EMPIRICAL DEMAND ANALYSIS FOR LONG - LENGTH ROUNDWOOD (SAWLOGS) IN GREECE

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Abstract

In Greece and internationally, the roundwood is one of the most important forest products as it is used widely in construction and building sector. In this study the process of wholesale long-length roundwood (>2m) price determination is depicted in the form of an inverse demand system. The empirical application based on five species of long-length roundwood using yearly data for auctions providing reasonable and promising results. The own-quantity flexibilities suggest that the responses of prices to own-quantity changes are inelastic while Allais coefficients suggest substitutability between the different species of log-length roundwood.

Key words: Inverse Almost Ideal Demand System, demand analysis, flexibilities, long-length roundwood, wood sector, Greece

Résumé

En Grèce et dans le monde, le bois rond, qui est largement utilisé dans le secteur de la construction et du bâtiment, est un des produits forestiers les plus importants. Dans cette étude, le processus de détermination du prix de gros des longs rondins (>2m) est décrit sous forme de système à la demande inverse. L'application empirique basée sur cinq espèces de rondins longs et utilisant les données annuelles des ventes aux enchères fournit des résultats satisfaisants et prometteurs. L' élasticité des quantités semblent indiquer que les prix ne s'ajustent pas en fonction de ces changements, tandis que les coefficiens d'Allais obtenus semblent indiquer que les différentes espèces de bois rond de la longueur d'un rondin sont interchangeables.

1. Introduction

In global level the production of industrial roundwood in 1961 amounted 1 billion cubic meters and in 2005 reached 1.7 billion cubic meters. Specifically, during the period 1990 – 2005 the same production was between 1.5 and 1.7 billion cubic meters. North and Central America have the greatest production of industrial roundwood, approximately 39.5% of the total timber production followed by the Europe with roughly 28.5%. The demand of industrial roundwood like construction timber, processed wood products and paper and paperboard is rising faster in rapidly growing economies (FAOSTAT 2007).

Generally, the consumption of wood and its products (roundwood, sawnwood, veneer sheets, plywood, particleboard, woodpulp, paper and paperboard etc) presents a continually increased trend because of the various uses nowadays. In particular, the factors which affect the consumption of wood and its products are: a) the population, b) the Gross National Product (GNP), c) the institutional and technological changes, d) the energy cost, e) the capital availability and f) the wood and its products prices (Lefakis et al., 1998). The increase in wood consumption (industrial and woodfuels) is estimated that it would be important and from 3.4 cubic meters in 1992 will amount to 5.5 billion cubic meters in 2010 and 6.5 billion cubic meters in 2020 (Nilsson, 1996; Stamou, 2006).

In the literature concerning the forest sector has been developed a great number of empirical models which refer to the production (supply), consumption (demand), imports and exports of various categories of wood and its products (Philippou and Lefakis, 1997; Tromborg et al., 2000; Solberg et al., 2003; Koulelis, 2005; Brodrechtova, 2008). In particular, the Global Forest Product Model (GFPM) is a model which was developed in the context of FAO for the production, the consumption and the forest products trade (imports-exports) for 180 countries and 14 commodity products during the period 1994-2010. (Tomberlin et al., 1998). Kangas and Baudin (2003) make estimation for the supply and demand of wood products for the period 2030 in 37 European countries. They point up that the increase of consumption during the last two decades will be based on the dynamic development of East-European countries. However, this increase will be retarded after the economic convergence. Also, Hetemaki et al (2004) investigate for the Finnish forest sector with short-term forecasting models (univariate and multivariate time series models) the wood exports and the saw long demand. Wibe (2005) constructed and used a simple linear supply and demand model. According to this model everything is formulated and understood in the fundamental concepts of economic theory, and is easy to use in simulating various scenarios and in particular about what will happen in production consumption and forest products trade in case of demand and supply changes. In order to forecast the industrial roundwood demand, empirical models have been specified and estimated by many researchers. In these models as explanatory variables have been employed variables such as the increase of population, the economic development, the models of final consumption, the technological advance and others specific factors (Apsey and Reed, 1995; Nilsson, 1996; Stamou, 2006). At present, despite the heavy reliance of Greece on wood imports, empirical economic research on country's demand for domestic wood is scare[1]. Actually, to the authors' knowledge, there is no any study that would concern the empirical demand analysis of roundwood in Greece. The non existence of any empirical study for this product is partly due to there is not easy to find data for this certain wood category.

