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Ragnar Jonsson's paper is included in this version, but is missing from the paper copy.

Testing Convergence between Roundwood Prices in Finland and Estonia

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Abstract:

Based on the Johansen's cointegration method, this study analyses the convergence of the Finnish and Estonian coniferous prices and if there exist any long run relationships between the wood assortments and species. The data is monthly time series from nominal delivery prices of spruce and pine sawlogs and pulpwood from the time period 1996 - 2003. Mainly, the results do not support the hypothesis of long run equilibrium of the roundwood prices between Finland and Estonia. Only the prices of pine sawlogs may contain information on the long run relationship. According to the descriptive trend analysis, however, all coniferous prices are converging against each other, and, if the trend growth of Estonian prices continues, they will coincide with Finnish prices in the forthcoming few years.

Keywords: Baltic Sea Area, roundwood markets, long run relationships, coniferous wood, price convergence

1. Introduction

Structure of wood and wood products markets in the North Eastern Europe is currently going through significant changes due to the large investments in sawmilling industry. In addition, accession of the Baltic States and Poland into the European Union in May 2004 will form and deepen economic integration around the Baltic Sea Area. International trade in roundwood has increased about 50 % between the years 1995 and 2001, and trade occurs mainly within this region. The Baltic Sea Area can therefore be considered as a relevant roundwood market area for the forest industry operating in the northern Europe. Since most roundwood traded in Baltic Sea Area is pulpwood, there are also differences between wood assortments regarding openness to international trade.

Development in roundwood prices is a key to understand how markets in different countries are functioning, to anticipate price changes for different roundwood assortments, and to assess how changes in these prices may affect on the investment planning of forest industry enterprises and their profitability. Also, the assessment and information of the development of roundwood prices certainly affect private forest owners' behavior.

Even though some analysis concerning regional integration of roundwood markets has been recently done in e.g. United States (Bingham et al. 2003) and Finland (Toppinen and Toivonen 1998), a deeper analysis of integration of international roundwood prices between different countries is needed. Typically, the studies analyzing market integration and linkages between forestry prices have had shortcomings with proper data sets. For example, integration between roundwood markets in Finland, Sweden and Austria was studied in Toivonen et al. (2002), but due to limited data, they used only simple regression analysis. Thorsen (1998) found countries with largest forest product industry in the Nordic countries, i.e. Finland and

Sweden to be price leaders with respect to smaller forestry countries, Norway and Denmark in the market of spruce sawlogs, but did not consider any other wood assortments. Recently, roundwood market linkages between Nordic and Baltic countries have been studied by Mäki-Hakola (2004), who established strong connections between Finnish and Estonian spruce sawlog prices, but found only a low correlation between spruce pulpwood prices.

In this study we try to deepen the understanding of development of roundwood prices and market integration between Finland and Estonia by using monthly observations of delivery prices of spruce and pine sawlogs and pulpwood (i.e. four main wood assortments in the market) from 1996 to 2003.

First we analyze differences in market integration between wood assortments and wood species (pine, spruce) and whether there exists any long run relationship in these prices. Secondly, this paper deals with studying possible price convergence in the roundwood markets using heuristic approach and extrapolation of deterministic price trends.

This paper is organized as follows. Section two presents shortly roundwood markets in Finland and Estonia and gives background of the market structure and of the importance of the forest sector. Section three describes the empirical method and data. In section four the main empirical results are presented and evaluated. Finally, section five concludes the study with some remarks.

2. Structure of roundwood markets

Even though Finland and Estonia differ from their land size and number of inhabitants, both countries have similarities regarding forestry, forest industry and nowadays also regarding the structure of roundwood markets. The share of forests of the total land area is over 70% in Finland and 49% in Estonia. Softwood species dominate the growing stock in both countries, even though broadleaved species are more common in Estonia than in Finland. Finland has larger forest resources: growing stock in Finland is about 1.9 billion m^3, and in Estonia about 0.3 billion m^3.

