Finnish Sawlog Market under Forest Taxation Reform

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The stepwise transition in forest taxation from site productivity tax to taxation of profits from timber sales was one of the major institutional changes to impact Finnish non-industrial private forest owners in the 1990s. In this study the effect of the forest taxation reform on the aggregate supply of sawlogs was investigated using time series analysis and quarterly data. In particular, we estimated two simultaneous equations systems for the pine and the spruce sawlog markets. According to the results, the forest taxation reform strengthened the supply of spruce and pine sawlogs in the anticipatory stage of the taxation reform in 1992. Also during the fiscal transition period, which started in 1993, the supply effect of the taxation reform has clearly been positive. The strong own-price elasticity of sawlog supply found in this study indicates high sensitivity to actual and expected wood price changes in the determination of sawlog supply in Finland. Furthermore, the results indicate that the theoretical assumption of a competitive market is suitable for the Finnish sawlog market, but that separate analysis of pine and spruce sawlogs provides additional insights into market behaviour.

Keywords forest taxation, reforms, roundwood supply, simultaneous equations
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1 Introduction

The reform of capital income taxation was effected in Finland at the beginning of 1993. For the Finnish forest taxation this meant a change-over from the previous site productivity taxation system (so-called area-based taxation) to the taxation of profits from timber sales. However, the non-industrial private forest (NIPF) owners were given the opportunity to remain in the site productivity taxation system for a 13-year transition period, till the end of 2005. This separated private forest owners, who accounted for 54% of Finland's forest area and 80% of its commercial harvest, into two fiscally different groups of roundwood suppliers.

One purpose of the long transition period for the forest taxation reform was to give forest owners the opportunity to cut their standing crops – already taxed once in the site productivity taxation system – free of any additional tax liability. Without the transition period the harvested timber would have been taxed twice in the proportional timber sales profit taxation. Consequently, it was advantageous to forest owners who were rich in harvestable forest resources to remain in the site productivity taxation system.

The opinions expressed on the effects of the forest taxation reform on the supply of roundwood have varied. On the one hand, it has been supposed that the realisation of the forest resources of those forest owners who stayed in the site productivity taxation would cause an oversupply of roundwood during the transition period. On the other hand, the Finnish forest industry has often expressed its concern about the possibility of a diminishing supply of roundwood after the transition period.

Although the forest taxation reform was one of the major institutional changes faced by Finnish NIPF owners in the 1990s, empirical evidence on its actual effects on the national level supply of roundwood is lacking. However, a positive transition-period effect of the 'old' site productivity taxation regime on NIPF owners' timber sales has been found in a logistic regression based on repeated inquiries in southeast Finland (Ovaskainen and Ripatti 1998) as well as in a Finnish regional panel data for 1994–1998 (Kaikai et al. 2002).

Thus the primary aim of this study is to determine how the forest taxation reform shows up in the Finnish sawlog market, using time series analysis and fresh aggregate level quarterly data. The need for updating the models for the Finnish sawlog market is evident not only because of the forest taxation reform but also because of the gradual dismantlement of the nationwide price recommendation system and the notable increase in roundwood imports in the late 1990s.

2 Taxation Systems and Expected Effects of Taxation Reform on Roundwood Supply

In the following, we present an overview of the two different forest taxation regimes in effect in Finland and discuss the expected roundwood supply effects of the forest taxation reform. The *site productivity tax* is based on the estimated net yield on forestry per hectare, defined by the average forest growth, the monetary value of the growth, and calculated average costs of timber production. The forest owner's final net forestry returns, on which the tax is levied, are calculated by deducting from the estimated net yield on forestry the yield on tax-free areas (i.e. established seedling stands) and the tax allowances for particular forest estates, such as the reforestation deduction. The net returns on forestry are then added to the forest owner's earned income, on which the tax is levied according to the forest owner's personal progressive income tax rate. In the site productivity taxation, the tax on forestry is paid annually and income from timber sales does not affect the tax liability. (Ovaskainen and Ripatti 1998)

In its basic form a 'lump-sum' site productivity tax does not influence forest owners' management decisions. However, the Finnish system contains several incentives aimed at furthering forest policy goals justified by their importance for national economy. The purpose of the exemptions for regeneration areas and the reforestation deduction, for example, is to encourage the regeneration of mature stands. Therefore the Finnish site productivity taxation system cannot be considered neutral. (Ovaskainen 1992)

In the *timber sales profit taxation* ('profit taxation') the net return from forestry, on which the tax is levied, is based on the income from timber actually sold. Unlike in the site productivity taxation, all the costs related to timber production are deductible in the profit taxation. The purchase price of forest estate is also partially deductible. (Ovaskainen and Ripatti 1998) Net income from timber sales is included in the forest owner's capital income, on which a uniform relative

Table 1. Expected effects of forest taxation reform on the supply of roundwood (Ovaskainen and Ripatti 1998).