To fill this gap, this paper focuses on the empirical investigation of the demand for long-length roundwood in Greece for the period 1964-2005. The data which are used in this paper concern yearly prices and quantities of five long-length roundwood categories (fir and spruce, pine, beech, oak and poplar & other broadleaved species). These five categories are auctioned by state forest farms (as it will decrypt afterwards). The analysis allows quantification of the responses of different species of long-length roundwood to changes in prices and expenditure. The price, scale and substitution flexibilities (which are the main outcomes of empirical inverse demand systems) enable researchers to measure the costs and benefits associated with changes in market or policies (either national or European). The broader contribution of this paper is to provide an improved price determination component for conducting forest and roundwood policy analysis which was the context within which the model was originally developed. The results therefore of the present study may be of particular interest to policy makers, the domestic wood industry as well as, forest management experts. The rest of the paper is organised as follows: In the following section the wood sector in Greece as well as the exploitation system is decrypted. In the third and fourth section the theoretical framework and the empirical results are presented. We continue by discussing the results and the paper ends with our concluding remarks.

2. Forest and wood sector in Greece

According to the most recent census, forests in Greece cover the 25.4% of the country's total area (i.e. 3,358 thousand ha). Of these, approximately two thirds (65.4%) belong to the state and the remaining 34.6% belong to private entities, local authorities, monasteries, and other welfare institutions (Ministry of Agriculture 1992; Ioannou et al., forthcoming; Koutroumanidis et al., forthcoming). The domestic production of technical wood (roundwood and sawnwood) during the 1980-1999 period ranged between 0.5 and 1 million cubic metres (only in 1998 the production was less than 0.5 millions cubic metres), while the years 2000-2005 presented decline and ranged between 0.39 and 0.44 million cubic metres (Ministry of Rural Development and Food, 2006).

The long-length roundwood constitutes the most important product of Greek forests as is of high added value and in its processing form (sawn wood, veneer, fibreboards, particleboards) it has a lot of uses in the building activity, constructions and furniture and is considered as the most important for the economy of a country. As in Greece the evolution in these sectors are quite promising, it is expected to be an increase in the demand for roundwood. Main source of

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[1] Among others Anagnos and Stamou 1980, 1981; Papastavrou et al 1986a, b; Philippou and Lefakis 1997; Lefakis et al 1998; Fousekis et al 2001.

long-length roundwood are species like fir, black pine and beech. To be more specific, from the 1995 and afterwards is observed an important increase of building activity with a Medium Annual Rate of 6.9%. The main reasons that contributed to this were on the one hand the accumulated housing needs and on the other hand the progressive de-escalation of interest-rates. This evolution contributes in the increase of consumer credit, which is expected to affect positively the size of building activity and the further demand for new residences. It is appreciated that during the 1998-2010 period, the size of consumer expenditures for accommodation will rise at about 3.4% annually. Quite promising also will be the evolution in the furniture which is an important customer for the products that are produced by the processing of roundwood (mainly sawn wood). The consumer expenditure for furniture is expected to show an increase at about 35% during the 1998 – 2010 period. This increase is expected also to influence the demand for roundwood substantially as the furniture will absorb large quantities. After 1994 there is a positive relationship between the various wood processing and constructing sectors. The works of Olympic Games and the works that are manufactured in the framework of the 3rd CSF (Community Support Framework) increased the demand in wood products considerably. This increase of construction activity is expected to be also continued during the application of 4th CSF (Polemis, 2002).