In both countries, forest industry is export oriented and very significant to the national economy. In Estonia, wood industry is currently among the most important export sector bringing about 15% of all export incomes. In Finland, forest industry as a whole is the second most important export sector covering about 25% of export incomes, but pulp and paper industry is much larger than the wood sector. Pulp and paper industry in Estonia is so far almost non-existent.

Forestry in both countries is characterised by private and fairly fragmented ownership structure. In Finland, over 50% of all forestland is owned by private inhabitants and even over 60% when only productive forest land is concerned. There are about 300 000 private forest holdings in Finland (including holdings that are at least five hectares in size). In Estonia, private forest ownership is being created through the land reform process, where real estates are returned to families owning the estates before World War II. Currently, the number of private forest holdings is over 50 000, but finally the number may increase close to 100 000. The share of private land is expected to increase to about 60% of all forestland, which will account for 1-1.2 million hectares. Therefore, roundwood supply has increased sharply from the privatized forests. An average size of a forest holding in Estonia is roughly 10 hectares while in Finland the average size is over 30 hectares.

In Estonia, domestic sawmill companies purchase sawlogs, but pulpwood is being almost totally exported to Germany and Sweden. Thus, the buyer structure has been fairly different regarding sawlog and pulpwood markets, and the number of actual buyers is clearly smaller for pulpwood than for sawlogs. However, the buyer structure is changing in Estonia quite rapidly towards the structure in Finland; large companies buy both sawlogs and pulpwood. In Estonia the domestic sawmill enterprises process sawlogs, and ship the pulpwood to their foreign factories while in Finland large forest companies utilise all assortments in their domestic factories. The number of companies is diminishing in Estonia along with the restructuring of the sawmill industry, and the number of market middlemen is also shrinking. Thus, also in this respect the structure of mechanical forest industry is increasingly similar in Finland and in Estonia.

Table 1. Production, Consumption and Trade of Roundwood and Sawnwood, mill.m^3 (roundwood measured over bark)

	Harvests	Exports	Imports	Apparent consumption	Sawnwood production	Exports	Imports	Apparent per capita consumption	
1995									
Estonia	3.5	2.7	0	0.8	0.4	0.3	0	0.1	(0.07 m^3)
Finland	51.0	1.2	11.3	61.1	9.9	8.4	0.2	1.7	(0.35 m^3)
2001									
Estonia	10.2	3.7	0.6	7.1	1.7	1.1	0.2	0.8	(0.7 m^3)
Finland	53.3	0.8	15.6	68.1	13.4	8.1	0.3	5.6	(1.1 m^3)

Source: Eurostat Forestry Statistics 1998-2001, Statistical yearbook of forestry (Finland 2003)

As shown in Table 1, wood industry has grown significantly both in Finland and in Estonia from 1995 to early 2000s. Relatively speaking, the growth has been stronger in Estonia, where harvests tripled between years 1995 and 2001. The sawmilling capacity has grown quickly in Estonia so that exports of sawlogs turned as net imports in 2002 and 2003 reflecting the fact that production of sawnwood has grown as four-fold while in Finland the growth between 1995 and 2002 was about 35%. The development has continuously and strongly increased the demand for sawlogs in Estonia during 1990s and early 2000s.

The development in Finnish sawmill industry has been somewhat similar as in Estonia during the last ten years; exports of sawnwood collapsed in early 1990s, but grew strongly during the latter part of 1990s. The growth stagnated in 2000 due to the downward development in the construction sector in Germany, and general economic recession in 2001-2003 in other important export destination countries. Even though the exports stagnated, domestic demand has continued to rise even in early 2000s. In 2002, domestic consumption of sawnwood was 5.4 million m^3, which was 54% more than in 1989. Pulp and paper production and exports have been growing continuously during 1990s and early 2000s, with the exceptions of 1991, 1996 and 2001. On the background are several new paper machines and pulp factories built in Finland between 1995 and 2002.