Stage of reform	Taxation group 1	Taxation group 2	Total supply of roundwood
Anticipatory stage before transition period	No direct effect	Increasing (possibility of tax-free realisation)	Temporarily increasing
Beginning of transition period (2–3 years)	Increasing (possibility of tax-free realisation, reforestation deductions)	Temporarily diminishing (anticipatory sales, stage of habituation); normalises soon afterward	Increasing
Middle and final section of transition period	Increasing (possibility of tax-free realisation)	No direct effect, continues to be on a normal level	Increasing
First years after transition period	Temporarily diminishing (anticipatory sales, removal of temporary tax incentives)	No direct effect	Temporarily diminishing

Taxation group 1 refers to the forest owners who chose to stay in the site productivity taxation system during the transition period.
Taxation group 2 refers to the forest owners who chose the timber sales profit taxation system for the transition period.

capital income tax (29% in 2003) is levied. The amount of tax on forestry varies greatly from year to year, for it is paid only when timber sales occur. Theoretically, a relative tax on income from timber sales does not affect rational forest owners' cutting decisions, provided the tax rate does not change (Ovaskainen 1992).

In spring 1994, when it was time to choose the forest taxation system for the transition period, 33% of the NIPF owners decided to stay in the site productivity taxation. Their proportion was 38% of NIPF land and 45% of harvestable forest resources (Pesonen and Räsänen 1994). Therefore, as regards harvestable resources, the newly-formed taxation groups of NIPF owners were nearly equal. However, as regards rational roundwood supply behaviour, the groups should differ at different stages of the taxation reform. The expected behavioural patterns of the different taxation groups, as well as their effect on the total supply of roundwood, are presented in Table 1 adapted from Ovaskainen and Ripatti (1998).

According to Ovaskainen and Ripatti (1998), the forest taxation reform increases the total supply of roundwood in Finland. Only immediately after the fiscal transition period in 2006, is the supply of roundwood expected to diminish temporarily. In the anticipatory stage, prior to the transition period, the increase in the total supply of roundwood is assumed to originate from cuttings of forest owners who chose the timber sales profit taxation system for the transition period (Taxation group 2). To these forest owners it was advantageous to cut the forests before the transition period because of the opportunity for 'tax-free' realisation of forest property.

The supply of roundwood of Taxation group 2 is expected to diminish temporarily in the beginning of the transition period. However, this temporary decrease in the cuttings is expected to be compensated by the increase in cuttings of forest owners who stayed in the site productivity taxation (Taxation group 1). The possibility of 'tax-free' realisation of forest resources and deductions related to regeneration are the main incentives for forest owners in Taxation group 1 to cut their forests during the fiscal transition period. Therefore, as regards the whole transition period the effect of the forest taxation reform on the level of total roundwood supply is expected to be positive, provided that the forest owners belonging under the different taxation groups act rationally. (Ovaskainen and Ripatti 1998)

3 Models

3.1 Introduction

In this paper, we focus on describing the functioning of the Finnish coniferous sawlog market. The markets for other timber assortments are left aside. This restriction of scope is grounded on the fact that coniferous sawlogs originate mainly from final cuttings, the very amount of which was expected to increase due to the forest taxation reform. However, in contrast to most earlier studies on the Finnish roundwood market, here the coniferous sawlog market is not considered a homogeneous entity but is divided further into two respective submarkets for pine and spruce sawlogs. For these markets, where perfect competition is assumed to prevail, two separate simultaneous equations systems are formulated. The hypothesis of perfect competition is assumed to hold also in the markets for the other factors of production as well as in the markets for the final products. It is also assumed there are no capital market imperfections or uncertainty related to decision making.

3.2 Supply of Roundwood

The aggregate level roundwood market data available do not allow us to estimate sawlog supply functions separately for the different taxation groups of NIPF owners. However, the supply reactions of the taxation groups to changes in taxation regimes can be revealed by using aggregate level market data in the following manner.

Consider a traditional aggregate level roundwood supply function based on a Fisherian two-period consumption-savings model of a utility maximizing NIPF owner (e.g. Kuuluvainen 1990). In this short-term model of roundwood supply, the forest owner's decision problem is how much to cut today and how much leave to be cut in the future. In a perfect capital market, the consumption decision and the decision on timber supply are separable and the income from the optimal intertemporal harvest can be allocated for optimal consumption via the capital market. Thus the forest owner's utility is maximized by maximizing the present value of returns from timber sales. In the model's basic form, the forest owner decides the optimal amount of cuttings (i.e. the roundwood supply) at period t (Q_t^s) with respect to the roundwood price at period t (p_t), the expected price of roundwood at the following period t + 1 ($p^e{}_{it+1}$), the interest rate (r_t) and the initial growing stock at the beginning of period t (v_t). (see e.g. Kuuluvainen 1990) Consequently, the roundwood supply function can be expressed in its basic form (with comparative static signs of explanatory variables) as

