EFORWOOD
Tools for Sustainability Impact Assessment

An econometric analysis of timber supply in eight northwestern European countries

Norwegian University of Life Sciences (UMB)
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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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EFORWOOD

Tools for Sustainability Impact Assessment

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Deliverable D1.3.3
AN ECONOMETRIC ANALYSIS OF TIMBER SUPPLY IN EIGHT NORTH-WESTERN EUROPEAN COUNTRIES

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	

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ABSTRACT

The paper presents an econometric analysis of the timber supply in eight North-Western European countries. For each country, the time series covers the years 1980 - 2006. Analysed explanatory variables are roundwood (log) price, real rate of interest and the growing stock. Different linear and log-linear models were tried, with common and individual slope and intercept coefficients, in addition to models where the countries were grouped. In the completely homogeneous models, we did not obtain significant price estimate, neither in the partly heterogeneous (with common slope coefficients and country-specific intercept) log-lin models. However, in the partly heterogeneous linear models, use of inverse FE (Fixed Effects) models gave positive and significant coefficients of price (0.25). The OLS and GLS estimators of the partly heterogeneous models are not consistent due to correlation between the explanatory variables and the latent country-specific effect. OLS estimation of the fully heterogeneous model resulted in wrong sign of many estimates. Dividing the countries into four groups gave significance of seven of the eight estimates, but unlikely high growing stock coefficient estimates (up to 2.16). Grouping the countries into two groups did not give significant price estimates, but more likely estimates of growing stock coefficients (circa 1.00).

Keywords: Econometric analysis, timer supply, panel data

1. INTRODUCTION

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In the EFORWOOD project, forest sector modelling applying the EFI-GTM global forest sector model is important for estimating the impacts of international trade. One vital component in this model is the magnitude of the timber supply elasticities, in particular in Europe, and in EFORWOOD econometric estimation of European timber supply elasticities was thus included as a particular task (specified as deliverable D1.3.3). The main objectives of this report is to analyse the timber supply elasticities in Europe at national and regional (sum of nations) level, applying panel data at national level.

Several studies of timber supply with use of panel data and FE (Fixed Effects) or RE (Random Effects) econometric methods are done like Bolkesjø & Solberg (2003), Bolkesjø, Solberg & Wangen (2008); Bolkesjø, Buongiorno & Solberg (2008). All these studies are, however, done at sub-national level, and Turner, Buongiorno & Zhu (2006) is the only panel study we have come across published on aggregated national data. They used ordinary pooled data for two selected years, but included all countries in the world covered by the FAO statistics.

The report is structured like this: First, we describe the methodology and data material, with emphasis on econometric specification and testing, and the origin of the empirical data. Then we present and discuss the main results, and finally conclusions are drawn.

2. METHODS AND MATERIAL

2.1 Economic model

Based on previous timber supply studies (e.g. Baardsen 1998 and the above mentioned literature) we assume that the timber supply depends on a range of variables including timber prices, interest rate, forest growing stock, owner characteristics (like age and income), national characteristics (capacity of forest industries, GDP growth, income level, taxes and regulations, etc.).

Since the EFI-GTM forest sector model includes prices and growing stock endogenously, we decided to concentrate on these two variables. In addition, we included the interest rate as explanatory variable, as it reflects the opportunity cost of capital and also influences the GDP growth and thus the demand for timber.

We have thus two groups of models. The following variables were included in the first group (group A) (assumed correlation between the explanatory variables and the dependent variable is in parenthesis):

Dependent variable: Harvested volume of industrial coniferous roundwood
Explanatory variables:

- Log price (+)
- Growing stock (+)
- Real rate of interest (+)

The second group (group B) excludes the interest rate variable as looks thus like:

Dependent variable: Harvested volume of industrial coniferous roundwood
Explanatory variables:

- Log price (+)
- Growing stock (+)

Harvest is assumed positively correlated with log price, growing stock and real rate of interest. The remaining explanatory variables were assumed to be covered by the choice of econometric method – as FE (or RE) specification (cf. chapter 2.3) were supposed to include significant national characteristics in addition to the above three explanatory variables.

2.2 Data

The original panel consists of data from 1980 to 2006 of the following thirteen European countries: Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and UK. Belgium was not included because of lack of data. However, some of the time series were for different reasons assessed to be of inadequate quality for this study, and therefore, data from Denmark, Italy, Portugal, Spain and UK were omitted. The remaining data set consists thus of the eight countries Austria, Finland, France, Germany, Netherlands, Norway, Sweden and Switzerland. In addition, the remaining panel was divided into two groups, the years up to 1992, and the years from 1993 to 2006. This division was chosen because the time series seemed to have much more volatility in the first period, whereas the market seems to be less volatile after 1992 (probably due to reconstruction of the monetary systems and policy following the breakdown of the Europeans Monetary System, affecting interest rates and exchange rates in particular). We expected thus better correlation in the second period.

<u>Country name codes (in results tables):</u>
Austria: AU
Finland: FI
France: FR
Germany: GE
Netherlands: NE
Norway: NO
Sweden: SE
Switzerland: SW

Data of harvest are from the UNECE Timber database of July 2007, while log prices and traded quantities were collected from Faostat (2008). However, this database does not provide domestic prices of wood, but quantities and total values of export and import. To obtain prices in the respective countries, a weighted price was found by using the formula:

$$\text{Weighted price} = \frac{\text{total export value + total import value}}{\text{export quantity + import quantity}}$$

From 1990, the Faostat database only reports trade statistics for the aggregate "industrial coniferous roundwood", which was used directly to calculate the weighted price. Until 1989, the industrial coniferous roundwood is divided into three groups, coniferous sawlogs + veneer logs, coniferous pulpwood and other coniferous roundwood. However, only data of the aggregate of all pulpwood (i.e. the sum of coniferous and non-coniferous) are available in the categories "values" and "traded quantities". For 1980-1989, the log price has thus been calculated as the weighted price of the (weighted) prices of pulpwood and coniferous sawlogs prices (data of other industrial coniferous roundwood price are neither available). This may cause bias, but pulpwood consists mostly of coniferous species in Europe, and "other industrial roundwood" includes rather small quantities.

All values were given in US dollars, but to take both inflation and exchange rate variation into account, and to have all values on the same scale, the below procedure was followed:

1. Current prices in US dollars were converted into national currencies using current exchange rates.

2. Current prices in national currencies were inflated into 2006 value using consumer price index for each country.
3. The 2006 prices were therefore converted into dollar. To avoid bias due to extreme exchange rates in some years, the average exchange rate for the years 1980-2006 was used. For the countries which changed their currency into Euro in 1999, the conversion factor 1980-1998 is the average exchange rate in these years, and the conversion factor after 1999 is the average exchange rate between Euro and dollar from 1999. For non-Euro countries, the conversion factor is the average for the years 1980-2006. Converting the currency changes the mean and the variance, as well as the mean of the log(variable). However, the variance of the log(variable) is unaffected.

This procedure was used because forest owners face prices in national currencies and not in dollar, making the conversion from dollar necessary. But since the country data are pooled into the panel and are analysed together in one model, the currency has to be on the same scale for all countries, and the national currencies were therefore converted back to dollar using 1 (2 for Euro-countries) exchange rates.

Data of growing stock for the years 1980 and 1990 are from Kuusela (2004). For the years after 2000 and 2005, the data are from the MCPFE (2007). To obtain a yearly growing stock, the data were interpolated and extrapolated. The MCPFE report does not contain data for Germany in 2005, so this observation was found in Federal Ministry of Food, Agriculture and Consumer Protection (2007).

Storms have caused exceptionally high removals in some countries and years, and may also cause price disturbances, leading to troubles in estimation. Storm years were found in the DFDE database (developed by the European Forest Institute and the Alterra in the Netherlands), covering all countries investigated except Norway. But this database only covers the years up to 1999, and distinguishes only to a limited degree between coniferous and broadleaves. Storm may trouble the market more in the years after the storm than in the storm year itself (for example, the storm in 1999 occurred in end of December). Thus, observations of harvest and price in years with exceptional high harvest and storm fellings were excluded with use of the DFDE database, detection of sudden changes in removals and visual inspection. The observations dropped due to high storm fellings are displayed in Table 1.

