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Substitution in the Finnish Forest Industry's Roundwood Procurement

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In this study, the interaction and substitution between domestic and imported roundwood in the Finnish forest industry's wood procurement is analysed by timber assortments. The results from the translog cost function approach and quarterly data of the total wood procurement and its components during the euro regime indicate that, to a certain extent, the Finnish forest industry has had the possibility of substituting imported roundwood volumes between countries in the Baltic Sea region. Contrary to earlier studies, also in the case of Russian birch pulpwood, the most important imported timber assortment, the results suggest that Russian birch pulpwood has rather substituted for than complemented the domestic supply in Finland. The increase in roundwood export duties in Russia has had a statistically significant effect on the trade in birch pulpwood and spruce sawlogs. Moreover, the results confirm the earlier findings of a rigid demand for roundwood in Finnish roundwood markets.

Keywords roundwood procurement, imports, substitution, translog cost function
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1 Introduction

The total roundwood procurement of the Finnish forest industry can be broadly divided into two components: roundwood of domestic and foreign origins. The latter of these components, i.e., roundwood imports, has fluctuated strongly in recent years. Simultaneously, public discussion on the reasons as well as the consequences of the roundwood imports has been active. The growth in roundwood imports into Finland coincides with the internationalisation of Finnish forest industry enterprises and major institutional changes in the Finnish roundwood markets. Lately, the unpredictable shifts in duties on roundwood exports by the Russian Federation have been the major source of concern and instability. Despite the importance of roundwood imports for the Finnish forest industry and the whole forest sector, empirical studies of their effects remain surprisingly scarce.

Finland has a long history of being a net importer of roundwood. Especially, imports from the Russian Federation and the former USSR have been substantial. However, it was not until the late 1990's that the ratio of import volumes to the total roundwood use by the Finnish forest industry began increasing significantly. The dissolution of the USSR, the independence of the Russian Federation and the Baltic countries, and the consequent liberalisation of trade improved the accessibility to new markets for final products and forest resources within the Baltic Sea region. Mergers of Finnish and Swedish forest industry companies, such as Enso-Gutzeit Ltd and Stora Ltd in 1998, aimed at enhancing the companies' international importance, also affected the fact that wood procurement is currently organised multinationally within the Baltic Sea region.

From the late 1960's until the late 1990's, the Finnish roundwood market was characterised by institutional collaboration between the forest industry and the non-industrial private forest (NIPF) owners, whose share has been over 80 per cent of the annual commercial fellings (Parviai nen and Västilä 2011). The collaboration was aimed at controlling the effects of unexpected business cycles in the roundwood markets and was manifested in a system of collective stumpage price negotiations. According to the competition legislation of the European Union (EU), this collaboration was an anticompetitive measure, and after Finland's membership in the EU, the practice was discontinued gradually by the end of the 1990's (Ollonqvist 2000). Ever since, the Finnish roundwood markets have been seemingly market-based, yet accusations of and even court decisions on anticompetitive actions of the market parties have emerged. In parallel with the institutional changes in the Finnish roundwood markets, roundwood imports into Finland increased rapidly, attaining the highest level of almost 18 million cubic meters in 2005. At that time, the roundwood imports covered one fourth of the Finnish forest industry's total wood consumption. In recent years, the use of imported roundwood has decreased, mainly due to the worldwide economic slowdown and the stepwise implementation of customs tariffs for Russian roundwood exports.

Hypothetically, roundwood imports could have several different impacts on the domestic Finnish roundwood markets. Firstly, from the standpoint of the forest industry, imports provide an alternative and additional source of raw material when the domestic markets cannot provide the needed roundwood volumes for a certain production level. In Finland, in the cases of birch sawlogs and especially birch pulpwood, the domestic supply has been far from adequate. Thus, one may claim that the birch sawlogs and pulpwood imports have probably complemented the domestic supply. Secondly, imports provide an alternative way to procure roundwood, from markets where the price level may be lower than in the domestic markets. In such a case, imports substitute for domestic roundwood in the forest industry's production and ease the pressure on prices in domestic roundwood markets. Thirdly, from the Finnish forest owners' standpoint, stumpage earnings can be either higher or lower depending on whether the imports are complementing or substituting for the domestic supply in the forest industry's production. If the imports substitute for domestic supply, stumpage earnings of private forest owners are lower. Conversely, if the imports are complementing for domestic supply, stumpage earnings can be higher than in the situation where imports are not provided. Finally, from the standpoint of society, roundwood imports and their different effects on the use of domestic wood resources, silviculture, and on the forest industry's production, should be taken into consideration when making and evaluating strategic decisions in forest policy or in the construction of infrastructure, not to mention regional income and employment effects. Therefore, a knowledge of the effects prevailing in the roundwood import trade and total wood procurement, such as own and cross price elasticities, are vital for long-term decision making at all levels of the forest sector.

Although there are studies scrutinising the price and market behaviour in the Finnish roundwood market (Toppinen and Kuuluvainen 1997, Mutanen and Toppinen 2005, Malaty et al. 2007), the integration of roundwood prices in the Russian–Finnish roundwood trade (Mutanen and Toppinen 2007) and, more widely, in the Baltic Sea region (Toppinen et al. 2005), only a few studies have concentrated on the analysis of the total wood procurement and its division into domestic and imported components. Tilli et al. (2001) modelled birch pulpwood imports into Finland and the effects of those imports on the demand for domestic birch pulpwood. In the Swedish context, Lundmark and Shahrammehr (2011) estimated the Armington elasticities between imported and domestic roundwood in the forest industry's wood procurement.

The aim of this study is to evaluate the substitution effects in the Finnish forest industry's total wood procurement. Previously, these effects have not been thoroughly scrutinised. The empirical estimates for own and cross price elasticities provide a means to evaluate substitution effects between roundwood procurement from different origins. The magnitude of these elasticities also helps anticipate the economic effects on domestic markets of increasing or decreasing roundwood imports. Similar to Uusivuori and Kuuluvainen (2001, 2002), who modelled global and Japanese wood imports, the approach is based on a translog cost function originating from two-step optimisation processes of forest industry enterprises. The data set, covering the years 2002–2010, includes quarterly figures, both the volumes and prices, of domestic fellings and roundwood imports into Finland.

