The round wood market in Greece: An empirical approach

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Abstract

The present study aims to determine the factors affecting the producer price of the industrial round wood. The factors examined as determinants of the producer price are the volume of domestic production, imports and exports of the industrial round wood in Greece. As a proxy for the producer price, the round wood of long length (> 2m) price is employed. For the achievement of the aforementioned objective, Johansen cointegration technique was implemented. The results confirmed the existence of a sole long-run relationship between the variables studied while the estimation of the vector error correction model indicated a statistically significant speed in the long-term equilibrium. The implementation of the Granger causality test has shown that the producer's price is affected by the imported volume while the domestic production is determined by the volume of exports. Finally, the producer prices are determined by the exports and the imports of the Greek wood sector and vice versa. All the aforementioned results are consistent with the classic supply-demand economic theory.

Key words: round wood market; Greece; cointegration technique; Granger causality.

Resumen

El mercado de madera en rollo en Grecia: una aproximación empírica

Este manuscrito tiene la intención de determinar los factores que afectan el precio de producción de la madera en rollo industrial. Como proxy para el precio de producción, se utiliza el precio de la madera en rollo de gran longitud (> 2 m). Los factores examinados como determinantes del precio de producción son el volumen del producción de las importaciones y el volumen de las exportaciones de la madera en rollo industrial en el sector griego. La aplicación de cointegración de Johansen ha indicado una relación de largo tiempo única entre las variables estudiadas. Además, la aplicación del VECM ha demostrado una velocidad importante en el equilibrio a largo plazo, mientras que la prueba de causalidad de Granger ha puesto de manifiesto que el precio del productor se encuentra fuertemente afectada por el volumen importado, mientras que la producción nacional se determina por el volumen de las exportaciones. Por último, se determinan los precios de producción, así como las exportaciones y las importaciones del sector griego de la madera. Todos estos resultados son compatibles con la teoría clásica de la oferta y la demanda.

Palabras clave: mercado de madera en rollo; Grecia; cointegración técnica; causalidad de Granger.

Introduction

General

The round wood market has been a subject of extended study within the last decades with the application of different econometric models (theoretic and empirical). For each domestic market usually different models are used given the particularities of each market. To be more specific, using as a criterion the degree of competition in the market under review, different market structures can be met ranging from perfect competition till monopoly (or monopsony) with a single seller (or, for monopsony, buyer) of a product in

the market. In between, there are various possible market structures, in which strategic interaction between different economic agents in the market may occur (Tirole 1988, Varian 1993). Another market structure that may well describe the roundwood market is the bargaining model. This model is related to the trade union behaviour between the associations of forest industry and forest owners. Given the complexity of roundwood markets and the great number of the theoretic models that may describe them, empirical modelling of every domestic wood market is a necessary tool in order to determine the market structure that matches best to the market studied (Toppinen and Kuuluvainen, 2010).

The global market

Worldwide, the prices of round wood products are characterized by significant fluctuation, based on historical trends. In terms of nominal prices, a peak is recorded at the beginning of the 1970s immediately after the first oil crisis (a common feature of many other commodities). From this point until the 1990s, trends in prices have varied by product and region. Until the decade of 1990, the prices of round wood products have become stable or decreasing in nominal terms while in real terms a significant decrease was recorded (UN, 2005). In Western Europe, the real prices of round wood products in general are characterized by a declining trend within the last three decades and the real prices in Eastern Europe are converging with those of Western Europe, through an increasing trend for the same time period.

The decrease of the real prices of the forest products within the last few decades is related to an increase in round wood production. This result may be attributed to a number of factors like; increases in plantation forests, tree varieties characterized by a faster growing rate, technological innovations and cost efficiencies (Johnson, 2009).

The world growth in production and consumption of industrial round wood in the long term had reached 1.4 percent between 1970 and 1990, but a decline in the decade 1990-2000 was recorded, as a result of decreasing production and consumption in Europe, mostly in the former Soviet Union; the substitution of other materials for wood; the global growth of recycling; and the industrialized economies' slowing consumption may account for this result (Reid *et al.*, 2004). Since the year 2000, industrial roundwood production and consumption has been slightly increased, and in

the year 2007 has reached the level of 1990 (Johnson, 2009). The main increases in production and consumption of industrial roundwood between 2000 and 2007 took place in Europe, Asia, Latin America, and the Caribbean. Production and consumption in Europe have not reached yet the levels of 1990. What also must be mentioned is the shift from Western Europe and America to emerging economies like China and Eastern Europe (Aulisi *et al.*, 2008).