In Greece two systems were used for the exploitation of state forests until the end of 1986. One involved self-supervision by the local Forest Services (State Forest Farms), under the framework of State Forest Exploitation (KED from the Greek acronyms) according to article 137 of Law 86/69; and the other involved the leasing of the forest production (allowable cut) by forest labour cooperatives (according to Law 86/69 article 134) or following an auction with interested parties (according to Law 86/69 article 120) (Papastavrou and Makris, 1988; Ministry of Rural Development and Food, 2004). According to the first system, the State undertakes the exploitation of the forest by assigning its logging to Forest Cooperatives, which are then paid per production unit of forest product. It has been shown that the implementation of this system on a long-term basis leads to a preferable exploitation of forests, a rehabilitation of forests degraded and damaged by grazing and illegal logging, and in general to products of a higher quality. Alternative, the State leases the production to the Forest Cooperatives or to tenants-woodcutters, who pay a fee per unit of produced product and then sell the products themselves, paying back to the Central Fund for Agriculture, Livestock and Forests the fee that was agreed upon or achieved at the auction (Ministry of Rural Development and Food, 2004).

Since 1987 and according to Law 1541/1985 article 74 and the Presidential Decree 126/1986 and Law 2169/1993, a third system has been introduced for the exploitation of state forests, through which the latter is conceded to Rural Forest Cooperatives, who pay a certain rate based on the sales price of the forest products, irrespective of product type. The payment is made to the Central Fund for Agriculture, Livestock and Forests and to the local authorities, within whose administrative boundaries the forest, forest compartment or stand (Tororis, 1994).

The State Forest Farms that conduct the auctions of the quantities of wood take place in different locations of Greece. The mean prices are determined in the aforementioned auctions (by the State Forest Farms) are negotiating prices and involve the supply of wood either from non – state forests or for the wood that is logged, harvested and traded by the Rural Forest Cooperatives (Anagnos and Stamou, 1981). The price of wood which is provided by the state forest farms (sellers) is shaped by the development of the free competition among the candidates buyers (timber merchants) and by the auctions which are organised by the Regional Forest Services (Stamou, 1985).

3. Theoretical Framework

As it was mentioned before, the wood trade supply is very inelastic in the short run and the producers are virtually price takers. Price-taking producers and price-taking consumers are linked with traders who select a price which they expect clears the market. In practice this means that at the auction the wholesale traders offer prices for the fixed quantities which after being augmented with a suitable margin are sufficiently low to induce consumers to buy the available quantity. The traders set the price as a function of the quantities. The causality goes from quantity to price. Hence, the use of quantity dependent (direct) systems in modeling the demand for such commodities is inappropriate and inverse demand functions where prices are functions of quantities, provide an alternative and fully dual approach to the standard analysis of consumer demand (Anderson 1980). The reason is that, given a predetermined quantity, the price must adjust in order to clear the market (Barten and Bettendorf 1989).

Until the late of 1980s, inverse demand systems were typically specified in an ad hoc manner (Freebain and Rausser 1975; Arzac and Wilkinson 1979). The last decades the search for better specification of direct demand systems has paid much attention to the choice of functional form (translong model, Rotterdam model AIDS). Since then, based on the above specific approaches to the consumer behaviour various specifications of inverse demand systems (dual and differential) have been formally derived and applied to commodities such as meat, fish, fresh fruits and vegetables (Eales and Unnevehr 1994; Barten and Bettendorf 1989; Rickertsen 1998; Fousekis and Revell 2002). The Inverse Almost Ideal Demand System (IAIDS hereafter) developed by Eales and Unnevehr (1994) is by far the most common used model in empirical work.

To derive an inverse demand system, one can start either from the direct utility function and exploit Wold's identity (which can yields ordinary inverse demands), or start from he distance (transformation) function and exploit Shephard's theorem (which yields compensated inverse demand function) (Moschini and Vissa 1992). Usually, preferences are represented by a distance function, characterizing the amount by which all quantities consumed must be changed proportionally to attain a particular level of utility. This means that it gives the proportional "distance" along a ray from the origin by which quantities must be reduced or increased to rach a particular indifference surface. Differentiation of the distance function with respect to quantity of a particular good yields the compensated inverse demand function for that good.