Both demand and supply of roundwood have increased in Estonia and Finland during the last ten years with the exception of years of economic recession. However, the growth has been even much more drastic in Estonia than in Finland. In Estonia, the demand for sawlogs has increased as manifold, while the demand in Finland has increased only some tens of per cents. The development in export demand for pulpwood is more difficult to estimate in Estonia, but in Finland the demand for pulpwood has increased about 30% between 1990 and 2003.

3. Methods data

Integration between Finnish and Estonian roundwood markets will be studied here using the concept of the law of one price (LOP). The fundamental principle of commodity arbitrage implies that prices in two countries should equal in equilibrium (net of transaction costs) when expressed in common currency. In practice, it is more complicated to find the equilibrium price levels because the adjustment of markets is occurring continuously. In our case, for example, we see Estonia catching up with other neighboring forestry countries with higher level of economic development, i.e. Finland and Sweden. Therefore, *a priori* our analysis will more likely demonstrate the adjustment process of Estonian wood markets than the actual state of equilibrium.

First, in order to understand the dynamics of these markets it is essential to know time series properties of wood prices in Estonia and Finland. In order for the LOP to hold in the long run, both prices need to be integrated of the same order. Previous studies analyzing the integration of wood markets have started by testing nonstationarity of time series with augmented Dickey-Fuller (ADF hereafter) approach (Dickey and Fuller 1979). However, testing the null hypothesis of stationary may provide different insights into market analysis, and therefore, along with the ADF test, we use also test introduced by Kwiatkowski et al. (1992) (KPSS hereafter).

In testing of cointegration between prices in Estonia and Finland, we start by using the bivariate version of statistical autoregressive model

(3.1.) $$z_t = A_1 z_{t-1} + \dots + A_k z_{t-k} + u_t,$$

where z_t is $(n \times 1)$ vector of endogenous variables and each of the A_i is an $(n \times n)$ matrix of coefficients.[1] k defines the lag length and u_t is the standard vector of error terms with normal IID assumptions. Equation (3.1.) can be reformulated into a vector error correction (VECM) form

(3.2.) $$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \dots + \Gamma_{k-1} \Delta z_{t-k-1} + \Pi z_{t-k} + u_t,$$

where $\Gamma_i = -(I - A_1 - \dots - A_i)$, $(i = 1, \dots, k-1)$, and $\Pi = -(I - A_1 - \dots - A_k)$. The rank of the Π matrix gives the number of cointegrating vectors in the system. If the rank of Π is zero, then Π is the null matrix indicating only a VAR process in differences and no cointegration between the variables. If Π is of full rank, the data in levels are already stationary. The most interesting case is when Π is of rank $0 < r < n$. Then, there are r cointegrating vectors describing the long-run equilibrium relationships, while the error correction mechanics embodies the short-run dynamics of the variables. To see this, the Π matrix can be decomposed as

(3.3.) $$\Pi = \alpha\beta',$$

where both α and β are $(n \times r)$ matrix. The columns of β matrix give the cointegration vectors including information on the long-run relationships while the elements in α represent the error correction mechanism and the rate of adjustment of the process towards equilibrium. Technically, to get the most reliable estimates of the Π matrix one should apply the multivariate maximum likelihood estimation of Johansen (1988) and Johansen and Juselius (1990).

Johansen procedure is a stepwise analysis including the following steps. First, to apply cointegration analysis one should work with time series that are known to be nonstationary. Second, given that the variables are nonstationary, one should select the precise form of the equation (3.2). Third, one should test the statistical significance of the number of cointegration relationships (rank r). Finally, one should estimate the cointegration equations and, if possible, impose restrictions on them.

The form of the equation (3.2) is selected according to the goodness-of-fit measures and several diagnostic tests. The tests of rank of the matrix Ð are based on the standard trace and maximum eigenvalue tests. When the estimated value of trace test is smaller than the critical value, the null hypothesis of at least r_o cointegrating vectors can be accepted.