$$Q_{it}^s = f(\underset{+}{p_{it}}, \underset{-}{p_{it+1}^e}, \underset{+}{r_t}, \underset{+}{v_{it}}) \tag{1}$$

where subindex i (i = 1,2) is used for emphasising the separation of pine and spruce sawlog markets. Theoretically, the introduction of a proportional profit tax on timber sales in the following period t + 1 *ceteris paribus* affects the optimal cuttings in the current period t similarly to a fall in the roundwood price in the following period, i.e. it has a positive supply effect (Ovaskainen 1992). However, in our case not all forest owners encounter the taxation change at the same time. As suggested in Table 1, some of the forest owners react to the forest taxation reform prior to the transition period and the rest during the transition period itself. This phenomenon may be captured in the aggregate level roundwood supply models by using time dummy variables. Here, the first one of these taxation dummies (D_1) represents the positive supply reaction of those forest owners who chose profit taxation for transition period; its value is 1 in the anticipatory stage prior to the transition period and 0 elsewhere. The other taxation dummies are for the transition period itself and are designed to capture the positive supply reactions of forest owners who stayed with site productivity taxation. Analogous to Table 1, the transition period is not considered homogeneous but is divided into two sub-periods, for which separate dummies (D_2, D_3) are introduced. This follows mainly from the length of the fiscal transition period and the contrasting supply reactions of different taxation groups at the beginning of the transition period (Table 1). Consequently, the aggregate level supply function for a particular sawlog assortment can be expressed with taxation dummies and expected signs as

$$Q_{it}^{s} = f(\underset{+}{p_{it}}, \underset{-}{p_{it+1}^{e}}, \underset{+}{r_t}, \underset{+}{v_{it}}, \underset{+}{D_1}, \underset{+}{D_2}, \underset{+}{D_3}) \quad (2)$$

In this study the model of adaptive expectations is applied to describe the formation of the expected price of roundwood in period t+1. When using time series data, the adaptive expectations process can be modelled with lagged price (p_{it-1}) and quantity ($Q_{it-1}{}^{s}$) (Brännlund 1988).

3.3 Demand for Roundwood

The aggregate demand functions for the pine and the spruce sawlogs are based on the profit maximizing behaviour of a representative forest industry enterprise, i.e. a sawmill. The output of the enterprise can be described by a continuous, strictly concave, and twice differentiable production function, $Y_i = f(Q_i, c_i)$, where Y_i is the quantity of final product (sawnwood), Q_i is the quantity of material input (roundwood), and c_i is the quantity of capital stock which can be assumed fixed in the short term. The subindex i is used here again for emphasising the separation of the two sawlog markets. Partial differentation of the profit function with respect to roundwood price yields the roundwood demand functions for the pine and the spruce sawlogs (see e.g Hetemäki and Kuuluvainen 1992, Toppinen and Kuuluvainen 1997) Thus, the estimable demand function for a certain sawlog assortment can be expressed as

$$Q_{it}^{d} = f(\underset{+}{P_{it}}, \underset{-}{p_{it}}, \underset{+}{c_{it}}) \quad (3)$$

where $Q_{it}{}^{d}$ is the demand for timber assortment i, P_{it} is the price of the final product made of timber assortment I, and c_{it} is the quantity of capital stock. The signs for comparative static effects are again presented below the explanatory variables.

4 Data and Methods

In contrast to the most of earlier studies on the Finnish roundwood market, we employed quarterly time series. The obvious advantage of quarterly over annual data was that it gave us a sufficient number of observations from the fiscal transition period (from 1993 onwards) for statistical analyses. Compared to monthly data, quarterly data was likely to contain less of the irregular seasonal variation typical of quantities of timber assortments traded in the Finnish roundwood market. In the following, we present a brief description of the variables used. A more detailed description is provided in Appendix 1.

The quarterly time series were obtained by calculating the averages of monthly observations which were available from public sources. The series covered the period from the first quarter of 1986 till the third quarter of 2003 (1986/1–2003/3). The dependent variables of the market models, i.e. the quantities of pine and spruce sawlogs, were the total quantities purchased from non-industrial private forests. The respective market prices were volume-weighted average stumpage prices of pine and spruce sawlogs.

The volume-weighted average unit export prices of pine and spruce sawnwood were used as the prices of final products. The average borrowing rate of commercial banks was used as the interest rate. The volume index of the industrial production of woodworking industry was used as a proxy for the capital stock of the sawmill industry. Therefore the capital stock variable is not to be regarded as the exact amount of sawmills' capital stock but rather as a variable describing the development of the scale of production capacity used for processing coniferous sawlogs.

The growing stock variables were based on simulated national level volumes of NIPF owners' pine and spruce sawlog stocks. Simple linear interpolation was used for converting annual into quarterly observations. A detailed description of the simulation process is presented in Leppänen et. al. (2001).

Prior to estimation, all the nominal prices, as well as the nominal interest rate, were deflated by the cost-of-living index. Because there were negative values in the deflated interest rate series,

Table 2. The results of the ADF tests for the unit root in individual time series.