The inverse of a Marshallian demand function can be expressed in terms of normalized prices (price divided by income or total expenditure) as a function of quantities (Deaton 1979). In this respect, the distance function (an inverse representation of the direct utility function) provides the theoretical framework for deriving inverse demand systems and their properties (Anderson 1980; Deaton 979). Starting with the PIGLOG cost function of the AIDS system (Deaton and Muellbauer 1980) and interchanging the price variable (p) with quantity (q), an analogous expression for the distance function can be specified as

$$\log D(u,q) = (1-U)\log A(q) + B(q), \quad (1)$$

where D denotes the distance function, u indicates utility and *A(q)* and *B(q)* are homogenous functions given by

$$\log\ A(q)\ =\ a_0\ +\ a_i \log\ q_i\ +\ \frac{1}{2}\sum_{i=1}^{n}\ \sum_{j=1}^{n} \gamma_{ij}\ \log\ q_i q_j \quad (2)$$

and

$$\log B(q) = \log A(q) + \beta_0 \prod_j q_j^{\beta_j} \quad (3)$$

Eales and Unnevehr (1994) and Moschini and Vissa (1992) followed this approach and developed an inverse AIDS. The expenditure share $\boldsymbol{w_i}$ of a good $\boldsymbol{i}$ is given by:

$$w_i = a_i + \sum_{j=1}^{n} \gamma_{ij} \log(q_j) + \beta_i \log(Q) \quad (4)$$

where q_j is the quantity of good j. The quantity index *log(Q)* is defined by:

$$\log(Q) = a_0 + \sum_{k=1}^{n} a_k \log(q_k) + \frac{1}{2} \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{kj} \log(q_k) \log(q_j)$$

(5)

Equation (1), with the geometric quantity index for *log(Q)*, is an approximate system in the sense that it provides a first-order local approximation to any arbitrary inverse demand system. Therefore, it is termed a linear approximate inverse demand system (LAIDS). Similar to the Rotterdam inverse demand system by Barten and Bettendorf (1989), LAIDS also satisfies the minimum flexibility criteria by Diewert's definition. Further, the restrictions implied by microfoundations can be imposed without any a priori implication for the substitution possibilities among commodities. Since the sum of shares across ***i*** is unity by definition, the parameters of (4) and (5) must satisfy the following adding up restrictions $\sum_i \alpha_i = 1$ $\sum_i \gamma_{ij} = \sum_i \beta_i = 0$

while the restriction of homogeneity $\sum_j \gamma_{ij} = 0$ and symmetry $\gamma_{ij}=\gamma_{ji}$ can be easily imposed or tested.

It should be noted that equation (4) together with the quadratic expression for *log(Q)* in (5) are not dual to the AIDS system. Therefore, they cannot represent the same preference structure. As such, the system is nonlinear in parameters. But the interesting aspect of this model is that it can be made linear by replacing the quadratic expression of *log(Q)* with an appropriate index[2]. From an empirical stand point, *log(Q)*, the scale which adjusts the quantities consumed to meet the particular utility level, can be assumed to be exogenous. In our analysis, this is facilitated by a geometric quantity index for the scale quantity,

$$\ln Q^* = \sum_i w_i \log q_i \quad (6)$$

Due to the fact that opposite to the prices, quantities are not collinear, Moschini and Vissa (1992) mentioned that this index is not invariant to the choice of the units of measurement and hence it was suggested to scale quantities by dividing through by the means. The adequacy of the linear approximation however, is an empirical question. In two empirical studies (Eales and Unnevehr 1994 and Rickertsen 1998), the use of linear approximation performed quite well.

To capture shifts of demand curve due to policy change, a dummy variable was added in the model which takes the value of one after the year 1987. Thus the form of model that was employed for the estimation of the parameters and flexibilities is given by the following equation:

$$w_i = a_i + \delta_i D + \sum_{j}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q^* \quad (7)$$

With inverse demand models, sensitivities are typically measured by flexibilities (Houck 1965). Price flexibilities defined as the percentage changes in normalised prices (prices divided by the total expenditure) caused by a 1 percent change in the consumption of that good. Furthermore, the scale flexibilities, defined as the percentage change in the normalized price of that good in response to the proportionate increase in the consumption of all goods.