Our data for Finnish prices consist of logarithmic nominal delivery prices of spruce and pine sawlogs and pulpwood (i.e. four main wood assortments in the market) as obtained from the Finnish forestry statistics. Delivery sales represent only about 20% of the total market, but due to the high correlation with stumpage prices, delivery prices are also indicative of the whole market development. The time series are monthly average prices of roundwood bought from the non-industrial private forest owners, and they are reported over bark as €/m^3.

The Estonian monthly logarithmic nominal prices for spruce and pine sawlogs and pulpwood at the road side are reported by the State Forest Management Center managing about 37% of forest land. Thus, prices refer to the state forests only, because prices for the wood from the private forests are not available. However, average prices for whole Estonia have a tendency to follow the state forest prices, possibly with a small publication lag. Originally, Estonian prices for sawlogs are EEK per solid cubic meter without bark, while prices for pulpwood are given over bark (Nordic-Baltic Forestry Statistics (2004)). Thus, to make Estonian sawlog price data comparable with that of Finnish data, it was necessary to adjust the Estonian price levels to also include an approximate proportion of measuring the bark (we used 15 %). Thus, we divided original Estonian prices with a constant of 1.15. Average monthly exchange rates were used to transform Estonian prices to Euros. Originally, the research period was 1994.1 – 2003.12, but after initial inspection, the observations for years 1994 and 1995 were excluded due to very high price volatility in Estonian wood markets. Thus, our final sample consists of 96 observations, which should be sufficient for the cointegration analysis although the data span is on the short end of the range.

4. Results

4.1. Time Series Properties and Cointegration Analysis

To ensure that the time series involved in analysis are nonstationary we first used ADF and KPSS tests. However, a few remarks are worth mentioning before reporting the test results. First, in some cases the test statistics were highly sensitive to the inclusion of a constant and/or trend components in regressions. To be consistent in reporting, we included the trend in regression only if its coefficient was statistically significant. According to the test statistics, in addition to the constant, the regressions should include trend only for the pine pulp wood series in Finland, while for Estonia both a constant and a trend should be included in all regressions. Second, the number of the lags in regressions is based on the Akaike's information criteria.[2] While in few cases (Finnish spruce pulp wood and Estonian pine pulp wood) this criteria led to the high tailed autoregressive process (i.e. AR(10)) in regression and declined

[1] See Banerjee et al. (1993) or Harris (1995) for background and technical details of the Johansen's method.

the power of the test statistics, we restricted the number of lags as small as possible which stillensured that the error term is serially independent. Typically, the first or second lag fulfilled this requirement.

Table 2. Stationarity Tests for Variables

Country	Assortment		Constant/Trend	Lags	ADF	KPSS	ADF	KPSS
					Level		First differences	
Finland	Sawlog	Pine	C	1	-1.771	0.905**	-12.946**	0.134
		Spruce	C	2	-1.537	1.228**	-10.078**	0.177
	Pulpwood	Pine	C,T	2	-4.570**	0.063	-4.971**	0.041
		Spruce	C	2	-2.225	0.235	-2.425*	0.402
Estonia	Sawlog	Pine	C,T	2	-3.443	0.109	-9.064**	0.139
		Spruce	C,T	2	-1.704	0.286**	-8.909**	0.249
	Pulpwood	Pine	C,T	1	-2.160	0.148*	-5.815**	0.051
		Spruce	C,T	3	-5.952**	0.142	-5.393**	0.094

The asterisks * and ** denote that the null hypothesis is rejected at 5% and 1% level, respectively. In ADF the null hypothesis is that the time series is nonstationary, while KPSS tests stationary as a null hypothesis.