Variables		t-ADF for level	lag	t-ADF for 1st difference	lag	t-ADF for 2nd difference	lag
lnqpsl	const.	–5.44***	1	–8.47***	2	–	–
lnqssl	const.	–6.04***	0	–9.18***	2	–	–
lnppsl	const., trend	–1.97	1	–5.13***	0	–	–
lnpssl	const., trend	–1.84	1	–5.07***	0	–	–
lnppsw	const., trend	–4.37***	3	–7.58***	0	–	–
lnpssw	const.	–5.19***	1	–5.76***	1	–	–
lnc	const., trend	–2.66	4	–7.28***	3	–	–
lnr	const., trend	–1.82	2	–6.34***	2	–	–
lnvpsl	const.	–1.71	1	–1.67*	0	–8.19***	0
lnvssl	const., trend	–1.68	1	–0.77	0	–8.17***	0

Asterisks denote the rejection of null hypothesis of non-stationarity; *** = rejection at 1% level, **= rejection at 5% level, * = rejection at 10% level, no asterisk = acceptance of null hypothesis.

a level transformation 1+r was made. Finally, all the series were transformed to natural logarithms in order to interpret the estimated coefficients as elasticities. The graphs of the logarithmic variables are shown in Appendix 2.

Furthermore, several dummy variables were introduced. Seasonal dummies were used for controlling the obvious deterministic seasonal variation of the quantity series. For the non-agreement period of the price recommendation institution (1991/2–1994/1) stumpage price slope dummies were used. The reason for using a slope dummy was the intuition that the price agreements were reflected more in market prices than in traded quantities (see also Toppinen and Kuuluvainen 1997). Two observations (1991/2 and 1996/2) of both the sawlog quantity series were interpreted as outliers, for which two level dummies were introduced. Finally and most importantly, three separate dummy variables were used for capturing the supply effects of the forest taxation reform. These taxation dummies described the anticipatory stage (1992/1–1992/4), the beginning of the transition period (1993/1–1994/4), and the middle part of the transition period (1995/1–2003/3).

The time series properties of the logarithmic variables were examined prior to estimation of the market models. The augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller 1979) was applied to the determination of the time series' order of integration. The two simultaneous equations systems consisting of the structural supply and demand equations for the pine and spruce sawlog markets were estimated using the two-stage least squares method (2SLS), in order to prevent possible simultaneous equation bias due to endogenous stumpage prices. The 2SLS method employs as instruments all the exogenous as well as lagged endogenous variables in the structural equations (see e.g. Greene 1993).

5 Results

The results of the ADF tests for unit roots are reported in Table 2. The levels of the variables were tested both with constant and with constant and trend. If the trend proved significant, it was left in the test specification. Following the strategy suggested by Doornik and Hendry (1994), the lag length of the test equation was determined by the last statistically significant lag. When testing the first differences, neither constant nor trend were included in the test equation. In case there was evidence of first differences being non-stationary, we proceeded with testing the second differences.

According to Table 2 the dependent variables, i.e. the quantities of pine and spruce sawlogs, are stationary series at the 1% level. Also the prices of final products, i.e. the export prices of pine and spruce sawnwood, are interpreted as stationary series at the 1% level.

The levels of the interest rate and the capital stock are interpreted as non-stationary series, but their first differences are stationary, which indicates integration of order 1. As is typical of

Table 3. Results of Johansen's cointegration analysis between the stumpage prices of pine and spruce sawlogs, 1986/1–2003/3.

Test pair	CE	lag	H_0	eigen-value	LR_{tr}	95% critical value	99% critical value
lnppsl,	constant	2	r=0	0.07	5.44	15.41	20.04
lnpssl			r≤1	0.00	0.31	3.76	6.65
lnppsl,	constant,	2	r=0	0.18	18.65	25.32	30.45
lnpssl	trend		r≤1	0.07	5.07	12.25	16.26

LR_{tr} refers to the trace test value (Johansen 1995). The deterministic variables of the hypothetical cointegration relation are presented in column CE. Column H_0 indicates the tested null hypothesis of the number of cointegrating vectors, i.e. the rank of the long-run matrix.

many simulated series, the statistical properties of the growing stock series seem to be problematic. There is evidence that the first differences of the volume series of pine and spruce sawlog stocks are non-stationary, indicating integration of order 2, which is however very unlikely for forest inventories.

For neither pine nor spruce stumpage price series is the null hypothesis of non-stationarity rejected. However, the first differences of these series are stationary, indicating again of integration of order 1. This finding, on the other hand, allowed us to test the validity of the explicit division of the coniferous sawlog market into pine and spruce sawlog markets. If pine and spruce sawlogs belonged in the same market, the concept of so-called law of one price (LOP), i.e. 'same price for same product', should hold between their prices. Under the LOP the long-term development of prices is uniform, which in the case of I(1) series is valid if the series are cointegrated, i.e. their linear combination produces stationary residuals (the literature is extensive; see e.g. Toppinen and Toivonen 1998).