Given that the Slutsky and Antonelli matrices are generalized inverses of one another, quantity elasticities derived from the inverse demand system are analogous to price elasticities derived from a direct demand system. However, empirical differences arise between the two estimates due to econometric artifacts of different dependent variables, price in the indirect and quantity in the direct demand functions. While the scale elasticities derived from the inverse demand specification behave like the income elasticities of the direct demand system in terms of establishing properties of the demand system, empirically they are difficult to compare as the scale

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[2] Deaton and Muellbauer (1980) provide intuitive reasoning for using Stone's price index for linearizing the AIDS system. Although the same argument does not apply here, Moschini and Vissa (1992) have shown that a geometric index provides a good approximation to the quadratic expression in (2)

effect accounts for the scalar movement along the distance function to compensate for a change in the consumption bundle, while the income effect accounts for income compensation necessary from a change in relative prices through the effect on expenditures (Anderson 1980).

The uncompensated and compensated price flexibility, f_{ij} and f_{ij}^* as well as scale flexibility f_i are calculated as:

$$f_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + \frac{\beta_i}{w_i}(\alpha_j + \sum_k \gamma_{kj} \ln q_k) \qquad (8)$$

$$f_{ij}^* = f_{ij} - w_j f_i \qquad (9)$$

$$f_i = -1 + \frac{\beta_i}{w_i} \qquad (10)$$

where δ is the Kronecker delta and is equal to 1 for i=j and 0 otherwise.

Green and Alston (1990) have shown that the AIDS price elasticity formula is inappropriate when the linear approximation is used. Therefore, Chalfant's (1987) formula should be employed in calculating price elasticities and the analog to Chalfant's formula is used to calculate flexibilities:

$$f_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + \frac{\beta_i w_j}{w_i} \qquad (11)$$

Interpretation of flexibilities can be made in a manner similar to elasticities. A commodity is said to be inflexible if a 1% increase in consumption of that commodity leads to a greater than 1% decrease in the marginal consumption value of that commodity (its normalized price). Likewise, we will refer to commodities with scale flexibilities less (greater) than -1 as scale inflexible (flexible). Commodities are termed gross q-substitutes if their cross-price flexibility is negative, cross q-complements if it is positive. Moreover, scale flexibilities are less than -1 for necessities and greater than -1 for luxuries. At the margin, normalized price is proportional to marginal utility. Therefore, as consumption of all goods increases 1%, the marginal utility of necessities declines more than proportionately and the marginal utility of luxuries declines less than proportionately.

4. The Empirical Results

We model the demand for long-length roundwood as a five-commodity demand system which includes q_1: "*fir & spruce*", q_2: "*pine*, q_3: *beech*", q_4: "*oak*" and q_5: "*poplar & other broadleaved*". The selection of the products involves the assumption of weak separability (Deaton and Muellbauer 1980). Under this assumption it may be thought that the timber industry allocating, at a first stage, aggregate expenditure over primary composite goods such as fuelwood, pulpwood, small size roundwood and splitwood, roundwood <2m and long-length roundwood >2m. Next, the timber industry may be thought of, as allocating the given expenditure for long-length roundwood (oak, fir and spruce, beech, pine and poplar and other broadleaved). Weak separability is very common in applied demand analysis (Mochini and Vissa 1992; Barten and Bettendorf 1989; Rickertsen 1998).

In order to incorporate the impacts of the changes made in the provision of forest products by the state forest farms in Greece since 1987 in the model was used a dummy variable with 0 to 1986 values and 1 afterwards.

Since structural demand systems, such as the Inverse AIDS (IAIDS) model, are singular, only four equations were specified (the poplar & other broadleaved equation was dropped and its parameters were obtained residually). In order to test the theoretical restrictions of homogeneity and symmetry, initially the unrestricted model was estimated using SUR estimation[3] and then the theoretical restrictions of homogeneity and symmetry were imposed. Likelihood ratio test (LRT) was employed in order to test the theoretical restrictions and the test results are given in the Table 1. According to Table 1, both of theoretical restrictions are accepted by the data

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[3] For the estimations the computer program SHAZAM 10 was employed. The maximum likelihood ensures that the results are robust to the equation dropped.

