. 1991). Therefore additional analyses of the relationships between roundwood prices in the three countries are necessary. Unfortunately, the use of the co-integration analysis, such as Johansen´s method for testing cointegration between several time series simultaneously, requires much higher number of observations than were available for this study.[4]

Therefore, as the second phase, we perform pairwise regression analyses in testing the LOP between the two countries. We restrict coefficient of the explanatory variable in equation (1) of H_0: b=1 to test the relative LOP between two price series. The absolute (strong) law of one price would be tested against the hypothesis that also the constant representing transaction costs is zero, i.e., a=0 and b=1. This would represent the hypothesis that roundwood prices in each country are exactly equal when the effect of transaction costs are excluded or do not exist.

We concentrate on testing the weaker form of LOP since the use of different price reporting systems in each country reduces accuracy in comparing actual price levels. In addition, differences in transaction costs between Sweden and Austria and Finland and Austria would be larger than those between Sweden and Finland due to geographic distance.

Finally, we test for causality between prices for different countries by applying bivariate Granger causality tests (Granger 1969) to each wood assortment. The Granger-causality measures precedence between prices in whether current prices in one country (Y) can be explained by past prices in another country (X), in addition to the first country´s own past price information. Thus, one is testing the null hypothesis cj=0 (j=1,…K) in

$$(2)\quad Y_t = a + \sum_{j=1}^{K} b_j Y_{t-j} + \sum_{j=1}^{K} c_j X_{t-j} + u_t$$

The procedure is applied in both directions, i.e., the causality is tested from Y to X and from X to Y. F-tests are used to determine whether prices in one country have any statistically significant power in explaining the prices in the other country. Both one and two year lags are used in the empirical analysis.

[4] On the other hand, if the time span is long then also the risk of structural changes in the markets increases (e.g. Thorsen 1998; Barrett 1996).

3 RESULTS

3.1 Time series data

We used data of four different roundwood assortments from three countries in the empirical analyses. Thus the data consists of twelve time series of annual average delivery prices of spruce and pine saw logs and spruce and pine pulp wood. Annual data was used although monthly prices would have been available from Austria and Finland. However, annual data only was available from Sweden. All time series start from 1980 and end to 1997. The delivery price refers to price per m^3 alongside forest road including stumpage, harvesting and transportation in forest. [5]

Annual roadside prices (delivery prices for Finland) were the most comparable prices available from each three countries. Since our aim was to disaggregate the analysis by wood assortments, the available data consist of only 18 observations. An obvious shortcoming of the data is thus that more sophisticated statistical methods cannot be applied.

In Sweden, 80-90 % of wood sold from private forests is sold on delivery sales. However, it is difficult to exactly differentiate the various sales types in Sweden. About 60-70 % of roundwood originate from the harvests of the private forests (over 40 mill. m^3). In Austria, at least 90 % of wood from private forests is sold on delivery sales. However, the share of stumpage sales is increasing. Private forests cover about 80-85 % (about 12-13 mill. m^3) of commercial roundwood fellings in Austria.

In Finland, about 80 % (over 40 mill. m^3) of commercial roundwood originates from private forests. In Finland about 20-30 % of this quantity has been sold on delivery sales (roughly 10-15 million m^3) during the 1980s and 1990s, and the relative importance of delivery sales has been declining. Pulpwood is sold a little more in delivery sales as compared with sawlog quantities. Thus the Finnish delivery prices might not be fully representative of the development of the whole commercial wood markets. However, using the delivery prices also from Finland was the only option to make prices of the three countries more directly comparable.

The size of wood markets (quantity of the industrial roundwood harvested annually) is the largest in Sweden. The quantities originating from the NIPF-owners´ (non-

[5] In Sweden prices are published in cubic meter under bark unlike in the other two countries. In addition, the measurement of the volume of stems may vary between the countries thus making comparisons of price levels per cubic meter very rough.

industrial private forest owners) forests to the commercial wood markets both in Finland and Sweden are, however, on the same level or even larger in Finland than in Sweden. The volumes in the Austrian wood markets are only about a third of those in the Swedish or Finnish wood markets.

The time series from Finland originate from the statistical service of the Finnish Forest Research Institute (Metinfo) and represent prices of wood sold from private forests only. Swedish wood prices 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 the information of 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.