Given that the Greek round wood market is a small market becomes evident that is strongly affected by the global round wood market. Thus, findings of a study on the Greek round wood market can be well interpreted by dominant conditions of the global market.

Literature Review

Within the last decades there has been an increasing interest in the use of quantitative methods, econometrics, linear programming and system dynamics in forest sector analysis and forecasting (Toppinen and Kuuluvainen, 2010). One of their most widespread applications is related to the survey of the price and the volume determination of round wood consumed. All the aforementioned surveys are based on different approaches (Johansson and Lofgren, 1985; Hulktrantz and Aronson, 1989; Hetemaki and Kuuluvainen, 1992). The traditional approach uses the assumption of competitive round-wood markets. In this case the equilibrium price is determined by assuming equality in demanded and supplied quantities (Koskella and Ollikainen, 1996). In more recent studies assuming or investigating imperfect competition is the minority, despite structural evidence against perfect competition. Behavioural evidence on imperfect competition is not clear according to Koskella and Ollikainen, (1998), Ronnila and Toppinen, (2000), Kallio, (2001).

Through another approach, the estimation of demand as a determinant factor of the equilibrium price is related to the profit maximization behavior of the firms while the supply of timber is related to the intertemporal behavior of the forest owners.

Another issue thoroughly studied is the determination of prices in the round wood market. One of the theories that account for the determination of prices is the Law of One Price (Richardson, 1978). This theory in its strong form argues that prices in sub-markets are equal; in its weak form though supports that the prices differ to a quantity equal to a constant transac-

tion cost (Buongiorno and Uusivory, 1992). The method mostly employed for the analysis of this issue is Johansen's cointegration technique (Johansen, 1988; 1996, and Juselius, 1990;1992). An important study conducted by Mutanen (2006), confirmed the non validity of the Law of one Price in the sawnwood market of Germany by modeling import demand and substitution between suppliers. Furthermore, the same method has been used to analyze the markets of forest industry products (Hänninen 1998, Kainulainen and Toppinen, 2006; Hänninen *et al.*, 2007).

Other important studies that refer to the existence of interregional relationships in the round wood are those of Thorsen (1998), Toppinen and Toivonen, (1998), while the forest product markets have been a subject of study by Buongiorno and Uusivori, (1992) as well as by Jung and Torodian (1994).

The price of industrial round wood is closely related to the power of the market, and this paper makes an attempt to trace the factors affecting the round wood producer price by testing whether the imported, exported volume and the domestic production are connected each other with a long-term relationship. This effort has been made in order to examine the factors that may account for the asymmetry in price transmission mechanism between consumer and producer prices in the round wood market (Koutroumanidis *et al.*, 2009). In particular, this paper surveyed the role of imports in the producer price determination substantiating a potential explanation for the existence of this asymmetry.

A last but not least effort in the price determination of forest products was conducted by Koutroumanidis *et. al.* (2009). This study aims at price determination and forecasting with the use of a hybrid method and is based on the combination of neural networks and ARIMA modeling providing satisfactory results.

The paper is organized as follows: The second section provides an insight to the Greek forest sector, while the third section describes the data and methodology employed in the present study. Section 4 gives the results of the different methodologies employed while section 5 concludes.

Research Area

The Greek forest sector

The forest lands in Greece occupy almost 2/3 of the total area of the country. The lands are mainly mountainous and semi-mountainous and are extensively exploited in the production of different goods and services. The calculation of Forestry contribution to the domestic economy is based on the following characteristics; 1) the value of the total primary forest production including technical wood, fuelwood, resin, games, various fruits and others 2) the non-monetary value of the forest benefits like their hydrological contribution, their protective role against erosion as well as their impact on hygiene, tourism and esthetics According to the aforementioned the contribution of forestry to GDP is estimated at about 5% (Papastavrou, 2008).

One of the most important objectives of projects regarding the forest policy and development is the increase in the forest production and especially the wood production in order the needs of the country for wood and wood products to be satisfied. Within the post-war era an important effort was made aiming at the improvement of the degrading forests, their sustainable management and exploitation having as a result a significant increase in the production of the industrial wood. Despite this effort though, Greece depends greatly on the wood imports in order to satisfy its needs in wood products (Koutroumanidis *et al.*, 2009; Klonaris and Arabatzis, 2009).