Table 1: Hypothesis tests for theoretical restrictions

Null	Alternative	LRT	DF[†]	Critical value at 5%	Conclusion
Homogeneity	No- restrictions	3.92	4	9.49	Accepted
Symmetry	No- restrictions	6.65	10	18.31	Accepted

†: DF denotes Degree of Freedom

The estimated parameters with homogeneity and symmetry to be imposed in the model are presented in Table 2. Of the twenty-two estimated parameters, sixteen are statistically different from zero at the 5 percent level. The estimated system appears to have a high explanatory power since the computed system R^2 is 0.99. However, this statistic is frequently very high and should be interpreted with caution (Berndt 1991). For this reason the R^2 coefficients for the four estimated equations are reported in the last row of the Table 1 and their computed value are 0.88, 0.90, 0.91 and 0.65 respectively indicating the good performance of the system. The conformity of the estimated model with the demand theory was further tested by checking the semi-definiteness of Antonelli substitution matrix. Its five eigenvalues are -0.000018, -0.12343, -0.32043, -0.36494, and -0.41243 implying that the underlining distance function is concave, as stipulated by the economic theory. Moreover, the change of the exploitation system of the public forests in 1987 had statistically significant effect in all species of roundwood except oak. An explanation is that oak, in spite of taking the 33% of the overall area of Greek forests, produces only a small quantity of roundwood. Also, this effect was negative for all the species of long-length roundwood but poplar & other broadleaved due to substantial quantities of poplar wood are produced by private plantations of poplar which were established in the framework of European Regulations.

Table 2: Inverse AIDS model - Estimation results

	Fir & Spruce	Pine	Beech	Oak	Poplar & other broadleaved
Constant	0.1862*	0.2642*	0.1116*	0.0383*	0.3997*
s.e[a].	0.014771	0.015246	0.007362	0.005630	0.020992
$\ln q_1$	0.1089*	-0.0447*	-0.0188*	-0.0009	-0.0446*
s.e.	0.007063	0.006154	0.003321	0.002346	0.007588
$\ln q_2$	-0.0447*	0.1647*	-0.0455*	-0.0120*	-0.0625*
s.e.	0.006150	0.012369	0.005960	0.003487	0.010054
$\ln q_3$	-0.0188*	-0.0455*	0.0932*	-0.0001	-0.0289*
s.e.	0.003321	0.005960	0.005059	0.002058	0.004857
$\ln q_4$	-0.0009	-0.0120*	-0.0001	0.0147*	-0.0017
s.e.	0.002346	0.003487	0.002058	0.001945	0.003506
$\ln q_5$	-0.0446*	-0.0625*	-0.0289*	-0.0017	0.1377*
s.e.	0.007587	0.010054	0.004857	0.003506	0.013470
Expenditure	-0.0057	0.0220*	0.0156*	-0.0062**	-0.0540*
s.e.	0.010763	0.009924	0.005336	0.003992	0.021430
D	-0.0332*	-0.0242**	-0.0288*	-0.0073	0.0936*
s.e.	0.014207	0.015186	0.007556	0.005604	0.019800
$\overline{w}_i$	0.22	0.29	0.15	0.22	0.03
$\mathbf{R^2}$	0.88	0.90	0.91	0.65	-

a.: standard errors, *(**) Statistically significant at 5%(10%) level

5. Results and Analysis

Tables 3 and 4 present information on the price and scale flexibilities computed from the IAIDS parameter estimates. Average (i.e. computed at the mean budget shares) uncompensated price and expenditure flexibilities are shown in the Table 2 while compensated price flexibilities are presented in Table 3.