The price data of Austrian wood assortments are based on statistics from the Austrian Statistical Office, but obtained to this study from The Yearbook of Finnish Forest Statistics (1998). The price statistics of saw logs are the quality class B 2a+ (pine sawlogs) and B 2b (spruce sawlog) prices, and those of pulpwood are the quality class (spruce) Fichte/Tanne 1a/b and (pine) Kiefer 1a/b prices. The Austrian prices represent sales by all ownership categories.

All price series were transformed into Finnish currency (FIM) using the average currency exchange rate of each year obtained from the Bank of Finland´s statistical service (July 1999). Moreover, the nominal prices were deflated to the value of 1990 using each country´s annual average consumer price index (CPI all items) obtained from the Etlatieto databank (http://). In analyses, logarithms of time series were used thus the analysis is based on relative changes in the actual price levels.

3.2 Development of roundwood prices during 1980-1997

In Figure 1 (next page), the delivery prices in each country are presented by wood assortment (real prices deflated with consumer price index, transformed in Finnish marks). Fairly similar fluctuations and overall development can be detected in especially the pine and spruce pulpwood prices in all the three countries.

Somewhat clearer divergence in the price development can be detected in the case of pine sawlogs. Especially during the eighties the Austrian prices seem to have developed somewhat differently from the Finnish and Swedish prices. The downward trend

in the price development seems more moderate regarding the spruce sawlog than the other wood assortments in all the three countries.

Since some of the prices are measured under bark and others on bark, and due to possible differences in the volume measurement systems, the price levels can not be exactly compared. However, especially the spruce sawlog prices seem to be higher in Austria than in Scandinavia, possibly due to higher logging costs in the mountaneous regions in Austria. In Austria, there are also specialty assortments of pine and spruce logs which are priced even higher than the assortments analyzed in this study. Furthermore, due to the domination of stumpage markets in Finland, the development of stumpage prices from Finland were compared with the delivery prices. The slope of the downward trend in the development of stumpage prices was less obvious as compared with delivery prices, but the correlation between the stumpage and delivery prices was still about 0,9 or above regarding all the four wood assortments. Hence, the results using relative changes in the delivery prices from Finland should give fairly sufficient insight in the wood markets as a whole.