2 Material and Methods

2.1 Sources of Roundwood

As depicted in Fig. 1, until the late 1990's, the increase in the industrial use of roundwood in Finland was satisfied by the increase in domestic removals. However, after the renunciation of the institutional collaboration system between the forest industry and NIPF owners in the late 1990's, the domestic removals stabilised at about

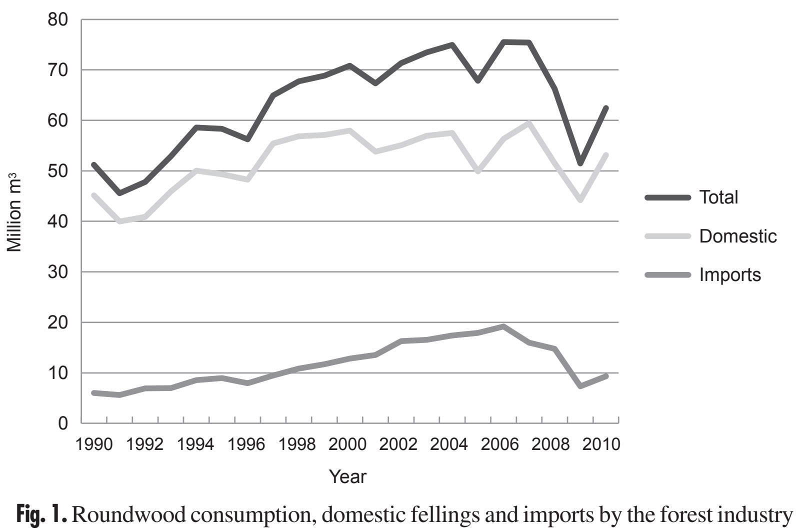

Fig. 1. Roundwood consumption, domestic fellings and imports by the forest industry in Finland 1990–2010 (Metinfo, Finnish Customs).

55 million cubic meters annually. Since then, the expansion of roundwood use has been primarily based on increasing roundwood imports. The increase in consumption from 64 million cubic metres in 1997 to about 73 million cubic metres in 2006 is approximately equal to the increase in import volume from 7.8 to 16.8 million cubic metres during the same period. In 2006, the record year of the total use of roundwood in Finland, almost a quarter of the industrial wood consumption consisted of imports. The worldwide economic slowdown, decreasing demand for forest products, and consequent decrease in production capacity, diminished the need for both domestic and imported roundwood after 2007.

Russia has been the main source of roundwood imports into Finland. Its geographical proximity and compatible rail gauge enables direct transportation from Russian loading places to mill gates in Finland. During the late 1990's, the increase in import volumes was attributable to the liberalisation of roundwood exports from Russia and to the devaluation of the Russian ruble in 1998.

Until recently, roundwood imports from Russia constituted circa 80 per cent of the total annual roundwood imports. Felling conditions during the winters of 2007 and 2008 were difficult in Russia and together with the stepwise introduction of a customs tariffs programme for roundwood exports and the diminishing need for roundwood by the Finnish forest industry, the share of roundwood imports from Russia began decreasing (Jutila et al. 2010). However, in 2009, the share of Russian roundwood was still 62 per cent, although the previously marginal imports from the Baltic countries and Sweden increased considerably. Simultaneously, the Finnish forest industry companies declared that in the near future they would concentrate more on domestic markets in their wood procurement.

During 2010 and 2011, the international demand for forest products slightly recovered and domestic commercial removals increased back to their long run average. Also, the volumes of roundwood imports increased slightly. In the autumn of 2011, Russia's negotiations for partnership in the World Trade Organisation (WTO) progressed and an agreement to set export quotas for coniferous roundwood and lowering the export taxes within the quotas was reached. Russia is expected to join the WTO in the summer of 2012. Concurrently, the major Finnish forest industry companies have publicly expressed their ambitions to increase roundwood imports from Russia again.

Some interesting specific observations can be made apropos timber assortment when studying the relative shares of roundwood procured by the Finnish forest industry from domestic and foreign sources. As can be seen in Fig. 2, the relative shares of birch pulpwood and sawlogs differ significantly from those of the coniferous assortments. Until 2005, only about one third of the industrial birch pulpwood consumed was procured from the domestic Finnish roundwood markets. The rest originated mainly from Russia. The reason for this high import intensity was that the total consumption of birch pulpwood had been much higher than the maximum sustainable removals in Finland (Mutanen and Toppinen 2007). A similar rationale applies to birch sawlogs. In recent years, however, a great deal of non-coniferous veneer production capacity has been closed down because of the economic slowdown. This has also collapsed the imports of birch sawlogs (Fig. 2).

Although the procurement shares of coniferous assortments between domestic markets and imports have slightly varied over the years, the majority of the coniferous roundwood consumed has been procured from domestic markets (Fig. 2). However, the combined import shares of Russia, the Baltic countries and Sweden have varied between 10 and 40 per cent of the total consumption of coniferous timber assortments. Consequently, also the imports of coniferous timber assortments of foreign origin play an important, yet not vital, role in the Finnish forest industry's wood procurement.

According to economic theory, in the interregional trade in similar products, i.e., perfect substitutes, and under perfect competition, the prices (exclusive of transportation costs, and measured in the same currency) tend to equal. This phenomenon is called the law of one price and is evident in the long run. In the short run, prices may differ, but because of trade, the differences are levelled out with the passage of time. The price developments of timber assortments from the Finnish roundwood markets and from

Fig. 2. Relative shares (%) of domestic and imported roundwood of total use of roundwood by the forest industry in Finland, 2002–2010 (Metinfo, Finnish Customs).