Therefore we proceeded with testing the market integration of the pine and spruce sawlogs using Johansen's cointegration analysis method (Johansen 1988, 1995). In the case of a bivariate model, one cointegrating vector should be found in the test VAR if the variables are cointegrated. The results of Johansen's cointegration analysis in Table 3 indicate that the stumpage prices cannot be considered cointegrated and therefore the LOP does not hold. Consequently, the inclusion of pine and spruce sawlogs in the same market would be theoretically unjustified. The differentiated stumpage price development likely originated from the differentiated market demand for the spruce and the pine sawnwood markets. However, the supply side characteristics, such as regionality of the wood market, may also have influenced the behaviour of stumpage prices (see Toppinen and Toivonen 1998).

To summarise the results from the statistical tests on time series properties, the levels of the dependent quantity variables were I(0), whereas some of the levels of the explanatory variables were I(0) and some not. Furthermore, differencing the data once would not have removed the problems related to non-stationarity, as the growing stock variables showed integration of order 2. Estimation experiments with the difference-form variables (without the growing stock variables) did not produce significant changes in parameters compared to the level-form estimations. Therefore the reported demand and the supply models for the pine and the spruce sawlog markets were estimated using mainly the levels of the variables.

The structural demand and supply equations for the pine and the spruce sawlog markets are presented in Table 4. The actual quantities and fits of the models are shown in Appendix 3. According to the diagnostic tests, the residuals of the models are not autocorrelated or heteroscedastic. The residuals also seem to be stationary. Consequently, the models do not suffer from critical misspecifications and the interpretation of estimated coefficients is justified (however, one must bear in mind the t-statistics-related conditions set by I(1) series).

As can be seen, all the relevant variables in both the demand and supply models have the expected signs, indicating that the assumption of perfect competition is relevant for describing the Finnish pine and spruce sawlog markets. This finding

Table 4. Results of 2SLS estimation for pine and spruce sawlog market models, 1986/1–2003/3.

Dependent variable: lnqpsl / lnqssl (quantity of pine / spruce sawlog) Independent variable	Pine sawlog market model Demand 2SLS-coefficient (t-statistics)	Pine sawlog market model Supply 2SLS-coefficient (t-statistics)	Spruce sawlog market model Demand 2SLS-coefficient (t-statistics)	Spruce sawlog market model Supply 2SLS-coefficient (t-statistics)
Constant	–7.21**	–1.98	–3.04	–17.98**
	(–2.10)	(–1.02)	(–0.90)	(–2.02)
lnppsl / lnpssl	–0.85*	7.11***	–0.91*	7.72***
(price of pine / spruce sawlog)	(–1.91)	(4.77)	(1.70)	(–4.72)
lnppsl(–1) / lnssl(–1)	–	–5.00***	–	–5.60***
(lagged price of pine / spruce sawlog)	–	(–2.83)	–	(–3.08)
lnppsw / lnpssw	1.93***	–	1.34**	–
(export price of pine / spruce sawnwood)	(2.93)	–	(2.04)	–
lnc	1.56***	–	1.50***	–
(production capacity of sawmill industry)	(4.37)	–	(3.74)	–
Δlnr	–	15.77***	–	13.53**
(difference of interest rate)	–	(3.17)	–	(2.45)
lnvssl(–1)	–	–	–	3.23**
(initial growing stock of spruce sawlog)	–	–	–	(2.37)
lnqpsl(–1) / lnqssl(–1)	0.20*	0.25***	0.13	0.11
(lagged quantity of pine / spruce sawlog)	(1.81)	(3.15)	(1.12)	(1.25)
Dtax1	–	0.88***	–	0.86***
(dummy for year 1992)	–	(4.19)	–	(4.89)
Dtax2	–	0.68***	–	0.51**
(dummy for years 1993–1994)	–	(2.71)	–	(2.60)
Dtax3	–	0.52***	–	0.42***
(dummy for years 1995–2003)	–	(4.55)	–	(5.10)
D1	–0.57***	–0.66***	–0.55***	–0.63***
(seasonal dummy for 1st quarter)	(–4.84)	(–8.77)	(–4.12)	(–7.38)
D2	–0.64***	–0.37***	–0.74***	–0.50***
(seasonal dummy for 2nd quarter)	(–4.89)	(–3.87)	(–5.10)	(–4.70)
D3	–0.01	–0.13*	–0.09	–0.25***
(seasonal dummy for 3rd quarter)	(–0.06)	(–1.69)	(–0.72)	(–2.82)
Dout1	–1.93***	–1.27***	–1.88***	–1.25***
(dummy for observation 1991/2)	(–5.62)	(–5.04)	(–4.93)	(–4.51)
Dout2	–0.93**	–1.12***	–0.98**	–1.16***
(dummy for observation 1996/2)	(–2.64)	(–5.00)	(–2.45)	(–4.55)
R^2	0.70	0.88	0.62	0.86
JB (normality)	0.30	1.07	0.06	0.17
DW (1st order autocorrelation)	1.88	2.29	1.81	2.42
LM_{BG} (higher than 1st order autocorrelation)	2.91	5.06	3.51	9.80
$LM_{(ARCH)}$ (heteroscedasticity)	6.60	1.49	5.22	1.19