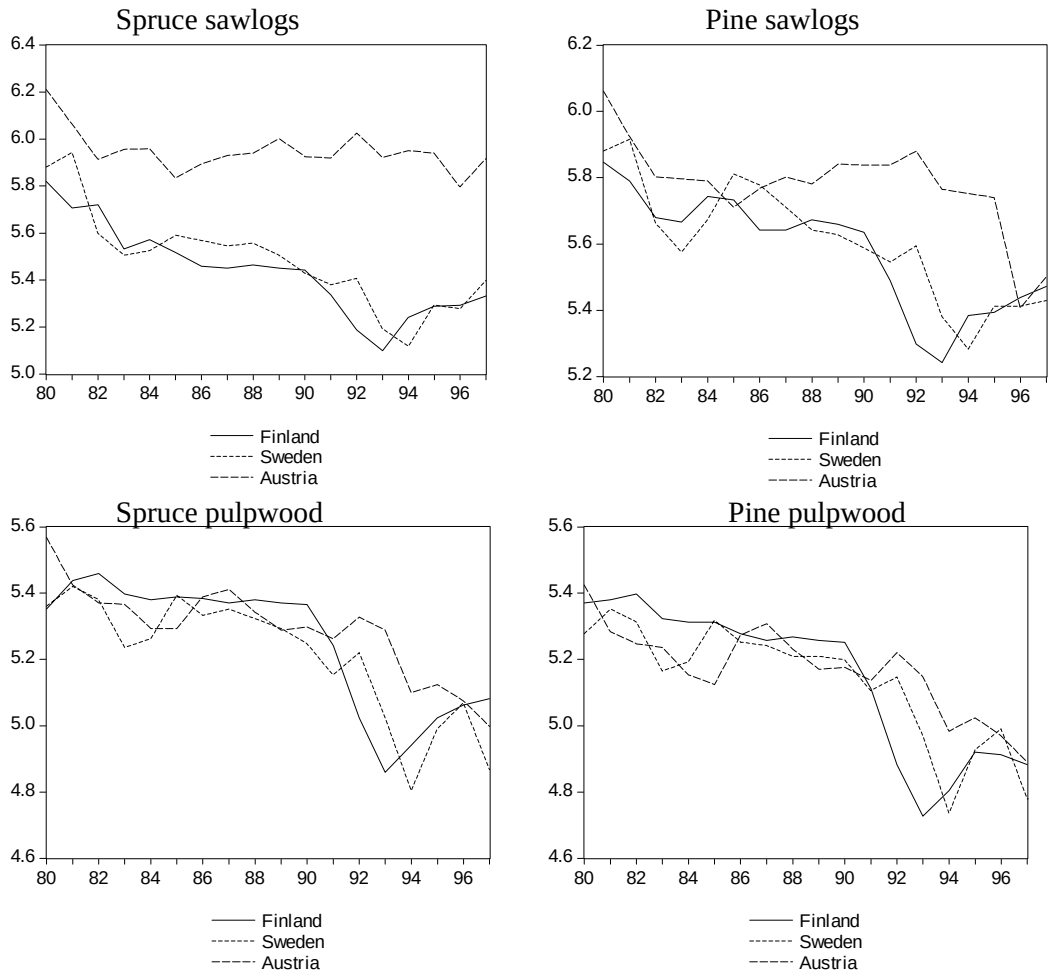

Figure 1. Development of pine and spruce sawlogs and pine and spruce pulpwood prices during 1980-1997, logarithmic series of prices in FIM/m^3 (real prices, 1990=100).

3.3 Co-movement of roundwood prices

Correlation of Prices

Wood prices by different assortments correlate fairly strongly between Austria, Finland and Sweden. Correlation coefficients of all wood assortment price series from the three countries are close to or above 0,5 (Table 2)[6]. The correlation coefficients indicate that the pulpwood prices seem to move more closely together than the sawlog prices regarding all the three countries. Price behavior of all wood assortments seems to be fairly similar especially between Sweden and Finland.

The correlations suggest that the co-variation between roundwood prices has been from moderate to relatively high between the spatial markets formed by Austria, Finland and Sweden during the 1980s and 1990s. The higher correlation between the Swedish and Finnish prices may reflect the higher similarity in wood quality in this area. It may also reflect the geographical closeness of markets, which facilitates more rapid availability of market information.

Higher co-variation of pulpwood prices than sawlog prices in all the three countries may result from common international pulp and paper markets. In other words, the demand for pulp and paper on the common end use markets is assumed to cause fairly instantly similar price development on the pulpwood markets in each country.

Table 2. Correlation between wood assortment specific prices in Austria, Finland and Sweden 1980-1997.

Assortment	Coefficients of correlation		
	AUT/FIN	AUT/SWE	FIN/SWE
Pine sawlogs	0,48	0,60	0,85
Spruce sawlogs	0,54	0,63	0,88
Pine pulpwood	0,71	0,80	0,89
Spruce pulpwood	0,65	0,82	0,87

[6] Correlations were also calculated of the nominal price series, and correlation coefficients obtained were somewhat lower. This especially regards those analyses comparing Austrian prices to Swedish and Finnish prices. The result probably reflects the fairly different inflation rate in Austria as compared with Sweden and Finland.

Results of Testing the Law of One Price

We tested the law of one price between the three countries by using simple regression analysis. Following the equation (1), we included an explanatory variable P_{jt} and a coefficient *b* representing the price in a first country, and a constant *a* representing transaction costs, as explaining the price P_{it} in another country to the regression model[7].

The weaker form of LOP was tested by restricting the coefficient b of the explanatory variable P_{jt} to one as in the equation (1). The interpretation of the model is that price change in one country can be fairly well explained by a price change in another country, and thus the price changes are, relatively speaking, similar.

Table 3. Results using the regression model in testing LOP (N=18).