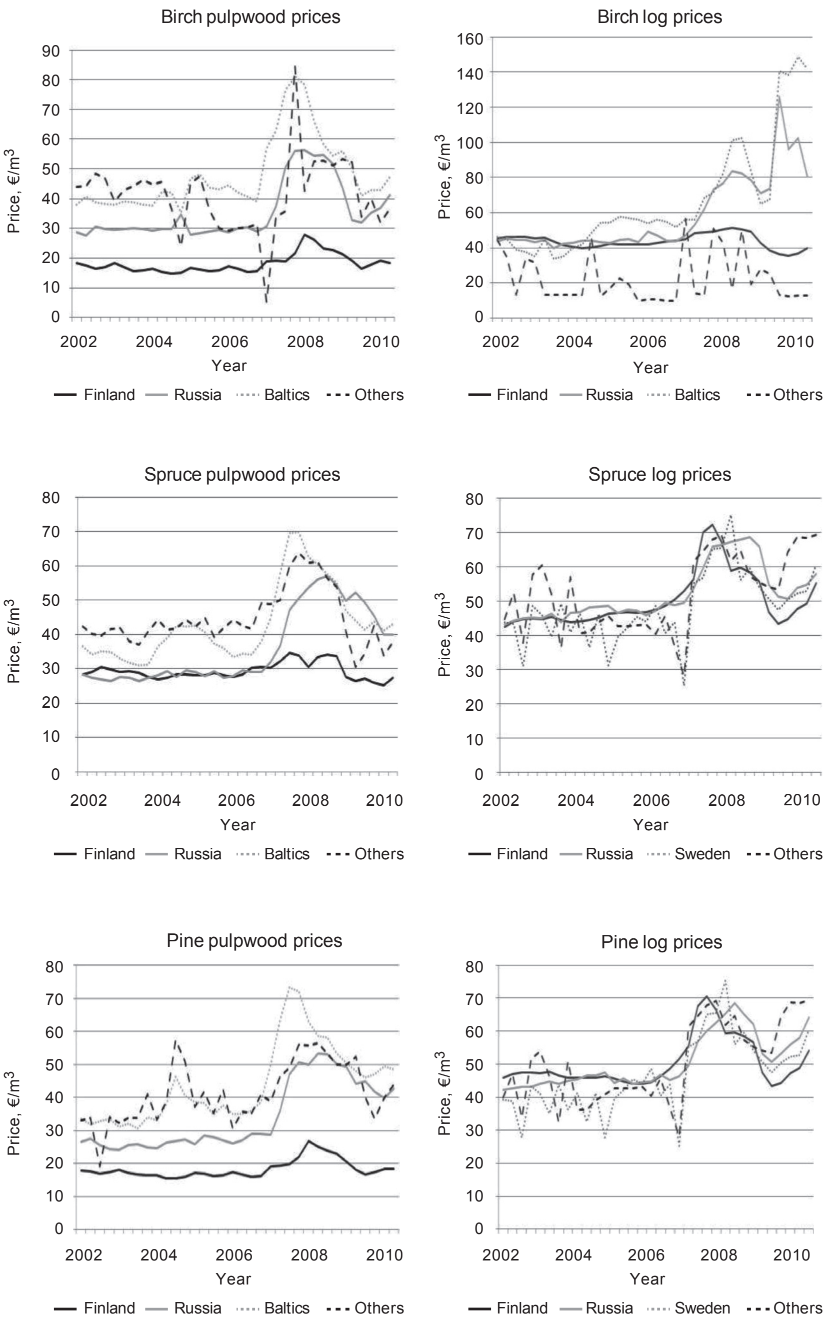

Fig. 3. Price development of timber assortments of different origins. Finnish prices are volume weighted averages of delivery and stumpage prices. Prices of imported pulpwood and sawlogs are volume weighted average values at the Finnish border. These CIF (cost, insurance and freight) values include, e.g., harvesting and transportation costs and possible export duties. (Metinfo).

abroad are depicted in Fig. 3. There are some similarities in the price developments of Finnish and imported roundwood, such as the price peak in 2007. However, especially in the cases of pulpwood assortments and birch sawlogs, the prices of roundwood of Finnish and foreign origins seem to have developed differently: the Finnish price has been lower and relatively stable compared to other prices. In the case of coniferous sawlogs, the prices seem to have fluctuated more uniformly. It is also worth noticing that previous studies (Toppinen et al. 2005, Mutanen and Toppinen 2007) have emphasised a close statistical relationship and long run equilibrium between the national prices of spruce sawlogs in the Baltic Sea region. Similar statistical relationships, however, have not been found for other timber assortments. The differentiated price developments may be caused, e.g., by shortcomings in the market competition, changes in the regulation of international trade, and sudden changes in supply–demand balance in different market areas. It is also worth noticing that the prices are measured in different spots of the markets (forest versus border), which may affect the levels and the perceived development patterns of the prices.

2.2 Data Description

The data consists of quarterly time series of cost shares and roundwood prices of six timber assortments: pulpwood and sawlogs of pine, spruce and birch of different origins during the period from 2002/Q1 to 2010/Q2 (34 observations). The period was selected to represent the time after the implementation of the euro and the restricted market behaviour under the institutional collaboration in Finland. In addition, the division of the import data into different timber assortments was not available until 2002.

The data on imported roundwood was retrieved from Uljas, the Finnish customs' foreign trade information service. The import volumes (m^3) and values (€) of the imported roundwood by assortments and by countries were extracted using the Combined Nomenclature Classification of the European Union (CN). The CN classification for timber assortments was: CN 44032039 for pine pulpwood, CN 44032031 for pine logs, CN 44032019 for spruce pulpwood, CN 44032011 for spruce logs, CN 44039959 for birch pulpwood, and CN 44039951 for birch logs.