Table 1: Observations of harvest and price deleted from the data set due to large storm fellings.

Country	Years dropped
Austria	1990
Finland	None
France	1990, 2000, 2001
Germany	1990, 2000
Netherlands	None
Norway	None
Sweden	2005
Switzerland	1990, 2000, 2001

Data of country-specific inflation are from World Economic Outlook's online database (http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/index.aspx). Nominal interest rates and exchange rates are from International Financial Statistics' online database (http://www.imfstatistics.org/imf). Due to negative numbers, all interest rates were added the constant 10. The variance of the linear model is not affected by this adding, while the constant adds 10 to the mean in the linear model. Thus, the slope coefficient estimate in the linear model remains the same with the added constant. Both the mean and the variance of the log(variable) are changed, and thus also the estimate of the slope coefficient. The interpretation of the slope coefficient becomes thus more difficult.

Table 2 presents summary of the data, before adding the constant to the interest rates. The figures of the four time series are displayed in the appendix.

Table 2: Statistics for the variables used.

Variable	Obs	Mean	Std. Dev.	Min	Max
harvest	206	19099.54	16353.63	522	57800
log_price	206	72.9847	20.13412	39.20713	153.9851
gr_stock	216	1370.067	972.3394	23.3625	3401.003
real_int_r~e	216	2.983473	2.510646	-4.53898	15.7608

In Table 3, the correlation matrix is presented. Harvest is negatively correlated with price and positively correlated with the other variables. The correlation between harvest and growing stock is high, while the correlation between harvest and the other explanatory variables is rather small. Harvest and log price are negatively correlated. Within the independent variables, is does not seem to be high correlation.

Table 3: Correlation matrix.

	harvest	log_pr~e	gr_stock	real_i~e
harvest	1.0000			
log_price	-0.0822	1.0000		
gr_stock	0.8601	-0.1228	1.0000	
real_int_r~e	0.1243	0.0060	0.0786	1.0000

2.3 Econometric model specification

Two groups of econometric models are considered. Group A has three explanatory variables; price, real rate of interest and growing stock. Group B has two explanatory variables; price and real rate of interest.

Model group A:

Model log-1: Log-lin model with common intercept and slopes
$\ln(y_{it}) = \alpha + \beta_1 * \ln(x_{it,1}) + \beta_2 * \ln(x_{it,2}) + \beta_3 * \ln(x_{it,3}) + u_{it}$

Model log-2: Log-lin model with common slopes and individual intercept
$\ln(y_{it}) = k + \alpha_i + \beta_1 * \ln(x_{it,1}) + \beta_2 * \ln(x_{it,2}) + \beta_3 * \ln(x_{it,3}) + u_{it}$

Model log-3: Log-lin model with individual slopes and intercept
$\ln(y_{it}) = k + \alpha_i + \beta_{i,1} * \ln(x_{it,1}) + \beta_{i,2} * \ln(x_{it,2}) + \beta_{i,3} * \ln(x_{it,3}) + u_{it}$

The first model is fully homogenous. Model 2 is heterogeneous in the intercept (partly heterogeneous), while the third model is heterogeneous in the slope coefficients, as well as in the intercept (fully heterogeneous).

In addition, three corresponding linear models are studied:

Model lin-1: Linear model with common intercept and slopes
$y_{it} = \alpha + \beta_1 * x_{it,1} + \beta_2 * x_{it,2} + \beta_3 * x_{it,3} + u_{it}$

Model lin-2: Linear model with common slopes and individual intercept
$y_{it} = k + \alpha_i + \beta_1 * x_{it,1} + \beta_2 * x_{it,2} + \beta_3 * x_{it,3} + u_{it}$
Model lin-3: Linear model with individual slopes and intercept
$y_{it} = k + \alpha_i + \beta_{i,1} * x_{it,1} + \beta_{i,2} * x_{it,2} + \beta_{i,3} * x_{it,3} + u_{it}$

Model group B:

Log models:

Model log-1: Log-lin model with common intercept and slopes
$\ln(y_{it}) = \alpha + \beta_1 * \ln(x_{it,1}) + \beta_2 * \ln(x_{it,2}) + u_{it}$

Model log-2: Log-lin model with common slopes and individual intercept
$\ln(y_{it}) = k + \alpha_i + \beta_1 * \ln(x_{it,1}) + \beta_2 * \ln(x_{it,2}) + u_{it}$

Model log-3: Log-lin model with individual slopes and intercept
$\ln(y_{it}) = k + \alpha_i + \beta_{i,1} * \ln(x_{it,1}) + \beta_{i,2} * \ln(x_{it,2}) + u_{it}$

Linear models:

Model lin-1: Linear model with common intercept and slopes

$y_{it} = \alpha + \beta_1 * x_{it,1} + \beta_2 * x_{it,2} + u_{it}$

Model lin-2: Linear model with common slopes and individual intercept
$y_{it} = k + \alpha_i + \beta_1 * x_{it,1} + \beta_2 * x_{it,2} + u_{it}$

Model lin-3: Linear model with individual slopes and intercept
$y_{it} = k + \alpha_i + \beta_{i,1} * x_{it,1} + \beta_{i,2} * x_{it,2} + u_{it}$

2.4 Tests and estimation

OLS provides MVLUE (minimum variance, linear unbiased estimators) of the coefficients in the models with only homogenous parameters (Biørn 2007).

Consider one of the partly heterogeneous models:

$y_{it} = k + \alpha_i + \mathbf{x}_{it}\boldsymbol{\beta} + e_{it}$, $e_{it} \sim IID(0, \sigma^2)$, i = 1, ... N, t = 1, ... , T

We can choose whether we will consider this model as fixed or random. If the model is considered as a random effect (RE) model, the α_i's are supposed to be stochastic, with a distribution around 0, and a variance σ_α^2. These variables contain country-specific factors which are not specified in the model. Population density, the economic importance of forest sector and property structure may be such factors. In a fixed effect (FE) model, the α_i's are seen as unknown constants. Whether the model is regarded as fixed or random influences the consistency and the efficiency of the estimators, as the estimation method is different for the two models. A relevant question is whether unobserved heterogeneity between the countries is present, and if this heterogeneity is so large that it should be taken into consideration in the model specification. If there is such heterogeneity, the next question is the correlation between this heterogeneity and the explanatory variables. Let us look at this first point first.

There are several indicators which can be used to test the occurrence of such heterogeneity:
1. From the output of the statistical software, we can obtain the results of a F-test of the hypothesis that $\sigma_\alpha^2 = 0$ from the FE estimation. The total unexplained variance in the model is given by $\sigma_\alpha^2 + \sigma^2$.

2. The RE report indicates how much of the total unexplained variance which is due to the individual heterogeneity, $\sigma_\alpha^2 /(\sigma_\alpha^2 + \sigma^2)$.

3. Breusch-Pagan test is performed of the RE model: H_0: $\sigma_\alpha^2 = 0$ vs. H_1: $\sigma_\alpha^2 > 0$.

If we have stated that there is such individual heterogeneity, the next question is whether the latent (unobserved) heterogeneity (α_i) is correlated with some of the explanatory variables. This question is important in deciding if the RE or the FE model is to be used. The RE model with

GLS estimation is the most efficient method, but for being consistent, it requires that all explanatory variables are uncorrelated with α_i (Hausman and Taylor 1981). OLS provided inconsistent estimators of the same reason; in addition, the OLS estimators are less efficient than the GLS estimators. If there is correlation, a kind of misspecification problem arises (omitted variables bias), resulting in inconsistence. The estimates of the coefficients will be affected by the $\alpha_{i,}$ and hence, we are not able to estimate the partial effect of x_{it1} on y_{it}.

What about the FE model? The estimation method for FE models is within-estimation, where only the variation within the countries is exploited for estimating the slope coefficients. Using within-estimation solves one problem and give arise to several others: Even if there is correlation between the unobserved heterogeneity and some of the explanatory variables, the within-estimation provides consistent and estimators of the slope coefficients. While this of course is a strength it comes at a cost: As a consequence of only applying the variation within the countries, it is not possible to distinguish the country-specific effect α_i and the effects of the individual explanatory variables, if any (not any in our models). We only get one estimator of these coefficients together, which is hard to interpret. It is for the same reason not possible to obtain the estimates of the countries' intercept in this estimation method. We may also be interested in the effects of the individual variables, which we are not able to find using the within-estimation. In addition, the estimates obtained (i.e. the estimates of $\boldsymbol{\beta}$) are not efficient, since only the within-variation is used for estimation, and nothing of the between-variation. The estimators' variance is consequently larger than in the RE model. Thus, there is a trade-off between efficiency and robustness. The third problem while using within-estimation is the consistency of the α_i's, which are consistent only if T (the number of periods) goes to infinity. If N (the number of countries) goes to infinity and T is finite, then the number of variables increases to infinity, while the number of observations rests limited, resulting in inconsistent α_i's.