P_{it} Dependent	P_{jt} Explanatory	Regression Coefficients		Model Characteristics		Wald Test H_0: b=1	
		b	**a**	**$R^2_{adj.}$**	**DW**	**F**	**p(F)**
Spruce sawlogs							
Austria	Finland	0,22*	4,78***	0,16	1,27	56,7	0,00
Finland	*Austria*	*0,98**	*-0,39*	*0,16*	*0,47*	*0,00*	*0,97*
Austria	Sweden	0,24**	4,63***	0,27	1,25	73,52	0,00
Sweden	*Austria*	*1,31***	*-2,33*	*0,27*	*0,58*	*0,42*	*0,53*
Sweden	*Finland*	*0,97****	*0,20*	*0,77*	*1,94*	*0,05*	*0,82*
Finland	*Sweden*	*0,81****	*1,00**	*0,77*	*1,8*	*3,25*	*0,09*
Pine sawlogs							
Austria	Finland	0,34*	3,87***	0,12	0,69	12,5	0,00
Finland	Austria	0,50*	2,64	0,12	0,38	3,15	0,10
Austria	Sweden	0,47**	3,16**	0,29	0,81	10,51	0,01
Sweden	*Austria*	*0,71***	*1,48*	*0,29*	*0,64*	*1,28*	*0,27*
Sweden	*Finland*	*0,84****	*0,88*	*0,68*	*1,36*	*1,2*	*0,29*
Finland	*Sweden*	*0,82****	*0,97*	*0,68*	*1,22*	*1,72*	*0,21*
Pine pulpwood							
Austria	Finland	0,41***	3,03***	0,45	0,95	30,58	0,00
Finland	*Austria*	*1,17****	*-0,94*	*0,45*	*0,71*	*0,34*	*0,56*
Austria	Sweden	0,61***	2,05**	0,66	1,33	14,04	0,00
Sweden	*Austria*	*1,11****	*-0,63*	*0,66*	*1,37*	*0,36*	*0,55*
Sweden	Finland	0,70***	1,53**	0,74	1,62	9,31	0,01
Finland	*Sweden*	*1,08****	*-0,42*	*0,74*	*1,35*	*0,31*	*0,59*
Spruce pulpwood							
Austria	Finland	0,46***	2,85***	0,38	0,79	14,99	0,00
Finland	*Austria*	*0,89****	*0,54*	*0,38*	*0,68*	*0,17*	*0,68*
Austria	Sweden	0,64***	1,96***	0,69	1,15	12,37	0,00
Sweden	*Austria*	*1,11****	*-0,65*	*0,69*	*1,26*	*0,36*	*0,55*
Sweden	*Finland*	*0,81****	*0,94*	*0,71*	*1,59*	*2,29*	*0,15*
Finland	*Sweden*	*0,90****	*0,57*	*0,71*	*1,37*	*0,55*	*0,47*

* significant at 10 % level, ** significant at 5 %, *** significant at 1 % level.

[7] Logarithms of the real prices were used in the analyses.

Except for pine pulpwood, the hypothesis of b=1 could not be rejected in most of the estimated regression models for the Finnish and Swedish prices (Table 3). In testing the hypothesis, a Wald test for significance of difference between the unrestricted estimation values and the restriction (in this case equality with one).

The results indicate that the weaker form of LOP holds between Sweden and Finland in the coniferous sawlog and spruce pulpwood markets. Instead, the results regarding the pine pulpwood markets between Finland and Sweden remained ambiguous, since the hypothesis of regression coefficient b being one did hold only when regressing the Finnish price on the Swedish one.

The LOP between markets of Austria and Finland/Sweden could not be clearly detected, since the results remained ambiguous regarding the markets of each of all four wood assortments.

Overall, the explanatory power of the estimated regression models was poor for sawlog prices between the Finnish/Swedish and Austrian markets. This is also reflected in the low values of DW-statistics. This may be also the reason why the test of LOP provided asymmetric results regarding the integration of wood markets between the countries. Instead, Finnish and Swedish prices seemed to explain each other fairly well. In general, the low coefficients of determination give a reason to treat the results with caution, although for example Buongiorno and Uusivuori (1992) conclude that low determination does not necessarily imply non-existence of LOP.

In sum, the results are roughly consistent with the preliminary inferences based on the correlations between time series, with the exception that correlation analysis would have suggested similarity in integration on the pulpwood markets between Finland/Sweden, and also between Austria and the two Nordic countries. [8]

[8] In addition, analyses were performed using nominal prices. Using nominal prices did not change the conclusions. Analysis were also performed transforming the Swedish prices into prices with bark but this did not affect on interpretation of the results markedly.

3.4 Causal relationships between prices

We proceeded by testing Granger causality between each pair of price series, and results are reported in Table 4 for models using one lag.

Table 4. Tests of Granger-Causality on round wood prices during 1980 to 1997 (H_0: no causality, 1 lag, N=17).