Until the end of the year 1986, only two systems of exploitation for the state forests were in valid. The first system involves self-supervision of the cultivation and supply process (logging, harvesting and distribution) by the local Forest Services (State Forest Farms) according to the article 137 (Legislative Decree 86/69) within the framework of the State Forest Exploitation (KED, according to the Greek acronyms). The second system involves leasing of the forest's production (wood logging) to forest labor cooperatives or wood cutters according to the article 134 of the Legislative Decree 86/69.

According to the Presidential Decree 126/86 a new exploitation system (the third), is introduced for the public forests. This system provides the exploitation of forests to the Forests Cooperatives that are obliged to pay an amount of money as a price proportion of forests products independently of the product type to the central Fund of Agriculture, Forests and Livestock and to the Local Authorities, under which the forest or the stand comes (Tororis, 1994).

The mean producer prices as formatted through auctions conducted by state Forest Farms-Local Forest Services (based on the first system) may well

function as negotiation prices for the wood supply of private forestry of the wood logged, harvested and distributed by the Rural Forest Cooperatives (Anagnos and Stamou, 1981; Koutroumanidis *et al.*, 2009).

The greatest proportion of domestic wood production is fuel wood while round wood is the second. In particular, the domestic wood production presents the following composition; 71% is consisted of fuel wood, 28.5% of round wood, while the railroad timber consists only 0.5% of the total production (Fousekis *et al.*, 2001). This situation implies that Greek industry depends heavily on imported wood in order to cover input needs (Stamou, 1996).

The industrial roundwood production includes all roundwood products other than fuelwood and charcoal. In particular, includes sawlogs or veneer logs, posts, pitprops, pulpwood, and other roundwood industrial products. All wood production data refer to both coniferous and non-coniferous species (World Bank, 2002).

The main characteristic of the Greek market of forest products lies on the fact that its needs are not satisfied by the domestic production with a few exceptions like those of fuelwoods, particleboards, veneers and the ply woods. The exports related to the imports are extremely limited.

The exports of technical wood and saw wood are relatively few and within all the time period of the Greek forestry, fluctuated under the 0.2 million cubic meters. The imports on the other hand in technical wood and veneers especially after 1986 overcome 1.0 million cubic meters while before the year 2002 (a few years before the Olympic games in the year 2004) reached 10.0 million cubic meters (Ministry of Environment, Energy and Climate Change, 2010).

Fousekis *et al.* (2001) presented through a flexible CBS model the aggregate demand for four types of wood imports. The inelasticity in the price of unprocessed wood may be accounted for the impact of the exported volume on the determination of the price of industrial round wood.

In addition, Klonaris and Arabatzis (2009) surveyed price determination in the market of wholesale long-length roundwood (> 2m) with the application of reverse demand system. According to their findings, responses of prices to own-quantity changes are inelastic while based on Allais coefficients substitutability between the different species of log-length round wood can be concluded.

Material and Methods

Data

In order to specify and estimate a relationship that describes the price formation in the round wood market, we employed the imports, exports, domestic production of round wood (data derived from FAOSTAT, 2011) and prices of round wood of long length (> 2m, data derived by the State forest Farms). The price is calculated as a weighted average of the prices (quantities are the weights) of the most important forest species used for this type of wood (included fir, spruce, pine, beech, oak, and poplar). What must be mentioned is the fact that the prices used above are formatted through auctions realized by the Local Forest Services. Thus, the producers are price takers, having as a result the wholesale traders to offer prices for the fixed quantities low enough to induce consumers to buy the available quantity, while the profit margin is obtained. Consequently, in this case the price should be determined by the quantities and not vice versa. According to the aforementioned findings, the function to be estimated through Johansen cointegration technique (Johansen, 1988; Johansen and Juselius, 1992) is the following;

$$pp = (imp, \exp, dp) \qquad [1]$$

where;

pp: Producer Price of round wood of long length (> 2m) (in euros);

imp: Imported Volume of Industrial round wood (in cubic meters);

exp: Exported Volume of Industrial round wood (in cubic meters);

dp: Domestic Production of Industrial round wood (in cubic meters);

The data used are expressed all in logarithmic form, derived by FAOSTAT database (FAOSTAT, 2011), they are annual, while they refer to the time period 1974-2008. The producer price is in Euros/m^3, while all the quantities are expressed in m^3. The data processing was achieved with the software Econometric Views 6. The existence of a long-term relationship between the time series studied is confirmed if their combination is cointegrated of order zero (I(0)).

The Figures 1-4 depict the evolution of each time series studied.