Until the beginning of 2005, the import data was recorded over-bark and later under-bark. Accordingly, the coefficients provided by the Finnish Forest Research Institute were implemented on the quantities of roundwood to make the under-bark data comparable with the over-bark figures. The data on the domestic commercial roundwood removals over-bark was gathered from the statistical information service Metinfo, produced by the Finnish Forest Research Institute. The countries of interest were the Russia Federation, the Baltic countries, Sweden, and the remaining countries.

The series of cost shares were calculated by adding up the values of imported and domestic procured roundwood assortments, and dividing the country specific procurement values by the total value. The cost share of the remaining imports excluding Russia and the Baltic countries (or Sweden) is referred to as "the other countries". The unit prices (€/m^3, over-bark) were calculated by dividing the quarterly value of the roundwood assortment by the traded volume. Import prices were measured at the border and include the costs of harvest and transportation as well as possible export custom duties (see Fig. 3). The Finnish prices were volume-weighted averages of the delivery and stumpage prices. Most of the roundwood from domestic markets is purchased via standing sales. However, especially as regards pulpwood assortments, delivery sales are substantial (up to 40 per cent of the total sales), and thus taking the development of delivery prices into consideration gives a more accurate overall picture of the price development. The unit prices of the assortments imported from the other countries were calculated by deducting first the import values of Russia and the Baltic countries (or Sweden) from the total import value of an assortment. Then the remaining value was divided by the total volume of the imported assortment from the other countries.

2.3 Estimation Methodology

The theoretical framework of this study is based on a two stage approach, which describes the optimisation process, i.e., cost minimisation, of a "representative" forest industry enterprise and yields the factor demand functions for roundwood from different sources. In the context of international trade, the two stage approach was first applied by Armington (1969), whose model employed a constant elasticity of substitution (CES) functional form. In this study, more flexible translog functions are applied, as outlined by Fuss (1977) and used more recently in the forest industry context in Uusivuori and Kuuluvainen (2001, 2002).

The representative Finnish forest industry enterprise is assumed to produce some wood-based product *(Y),* such as sawnwood, pulp or paper, which is sold on competitive end use markets. The enterprise uses roundwood (*R*) and other inputs (*O*) as factors of production. The inputs are acquired from markets in which the enterprise acts as a price taker. It is further assumed that the aggregate inputs (*R*, *O*) may consist of several subcomponents. For example, the aggregate amount of roundwood purchased can be divided into components according to the country of origin ($R(R_1,\ldots R_n)$). Taking into account this subdivision, the weakly separable production function of the forest industry enterprise can be written:

$$Y = f(R(R_1,...,R_n),O) \tag{1}$$

The production function *f(.)* is assumed to be at least twice differentiable. A weakly separable functional form implies that the marginal rates of substitution between the subcomponents of *R* are independent of the use of the other inputs *O*. This restriction allows focusing on the determination of the subcomponents of the aggregate roundwood (*R*) as the changes in the use of other inputs (*O*) affects only the aggregate volume of roundwood used (*R*) but not directly the ratios of the subcomponents (R_i/R_j).

At the first stage of the cost minimisation, the enterprise decides the optimal amounts of aggregate inputs (*R, O*) with respect to the chosen production level (*Y*). At the second stage, the enterprise chooses the optimal amount of each subcomponent constituting the aggregate inputs. Furthermore, the sub-function *R* is assumed to be homothetic in terms of R_i, which implies that the optimal combination of roundwood volumes from different sources ($R_1,\ldots,R_n$) is independent of the total roundwood volume used (*R*). Thus, the first stage of the cost minimisation is described by a total cost function

$$C = g(P_R, P_O; Y) \tag{2}$$

where P_R and P_O are the price functions of the components constituting the aggregate rounwood and other inputs, respectively. Hence, $P_R = P_R(P_{R1},\ldots,P_{Rn})$, where the subscripts refer to roundwood of different geographic origins ($1,\ldots,n$). As the production function and the corresponding total cost function are weakly separable, the enterprise chooses the optimal amounts of sub-components constituting each of the aggregate factors at the second stage of cost minimisation. The second stage is characterised by so-called sub-cost functions, which in the case of roundwood can be written

$$C_R = f(P_{R1},...,P_{Rn}; R) \tag{3}$$

In order to empirically estimate the sub-cost function for roundwood in (3), the function is assumed to be in a translog (transcendental logarithmic) form. The translog specification is flexible and requires no a priori restrictions on the substitution possibilities between the factors of production. Following Berndt (1996), the sub-cost function for roundwood can be expressed by

$$\begin{aligned} &\ln C_R(P_{R1},...,P_{Rn}; R) = \\ &\alpha_0 + \sum_{i=1}^{n} \alpha_{Ri} \ln P_{Ri} + \frac{1}{2}\sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{RiRj} \ln P_{Ri} \ln P_{Rj} \\ &+ \alpha_R \ln R + \frac{1}{2}\beta_{RR} \ln(R)^2 + \sum_{i=1}^{n} \beta_{RiR} \ln R \ln P_{Ri} \end{aligned} \tag{4}$$

where $\beta_{RiRj} = \beta_{RjRi}$. A well behaved cost function must be homogenous of degree one in prices, which requires the following restrictions on the parameters (Berndt 1996):

$$\sum_{i=1}^{n} \alpha_{Ri} = 1, \sum_{i=1}^{n} \beta_{RiRj} = \sum_{j=1}^{n} \beta_{RjRi} = \sum_{i=1}^{n} \beta_{RiR} = 0 \tag{5}$$

Furthermore, assuming the cost function to be homothetic and that homogeneity of constant degree prevails in production requires that $\beta_{RiR}=0$ and $\beta_{RR}=0$. Constant returns to scale are ensured by the restriction $\alpha_R=0$ (Berndt 1996). According to Shephard's Lemma, differentiating the cost function of roundwood (4) with respect to roundwood prices yields the cost minimising demand functions for roundwood of different origins. Thus, the demand functions for roundwood of different origins are

$$\begin{aligned} \frac{\partial \ln C_R}{\partial \ln P_{Ri}} &= \frac{P_{Ri}}{C_R} \cdot \frac{\partial C_R}{\partial P_{Ri}} = \frac{R_i P_{Ri}}{C_R} \\ &= S_{Ri} = \alpha_{Ri} + \sum_{j=1}^{n} \beta_{RjRi} \ln P_{Rj} + \beta_{RiR} \ln R \end{aligned} \tag{6}$$