Asterisks denote the significance of a variable: *** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level, no asterisk = insignificant.

is consistent with previous studies on Finnish sawlog markets (see e.g. Toppinen and Kuuluvainen 1997). The significant coefficients of the seasonal dummies in the demand and supply models indicate that there is plenty of seasonal variation in the quarterly quantities of pine and spruce sawlogs traded in the Finnish roundwood market. The stumpage price slope dummies for 1991/2–1994/1 were not significant in any of the models and were therefore excluded from the final models.

Because the focal point of the study is the change in sawlog markets induced by the forest taxation system, the following paragraphs will focus on an examination of the roundwood supply equations. Although giving important information, the demand equations play a somewhat subordinate role in providing the instrumental variables required for the estimation procedure of the supply equations.

In both the supply models, the coefficients of determination are high and the short-term own-price effects are large. This phenomenon, however, is not due to the presence of the trending series, as the strong interdependence of the quantities and the prices of sawlogs was also evident in the difference-form data. In comparison with the short-term own-price elasticities of supply, 7.11 for pine sawlogs and 7.72 for spruce sawlogs, the long-term own-price elasticities (the differences between current prices and price expectations coefficients, weighted by the partial adjustment terms, i.e. the lagged roundwood quantities (Koutsoyannis 1977)) are more moderate by their absolute values, i.e. 2.81 for the pine and 2.38 for the spruce. Although these values are high, the own price elasticities of supply are consistent with some of the previous Finnish roundwood market studies. Toppinen and Kuuluvainen (1997), for example, found, using *annual* data that the long-term own-price elasticity of the supply of coniferous sawlog was 2.7 in 1976–1992. Thus it seems that in the Finnish sawlog market, the strong price effects of supply are indeed real and not dependent on estimation period or temporal structure of the data used.

The interest rate was introduced into the supply models as a stationary difference. Due to the level transformation, the seemingly strong effects of the interest rate must be understood as percentage changes in supplied sawlog quantities due to each one *percentage unit change* in the interest rate ($\ln r = \ln(1 + r) \approx r$ and $\ln(1 + r_{t+1}) - \ln(1 + r_t) \approx r_{t+1} - r_t = \Delta r$). The interest rate has the expected positive sign in both the supply models, which implies that the forest owners have not faced imperfections, e.g. binding credit rationing, in the capital market. This interpretation is quite acceptable, as the Finnish capital market liberalisation was completed by year 1986.

As mentioned before, the growing stock variables were problematic in their statistical properties. Furthermore, there was a distinctive difference between developments in the pine and spruce sawlog stocks. During the fiscal transition period the pine sawlog stock has been steady, while the spruce sawlog stock has decreased drastically (Appendix 2). The differentiated development of the pine and the spruce sawlog stocks can be considered an extra reason why these two timber assortments should not be included in the same market. The estimation experiments showed that the stock variable was insignificant in the pine sawlog supply model and so it was not included in the final model. However, in the spruce supply model the stock variable received a significant positive coefficient 3.23. The quantity of spruce sawlog stocks was left also in the final spruce sawlog supply model, for it did not, despite its time series properties, affect the values or t-statistics of the coefficients of the other variables.

As expected, the forest taxation reform has increased the aggregate level supply of spruce and pine sawlogs during both the anticipatory stage of the transition period in 1992 and the transition period itself. It appears that during the anticipatory stage the positive effect of taxation reform on the supply of sawlogs was stronger than during the beginning or the middle section of the fiscal transition period. It also seems that the increase in the supply of both pine and spruce sawlogs has been greater at the beginning of the transition period than in the middle part. This, however, may be due to the length of dummy variable used for describing the middle part. According to Finnish forest statistics, the proportion of roundwood originating from forest estates subject to site productivity taxation varied between 52–56% in 1997–2002 (Finnish Statistical… 2003). Thus during the fiscal transition period the site-productivity-taxed NIPF owners' proportion of total roundwood supply has been larger than could have been expected based on their proportion of total harvestable forest resources. In other words, the NIPF owners subject to site productivity taxation have actually increased their supply of roundwood during the transition period. At the same time forest owners subject to timber sales profit taxation have reduced, or rather adjourned, the sale of roundwood because of either negative developments in the current price of roundwood or positive post-transition-period price expectations, for example. Apparently, and also in the light of this study, this decrease in cuttings by NIPF owners subject to timber sales profit taxation was counterbalanced and even exceeded by the increase in cuttings by forest owners who chose to continue in site productivity taxation.