Figure 1 depicts the evolution of the producer price which is characterized by an increasing trend with a declining rate though especially within the last decade.
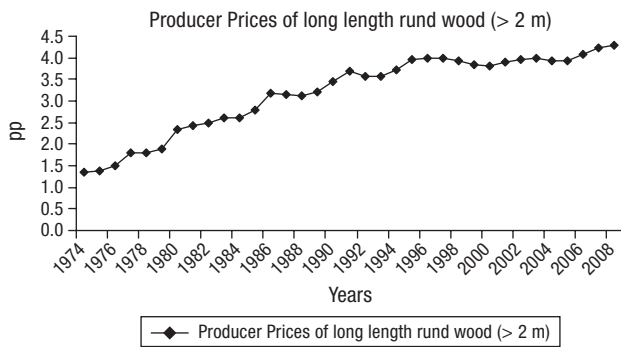
Producer Prices of long length rund wood (> 2 m)

Figure 1. The producer price in the Greek roundwood market.

Evolution of round wood production in Greece
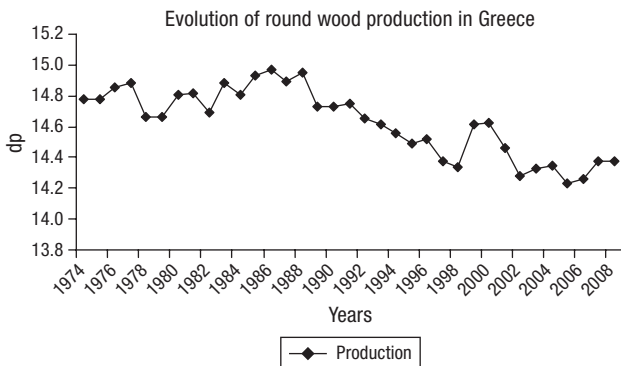
Figure 2. The volume of domestic production in Greece (in m³).

Evolution of round wood imports in Greece

Figure 3. The imported volume (in m³).

Evolution of round wood exports in Greece
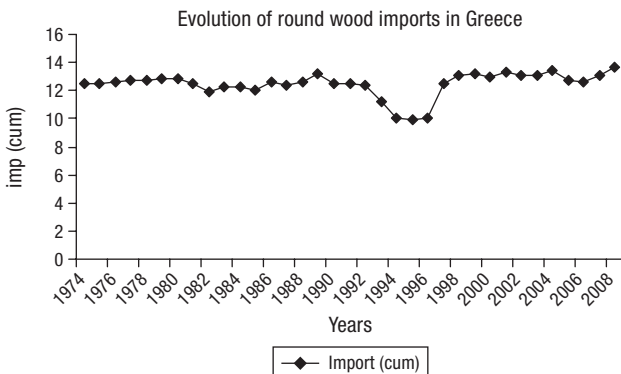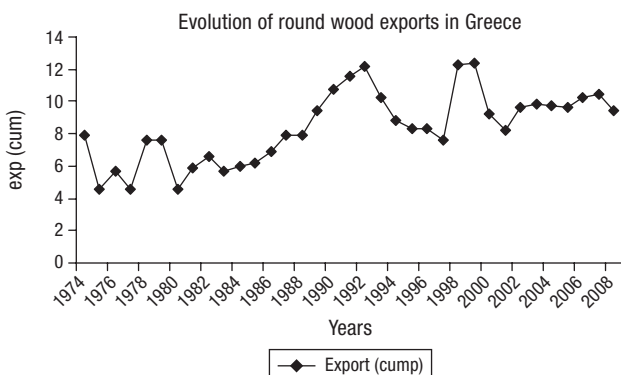

Figure 4. The exported volume (in m³).

According to Figure 2 the volume of domestic production is more volatile and without an evidend upward or downward trend. Though there has been a slight upward trend throughout all the time period studied, while a peak is observed in the year 1990.

The next figure, Figure 3 presents the volume of round wood imports mesured in cubic meters. Generally, the volume of imports presents stability with an exception for the time period 1994-1996, that a sharp decline is evident.

Finally, Figure 4 depicts the evolution of the Greek round wood exports with significant fluctuations throught the time period studied, without a particular trend though.

Methodology

Unit Root Test

In order to apply the cointegration technique, we examine the stationarity of the time series studied. A precondition for the implementation of a multi-Var contegration technique is the application of a unit root test. The unit root test, employed in our data is the Augmented Dickey Fuller (ADF) test (1979). Additionally, KPSS test was employed since the last few years, it is considered a more reliable test than ADF test (Elliot *et al.*, 1996).