As can be seen, the demand functions are, in fact, cost share functions (S_{Ri}) of roundwood originating from different countries. The cost shares fulfil the adding up criterion, i.e., $\sum_{i=1}^{n} S_{Ri} = 1$. Applying the homotheticity restriction ($\beta_{RiR}=0$), the cost share functions for the roundwood assortments originating from Finland (FIN), Russia (RUS) and other countries (OTH) are

$$\begin{aligned} S_{FIN} &= \alpha_{FIN} + \beta_{FINFIN} \ln P_{FIN} + \beta_{FINRUS} \ln P_{RUS} \\ &\quad + \beta_{FINOTH} \ln P_{OTH} \\ S_{RUS} &= \alpha_{RUS} + \beta_{RUSFIN} \ln P_{FIN} + \beta_{RUSRUS} \ln P_{RUS} \\ &\quad + \beta_{RUSOTH} \ln P_{OTH} \\ S_{OTH} &= \alpha_{OTH} + \beta_{OTHFIN} \ln P_{FIN} + \beta_{OTHRUS} \ln P_{RUS} \\ &\quad + \beta_{OTHOTH} \ln P_{OTH} \end{aligned} \tag{7}$$

The coefficients of this system of cost share equations fulfil the previously mentioned symmetry and other restrictions related to a well-behaved cost function. The basic own (e_{RiRi}) and cross price (e_{RiRj}) elasticities can be calculated using these coefficients as follows (Berndt 1996):

$$\begin{aligned} e_{RiRi} &= \frac{\beta_{RiRi} + S_{Ri}^2 - S_{Ri}}{S_{Ri}} \\ e_{RiRj} &= \frac{\beta_{RiRj} + S_{Ri} S_{Rj}}{S_{Ri}} \end{aligned} \tag{8}$$

As can be seen, the cross-price elasticities between the factors, i.e., roundwood of different origins, are not necessarily symmetric. In addition, as the cost shares (S_{Ri}) may fluctuate over time, the elasticities are not constant. In the calculation of elasticites, the S_{Ri}'s are usually the average values of the cost shares for the whole study period or for shorter intervals.

As the cost shares sum to unity, there are only $(n-1)$ linearly independent equations in system (7). Hence, straightforward estimation of the system as presented in (7) is not feasible. The solution is to drop one of the cost share equations and then to estimate the remaining $(n-1)$ equations by seemingly unrelated regression (SUR) or maximum likelihood (ML) methods. If the weighting matrix is iterated sequentially together with the coefficients in SUR, the results from SUR and ML estimations are numerically identical (Berndt 1996). For example, in the case of system (7), dropping the cost share equation of the country group Others yields

$$\begin{aligned} S_{FIN} &= \alpha_{FIN} + \beta_{FINFIN} \ln(P_{FIN} / P_{OTH}) \\ &\quad + \beta_{FINRUS} \ln(P_{RUS} / P_{OTH}) \\ S_{RUS} &= \alpha_{RUS} + \beta_{RUSFIN} \ln(P_{FIN} / P_{OTH}) \\ &\quad + \beta_{RUSRUS} \ln(P_{RUS} / P_{OTH}) \end{aligned} \tag{9}$$

where P_{Ri}/P_{Rj} are the so-called transformed prices. The coefficients of the omitted cost share equation can be calculated by using the restrictions provided in (5). The coefficients of system (9) should satisfy the symmetry restrictions ($\beta_{RiRj}=\beta_{RiRi}$), which can be investigated by using the Wald test. The usual procedure is first to estimate the unrestricted system (9), then to check the symmetry restriction by the Wald test, and finally to impose the parameter restrictions and to estimate the restricted system. The estimates of the coefficients in (9) are not interesting as such, but they are used to calculate the own and cross price elasticities as described in (8).

2.4 Time Series Properties

Before the estimation, the original prices were transformed to P_{Ri}/P_{Rj} and natural logarithms were taken of the transformed price series. The order of integration of all the time series was investigated by using the augmented Dickey–Fuller (ADF) test (Dickey and Fuller 1979). The results of the ADF non-stationarity tests are presented in Appendix 1. The results indicated that most of the time series used were I(0), and thus stationary in levels. In the cases where the null hypothesis of I(1) series was not rejected, the system of cost share equations was still estimated using the levels of the variables as the theoretical model, the related parameter restrictions, and formulae for calculating the different elasticities were defined in levels. However, the non-stationary time series were usually on the dependent side of the models and thus the risk of spurious regression was considered lower than in the case of the regressors being non-stationary. Indeed, the estimation results showed that the typical diagnostics of spurious regression, such as high values of the coefficients for multiple correlation or high *t*-values, were not present in the data. A dummy variable (from the 2nd quarter of 2007 onwards) was included in the regressions to control for the increase in the custom tariffs for Russian roundwood exports in April 2007. The seasonal variation was controlled using dummy variables for the 2nd, 3rd and 4th quarters.

3 Results

3.1 Estimation Results

The results of the seemingly unrelated regression (SUR) estimation of cost shares for the pulpwood and sawlog assortments are presented in Tables 1 and 2, respectively. The coefficients, as noted earlier, are not interesting per se but they are employed in calculating the elasticities. Nevertheless, the significance levels of the estimated coefficients determine how reliable the basis of the calculations is.