The printout of the FE model gives an estimate of the correlation between the fixed effect and the regressors. We can also make a formal test for the correlation between the regressors and the country-specific effects (the so-called Hausman specification test):

The average of the observations over the periods within a country is given by

$$\bar{x}_{i*} = \frac{1}{T}\sum_{t=1}^{T} x_{it}\ , (i = 1, \ldots, N, t = 1, \ldots, T).$$

The correlation between α_i and the explanatory variables vector $\bar{x}_1$ is formalized as

$\alpha_i = c + \bar{x}_{i*}\boldsymbol{\lambda} + u_i$

H_0: $\boldsymbol{\lambda} = \mathbf{0}$. Both within and GLS estimators are consistent, GLS is efficient.
H_A: $\boldsymbol{\lambda} \neq \mathbf{0}$. GLS estimators are not consistent

We thus have the choice between the more efficient, but not always consistent RE, and the more robust FE, which is consistent even when correlation between the variables and the country-specific effect is present.

FE estimators only exploit the variation within the country, and are calculated on the basis of the distance from each year's observation to the average over all years for each country:

$$\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \bar{x}_{i*}) \text{ , (i = 1, …, N, t =1, …, T).}$$

But it is also possible to calculate the estimators the other direction. Instead of calculating the observations' distance from the average over all periods for each country, we calculate the distance from the average over all countries, for each period:

$$\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \bar{x}_{*t}) \text{, } \bar{x}_{*t} = \frac{1}{N}\sum_{i=1}^{N} x_{it} \text{ , (i = 1, … N, t =1, … T).}$$

Thus, it is the variation within the time periods which is exploited in the estimation.

We also found that the autocorrelation of first degree is so small that the OLS estimators of the parameters of model 3 (full heterogeneity) are MVLUE.

3. RESULTS AND DISCUSSION

3.1 Model group A

Log-lin models

Heterogeneity

All heterogeneity tests were performed in the log-lin model 2 (partly heterogeneous). The fraction of the variance in the RE model due to α_i, i.e. the unexplained individual variance, is 0.86. From the result of the Breusch-Pagran multiplier test of zero variance of the individual effect (H_0), we reject H_0 on a 1 % level ($chi^2(3) = 141.72$). The F-test performed in the FE estimation (7, 195) reject the H_0 that $\sigma_\alpha^2 = 0$ on a 1 % level. All these tests give the same result: There is large heterogeneity between the countries which is not taken into consideration in the models. The next question is if this individual effect is correlated with some of the explanatory variables.

From the FE model output, the correlation between the regressors and the fixed individual effect is reported to 0.93. Thus, the condition of consistency is violated.

Hausman specification test was impossible to execute, due to assumptions of the test which were not met. However, even without the result of the test, we can conclude that the RE is inconsistent, since the assumption of no correlation between the independent variables and the country-specific effect is not satisfied. In our model, without any country-specific (time-invariant) variables, FE may be used for estimating all variables except the country dummies. For estimation of the country dummies (model 2), we use the inverse FE, explained earlier. Even if FE estimation method is less efficient, it is more robust, which is also true for the inverse FE.

Table 4 displays the result of the pooled OLS estimation of the model log-1 (no heterogeneity). The overall R^2 adj is 0.94, a very high value. It suggests that the trend in growing stock is driving the main explanatory power. The price coefficient is positive, but not significant. The other variables have expected sign, and are also highly significant. The elasticity of growing stock is 0.99.

Table 4: Result of pooled OLS of model log-1. Standard errors in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	b/se
ln_price	0.06
	(0.09)
ln_gr_stock	0.99***
	(0.02)
ln_rate_10	0.53***
	(0.12)
_cons	0.99**
	(0.47)

When dividing the panel into two time periods (Table 5), the price coefficient turns negative in both periods. The other coefficients remain positive, but the variables seem to be more elastic in the latest period.

Table 5: Result of pooled OLS of model log-1 divided into the years 1980-1992 (P1) and 1993-2006 (P2).

	log1_P1	log1_P2
	b/se	b/se
ln_price	-0.01	-0.35
	(0.17)	(0.22)
ln_gr_stock	0.94***	1.06***
	(0.02)	(0.03)
ln_rate_10	0.41***	0.76***
	(0.15)	(0.29)
_cons	1.96*	1.63*
	(1.01)	(0.90)

In model log-2 (Table 6), heterogeneity is allowed in the intercept, but not in the slopes. All country dummies are significant on 1 % level. The estimate of interest rate and price is not significant in any of the models. The growing stock coefficient is smaller than in the pooled model, but still significant. The two models provide quite similar estimates, despite the fact that the RE model estimates are not consistent.

Table 6: Result of RE (column 1) and inverse FE (column 2) of model log-2. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	log2_re	log2_fe2
	b/se	b/se
ln_price	0.00	0.09
	(0.05)	(0.08)
ln_gr_stock	0.39***	0.33***
	(0.07)	(0.09)
ln_rate_10	0.01	0.11
	(0.05)	(0.08)
austria	0.87***	0.92***
	(0.08)	(0.09)
finland	1.85***	1.94***
	(0.12)	(0.15)
france	1.10***	1.20***
	(0.12)	(0.15)
germany	1.39***	1.50***
	(0.14)	(0.17)
netherlands	-0.71***	-0.84***
	(0.18)	(0.19)
norway	0.78***	0.79***
	(0.05)	(0.07)
sweden	1.98***	2.09***
	(0.14)	(0.17)
_cons	5.67***	5.42***
	(0.65)	(0.72)

The results of division of the panel into two time periods do not seem to support our hypothesis that the correlation is better after 1992, neither for the homogeneous model (Table 5) nor for the partly heterogeneous model (Table 7). In the homogeneous model, the price coefficient becomes negative when dividing the panel, and in the partly heterogeneous model, the interest rate coefficient turns negative in the second period. We will thus cease this division.

As for the homogeneous model, growing stock seems to be more elastic in the second period than in the first, the difference is greater in this model than in log-1. Further, it is more difficult to obtain significance of the dummies in the second period than in the first, suggesting that the differences between the countries are decreasing with time, i.e. the markets cross the national borders become more integrated. The Nordic countries are the only significant dummies in the second period, so these countries may be less integrated in the European market than the others.

Table 7: Result of RE of 1980-1992 and 1993-2006 (column 1 and 2 respectively) and of inverse FE of 1980-1992 and 1993-2006 (column 3 and 4 respectively) of model log-2.

	log2_RE_P1	log2_RE_P2	log2_FE2_P1	log2_FE2_P2
	b/se	b/se	b/se	b/se
ln_price	0.02	0.05	-0.00	0.05
	(0.07)	(0.09)	(0.08)	(0.09)
ln_gr_stock	0.32***	0.95***	0.24***	0.84*
	(0.07)	(0.31)	(0.07)	(0.50)
ln_rate_10	0.07	-0.13	0.08	-0.14
	(0.05)	(0.12)	(0.06)	(0.16)
austria	0.94***	0.37	1.00***	0.47
	(0.07)	(0.30)	(0.08)	(0.46)
finland	1.83***	1.15**	1.93***	1.31*
	(0.11)	(0.48)	(0.14)	(0.75)
france	1.14***	0.31	1.24***	0.49
	(0.11)	(0.50)	(0.13)	(0.79)
germany	1.40***	0.37	1.51***	0.60
	(0.12)	(0.64)	(0.13)	(1.00)
netherlands	-0.78***	0.37	-0.97***	0.15
	(0.18)	(0.67)	(0.16)	(1.06)
norway	0.87***	0.47***	0.90***	0.53**
	(0.05)	(0.17)	(0.07)	(0.24)
sweden	2.00***	1.10*	2.13***	1.30
	(0.14)	(0.58)	(0.15)	(0.91)
_cons	5.90***	2.44	6.43***	3.09
	(0.67)	(2.20)	(0.61)	(3.10)

Results of the country-specific estimations (log-3) are displayed in Table 8. Several countries have negative interest rate coefficient, while Sweden is the only country having negative price coefficient. All countries have positive growing stock coefficient, many of these are also significant. The value of the price coefficients are, as in the previous models, small, and barely shows any significance.