As regards the demand models, the demand for pine sawlog has been more elastic with respect to the own price as well as to the price of the final product than has the demand for spruce sawlog. Problems with obtaining negative own-price elasticities for the spruce sawlog demand, as encountered in Hetemäki et al. (2004), were not present here, possibly due to our simultaneous equations approach. The proxy variable for capital stock receives a significant positive coefficient, nearly of the same value in the two demand models. When interpreting coefficients of the capital stock, one should bear in mind that the capital stock variable is the same in the two demand models. However, in reality the volume of production capacity used for processing pine sawlogs may have developed differently from the volume of production capacity used for processing spruce sawlogs. Although not statistically significant, the lagged sawlog quantities, which can be interpreted as variables describing the adjustment process of production towards the optimal level (Brännlund 1988), were included in both the final demand models, because they improved the statistical properties of the residuals.

6 Conclusions

The aim of this study was to examine the supply effects of forest taxation reform on the Finnish sawlog market. Two separate simultaneous equations systems were estimated for pine and spruce sawlogs. According to the results, the taxation reform, as expected, increased the supply of sawlogs in the anticipatory stage before the fiscal transition period. An increase in the supply of sawlogs is also visible in the fiscal transition period. Consequently, this study suggests that the actual supply effects of the forest taxation reform have been – so far – similar to those expected. However, conclusions concerning the exact supply behaviour of the different taxation groups are only suggestive, given the use of aggregate market level data.

All in all, the actual effects of the taxation reform on the supply of roundwood seem to have been less dramatic than was assumed before the initiation of the reform. The fear of a serious oversupply of roundwood, for example, has proved premature. The strong own-price elasticity of sawlog supply found in this study indicates a high sensitivity to actual and expected stumpage price changes in the determination of sawlog supply in Finland. This observation may provide us some insight into the Finnish sawlog market after 2005, as it seems that the level of sawlog supply is critically dependent on stumpage price development.

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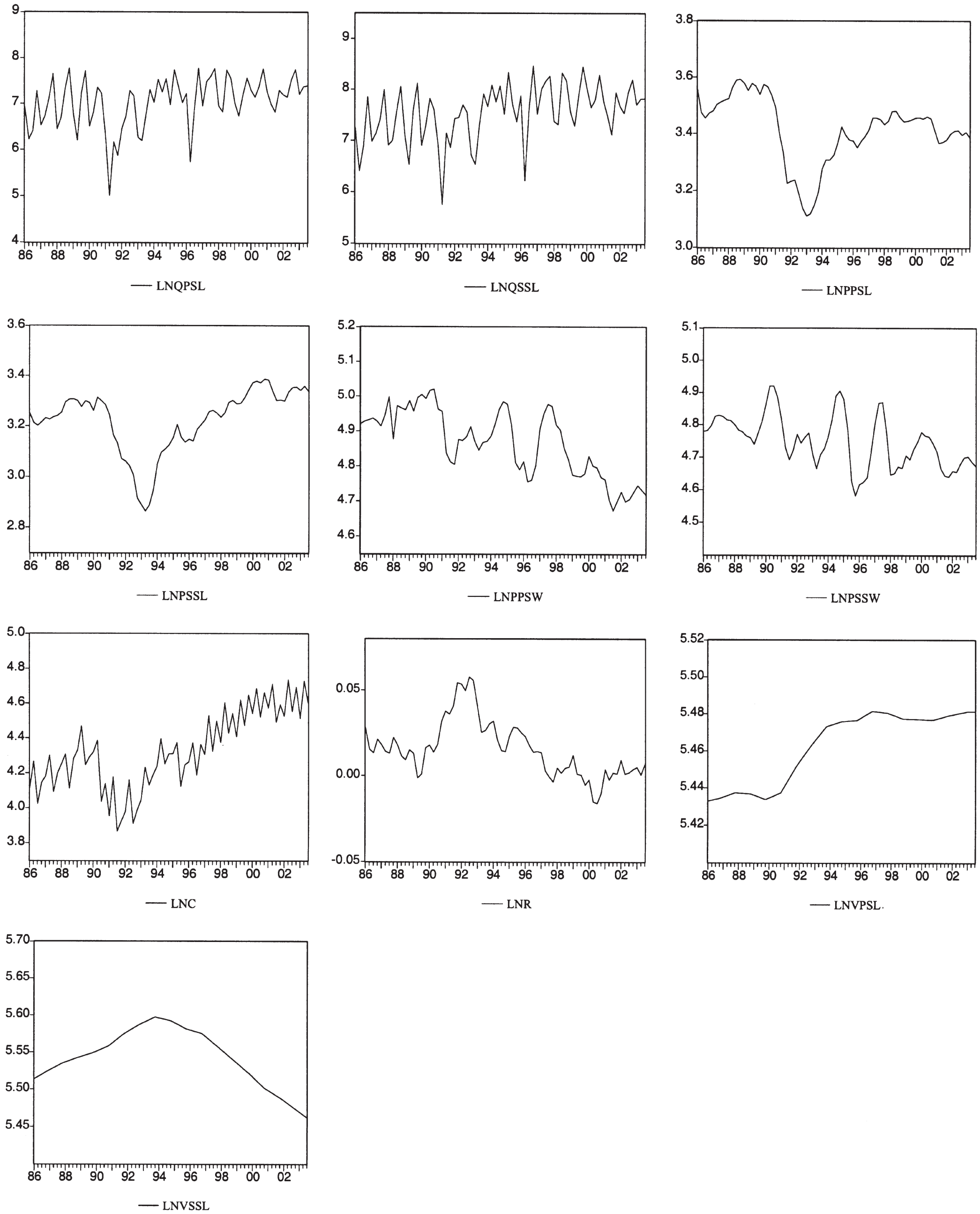
Appendix 1. The description of the variables.