Starting with the price flexibilities (Table 3), it may be observed that, on average, aggregate demand for long-length roundwood of all wood categories, is inelastic to own quantity changes. More precisely, in the case of the fir & spruce, a 1% rise in the own consumed quantity is estimated t cause a cete*ris paribus* average reduction of 0.52% to the marginal consumption value of this wood (its normalized price) during the 1964-2005 period. Similarly, in the case of the rest wood categories (pines, beech, oak and poplar & other broadleaved), a 1% rise of the supplied quantity of the each, will lead to a reduction of their normalised price equal with 0.42%, 0.36%, 0.34% and 0.61% respectively.

Average scale flexibilities (also appearing in Table 3) indicate that on the average, and for the period examined, in case where the consumption of all wood categories increase by 1%, the marginal utility of pine and beech decline by 0.93% and 89% respectively. In contrast, for the remain three long-length roundwoods categories (fir & spruce, oak and poplar & other broadleaved), their marginal utility will decrease by 1.03%, 1.28% and 1.08% respectively if the consumption of all categories increase by 1%.

Table 3: Uncompensated price and expenditure flexibilities

	Uncompensated price flexibilities (f_{ij})					
	Fir & Spruce	Pine	Beech	Oak	Poplar & other broadleaved	**Expenditure (f_i)**
Fir & Spruce	**-0.84***	**0.11***	**0.07***	**0.22***	**-0.05***	**-0.49***
s.e.	0.01386	0.01823	0.01498	0.03565	0.00901	0.07102
Pine	**-0.01**	**-0.64***	**-0.08***	**-0.32***	**-0.01**	**-1.05***
s.e.	0.01178	0.02844	0.02225	0.04443	0.01004	0.05057
Beech	**-0.02**	**-0.13***	**-0.38***	**-0.53***	**0.00**	**-1.06***
s.e.	0.01714	0.03295	0.04433	0.06468	0.01595	0.06902
Oak	**-0.03***	**-0.19***	**-0.19***	**-0.77***	**-0.01**	**-1.19***
s.e.	0.00758	0.01441	0.01460	0.03125	0.00643	0.03187
Poplar & other broadleaved	**-0.22***	**-1.38***	**-1.51***	**0.10**	**-0.67***	**-0.72***
s.e.	0.02916	0.15920	0.15617	0.08104	0.03276	0.09329

s.e.: Standard errors, *(**) Statistically significant at 5%(10%) level

Table 4 presents the compensated quantity flexibilities. The negative signs of the compensated own–quantity flexibilities for the five wood products ensure the concavity of the underling distance function[4]. The positive sign indicates gross compementarity while the negative indicates gross substitution relationships between the wood products (Hicks 1956). Regarding cross price relationships among the woods examined, Table 3 indicates complementarity in all the cases. Substitutability appears in the cases of pine for beech as well as, pine for oak but this relationship does not appears as statistically significant.

[4] This is a sufficient condition but not the necessary one.

Table 4: Compensated price flexibilities

	Fir & Spruce	Pine	Beech	Oak	Poplar & other broadleaved
Fir & Spruce	**-0.75***	**0.22***	**0.13***	**0.43***	**-0.03****
s.e.	0.00816	0.01162	0.01192	0.01509	0.00803
Pine	**0.18***	**-0.41***	**0.06***	**0.13***	**0.04***
s.e.	0.00952	0.03049	0.02152	0.03115	0.00939
Beech	**0.17***	**0.10***	**-0.24***	**-0.08***	**0.04***
s.e.	0.01518	0.03348	0.04524	0.04748	0.01497
Oak	**0.17***	**0.07***	**-0.02***	**-0.26***	**0.04***
s.e.	0.00612	0.01544	0.01513	0.02288	0.00604
Poplar & other broadleaved	**-0.10***	**0.18***	**0.14***	**0.41***	**-0.63***
s.e.	0.03129	0.04468	0.04579	0.05796	0.03091