Keeping in mind these restrictions in estimation the test results are given in Table 2. In most cases the time series are nonstationary (see also Figures 1-4 in Appendix). Only the series for Finnish pine pulpwood and Estonian spruce pulpwood are clearly stationary.[3] The test statistics are conflicting for Finnish spruce pulpwood and Estonian pine sawlogs: according to the ADF test, both series are nonstationary, while KPSS test accepts the hypothesis of stationarity. The first differences of the variables are all stationary. Even though the test results concerning Estonian pine sawlogs are conflicting, we include it into the analysis but refrain from making any strong conclusion of the results concerning it. Because of the stationarity, both pairs of pulpwood price series are extracted from the cointegration analysis.

To proceed, we next tested the adequate form of the vector autoregressive model (3.1) for both species of sawlogs. The lag structure in VAR is based on the Akaike's information criteria. The test for homoskedasticity of the residuals is an extension of White's test to systems of equations. The test statistic is obtained by regressing each cross product of the residuals on the cross products of the regressors and testing the joint significance of the regression. The test for autocorrelation is a Ljung-Box test for the joint hypothesis that all the lagged autocorrelation coefficients are simultaneously equal to zero. Doornik-Hansen test is a multivariate extension of the standard Jarque-Bera residual normality test comparing the third and fourth moments of residuals to those from the normal distribution.

Table 3 depicts the results for the diagnostic tests. If the calculated probability value is lower than 0.05 (5%), the null hypothesis of homoskedasticity, no autocorrelation and/or normality are rejected. According to the Akaike's information criteria, one-lag model minimized the loss function for both sawlog assortments. However, the diagnostic tests for both assortments revealed that the residuals for this one-lag model are not well behaving: the assumptions of

[2] According to the Figures in Appendix the heuristic intuition of the existence of the trend component is often misleading. Also, the test statistics based on different goodness-of-fit measures led sometimes to the conflicting results. For example, according to the Akaike's information criteria the trend component in the series of Finnish spruce sawlogs was not statistically significant, while the SIC criteria accepted the trend in regression.

[3] The exclusion of trend component resulted in nonstationary series for Finnish pine pulpwood

homoskedasticity and normality of residuals are rejected.[4] To improve the statistical performance of the model we also tried to include more lags in VAR models. These experiments did not eliminate the heteroskedastic structure of the residuals or the non-normality for both assortments. According to Gonzalo (1994), however, the results for Johansen's cointegration analysis should not be biased despite of the non-normality of the residuals, while the heteroskedasticity may lead to the inaccurate statistical inferences of the following cointegration test results.

Table 3. Diagnostic Tests of Form of VAR Models

Sawlog assortment	Lags	Homoskedasticity		Autocorrelation		Normality	
		Estimated	p-value	Estimated	p-value	Estimated	p-value
Pine	1	36.796	0.0014	61.092	0.0972	29.949	0.0000
Spruce	1	26.979	0.0289	53.070	0.2851	30.926	0.0000

The critical values to reject the null hypothesis of homoskedasticity, no autocorrelation and normality at 5% level of significance are χ^2 (15) = 24.996, χ^2 (50) = 67.505 and χ^2 (4) = 9.488, respectively. The test statistic for autocorrelation is based on 12 lags.

To identify the existence of cointegration in a case of two variables is a test of null hypothesis that there are no cointegration vectors against the alternative that there is one. The null hypothesis is rejected if the test statistic exceeds the critical value. Table 4 shows the results for cointegration analysis. Clearly, the results do not indicate any long run equilibrium between Finnish and Estonian prices for spruce sawlogs. For pine sawlogs, the hypothesis of one cointegrating equation is accepted giving a long-run relationship

(3.6.) $\quad Lepsl - 2.5406\ Lfipsl + 6.2739 = 0,$

where Lepsl and Lfipsl are logarithmic prices for pine sawlogs in Estonia and Finland, respectively.[5] The respective rate of adjustment, i.e. the error-correction parameter, for the Estonian prices is –0.228 while for the Finnish prices it is only –0.030. Thus, when testing for weak exogeneity between prices, causality is found originating from the Finnish pine sawlog price to that in Estonia.