Table 8: Result of OLS of model log-3. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	log3_AU	log3_FI	log3_FR	log3_GE
	b/se	b/se	b/se	b/se
ln_price	0.31	0.01	0.01	0.23
	(0.18)	(0.13)	(0.10)	(0.49)
ln_gr_stock	0.68	1.33**	1.04***	0.43
	(0.40)	(0.57)	(0.22)	(0.29)
ln_rate_10	-0.23	-0.33***	0.24***	-1.42***
	(0.19)	(0.09)	(0.08)	(0.31)
_cons	3.83	1.36	1.30	9.42**
	(3.58)	(4.87)	(2.09)	(4.12)

	log3_NE	log3_NO	log3_SE	log3_SW
	b/se	b/se	b/se	b/se
ln_price	0.12	0.65***	0.20*	-0.08
	(0.16)	(0.18)	(0.12)	(0.16)
ln_gr_stock	0.26*	1.22**	2.88***	0.10
	(0.14)	(0.56)	(0.48)	(0.46)
ln_rate_10	0.62***	0.29***	-0.11**	0.06
	(0.14)	(0.09)	(0.05)	(0.11)
_cons	3.43***	-2.42	-12.37***	7.68**
	(1.09)	(4.43)	(4.21)	(3.47)

We have not found many studies dealing with aggregated panel data on timber supply to compare with. Probably, the time trends should be investigated more. Several of the time-series are probably non-stationary, i.e. the mean changes over time, which also can be seen from the graphs, notably the stock variables but also the other variables may very well be non-stationary. Non-stationarity may lead to estimation problems, or at least requires different model formulations and estimation procedures to result in reliable estimates. This issue has not been investigated in this work, but should be included in any further analysis.

When changing the time and the panel variables, the estimates change rather much, as we saw. It is therefore interesting to look at the differences in the estimation. Table 9 and 10 report some key indicators in the estimation of the FE models. The within R^2 of the first model is low (0.23), but very high in the inverse model (0.99), signifying that the model is much better for predicting a value of another year (for a country in the study) than a value of a new country (for a year already in the analysis). Both the overall R^2 and the value of the F-test indicate that the FE inverse model is better suited to the data. The correlation between the country-specific effect (reported as u_i) and the explanatory variables is reported to be 0.93 in the first model. In the second, the correlation between u_i (which is now the time-specific effect) and the regressors is -0.005.

Table 9: Indicators of the FE model.

```
Fixed-effects (within) regression               Number of obs      =       206
Group variable: country                         Number of groups   =         8

R-sq:  within  = 0.2268                         Obs per group: min =        24
       between = 0.9495                                        avg =      25.8
       overall = 0.9372                                        max =        27

                                                F(3,195)           =     19.07
corr(u_i, Xb)  = 0.9296                         Prob > F           =    0.0000
```

Table 10: Indicators of the inverse FE model

```
Fixed-effects (within) regression               Number of obs      =       206
Group variable: year                            Number of groups   =        27

R-sq:  within  = 0.9928                         Obs per group: min =         4
       between = 0.3383                                        avg =       7.6
       overall = 0.9907                                        max =         8

                                                F(10,169)          =   2343.63
corr(u_i, Xb)  = -0.0050                        Prob > F           =    0.0000
```

The results show that it is difficult to say something about the price driver in the national and in the European markets. However, the markets may be more regional divided. For testing this hypothesis, the countries were grouped. Two different groupings were tried according to geographical distribution:

Grouping 1 (two groups):
North: Finland, Norway and Sweden
Central: Austria, France, Germany, Netherlands and Switzerland.

Grouping 2 (four groups):
Group 1: Finland
Group 2: Norway and Sweden
Group 3: France, Germany and Netherlands
Group 4: Austria and Switzerland

In all regressions of groups, pooled OLS is applied. The results of the first grouping are displayed in Table 11. The R^2 adj values are 0.94 for both groups. The price estimate is negative in the North group and positive, but not significant in the Central group. The estimates of growing stock and interest rate are positive and significant in both groups. While the growing stock estimate is identical in North and Central, the interest rate seems more elastic in North. When regressing all countries together with a dummy for North, the estimates are identical as for the pooled OLS (Table 4), and the dummy is not significant, i.e. there is no significant difference between North and Central country groups (3rd column in Table 11).

Table 11: Results of dividing the countries into two groups, North and South, and regressing all countries together with a dummy for the northern countries. OLS on all years.

	log_north	log_central	log3_all_du
	b/se	b/se	b/se
ln_price	-0.22	0.15	0.06
	(0.18)	(0.10)	(0.09)
ln_gr_stock	0.99***	0.99***	0.99***
	(0.03)	(0.02)	(0.02)
ln_rate_10	0.79***	0.49***	0.53***
	(0.27)	(0.13)	(0.12)
north			-0.01
			(0.05)
_cons	1.49*	0.70	1.00**
	(0.84)	(0.56)	(0.47)

Table 12 presents the results from the four groups, two in Northern and two in Central Europe. Three of the four price coefficients are now positive and significant, all betweeen 0.31 and 0.42. Finland has very low and not significant price estimate. An argument for having Finland in its own group is its large import from Russia, which may also make estimation of this country difficult without taking the Russian market in consideration. All four groups have significant growing stock coefficient, but fairly high (up to 1.33). The estimates of interest rate coefficients are mostly not significant.

Table 12: Results of dividing the countries into four groups, Finland; Norway and Sweden; France, Germany and the Netherlands; Austria and Switzerland. OLS on all years.

	log3_FI	log_NO_SE	log_FR_GE_NE	log_AU_SW
	b/se	b/se	b/se	b/se
ln_price	0.01	0.31***	0.42***	0.39***
	(0.13)	(0.08)	(0.09)	(0.06)
ln_gr_stock	1.33**	1.26***	0.88***	1.31***
	(0.57)	(0.02)	(0.01)	(0.04)
ln_rate_10	-0.33***	0.10	0.14	0.11
	(0.09)	(0.08)	(0.15)	(0.10)
_cons	1.36	-0.75*	1.13***	-1.73***
	(4.87)	(0.43)	(0.40)	(0.39)

Linear models

The coefficients of the linear models were also estimated after same procedure as the log-lin models. Table 13 shows the result of model Lin-1, the calculated elasticities may be found in Table 18. As for the log-lin model (Table 4), the price estimate is not significant; in addition, the interest rate estimate is neither significant in the linear case.

Table 13: Results of OLS of model lin-1. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin1
	b/se
log_price	18.60
	(29.17)
gr_stock	14.53***
	(0.61)
int_rate_10	365.25
	(230.22)
_cons	-6668.30*
	(3783.97)

Estimation of lin-2, i.e. the linear model with homogenous slopes and heterogeneous intercepts, by use of RE and inverse FE, resulted in the estimates displayed in Table 14. The price coefficient in the RE model has now turned negative and the interest rate coefficient is significantly negative, indicating that this specification is wrong. The price coefficient is positive and significant in the inverse FE, but the interest rate coefficient is negative. All dummies except Netherlands are significant. The differences in estimates between the RE and FE models are larger in this linear model than in the log-2 model (Table 6).

As seen from the Table, the difference between the countries is huge (increasing the intercept from 4200 for Austria to 30500 for Sweden). It might therefore have been beneficial to rescaling the variables, since the variation between the countries now is so much greater than the variation within the countries, causing difficulties in use of FE.