The ADF (1979) test has been widely used for testing the existence of a unit root in the time series studied.

This test is based on the following auxiliary regression of the general form:

$$\Delta p_t = \gamma_0 + \gamma_1 t + \gamma_2 p_{t-1} + \Xi(L)\Delta p_{t-1} + e_t \qquad [2]$$

where;

$\Xi(L): p-th\ order\ polynomial\ in\ the\ lag\ operator\ L$

$e_t \sim N(0, \sigma^2)$

This test aims at testing the null hypothesis that $\gamma_2 = 0$ which is tantamount for a single unit root in the data-generating process for p_t. In order to determine the ADF form, the significance of the constant and of the time trend coefficient was tested. Following the aforementioned steps, we ended up to the final form of the regression that includes no constant and no time trend. Due to lack of power in the ADF test (Elliot *et al.,* 1996), another stationarity test was applied. In particular, the KPSS test was employed with the null

of stationarity against the alternative of a unit root. The particular test uses the components model:

$$y_t = \alpha + \delta t + x_t + v_t, \quad x_t = x_{t-1} + u_t \qquad [3]$$

where;

y_t: The sum of the deterministic trend, a random walk x_t, and a stationary error v_t. $u_t \sim (0, \sigma_u^2)$.

v_t: is assumed to be stationary for the null hypothesis that y_t is trend stationary we simply require that $\sigma_u^2 = 0$.

When the variance of the error is equal to zero, x_t is a constant and is added to the intercept of equation 3. The coefficient of the trend may be set equal to zero in which case the null hypothesis that y_t is stationary around a level rather than around a trend is tested.

Cointegration with the Johansen technique

The cointegration analysis was based on Johansen's multivariate cointegration methodology. Additionally, the estimation of the cointegration vectors was applied with the treatment of the Johansen's maximum likelihood approach. According to Johansen (1988, 1991) any p-dimensional vector autoregression can be written in the following "error correction" representation.

$$\Delta X_t = \sum_{i=1}^{k} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \mu + \varepsilon_t \qquad [4]$$

where;

X_t: p-dimensional vector of I(1) processes;

μ: a constant;

ε_t: a p-dimensional vector with zero mean (Π is the variance-covariance matrix);

The Π matrix has a rank that is limited in the (0,r) and can be decomposed into:

$$\Pi = \alpha\beta' \qquad [5]$$

where;

α, β: p x r matrices;

r: distinct cointegrating vectors.

The procedure of Johansen provides the maximum likelihood estimates of α, β, while Π and the two likelihood ratio test statistics determine the order of the cointegration space. The trace and the maximum eigenvalue statistics are used to determine the rank of Π and to reach a conclusion on the number of cointegrating equations, r, in our multivariate VAR system. The economic time series of the price indices and the exchange rates are I(1) while when only one relationship in the long run exists their combination is I(0).

The cointegration technique may well be applied since the time series are non-stationary in levels and stationary in first differences. The Johansen cointegration technique (1988) includes the testing of the null hypothesis that there is no cointegration against the alternative that there is cointegration. In order to apply the Johansen technique it is necessary to calculate the number of lags of the endogenous variables of the model since an autoregressive coefficient is used for the modeling of each variable. The determination of the number of lags depended on the likelihood test statistic that was introduced by Sims (1980).

This test is given by the following formula:

$$LR = -2(l_o - l_1) \qquad [6]$$

Where l_i is the likelihood given by the VAR test with the use of $p_{o,1}$ lags. According to the results taken by E-views 5.0, the number of lags was found equal to 4.

The LR trace statistic and the maximum eigenvalue LR test were employed for the determination of the number of the relations connecting the variables under preview (rank of r). In particular this statistic test the null hypothesis of r cointegrating relations against k cointegrating relation (r = 0, 1, 2, ..., k − 1).

The LR trace statistic is calculated with the formula;

$$LR(r/k) = -T \sum_{i=r+1}^{k} \ln(1 - l_i) \qquad [7]$$

The (nonstandard) critical values are taken from Osterwald-Lenum (1992), which differ slightly from those reported in Johansen and Juselius (1990).

VAR Model with an Error Correction Mechanism

The process of cointegration is followed by the estimation of a VAR model in which a vector error correction mechanism should be included. This step is necessary given the fact that the variables under preview in logarithmic form are cointegrated.