Table 4. Cointegration Tests

Variable	Hypothesis	Eigenvalue	Test Statistics		Critical Values (5%)	
			λ_{Trace}	λ_{Max}	λ_{Trace}	λ_{Max}
Pine	r = 0	0.168	17.310*	20.970*	15.7	20.0
	r ≤ 1	0.038	3.665	3.665	9.2	9.2
Spruce	r = 0	0.119	11.930	14.670	14.1	15.4
	r ≤ 1	0.029	2.735	2.735	3.8	3.8

The asterisk * denotes that the null hypothesis is rejected at 5% level

[4] It is noteworthy, that even though the joint hypothesis of no autocorrelation for all coefficients cannot be rejected, the coefficient for the twelfth lag turned out to be statistically significant. The reason is easily seen from the Estonian time series: The spruce sawlog prices in Estonia decrease systematically in summers. The reason for this price decrease, however, is difficult to explain.

4.2. Convergence in Prices

According to the results above it seems that, except for the pine sawlogs, there are not any long run equilibrium levels between the Finnish and Estonian coniferous assortments. However, the Figures 1-4 in Appendix reveal that during the past ten years both the sawlog and pulpwood prices have clearly converged in nominal terms. Thus, after few years and after the adjustment process, we may be able to detect long run relationships between the prices. The growth in demand of sawlogs has been stronger than supply, and sawlog prices have increased particularly in Estonia. In 2002, the difference in price levels of spruce sawlogs was about 15-20%, the higher prices being in Finland. The demand-supply balance is different for pulpwood both in Finland and in Estonia: pulpwood is competing with wood chips and in Finland also with imported pulpwood. Particularly in Estonia roundwood trade is concentrated on sawlogs both quantitatively and on the value basis; partly this true also for Finland where the trade tends to be dominated by demand and supply situation of sawlogs.

If the trend growth of Estonian prices continues, *ceteris paribus*, it will be only after few years when the prices between Finland and Estonia converge. A simple extrapolation of the trends shows that the prices for spruce sawlogs will coincide around the end of 2005, for spruce pulpwood in the end of 2007 and for the pine pulpwood in the end of 2006.[6] For the pine sawlogs, the adjustment process seems to take more time even though it was the only assortment where cointegration was found. The corresponding equilibrium euro values for spruce sawlogs, spruce pulpwood and pine pulpwood would be roughly 50€, 31€ and 24€, respectively. However, because of the uncertainty concerning the forestry sector in both countries and international economic growth together with increasing roundwood supply and trade (from Russia and other Baltic Area), these results should be interpreted as preliminary rather than strictly concluding.

5. Concluding remark

This study has analyzed the convergence of Finnish and Estonian roundwood prices for pine and spruce sawlogs and pulpwood, and tested for the existence of long run equilibrium relationships between the prices. After declaring independence the Estonian economy has undergone a significant structural change and showed a remarkable economic success. The forestry sector has been partly privatized and investments on sawmilling capacity have increased considerably. Therefore, along the accession into the European Union in May 2004, it is reasonable to suspect that the roundwood prices in the Baltic Sea Area will converge and eventually constitute an integrated market area.

To summarize, time series properties between Finnish and Estonian pulpwood prices were rather different, and for example the Finnish delivery price for pine pulpwood was found to be stationary according to the test statistics. These results are conflicting with the volumes of international trade, which occurs mainly in the pulpwood side of the market and could be expected to force national prices to converge. The results based on the standard cointegration analyses and monthly time series of nominal delivery prices from the time period 1996 - 2003, however, did not yet give support for the long run equilibrium between the Finnish and Estonian

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[5] Using a simple two step Engle-Granger analysis we, however, found evidence for cointegration between Finnish and Estonian prices of both pine and spruce sawlogs.