Table 14: Results of RE (column 1) and inverse FE (column 2) of the linear model 2. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin2_re	lin2_fe2
	b/se	b/se
log_price	-15.64	64.22**
	(13.54)	(25.33)
gr_stock	6.91***	5.95***
	(0.86)	(0.88)
int_rate_10	-311.91***	-13.30
	(94.37)	(145.42)
austria	4206.04***	4286.39***
	(1018.07)	(1053.29)
finland	24728.79***	26345.43***
	(1505.85)	(1686.16)
france	4660.02***	6766.56***
	(1528.14)	(1702.23)
germany	8938.38***	11175.75***
	(2043.11)	(2161.98)
netherlands	186.58	1188.44
	(1039.66)	(1151.96)
norway	4477.90***	4561.56***
	(966.37)	(1101.36)
sweden	30558.15***	32595.19***
	(2032.79)	(2166.74)
_cons	5069.72***	-4476.55
	(1801.84)	(2789.76)

Results of estimation of the linear model with full heterogeneity (lin-3) are shown in Table 15. As for the log model, it is difficult to obtain logical sign and significant estimates.

Table 15: Results of estimation of the fully heterogeneous linear model (lin-3). Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin3_AU	lin3_FI	lin3_FR	lin3_GE
	b/se	b/se	b/se	b/se
log_price	45.04**	-44.12	-6.37	308.85*
	(21.67)	(65.82)	(26.39)	(165.44)
gr_stock	9.73**	19.38*	8.59***	10.68**
	(4.40)	(10.62)	(2.18)	(3.80)
int_rate_10	-109.59	-870.06***	309.18**	-3061.72***
	(159.95)	(213.30)	(117.41)	(707.37)
_cons	-993.95	16611.49	-2202.06	14820.99
	(6647.84)	(24916.30)	(6537.98)	(24387.16)

	lin3_NE	lin3_NO	lin3_SE	lin3_SW
	b/se	b/se	b/se	b/se
log_price	1.35	67.60***	130.97	0.16
	(2.09)	(22.48)	(79.88)	(5.49)
gr_stock	4.57	14.07*	55.06***	2.87
	(3.05)	(7.77)	(10.17)	(3.35)
int_rate_10	33.45***	210.95***	-392.52**	20.90
	(8.09)	(64.06)	(175.72)	(41.73)
_cons	-55.64	-8610.98	-96668.41***	1782.51
	(239.96)	(7004.23)	(31195.72)	(1966.03)

Compared with the corresponding group log model (Table 11), we see that the price coefficient remain negative in the North group in the linear specification (Table 16). The growing stock coefficient remains positive and significant, while the interest rate is no longer signficant.

Table 16: Results of dividing the countries into two groups, North and South, and regressing all countries together with a dummy for the northern countries. OLS on all years.

	lin_north	lin_central	lin_du
	b/se	b/se	b/se
log_price	-35.05	38.57	19.41
	(67.96)	(31.84)	(29.45)
gr_stock	14.18***	14.72***	14.53***
	(1.10)	(0.73)	(0.61)
int_rate_10	415.44	408.72	370.98
	(540.10)	(250.19)	(232.12)
north			279.28
			(1223.76)
_cons	-2910.19	-9102.50**	-6903.71*
	(7368.50)	(4417.62)	(3930.64)

In the linear model of the four groups, the price estimate is negative for two of the groups (Table 17), compared to none in the log-lin model (Table 12). Also, two more groups have now negative interest rate estimate.

Table 17: Results of dividing the countries into four groups, Finland; Norway and Sweden; France, Germany and the Netherlands; Austria and Switzerland.

	lin3_FI	lin_NO_SE	lin_FR_GE_NE	lin_AU_SW
	b/se	b/se	b/se	b/se
log_price	-44.12	-6.19	73.55***	29.07***
	(65.82)	(27.00)	(20.96)	(5.54)
gr_stock	19.38*	20.88***	9.42***	12.44***
	(10.62)	(0.45)	(0.30)	(0.50)
int_rate_10	-870.06***	-62.12	-237.73	150.11*
	(213.30)	(149.95)	(197.96)	(77.17)
_cons	16611.49	-3871.74	-1081.52	-5659.99***
	(24916.30)	(2968.64)	(2586.74)	(976.56)

Based on the comparisons, the log-lin models seem to better fitted to the data than the linear models.

Since the elasticities cannot be seen directly from the estimates of the linear model, they are calculated with use of the following formula:

Elasticity between harvest and the independent variable k =

$$\varepsilon_k = \frac{\hat{\beta}_k * \overline{x}_k}{\overline{y}}$$

where $\hat{\beta}_k$ is the estimate of coefficient β_k, $\overline{y}$ the average value of harvest and $\overline{x}_k$ the average value of the independent variable x_k over all observations. Table 18 provides the calculated elasticities of price and growing stock of the linear models.

The estimates of the fully homogeneous model are almost identical in the linear as in the log-lin model (Table 4). In the partly heterogeneous FE2 model, the price estimate has now turned significant, and also more elastic (0.25 versus 0.09). The growing stock estimates in the RE and FE models are a little more elastic in the linear than in the log-lin models (Table 6). There is no unambiguous difference between the linear and the log-lin fully heterogeneous models. All the grouped models are rather similar for price and growing stock in the two model specifications.

Table 18: Calculated elasticities of the linear models and significance levels.

Model	Estimation method	Country	Price	Growing stock
1 (Fully homogeneous)	**Pooled OLS**	All	0.07	1.04 ***
2. (Partly heterogeneous)	**RE**	All	-0.06	0.50 ***
2. (Partly heterogeneous)	**FE inverse**	All	0.25 **	0.43 ***
3. (Fully heterogeneous)	**OLS**	Austria	0.34 **	0.88 **
		Finland	-0.08	0.96 *
		France	-0.02	0.93 ***
		Germany	0.87 *	1.04 **
		Netherlands	0.12	0.31
		Norway	0.58 ***	1.08 *
		Sweden	0.21	2.93 ***
		Switzerland	0.00	0.36
Grouping into two groups	**Pooled OLS**	North	-0.13	1.02 ***
		Central	0.15	1.05 ***
Grouping with dummy for North	**Pooled OLS**	All	0.07	1.04 ***
Grouping into four groups	**Pooled OLS**	FI	-0.08	0.96 *
	Pooled OLS	NO, SE	-0.02	1.20 ***
	Pooled OLS	FR, GE, NE	0.34 ***	0.98 ***
	Pooled OLS	AU, SW	0.34 ***	1.19 ***

3.2 Model group B

Log-lin models

The price and growing stock estimates in the fully homogeneous model are almost identical in the models with and without interest rate (Table 19 versus Table 4), suggesting that the interest rate does not affect the other variables much.

The adjusted R^2 is almost as high for this model as for the corresponding model in group A; 93.6 versus 94.2.

Table 19: Result of pooled OLS of model log-1 in model group B. Standard errors in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	b/se
ln_price	0.07
	(0.09)
ln_gr_stock	1.00***
	(0.02)
_cons	2.23***
	(0.40)

The estimates of price and growing stock are not affected by the absence of the interest rate variable in the partly heterogeneous model either (Table 20).

Table 20: Result of RE (column 1) and inverse FE (column 2) of model log-2 in model group B. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	log2_B_re	log2_B_fe2
	b/se	b/se
ln_price	0.00	0.09
	(0.05)	(0.08)
ln_gr_stock	0.39***	0.30***
	(0.07)	(0.08)
austria	0.88***	0.97***
	(0.08)	(0.09)
finland	1.85***	2.01***
	(0.11)	(0.13)
france	1.11***	1.27***
	(0.12)	(0.14)
germany	1.39***	1.57***
	(0.14)	(0.16)
netherlands	-0.71***	-0.88***
	(0.18)	(0.19)
norway	0.78***	0.84***
	(0.05)	(0.06)
sweden	1.98***	2.17***
	(0.14)	(0.16)
_cons	5.69***	5.85***
	(0.63)	(0.65)

The same trend is present in the fully heterogeneous model; there is no trend of changes in the estimates of price and growing stock coefficients when the interest rate is taken away (Table 21 versus Table 8). But, many of the estimates seem still unlikely, for example growing stock estimate above 2. Several of the price coefficients are very low.