The error correction model may well be derived by the long-run cointegration vector having the following form;

$$\Delta pp = lagged(\Delta dp, \Delta imp, \Delta \exp) + \delta e_{t-1} + u_t \qquad [9]$$

where;

Δ: denotes the first differences of the variables;

e_{t-1}: are the estimated residuals from the cointegrated regression;

δ: is the short run parameter that takes values in the (0,1);

u_t: is a white noise.

What must be underlined in the process of estimation of a VAR model is the criterion used for the correct specification of the model. In particular, the researcher should pre-determine the deterministic components as well as the number of lags used in the model. In this study the Schwartz-Bayesian criterion was used which according to Mills and Prasad (1992) outperforms other criteria.

Granger Causality Test

The next step in our analysis was to examine the Granger causal relationships among the variables under preview. The criterion used for this test is F-statistic. The null hypothesis tested was that each variable used in the model Granger cause the other.

The number of leads and lags used were determined with the assistance of the Akaike's information criterion (AIC) as well as the criterion of Schwartz (SC).

Results

The first tests employed aiming at survey the stationarity of the variables under preview are the ADF and KPSS tests. The results of those tests are presented in Tables 1 and 2.

According to the results of the ADF test, the nonstationarity of all the time series studied in levels and their stationarity in first differences is empirically confirmed.

Table 1. Results of the ADF test

	τ	k
Dp	−0.6773	0
Pp	−2.03355	7
Exp	2.7433	1
Imp	−0.43245	5
Δdp	−5.121	2
Δpp	4.725	8
Δexp	−4.4832	1
Δimp	−3.122	15

Notes: The critical values for the ADF test when no trend and no constant are included for 1, 5 and 10% are −2.64, − 1.95 and −1.61 respectively. K denotes the numbers of lags. These critical values are valid for the variables dp and imp. Regarding the cp a constant was used as exogenous and thus the critical values for 1, 5 and 10% are −3.711, −2.98 and −2.63 respectively. As far as the exp and the imp variables both trend and constant were used and consequently the critical values are the following; −4.27, −3.55, −3.21, for 1, 5 and 10% respectively.

Table 2. The results of KPSS test

	T
Dp	0.26798
Pp	0.206075
Exp	0.728
Imp	0.16254
Δdp	−5.067
Δpp	4.812198
Δexp	−4.917265
Δimp	0.0757

Notes: The critical values for the KPSS test when trend and constant are included for 1, 5 and 10% are 0.216, 0.146 and 0.119 respectively. These critical values are valid for the variables dp, cp and imp. As far as the exp variable only constant was used and consequently the critical values are the following; 0.719, 0.461 and 0.147 for 1, 5 and 10% respectively.

The same results are derived with the application of another more reliable stationarity test, the KPSS test. The next step in our analysis involved the application of Johansen cointegration technique. The number of lags chosen based on the methodology introduced by Sims (1980) is equal to 4. The results of this application are presented in Table 3.

Based on the results of maximum eigenvalue and LR statistics, the existence of a sole relationship between the variables employed can be confirmed. The sole relationship is presented by the following vector;

$$pp = -0.520299exp - 2.315103imp + 0.429225dp \quad [8]$$

The confirmation that the variables under preview are cointegrated allows us to estimate the VAR model by embodying an error correction mechanism that may express the long run dynamics. The results of VECM

Table 3. Johansen and Juselious cointegration test for the variables pp, imp, exp, dp lags in VAR = 4

Null	Eigenvalue	Trace Statistic	0.05 Critical Value
r = 0	0.608167	55.63105	47.85611
r ≤ 1	0.387829	25.64961	29.79707
r ≤ 2	0.238953	9.945824	15.49471
r ≤ 1	0.037044	1.207919	1.841466

Null	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value
r = 0	0.608167	29.98144	27.07
r ≤ 1	0.387829	15.70378	20.97
r ≤ 2	0.238953	8.737905	14.07
r ≤ 1	0.037044	1.207919	3.76

Table 4. Error correction model

$D(cp) = -30,21 - 0.016e_{t-1} + 0,97D(cp(-1)) - 0.00422D(dp(-1)) - 0.006D(imp(-1)) - 0,108D(exp(-1))$
$\qquad\qquad (-7.44)\quad (-2.427)\quad (4.497)\qquad\quad (-2,70758)\qquad\quad (-2.22614)\qquad\quad \ldots(-1.275)$
$\bar{R}^2 = 0.6412\quad F(9,21)\text{–statistic}=111.6145\quad D.W=1.8892$
$\qquad\qquad\qquad [0.000]$
$AX^2(1) = 0.122450[0.417],\qquad BX^2(2) = 1.4152[0.7150],\qquad\qquad CX^2(1) = 0.4152\,[0.179]\ldots DX^2(1) = 1.4255[0.121]$