For birch pulpwood, the coefficients of own price were statistically significant for Russia and for the Baltic countries at the 1 and 5 percent levels, respectively. For Finland, the coefficient turned out to be statistically insignificant. As regards to cross price coefficients, for Russia and the Baltic countries, and for Finland and the Baltic countries, the coefficients were statistically significant at the 1 and 10 percent levels, respectively. It is noteworthy, however, that the cross price effect between Finland and Russia did not appear to be statistically significant. The dummy variable dividing the data by the 2nd quarter of 2007, when the tariffs for roundwood exports from Russia rose substantially, was highly significant in all the birch pulpwood models. The negative coefficient for Russia suggests that the implementation of the export tariffs reduced quite strongly the cost share of Russian birch pulpwood, while the effect was the opposite for Finnish and Baltic pulpwood. The symmetry restrictions of the models, which confirm the suitability of the translog approach to the data, are accepted according to the Wald test.

For spruce and pine pulpwood, the theoretical symmetry restrictions applied to the parameter

Table 1. Estimated coefficients for the cost share equations for pulpwood assortments.

	$\ln(P_{FIN}/P_{OTH})$	$\ln(P_{RUS}/P_{OTH})$	$\ln(P_{BAL}/P_{OTH})$	d2007	R^2	DW	Wald
Birch pulpwood							
S_{FIN}	0.12	0.04	–0.10*	0.09***	0.44	1.82	2.86
S_{RUS}	0.04	–0.36***	0.25***	–0.17***	0.45	1.52	
S_{BAL}	–0.10*	0.25***	–0.14**	0.07***	0.29	1.83	
Spruce pulpwood							
S_{FIN}	0.59***	–0.08*	0.00	–0.01	0.38	1.25	35.85***
S_{RUS}	–0.08*	–0.15***	0.14***	0.01	–0.19	1.18	
S_{BAL}	0.00	0.14***	0.13**	0.00	0.69	1.02	
Pine pulpwood							
S_{FIN}	0.27**	0.12**	–0.21***	–0.03	–0.01	0.80	9.84**
S_{RUS}	0.12**	–0.38***	0.13***	0.01	0.35	0.84	
S_{BAL}	–0.21***	0.13***	0.10**	0.00	0.43	0.86	

Asterisks denote the statistical significance of the parameters: *, ** and *** are significant at 10, 5 and 1 per cent level of significance, respectively. The null hypothesis of Wald test is that the symmetry restrictions ($\beta_{RiRj}=\beta_{RjRi}$) hold between the equations.

Table 2. Estimated coefficients for the cost share equations for sawlog assortments.

	$\ln(P_{FIN}/P_{OTH})$	$\ln(P_{RUS}/P_{OTH})$	$\ln(P_{BAL}/P_{OTH})$	d2007	R^2	DW	Wald
Birch sawlogs							
S_{FIN}	–0.24***	0.23***	0.02	0.06	0.37	0.56	0.60
S_{RUS}	0.23***	–0.28***	0.03	–0.05	0.38	0.56	
S_{BAL}	0.02	0.03	–0.05**	–0.02	0.04	1.14	
Spruce sawlogs							
S_{FIN}	0.49***	–0.43***	–0.07*	0.10***	0.39	0.96	2.18
S_{RUS}	–0.43***	0.38***	0.07**	–0.13***	0.57	1.01	
S_{SWE}	–0.07*	0.07**	0.01	0.02***	0.28	1.20	
Pine sawlogs							
S_{FIN}	0.15	–0.14		0.010	0.16	0.97	3.96
S_{RUS}	–0.14	0.14		–0.01*	0.19	1.15	

Asterisks denote the statistical significance of the parameters: *, ** and *** are significant at 10, 5 and 1 percent level of significance, respectively. The null hypothesis of Wald test is that the symmetry restrictions ($\beta_{RiRj}=\beta_{RjRi}$) hold between the equations.

estimates were not accepted according to the Wald test. Thus, the framework used is not completely suitable for the data of pine and spruce pulpwood. Also, although there seem to be statistically significant parameters in the regressions, the division of time series for sub-periods is not necessary according to the statistical performance of the dummy variable. Thus, the increases in Russian roundwood export duties did not affect the import of pine and spurce pulpwood into Finland. The calculated coefficients (not reported in the tables) for the cost shares for other countries turned out to be rather small in the case of all pulpwood assortments. This is not surprising as the imported volumes from the other countries than Russia and the Baltic countries have been marginal.

For sawlogs, the theoretical restrictions on the coefficients were accepted in all regressions according to the Wald test. The coefficients of own price for birch logs were statistically significant in all the cost share equations. For spruce sawlogs, the coefficient for own price effect was significant at the 1 per cent level of significance in the case between Finland and Russia, whereas for Sweden the coefficient did not statistically differ from zero. In the case of pine sawlogs, none of the coefficients were statistically significant. It is also interesting to note that only for spruce sawlogs was the coefficient of the customs tariffs' dummy statistically significant, suggesting that the increase in export tariffs had a negative effect on the demand for Russian spruce sawlogs, while for the other cost shares, the effect was positive.

Overall, the statistical properties, such as the level of multiple correlation or the autocorrelation of the residuals, left room for improvement in many of the models. This problem has been evident also in earlier studies employing the translog approach in the context of the forest industry (see, e.g., Hänninen 1998).

3.2 Elasticities

The own and cross price elasticities of the demand for different roundwood assortments were calculated as in (8). The means of the elasticities are presented in Table 3. Many of the elasticities were based on coefficients that were not statistically significant. Although one should be cautious when interpreting the results, some interesting remarks can still be made. In the Finnish roundwood market, the own price elasticities of demand for different wood assortments are close to zero. In the cases of spruce and pine pulpwood and spruce sawlogs, the elasticities seem to contradict the standard economic theory according to which an increase in the price of an input leads to decreasing demand for the same input. These findings imply that the demand side of roundwood markets in Finland is fairly rigid. Thus, the result are in line with previous studies: the demand for domestic sawlogs has been found inelastic, with values of price elasticity smaller than (minus) one (e.g., Kuuluvainen et al. 1988, Mutanen and Toppinen 2005). The demand for pulpwood, in

Table 3. Own and cross price elasticities [a)].