Acronym	Variable	Unit	Description	Data Source
lnqpsl	Quantity of pine sawlogs	m^3	Total quantity of pine sawlogs traded between NIPF owners and forest industry in Finland.	Finnish Forest Res. Institute: Metinfo
lnqssl	Quantity of spruce sawlogs	m^3	Total quantity of spruce sawlogs traded between NIPF owners and forest industry in Finland.	Finnish Forest Res. Institute: Metinfo
lnppsl	Real unit price of pine sawlog	€/m^3	Stumpage price of pine sawlog. Quarterly data consists of volume-weighted averages of monthly observations.	Finnish Forest Res. Institute: Metinfo
lnpssl	Real unit price of pine sawlog	€/m^3	Stumpage price of spruce sawlog. Quarterly data consists of volume-weighted averages of monthly observations.	Finnish Forest Res. Institute: Metinfo
lnppsw	Real unit price of pine sawnwood	€/m^3	Export price (FOB) of pine sawnwood. Quarterly data consists of volume-weighted averages of monthly observations.	Finnish Board of Customs
lnpssw	Real unit price of spruce sawnwood	€/m^3	Export price (FOB) of spruce sawnwood. Quarterly data consists of volume-weighted averages of monthly observations.	Finnish Board of Customs
lnc	Proxy for production capacity of sawmills	Volume index	Production volume index of woodworking industry. Quarterly data consists of arithmetic averages of monthly observations.	Research Institute of Finnish Economy
lnr	Real interest rate	1/100	Average borrowing rate of commercial banks. Quarterly data consists of arithmetic averages of monthly observations. Before taking logarithms, transformation 1+r was executed (r is the real interest rate).	Research Institute of Finnish Economy
lnvpsl*	Growing stock of pine sawlog	m^3	Growing stock quantities based on a simulation which employed national forest inventory data as checkpoints.	M.Sc. Jussi Leppänen, Metla
lnvssl	Growing stock of spruce sawlog	m^3	Growing stock quantities based on a simulation which employed national forest inventory data as checkpoints.	M.Sc. Jussi Leppänen, Metla
prinegppsl*	Slope dummy for 1991/2–1994/1	€/m^3	1*lnppsl in 1991/2–1994/1and 0 elsewhere.	
prinegpssl*	Slope dummy for 1991/2–1994/1	€/m^3	1*lnpssl in 1991/2–1994/1 and 0 elsewhere.	
Dtax1	Dummy for 1992		Level dummy for the anticipatory stage of the forest taxation reform. 1 in 1992/1–1992/4 and 0 elsewhere.	
Dtax2	Dummy for 1993–1994		Level dummy for the beginning of the fiscal transition period. 1 in 1993/1–1994/4 and 0 elsewhere.	
Dtax3	Dummy for 1995–2003		Level dummy for the middle section of the fiscal transition period. 1 in 1995/1–2003/3 and 0 elsewhere.	
Dout1	Dummy for 1991/2		Level dummy for sawlog quantity series' outlier caused by the NIPF owners' timber sales 'strike'. 1 in 1991/2 and 0 elsewhere.	
Dout2	Dummy for 1996/2		Level dummy for sawlog quantity series' outlier caused likely by the anomalities in the coniferous sawnwood import markets. 1 in 1996/2 and 0 elsewhere.	
D1, D2, D3	Seasonal dummies		D1 is 1 at 1^{st} period of each year and 0 elsewhere. In the same way, D2 is 1 at 2^{nd} period and D3 is 1 at 3^{rd} period.	

All variables, the acronym of which starts with letters ln are in natural logarithmic form. Those variables, which were not included in the final models, are marked with an asterisk (*). Prices were deflated with respect to the price level of 1986/1 using the cost-of-living index. Real interest rate was composed by deducting the annual inflation rate, which was measured by the annual relative change of the cost-of-living index, from the nominal interest rate series.

Appendix 2. The graphs of the variables (excluding the dummy variables).



Appendix 3. Actual and fitted values and residuals.