Notes: Estimates via E - Views 5.0. D: Denotes the first differences of the variables. $\bar{R}^2$: Coefficient of multiple determination adjusted for the degrees of freedom (d.f). D.W. = Durbin Watson statistic. F(n,m) = F statistic with n,m d.f. respectively. A: $X^2(n)$ Lagrange multiplier test of residual serial correlation, following X^2 distribution with n d.f. B: $X^2(n)$ Normality test based on a test of skewness and kyrtosis of residuals, following X^2 distribution with n d.f. C: $X^2(n)$ Heteroscedasticity test following X^2 distribution with n d.f. D: $X^2(n)$ Ramsey's RESET test using the square of the fitted values following X^2 distribution with n d.f. ( ) = We denote the t – ratio for the corresponding estimated regression coefficient. [ ] = We denote prob. Levels.

estimation as well as the results of the diagnostic tests of the model are presented in Table 4.

The application of the last but certainly not least test is the Granger causality test through which we tried to trace the existence and the direction of causality between the variables employed in our study. The results of those tests are presented in Table 5, and are based on the Vector Error Correction Model.

As it is obvious according to the results of the Granger causality test the producer price is affected by the volume of exports and the volume of imports a result that is consistent with the economic theory. Furthermore is affected by the domestic production in 10% level of significance. The reverse relationship is confirmed as well.

Thus, according to the aforementioned results there is a bilateral relationship between the exported volume and the producer price, the imported volume and the

Table 5. Granger Causality results

Null Hypothesis	F-Statistic	Probability
Exp Granger cause pp	0.61844	0.51590
Pp Granger cause exp	1.09777	0.14805
Imp Granger cause pp	0.26145	0.77186
pp Granger cause imp	0.81146	0.45475
dp Granger cause pp	2.67005	0.08748**
Pp Granger cause dp	2.04497	0.14895
imp Granger cause exp	8.09685	0.00814*
exp Granger cause imp	1.02951	0.06501**
dp Granger cause exp	8.71159	0.00119
exp Granger cause dp	0.50691	0.60796
dp Granger cause imp	0.79756	0.46076
imp Granger cause dp	2.69047	0.08600

Notes: The figures in parenthesis after the F – statistics are the numbers of lags and leads for the dependent variables and causal variables. Critical value: (2.14) 5.14, 1.1 (1.14) 4.4, 2.87 (4.14) 1.87, 2.65 for 1% and 5% significance levels respectively. *, ** indicate that the statistics under preview are rejected in 1% and 5% significance levels respectively.

producer price. Additionally, the exported volume Granger-cause the imported volume while the domestic production Granger cause the imported volume.

Discussion

The result of the ADF test presented on Table 1, indicates that the time series studied are I(1) and is indicative that the Johansen cointegration technique can be used in order to survey a stationary combination of those time series. Nonstationarity of the variables under preview means that there is no an equilibrium value for every variable to which after every shock stabilizes, after a few time periods but it returns to another point different from the equilibrium point. Nonstationarity is valid for the levels of the variables while the opposite has been confirmed for the fist differences of the variables under preview.

The implementation of Johansen cointegration technique confirmed that the variables are cointegrated. The fact that the variables are cointegrated confirms the co-movement of all the variables employed in our study. A result of this type amplifies the role of supply and demand in the producer price formation and furthermore, is indicative of the competitiveness of the round wood market in Greece.

The sole relationship among the variables was presented at the results section. The coefficients of the variables represent elasticities given that all the variables are expressed in logarithmic form. The producer price is inelastic to changes in the volume of exports and of the domestic production whereas the volume of imports is significant elastic. In addition an increase in the domestic production affects positively the producer price while the opposite is valid for the imports and the exports. The last result opposes the standard

economic theory but may well be attributed to the limited exports' activity in the Greek round wood sector.

Accoring to the results of VECM estimation we can say that the model's performance is quite good, given that the coefficient of adjustment reaches 64,1%. This value is high enough to explain the variability of the dependent term. Furthermore, the coefficient of the error correction term is statistically significant and has a negative sign, a result implying a reversion to the long run equilibrium. The value of the coefficient in addition, indicates a satisfactory rate of convergence. As far as the results of the diagnostic tests are concerned which are also presented in Table 4 does not indicate a troublesome model. Actually, no problem of heteroscedasticity, autocorrelation or normality has been confirmed.