	Pulpwood			Sawlogs		
	Birch	Spruce	Pine	Birch	Spruce	Pine
$e_{FIN,\,FIN}$	–0.21	0.60	0.09	–1.06	0.41	–0.01
$e_{RUS,\,RUS}$	–0.94	–1.63	–4.50	–1.28	3.88	4.04
$e_{BAL,BAL}$	–2.36	3.71	–0.05	–2.79		
$e_{OTH,\,OTH}$	–0.53	3.56	115.71	–0.35	–2.41	–0.87
$e_{FIN,\,RUS}$	0.83	0.06	0.31	0.97		0.01
$e_{RUS,\,FIN}$	0.30	0.16	1.85	1.14	–0.37	–3.93
$e_{FIN,\,BAL}$	–0.34	0.10	–0.17	0.10		
$e_{BAL,FIN}$	–0.79	0.73	–1.05	1.60		
$e_{BAL,RUS}$	3.23	4.94	1.19	1.30		
$e_{RUS,\,BAL}$	0.52	0.83	1.35	0.10		
$e_{FIN,\,OTH}$	–0.28	–0.18	–0.23	–0.02	0.03	0.00
$e_{OTH,\,FIN}$	–5.56	–0.52	–386.22	–2.08	7.63	0.71
$e_{RUS,\,OTH}$	0.12	0.05	–0.10	0.04	–0.18	–0.12
$e_{OTH,\,RUS}$	6.79	0.12	–25.67	3.03	–4.83	0.16
$e_{BAL,OTH}$	–0.08	–0.29	–0.08	–0.11		
$e_{OTH,\,BAL}$	–0.69	0.02	–25.69	–0.63		
$e_{SWE,\,SWE}$					–0.78	
$e_{FIN,\,SWE}$					–0.07	
$e_{SWE,\,FIN}$					–1.98	
$e_{SWE,\,RUS}$					2.78	
$e_{RUS,\,SWE}$					0.87	
$e_{SWE,\,OTH}$					–0.04	
$e_{OTH,\,SWE}$					–0.34	

[a)] The country structures of the models differ slightly by timber assortments and thus there is variation which cross price elasticities are calculated. The elasticities that were calculated using statistically significant coefficients are highlighted.

turn, has been found even more inelastic than the demand for sawlogs and the reported own price elasticities have varied on both sides of zero or have been statistically insignificant (Kuuluvainen et al. 1988, Hetemäki and Kuuluvainen 1992, Toppinen and Kuuluvainen 1997).

An interesting result is also revealed when scrutinising the effects of Russian birch pulpwood, the most important import assortment by volumes, on Finnish wood procurement and roundwood markets. The positive cross price elasticities contradict the earlier findings that Russian birch pulpwood has complemented Finnish birch pulpwood in the pulp and paper industry's wood procurement (Tilli et al. 2001). However, the positive value is based on a calculation using a coefficient that was not statistically significant. An interesting observation is also that the increased price of Russian birch pulpwood has increased the demand for Baltic birch pulpwood which, in turn, has been rather elastic. Thus, the birch pulpwood procurement as well as cost shares have rapidly decreased as the prices have risen either in Russia or in the Baltic countries.

The cross price elasticities for Finnish and Russian spruce and pine pulpwood were positive, indicating that the procurements from these countries have substituted for each other during the study period. In addition, the cross price elasticities between Russian and Baltic spruce pulpwood were also positive, again a sign of substitution in the Finnish forest industry's wood procurement. The same seems to apply to pine pulpwood of Russian and Baltic origin, yet in this case, the elasticities were calculated using coefficients which were not statistically significant.

In the case of birch sawlogs, the cross prise elasticities suggest that Finnish, Russian, and Baltic birch sawlogs have been substitutes for each other during the study period. The elasticity between Finland and Russia has been close to unity, while the price changes in Baltic birch sawlogs have affected the procurement for Finnish birch sawlogs only slightly. As regards the group of other countries, an interesting results is that birch sawlogs from Russia and other countries have been substitutes for each other, suggesting that the Finnish forest industry has been able to create a competition in its birch sawlogs procurement from abroad.

For spruce and pine sawlogs, the imported volumes have been rather small and one should interpret the results with caution. Especially, the elasticities for pine sawlogs are based on coefficients which were not statistically significant. However, it seems that according to the cross price elasticities, Finnish and Russian and Finnish and Swedish spruce sawlogs have complemented each other. This result could be spurious, as the peak of the business cycle in the sawnwood markets of Europe may have had a similar effect around the Baltic Sea region. The high sawnwood prices were reflected in the spruce sawlog prices and simultaneously the demand for spruce sawlogs increased in most if not all of the countries in the Baltic Sea region, creating a shortage of spruce sawlogs.

4 Discussion

This study aimed at evaluating the market structure and the interaction between domestic and imported timber assortments in the total wood procurement of the Finnish forest industry during 2002–2010. The results from the translog approach and quarterly data of the total wood procurement provided new insight into the determination of roundwood imports into Finland and confirmed some expectations, such as the negative effect of Russian customs tariff's programme on the imports of certain timber assortments. The limited data and the challenging study period, with several breakpoints, contributed to the statistical properties of the models being only just tolerable. Thus, this study should be regarded as the first attempt to describe the effects of roundwood imports into Finland quantitatively in a new operational environment, where many of the trading partners belong to the EU and the Finnish roundwood market functions on a seemingly competitive basis.

Despite the problems involved in the statistical analysis, some interesting remarks can be made. It seems that imported wood has substituted for domestic wood in the Finnish forest industry's wood procurement during the study period. This has probably been the case with imported Russian birch pulpwood, the most important import assortment, which earlier was considered a complement to birch pulpwood of Finnish origin. In addition, it seems that the Finnish forest industry has had the possibility of substituting imported roundwood volumes between countries in the northern Baltic Sea region. If the roundwood prices have increased, say, in the Baltic countries, the procured volumes from Russia and/or Sweden have increased, and vice versa. Furthermore, the small and sometimes positive own price elasticities confirm the earlier findings of a rigid demand for roundwood in Finnish roundwood markets. The implementation of the customs tariffs programme for roundwood exports by the Russian Federation has affected the wood procurement from Russia in recent years. However, the negative effect was statistically significant only in the cases of birch pulpwood and spruce sawlogs.