Table 21: Result of OLS of model log-3, all years. Standard errors are in parenthesis. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	log3_B_AU	log3_B_FI	log3_B_FR	log3_B_GE
	b/se	b/se	b/se	b/se
ln_price	0.31	0.10	0.01	-0.61
	(0.18)	(0.17)	(0.12)	(0.63)
ln_gr_stock	0.78*	2.16***	0.91***	0.13
	(0.40)	(0.66)	(0.26)	(0.39)
_cons	2.57	-6.12	2.86	11.72*
	(3.46)	(5.60)	(2.42)	(5.66)

	log3_B_NE	log3_B_NO	log3_B_SE	log3_B_SW
	b/se	b/se	b/se	b/se
ln_price	0.39*	0.54**	0.15	-0.10
	(0.20)	(0.21)	(0.12)	(0.16)
ln_gr_stock	0.37*	0.64	2.60***	0.07
	(0.19)	(0.61)	(0.51)	(0.45)
_cons	3.52**	2.59	-10.25**	8.09**
	(1.46)	(4.78)	(4.51)	(3.30)

As Table 22 shows, the price and growing stock estimates are not affected by the absence of the interest rate variable in the models where the countries are grouped into two groups. The growing stock estimate is stable around 1, as in the corresponding models in group A (Table 11).

Table 22: Results of dividing the countries into two groups, North and South, and regressing all countries together with a dummy for the northern countries. OLS on all years.

	log_B_north	log_B_cent~l	log_B_du
	b/se	b/se	b/se
ln_price	-0.08	0.13	0.07
	(0.18)	(0.11)	(0.09)
ln_gr_stock	1.01***	1.00***	1.00***
	(0.03)	(0.02)	(0.02)
north			-0.02
			(0.05)
_cons	2.78***	2.03***	2.26***
	(0.76)	(0.46)	(0.40)

The four-group model displays also almost identical estimates without (Table 23) and with the interest rate (Table 12), except for Finland. Finland's both coefficients tend now to be more elastic, and the growing stock elasticity is unreasonable high.

Table 23: Results of dividing the countries into four groups, Finland; Norway and Sweden; France, Germany and the Netherlands; Austria and Switzerland. OLS on all years.

	log3_B_FI	log_B_NO_SE	log_B_FR_G~E	log_B_AU_SW
	b/se	b/se	b/se	b/se
ln_price	0.10	0.32***	0.45***	0.39***
	(0.17)	(0.08)	(0.08)	(0.06)
ln_gr_stock	2.16***	1.26***	0.87***	1.33***
	(0.66)	(0.02)	(0.01)	(0.03)
_cons	-6.12	-0.46	1.36***	-1.60***
	(5.60)	(0.37)	(0.32)	(0.37)

Linear models

The linear homogeneous model also remains rather stable when taking away the interest rate (Table 24 compared to Table 13). The adjusted R^2 is 0.74 in the both models. The R^2 is higher for the log-lin models than for the linear models, but since the variables are not the same in the two model specifications, they cannot be compared. However, the coefficient of determination may be compared between the same model types with different number of variables, since the R^2 adj is used, where the number of variables is taken into account. This is different for the R^2, which tends to increase with the number of variables and therefore gives a biased image when comparing for example models in group B with models in group A.

Table 24: Results of OLS of model lin-1 in model group B. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin1_B b/se
log_price	19.34 (29.27)
gr_stock	14.60*** (0.61)
_cons	-2085.87 (2453.73)

Also the partly heterogeneous model is almost identical in model group B (Table 25) as in group A (Table 14).

Table 25: Results of Random effect and inverse FE of the linear model 2, model group B. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin2_B_re b/se	lin2_B_fe2 b/se
log_price	-16.90 (13.88)	64.27** (25.25)
gr_stock	7.30*** (0.87)	5.96*** (0.88)
austria	3306.01*** (1005.51)	4252.66*** (983.74)
finland	23019.24*** (1449.60)	26287.99*** (1560.22)
france	3233.26** (1502.56)	6721.85*** (1625.74)
germany	7374.40*** (2037.26)	11129.95*** (2097.03)
netherlands	-436.29 (1048.00)	1161.40 (1110.12)
norway	3108.66*** (894.90)	4507.06*** (923.44)
sweden	28754.83*** (2007.17)	32540.87*** (2077.64)
_cons	1768.59 (1537.20)	-4622.51** (2281.34)

In the fully heterogeneous model, most price coefficient estimates are quite similar as in the model with interest rate, except for Finland, where it has shifted from negative to positive, and for Switzerland, where the opposite has happened (Table 26).

Table 26: Results of estimation of the fully heterogeneous linear model (lin-3), model group B. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

	lin3_B_AU	lin3_B_FI	lin3_B_FR	lin3_B_GE
	b/se	b/se	b/se	b/se
log_price	46.07**	29.66	-25.88	310.32
	(21.37)	(81.33)	(28.69)	(222.34)
gr_stock	10.57**	39.61***	6.10**	13.52**
	(4.18)	(12.07)	(2.23)	(5.04)
_cons	-3277.78	-37900.24	7884.94	-31448.38
	(5685.05)	(27026.07)	(6000.27)	(29457.85)

	lin3_B_NE	lin3_B_NO	lin3_B_SE	lin3_B_SW
	b/se	b/se	b/se	b/se
log_price	4.56*	42.30	121.33	-1.38
	(2.51)	(25.09)	(86.41)	(4.47)
gr_stock	7.28*	1.99	53.08***	2.15
	(3.85)	(8.13)	(10.97)	(2.98)
_cons	59.78	4056.28	-96197.57***	2406.35
	(308.00)	(6951.25)	(33792.62)	(1493.94)

As Table 27 displays, the two-group models without interest rate look almost the same as with interest rate (Table 16).

Table 27: Results of grouping the countries into North (column 1), Central (column 2) and all together, with a dummy for North (column 3), model group B.

	lin_B_north	lin_B_cent~l	lin_B_du
	b/se	b/se	b/se
log_price	-20.63	33.84	19.53
	(65.14)	(31.91)	(29.56)
gr_stock	14.27***	14.81***	14.60***
	(1.09)	(0.73)	(0.61)
north			67.79
			(1221.26)
_cons	1197.43	-3472.25	-2125.56
	(5062.89)	(2781.74)	(2561.63)

The most important difference between the two linear four-group models is the sign of Finland's price estimate, which has changed to positive. Also, the growing stock coefficient for Finland has doubled in size. For the other groups, there are only small differences.

Table 28: Results of dividing the countries into four groups, Finland; Norway and Sweden; France, Germany and the Netherlands; Austria and Switzerland, model group B.

	lin3_B_FI	lin_B_NO_SE	lin_B_FR_G~E	lin_B_AU_SW
	b/se	b/se	b/se	b/se
log_price	29.66	-6.99	65.65***	28.87***
	(81.33)	(26.70)	(19.96)	(5.71)
gr_stock	39.61***	20.92***	9.47***	12.90***
	(12.07)	(0.44)	(0.30)	(0.46)
_cons	-37900.24	-4732.45**	-3671.40**	-4221.63***
	(27026.07)	(2102.77)	(1432.65)	(656.49)

Table 29 gives the calculated elasticities of the linear models in group B; most elasticities are quite similar to the corresponding elasticities in group A, Table 18. The clearest difference from the log-lin models is the negative price coefficient estimate for the group Norway-Sweden, which is positive and significant in the log-lin model (Table 23). On the other hand, the inverse FE estimator of the price coefficient has changed from not significant (Table 20) to significant.

Table 29: Calculated elasticities of the linear models and significance levels, model group B. Significance levels: * = 10 %, ** = 5 %, * = 1 %.**

Model	Estimation method	Country	Price	Growing stock
1 (Fully homogeneous)	Pooled OLS	All	0.07	1.05 ***
2. (Partly heterogeneous)	RE	All	-0.06	0.52 ***
2. (Partly heterogeneous)	FE inverse	All	0.25 **	0.43 ***
3. (Fully heterogeneous)	OLS	Austria	0.35 **	0.95 **
		Finland	0.05	1.97 ***
		France	-0.10	0.66 **
		Germany	0.87	1.32 **
		Netherlands	0.41 *	0.50 *
		Norway	0.36	0.15
		Sweden	0.19	2.83 ***
		Switzerland	-0.04	0.27
Grouping into two groups	Pooled OLS	North	-0.07	1.03 ***
		Central	0.13	1.06 ***
Grouping with dummy for North	Pooled OLS	All	0.07	1.05 ***
Grouping into four groups	Pooled OLS	FI	0.05	1.97 ***
	Pooled OLS	NO, SE	-0.02	1.21 ***
	Pooled OLS	FR, GE, NE	0.30 ***	0.99 ***
	Pooled OLS	AU, SW	0.34 ***	1.23 ***

In general it is easier to obtain logical signs and significance of growing stock estimate than of price and interest rate. Thus, across time and countries, supply in general or eventually will increase as stock increases, which is intuitively correct. There may be several reasons for the apparent lack of consistent and plausible estimates of the effects of price and interest rate on supply, apart from using other modeling and estimation techniques (e.g. from the time series literature). For example may industrial forest owners be less sensitive to price signals in the relative short run due to opportunity cost of industrial capacity and state forest areas and protected forest areas varying across countries. Also, different forest owners (private as public) are likely to react differently as compared to the underlying assumptions in economic model used.