This means that despite the fact that the producer price in the case of round wood is not determined by the market but by the forest cooperatives, the demand-supply theory keeps on being extremely important. What is interesting from the results given above is the fact that the domestic production does not Granger cause and thus does not affect the volume of exports, a result for which may account the fact that the country under preview is an import and not an export country. Regarding the volume of imports is affected by the domestic production but the reverse is not confirmed, only in 10% level of significance.

Conclusions

This paper aims at examining the long-term relationship between the producer prices of the industrial round wood and the volume of exports, imports and domestic production of this type of wood. As it has been confirmed by a previous study (Koutroumanidis *et al.*, 2009) the mechanism of transmission between producer and consumer prices is asymmetric and thus we are trying to trace the determinants of the producer prices in the round wood market.

As a means of achieving this objective we used a multivariate autoregressive VAR model for the Greek round-wood market, while the examined period extended from 1974-2008.

ADF and KPSS tests were employed for examining the stationarity of the time series under preview. These tests preceded the application of Johansen cointegration techniques. All the time series are I(1). The Johansen maximum likelihood technique was used for the estimation and testing of the cointegrating relations based on

vector autoregressive models. Furthermore, the vector error correction model was used in order to be able to combine both the dynamics of short-run and long run processes of adjustment.

The results for the period studied, suggested that there is only one cointegrating vector implying the existence of a long run equilibrium relationship, a result that is in line with the economic theory. Such a result has confirmed the function of the market mechanism in the round wood sector in Greece. Surveying how the round wood market functions provides policy makers with necessary information, in implementing optimal forest policies, given the fact that if there are significant distortions from competitive market equilibrium, public intervention should be imposed in order to correct them. The estimation of the sole cointegrating vector provided us with the elasticity of the producer prices to changes in the volume of the production, the imports and exports of round wood. Actually this result can be used to evaluate how sensitive the producer prices are to changes in quantities demanded (in the foreign market) through exports and supplied (in the domestic market). This information can be useful not only for the policy makers but also for the individual economic agents related to the round wood market.

The results of the Granger causality tests (for the data employed during the examined period), has given us an insight regarding the determination of the producer prices in the round wood market. The volume of the domestic production, the volume of imports and exports affect the producer prices. Despite the particularities of the pricing system in Greece (the three different pricing systems), the formation of the producer prices is affected by the total supply of the industrial round wood and especially the volume of the imported wood. In particular, in an indirect way the total demand and the total supply of the round wood determine the producer prices of the industrial round wood.

Generally, the prices of wood and wood products determine strongly the type, the quality and the quantity of the wood production, as well as the wood and wood products consumption. Furthermore, its substitution with other products and the net imports (imports-exports) is also affected by the wood prices. Wood is an important raw material for the domestic industry and thus the domestic economy. In addition, the round wood market depends significantly on net imports (imports-exports). This problem can be limited through an increase in the wood production and its successful exploitation in every stage of manufacture. The quality though of the produced wood is not appropriate for

further treatment, resulting in the productivity limitation and in the increase of the logging cost.

Additionally, according to the theory of cointegration the estimated cointegrating residual is the error correction term in a dynamic VEC model. This term in our case is statistically significant and negative, while the value of this term indicates a high speed of convergence to the long-term equilibrium. Furthermore, the statistical significance of this term may be considered as an evidence of the existence of the equilibrium long-run relationship of the model.

Another finding of this study is the existence of the Granger causality relationships among the variables studied. In particular, the domestic production Granger causes the imported volume of the type of wood under preview, while the exports do affect the domestic production and finally, producer prices do affect the volume of exports and imports and vice-versa. What also must be mentioned is the function of the Greek round wood market within the economic framework of European Union. Thus, higher transparency of wood prices between different countries in the EMU environment has certainly enhanced competition by increasing the degree of roundwood market integration between countries.

All the aforementioned results indicate that special programs should be designed concerning the increase of the Greek forests productivity and the investments needed for the implementation of such programs. Thus, an appropriate planning is necessary aiming at an effective protection, improvement; development and management of the forests in order the alternative solutions to be identified. In addition, a strategy should be adopted and measures to be taken leading to the implementation of the objectives accompanied by other services provided by the Greek forests. In particular, the measures need to be taken are the following; a) increase of reforestation, b) afforestation of agricultural lands, c) management of forests that have not been management till now, d) utilization of fast growing species, e) mechanization of forest works, f) improvement of the forest road network.

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