As mentioned before, the study period after the implementation of the euro regime was short and included many cycles and breakpoints. These include the peak in industrial roundwood imports in the mid 2000's, the peak in sawnwood demand and prices, the stepwise increase in the export tariffs for Russian roundwood, the economic recession in 2008, together with a permanent decrease in Finland of the production capacity of paper, pulp and non-coniferous veneer. The end of the transition period of the forest taxation reform in Finland occurred in 2005 and caused a peak in the supply of roundwood in the domestic market, as shown in Mutanen and Toppinen (2005). In Finland, there also appeared a price cartel between the three largest forest industry concerns during 1997–2004, covering two years of the study period. Furthermore, strategic reasons are likely to prevent free market pricing in roundwood trade across borders. When small volumes are imported with a high price, this tends to keep the domestic price level at a lower level compared to the case where all the volumes would be procured from domestic markets. Logistical matters and local availability, such as poor logging conditions due to weather, also strongly affect the acquisition possibilities of wood raw material.

Economic models usually include strong assumptions and generalisations, and they often are formed on and to test for the assumption of a free, integrated market with perfect competition. Often these assumptions are not true in real life. In order to avoid too complex a model and econometric problems with all the possible overlapping phenomena and breakpoints mentioned above, this study included only one breakpoint, that is, the implementation of the customs tariff programme for roundwood exports by the Russian Federation, which can be seen as the most important event to affect the roundwood trade within the Baltic Sea region.

The production capacity in Finland of pulp and paper has been reduced considerably during 2007–2011. According to many forecasts, the consumption of paper and paperboard products will not increase in the near future in the euro area, the main market for the Finnish forest industry. Thus, the total consumption of roundwood in Finland is not likely to increase. Another change, which will affect the roundwood markets in the Baltic Sea region, is the future membership of Russia in the WTO. This membership is anticipated to begin after the summer of 2012, and the customs tariffs programme for roundwood exports will be partly phased out. Although the imported Russian roundwood volumes are not likely to recover to those of the record year 2005, the price competitiveness of Russian roundwood will increase again to certain extent. Thus, the result of substitution between roundwoods of different origins found in this study can be utilised when evaluating the effects of Russian WTO membership. For example, the possibly increasing imports from Russia that substitute for domestically procured roundwood are likely to have a negative effect on Finnish roundwood prices and decrease the stumpage earnings of NIPF owners.

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Appendix 1. Stationarity tests of the time series.

Table A1. ADF-unit root tests of time series.

Variable	constant, trend	lags	t-ADF	probability	
Birch pulpwood					
$\ln(P_{FIN}/P_{OTH})$	c	0	–4.79	0.00	***
$\ln(P_{RUS}/P_{OTH})$	c, tr	0	–5.05	0.00	***
$\ln(P_{BAL}/P_{OTH})$	c	0	–4.10	0.00	***
S_{FIN}	c	0	–4.49	0.00	***
S_{RUS}	c, tr	0	–2.50	0.33	
S_{BAL}	c, tr	3	–0.50	0.98	
Spruce pulpwood					
$\ln(P_{FIN}/P_{OTH})$	c	0	–2.75	0.08	*
$\ln(P_{RUS}/P_{OTH})$	c, tr	0	–2.23	0.46	
$\ln(P_{BAL}/P_{OTH})$	c, tr	0	–2.96	0.16	
S_{FIN}	c	0	–2.62	0.10	*
S_{RUS}	c	0	–3.47	0.02	**
S_{BAL}	c, tr	0	–3.20	0.10	
Pine pulpwood					
$\ln(P_{FIN}/P_{OTH})$	c	0	–3.84	0.01	***
$\ln(P_{RUS}/P_{OTH})$	c, tr	1	–2.60	0.28	
$\ln(P_{BAL}/P_{OTH})$	c	0	–3.75	0.01	***
S_{FIN}	c, tr	1	–3.46	0.06	*
S_{RUS}	c, tr	0	–2.40	0.37	
S_{BAL}	c, tr	3	–4.13	0.02	**
Birch sawlogs					
$\ln(P_{FIN}/P_{OTH})$	c	0	–5.57	0.000	***
$\ln(P_{RUS}/P_{OTH})$	c	0	–4.86	0.000	***
$\ln(P_{BAL}/P_{OTH})$	c	0	–4.31	0.00	***
S_{FIN}	c	2	0.85	0.89	
S_{RUS}	c	0	–2.45	0.14	
S_{BAL}	c	0	–3.07	0.04	**
Spruce sawlogs					
$\ln(P_{FIN}/P_{OTH})$	c	0	–3.48	0.02	**
$\ln(P_{RUS}/P_{OTH})$	c	0	–3.86	0.01	***
$\ln(P_{SWE}/P_{OTH})$	c	1	–2.68	0.09	*
S_{FIN}	c	1	–5.24	0.00	***
S_{RUS}	c, tr	1	–5.01	0.00	***
S_{SWE}	c, tr	1	–4.91	0.00	***
Pine sawlogs					
$\ln(P_{FIN}/P_{OTH})$	c	2	–1.60	0.47	
$\ln(P_{RUS}/P_{OTH})$	c	2	–2.08	0.25	
S_{FIN}	c	1	–4.52	0.00	***
S_{RUS}	c	0	–3.77	0.01	***

Constant (c) and/or trend (tr) were included in equations, if they turned out to be statistically significant. Lags denote the number of the lags in the ADF equations. Asterisks denote the level at which the null hypothesis of unit root is rejected: * at 10 per cent, ** at 5 per cent and *** at 1 per cent level of significance.