Non-stationarity and lack of country-specific variables have already been mentioned as a possible reason for problems of estimation. Other important possible reasons may be factors like:

- Poor data (the data of values are weighted import/export prices and not domestic prices, as well as modification of the categories during the period),
- autocorrelation (first order autocorrelation was in doubt, higher order has not been investigated),
- model misspecification (for example including simultaneous demand/supply estimation in each country, taking trade into effect),
- uneven changes in taxes, (bio)energy policies and agriculture/land use policies,
- changes in foreign exchange rates between countries caused by internal national factors outside the forest sector,
- different price expectations in the various countries
- the adjustment done in the data related to storm fellings (cf. chapter 2.2.) and the fact that heavy stormfellings often influences neighbouring countries,
- the large variation between the countries compared to the variation within the countries makes FE estimation difficult, and scaling the variables could improve the estimation,
- also, even if Cobb-Douglas production function is rather well documented on forest-owner level, it is less documented on aggregate levels, causing uncertainty how appropriate the function is on national and international levels.

In further analyses, these issues should be more investigated, but would demand a lot of additional work. In fact, a more promising approach might be to perform more detailed national studies in specific countries.

4. CONCLUSIONS

Several models are tried out in this analysis. In general, it was more difficult to obtain logical sign and significance of price coefficient than of growing stock. The interest rate does not seem to influence much the other variables, as they remain almost the same when taking out interest rate.

Pooled OLS of the homogeneous models is consistent, but the price estimate is not significant. Estimation of the partly heterogeneous model showed some difficulties, due to inconsistent estimators and low variation within the countries. Thus, the FE is not efficient and the GLS/OLS are not consistent. However, with use of inverse FE, we obtained positive and significant estimate of the price (0.25) in the linear models, but not significance in the log-lin model.

The two-group models were not very promising in estimation of the price coefficient, and also did not show any significant difference between North and Central. However, grouping the countries into four in the log-lin model, gave positive and significant estimate of all price and growing stock coefficient estimates, except for price in Finland. This model is maybe the most promising one with regard to price, but gives unlikely high estimates for growing stock. The two-group log-lin models provides lower growing stock estimates, around 1 in all these models. The best estimates to the EFI-GTM may be the price estimates in the four-group model (Table 23), together with the growing stock estimates from the two-group model (Table 22). The price estimate for Finland should might be slightly increased, for example by use of the linear FE estimate, which is in the same order of magnitude as the suggested applied price estimates for the other countries.

Estimation of pure time-series gave much illogical signs. The best results were thus obtained from inverse FE of the model 2 and grouping of the countries. The division of the panel into two periods did not seem to improve the estimation.

Future work should concentrate on meeting the issues mentioned on p. 29.

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APPENDIX: OVERVIEW OF THE DATA

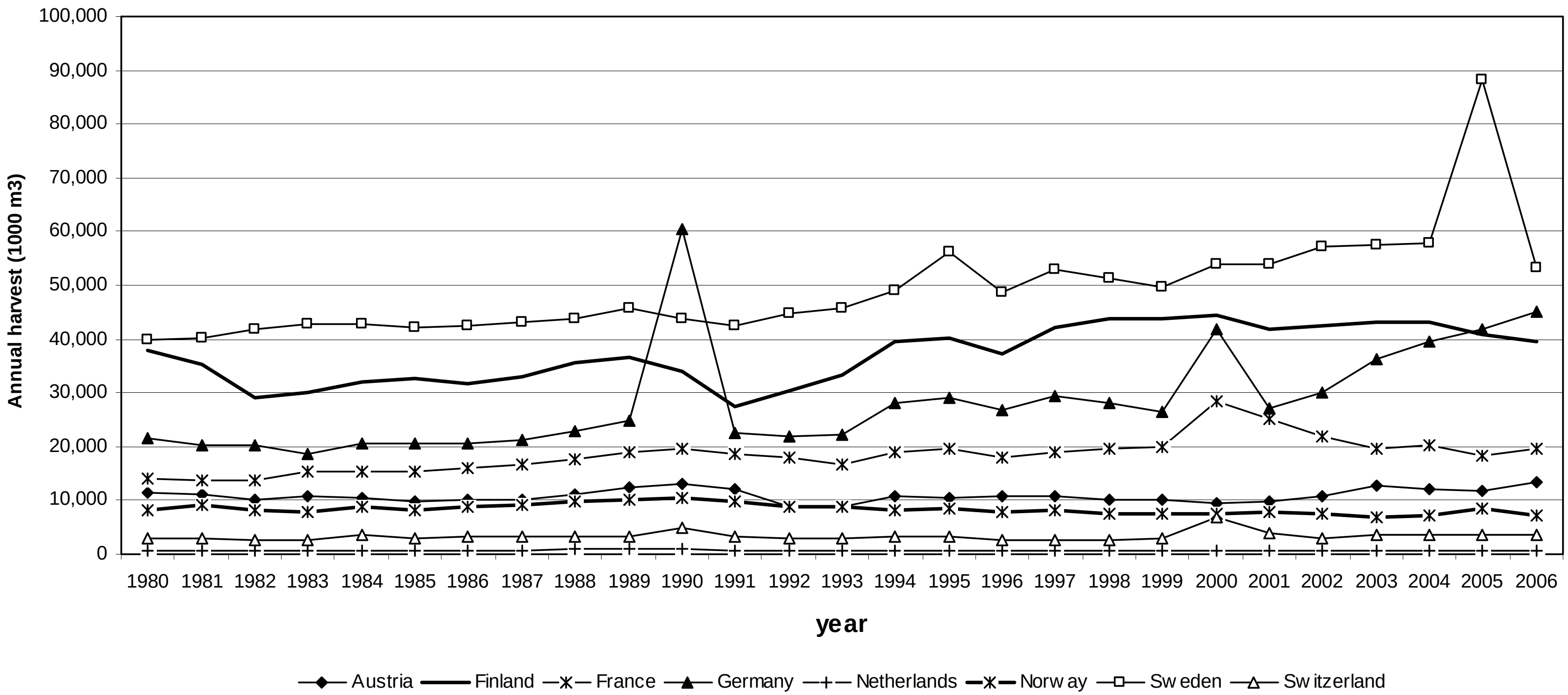

Figure 1: Removals of coniferous industrial roundwood (1000 m^3).