s.e.: Standard errors, *(**) Statistically significant at 5%(10%) level

Barten and Bettendorf (1989) argue that the cross-quantity compensated (Antonelli) effects in differential systems are imperfect indicators of the relationships among goods. This is because the homogeneity restriction, along with the negative semi-definiteness of the Antonelli matrix entails dominance of positive cross-quantity compensated effects (i.e. dominance of complementarity). As they point-out a slightly superior indicator has been proposed by Allais (1943). Allais essentially worked with the transformation of the Hessian matrix such that the result is invariant under the monotone transformation of the utility function and can be considered to reflect interactions within the preference order independently of how it is represented. He also proposed a measure of the intensity of interaction namely:

$$a_{ij} = \frac{a_{ij}}{\sqrt{a_{ii}a_{jj}}} \qquad (12)$$

where

$$a_{ij} = f^{*}_{ij}/w_i w_j - f^{*}_{rs}/w_r w_s + (f_i/w_i - f_r/w_r) + (f_j/w_j - f_s/w_s) \qquad (13).$$

In Eq. (13) r and s refer to some standard pair of goods r and s. The scalar $\boldsymbol{\alpha}$ makes α_{rs}=0. Thus, $\alpha_{ij}>0$ indicates that i and j are more complements than r and s, while $\alpha_{ij}<0$ reflects that i and j are stronger substitutes than r and s. Clearly $\alpha_{ij}=0$ means that i and j have the same type of interactions as r and s. Allais coefficients for the five long-length roundwood products in Greece are reported in Table 5. We have selected as standard pair the interaction between the "*Pine*" and "*Poplar & other broadleaved*". Diagonal entries of the table by construction are -1 consistent with the notion that a good is its own perfect substitute. All Allais interactions appear to be negative which expresses the intuitive idea that all the long-length roundwood products considered here as substitutes. The highest degree of substitutability appears in the case of *pine* for *oak*, given a change in their auctioned quantities. By contrast, the lowest degree of substitutability appears in the case of *fir & spruce* for *poplar & other broadleaved*. The almost same degree of substitutability appears in the cases of *pine* for *beech*, *fir & spruce* for *oak* and *beech* for *oak*.

Table 5: Allais coefficients

	Fir & Spruce	Pine	Beech	Oak	Poplar & other broadleaved
Fir & Spruce	-1	-0.15	-0.24	-0.64	-0.14
Pine		-1	-0.58	-1.38	0.00
Beech			-1	-0.47	-0.29
Oak				-1	-0.41
Poplar & other broadleaved					-1

6. Concluding remarks

This study investigates empirically the Greek demand for five major species of long-length roundwood (fir and spruce, pine, beech, oak and poplar and other broadleaved) using yearly data from auctions of forest products covering the period between 1964 and 2005. Since the quantity is predetermined, the inverse almost ideal demand system was employed as the most appropriate model. The results of this study may have further used within market models of supply and demand that are frequently used for policy analysis or welfare changes.

The theoretical restrictions of homogeneity and symmetry were accepted by the data and the conformity of the estimated model with the demand theory was tested further by checking the semi-definiteness of Antonelli substitution matrix.

The own-quantity flexibilities are substantially lower than one (in absolute value terms) suggesting inelastic responses of normalized prices to own-quantity changes for the five species of long-length roundwood.

According the estimated scale flexibilities, 1% increase in the supply of all species of long-length roundwood will lead to a decrease of normalized price for all species of long-length roundwood. Finally, all Allais interactions appear to be negative which expresses the intuitive idea that all the long-length roundwood products considered here as substitutes.

As it is known, the formation of the forest policy and specifically the decision making and the organizing of developmental programs on forestry in the long term, is based on the future trend of supply, demand and price evolution of various forest products.

According to our results, an increase in the supply of various goods of roundwood will lead to very small reduction of their prices. Thus, taking into account that the demand of forest products and especially in roundwood is accumulated every day while the same time the supply it is not seem to grow substantially, the foundation of a more intensive management of forests, a more efficient use of timber and an increase in financing of various developmental forestry programs will be beneficial first for the Greek economy reducing the exchange flow and secondly for the economy of rural and mainly of marginal areas increasing the employment for the local people and the residents of such areas. The annual employment of these people in the forestry contributes significantly in the improvement of the standards of living, in keeping them in their homes they live and in the stabilization of the economy of the mountainous regions.

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