[6] It should be stressed that although explanatory power of linear trends was rather good, we made this experiment to emphasize the approaching convergence and not to forecast actual markets.

roundwood prices. Only the prices of pine sawlogs may contain information on the long run equilibrium. Also the statistical performance of the residuals of the VAR models was unsatisfactory. However, our results are also supported by simple price correlations that were very high between sawlog prices and very low between pulpwood prices. Reasons behind this phenomenon should be investigated in further studies possibly using other theoretical assumptions than that of perfect competition. Also, other exogeneous variables (such as inflation or GDP growth) may be used to explain the price convergence.

In any case, the results point out for the importance of analyzing wood prices by specific assortments than by aggregate sawlogs or pulpwood. According to the descriptive trend analyses, there is a clear convergence of the prices. If the trend growth of the Estonian roundwood prices continues, *ceteris paribus*, it is likely that after few years roundwood prices between Finland and Estonia will coincide. However, a more rigorous modeling of factors explaining the convergence of wood prices is needed when the integration of roundwood markets in the Baltic Sea Area is of further interest.

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Appendix: Roundwood Prices and Linear Price Trends (extrapolated to end in 2008) in Finland and Estonia

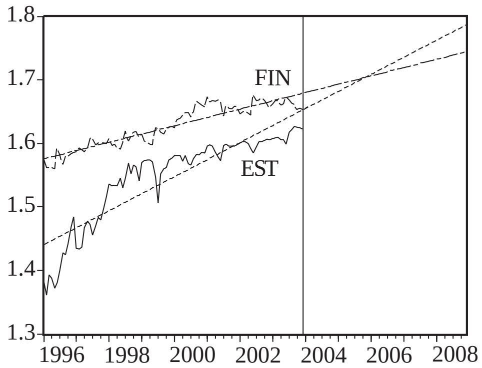

Figure 1. Spruce Sawlogs

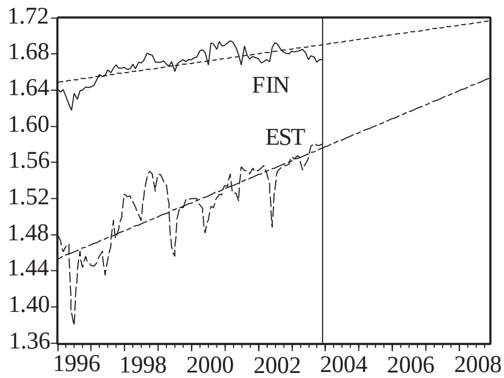

Figure 2. Pine Sawlog

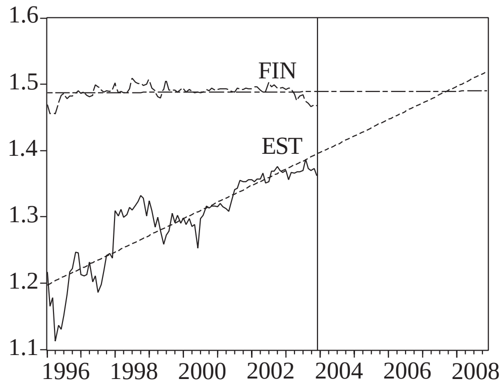

Figure 3. Spruce Pulpwood

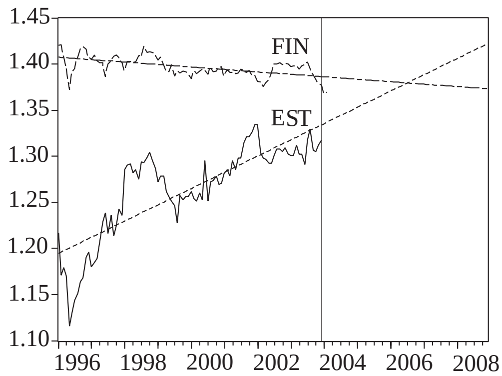

Figure 4. Pine Pulpwood