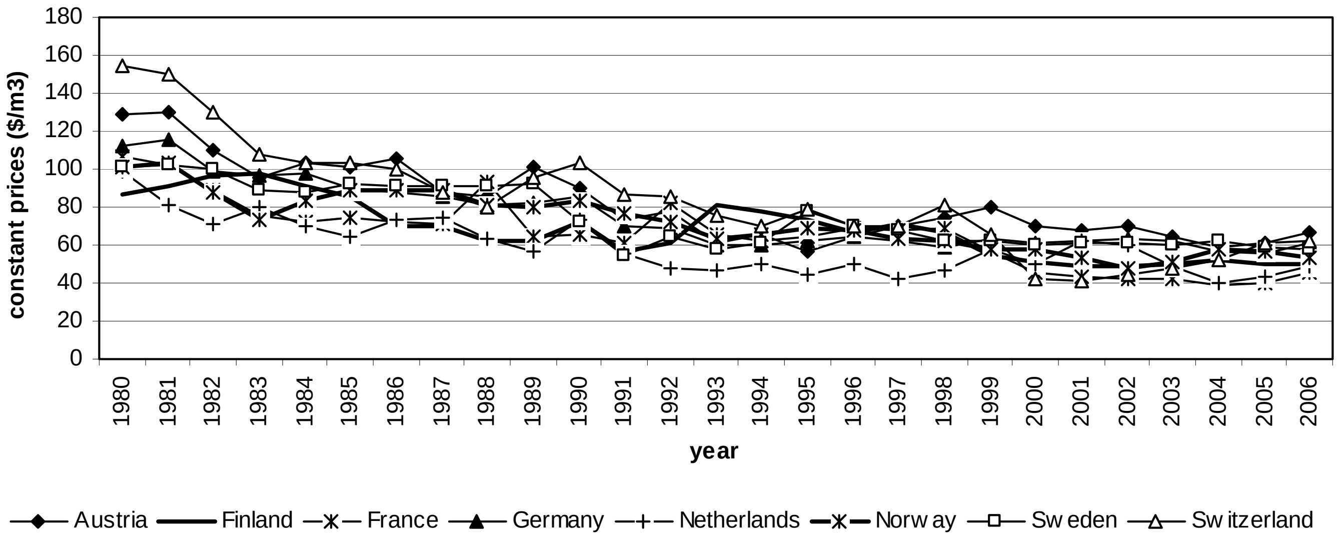

Figure 2: Weighted industrial roundwood price (US $/m^3, constant 2006 prices).

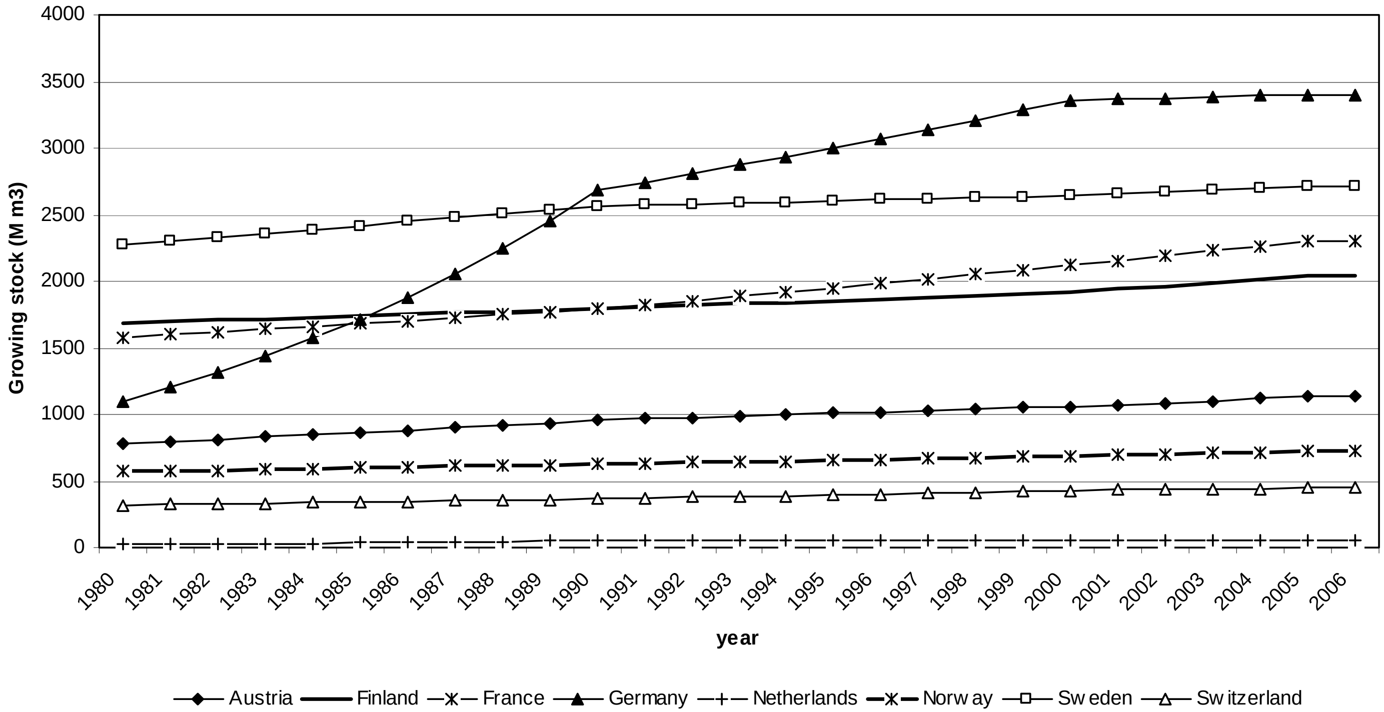

Figure 3: Growing stock (M m^3)

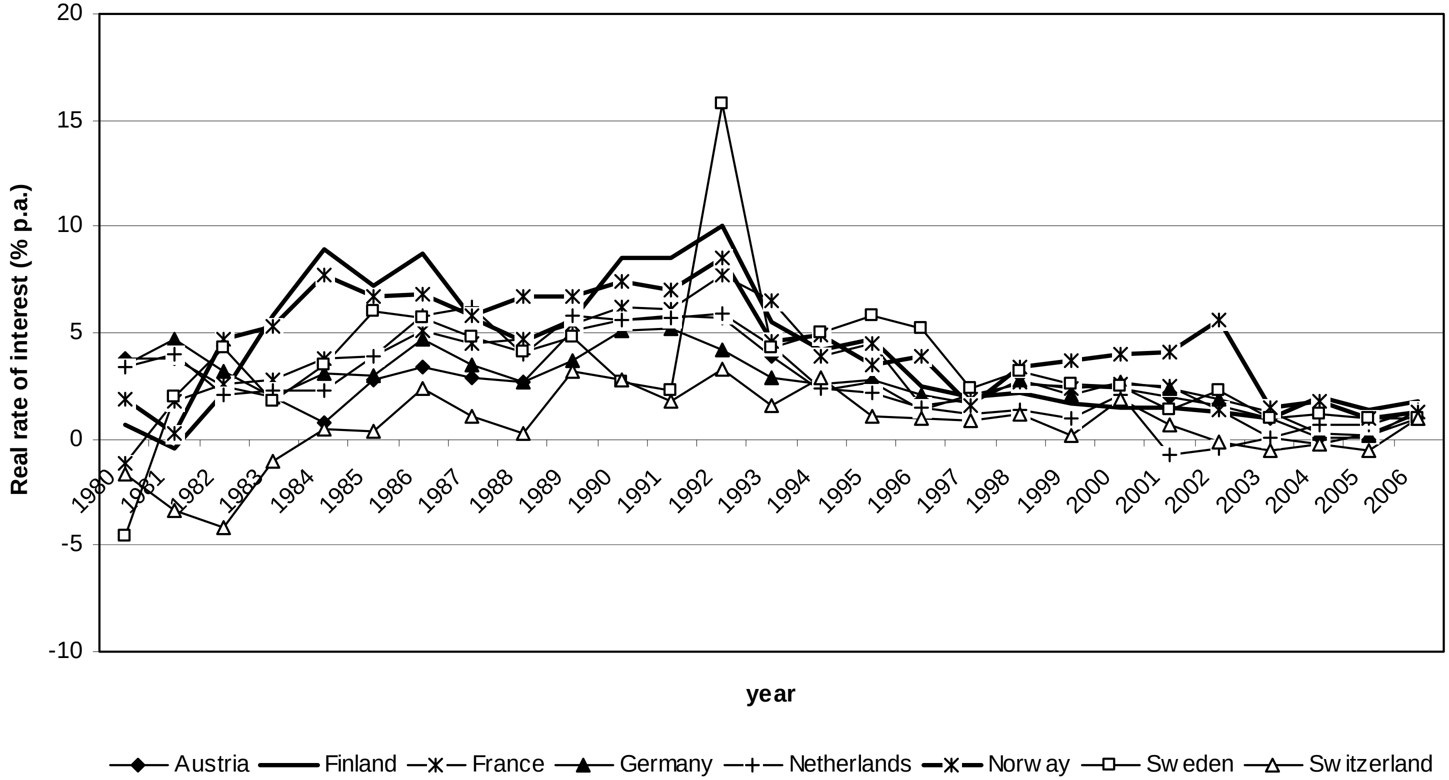

Figure 4: Real rate of interest.