Exogenous	**Endogenous**	**F-value**	**P(F)**
Spruce Sawlogs			
Austria	Finland	0,02	0,90
Finland	Austria	0,13	0,72
Austria	Sweden	0,01	0,93
Sweden	Austria	0,08	0,78
Finland	*Sweden*	*10,02*	*0,01***
Sweden	Finland	0,26	0,61
Pine Sawlogs			
Austria	Finland	1,36	0,26
Finland	Austria	1,02	0,32
Austria	Sweden	0,02	0,90
Sweden	Austria	1,00	0,33
Finland	*Sweden*	*18,02*	*0,00****
Sweden	Finland	0,97	0,34
Pine Pulpwood			
Austria	Finland	0,01	0,92
Finland	*Austria*	*6,89*	*0,02**
Austria	Sweden	0,61	0,45
Sweden	*Austria*	*6,05*	*0,03**
Finland	*Sweden*	*21,13*	*0,00****
Sweden	Finland	2,00	0,18
Spruce Pulpwood			
Austria	Finland	0,22	0,65
Finland	*Austria*	*9,28*	*0,01***
Austria	Sweden	0,58	0,46
Sweden	*Austria*	*5,41*	*0,04**
Finland	*Sweden*	*11,65*	*0,00****
Sweden	Finland	0,10	0,75

The results indicate that there is Granger-causality running from the Finnish sawlog and pulpwood prices to the Swedish prices, i.e. that the Finnish prices are rather the exogenous prices in the markets (Table 4). Price changes in the Finnish and Swedish pulpwood prices seem to precede the Austrian pulpwood prices but the same does not hold for the sawlog prices.

The analyses were also carried out using the transformed Swedish prices on bark, but there were no major differences in results. The nominal price series (price levels) were also analysed, and the results were mainly in accordance with the results reported here.

The obtained results regarding causality were consistent with the conclusions on fairly strong co-movement of the Finnish and Swedish prices and weaker connections between the development of Nordic and Austrian prices. The observation of causality running from the Finnish to the Swedish prices was also consistent with results obtained by Thorsen (1998).

4 SUMMARY AND DISCUSSION

With globalization of economy and deepening economic integration of Europe, the need for information on the functioning of international roundwood markets has increased. This study attempts to increase this information on markets for Austria, Finland and Sweden. A simple empirical testing of the law of one price (LOP) is performed on the spatial roundwood markets formed by Austria, Finland and Sweden, using annual delivery prices of pine and spruce sawlogs and pulpwood from 1980 to 1997.

Results of pairwise testing the LOP by different wood assortments indicate that the roundwood markets in Finland and Sweden would be integrated. However, the results between Austria and the two Nordic countries remain ambiguous, although there is a quite high positive correlation between prices in all three countries, in particular for pulpwood prices.

The largest deviation between price levels was found between the Nordic and Austrian markets of spruce sawlogs. Partly this may be caused by higher logging costs in mountaneous regions of Austria but partly this may also indicate differences in the quality of sawlogs, and thus point out for segmentation of the markets. In general, end-use markets of sawnwood are also likely to be more fragmented than pulp markets.

Also the longer geographical distance between Austria and the Nordic countries may widen the span in which the regional prices can vary without the inter-regional transportation costs being exceeded. In other words, there may be larger variation in the development of the regional markets in this case than in the case of the fairly closely located markets between Finland and Sweden. This may be a reason for the lower correlation and more ambiguous results regarding the relationships between the Austrian and Nordic wood markets.

In conclusion, it seems that the law of one price holds between Finnish and Swedish spruce and pine sawlog markets and spruce pulpwood market when analysing the markets at annual level. The degree of price co-movement between Austria and the two Nordic countries could not be clearly detected with testing for the LOP with the data used. However, testing Granger-causality between country specific prices suggested that the Nordic roundwood markets may have been determining pulpwood prices in the smaller Austrian wood markets rather than vice versa.

Our results provide empirical evidence that the Finnish wood markets have impacted on the development of Swedish markets. Thus, shocks affecting Finnish roundwood prices should get carried to the Swedish roundwood prices while the impacts to the other direction would not be as evident. Moreover, a shock affecting the Nordic pulpwood markets get eventually carried to the Austrian markets, although linkages between Austria and the Nordic countries are not as strong than within the Nordic region.

Due to various limitations related to the data used, and keeping in mind the low degree of determination in the regressions, further analyses are needed to test the robustness of the results. Most importantly, further analyses including a larger number of countries would be necessary in order to understand functioning of the roundwood markets in the whole European union. As well, analyses using more frequent data, such as monthly prices, could provide additional information about the linkages in price development between the three countries. Nonetheless, the results at hand provide new insights into common behavior of roundwood markets of three important forestry countries in the EU, and suggest that disaggregated modeling is needed for international markets for softwood assortments.

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