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Analyzing the effects of salvage on timber price in a reforested region with plantations in the Iberian Peninsula

Auswirkungen von Schadholzanfall auf den Holzpreis in wiederbewaldeten Plantagen auf der iberischen Halbinsel

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Schlagwörter: Waldbrand, Markt mit Nachfragemonopol, Vorrat; statistische Methoden

Abstract

Under perfect competition, the economic law of supply suggests that a catastrophe such as forest fires or hurricanes will push timber prices down in the short-run, while in the long-run the price will increase due to the losses of standing inventory. The main goal of this research is to check if this fact is verified in the eucalyptus timber market of Galicia. This region is characterized by having one of the highest number of forest fires per hectare in South Europe and by the concentration of the eucalyptus timber demand in one pulp company that exports most of the output. In our study, we specifically analyze the statistical relationship between eucalyptus salvaged timber and eucalyptus timber price. We make use of three statistical methods: the Pearson´s correlation coefficient, the Granger causality test and the cross-correlation functions. We found that damaged timber does not have causal effect on eucalyptus timber price. This finding is in line with previous results for pulpwood in other countries. It suggests that the specific structure of the eucalyptus timber market in Galicia, the development of growing stock and the high risk level of wildfires in this region may have limited the response of eucalyptus pulpwood price to salvage timber.

Zusammenfassung

Unter normalen Wettbewerbsbedingungen führt ein höheres Holzangebot auf Grund von Kalamitäten wie etwa Waldbrände oder Sturmereignisse, zumindest zu einer kurzfristigen Reduzierung des Holzpreises. Ziel dieser Untersuchung ist es, abzuklären ob dies für den Eukalyptus-Holzmarkt in Galizien ebenfalls zutrifft. Charakteristisch für diese Region ist eine der höchsten Anzahlen an Waldbränden/ha in Südeuropa, sowie eine konzentrierte Nachfrage nach Eukalyptus-Holz durch eine Zellstoff-Fabrik, die hauptsächlich für den Export arbeitet. In dieser Studie analysieren wir die statistische Beziehung zwischen Eukalyptus-Schadholz und dem Preis für Eukalyptus-Holz. Drei verschiedene statistische Methoden, den (i) Korrelations-Koeffizienten von Pearson, den (ii) Granger Kausalitäts-Test und die (iii) Kreuz-Korrelations-Funktionen werden für die Analyse herangezogen. Wichtigstes Ergebnis der Analyse ist, dass der Schadholzanfall keinen kausalen Effekt auf den Eukalyptus-Holzpreis hat. Diese Ergebnisse bestätigen frühere Ergebnisse im deutschsprachigen Raum. Die spezifische Struktur des Eukalyptus-Holzmarktes in Galizien, die vorratsentwickung und die große Gefahr von Waldbränden federn den Einfluss der Waldbrände bzw. Eukalyptus-Schadholz auf die Preise ab.

Introduction

There is an increasing prevalence of hurricanes, windbreaks, tornadoes, forest fires and other catastrophes on timber market. Previous research carried out in the USA (Prestemon and Holmes, 2000; Butry et al., 2001, Prestemon et al., 2006) and in German spoken countries (Mantau, 1987; Bergen et al., 2002; Schwarzbauer, 2007) has studied the economic effects of hurricanes, windbreaks and forest fires on timber market. Some of these studies have found that a natural catastrophe has an important impact on the timber price in markets with many sellers and buyers; and this impact is not homogeneous along time. In fact, just after the catastrophe, the timber price tends to decrease because of the arrival of damaged timber to the market. However, after this salvage glut period, the timber supply will be reduced. The reason of this is that the catastrophic event will have destroyed valuable standing timber, and forest stocks will need time to recover from the loss in standing inventories. Therefore, the scarcity of the resource will increase the timber price in the long-run. This dynamic evolution of the price seems to be a stylized fact observed in the timber market, and is consistent with the economic law of demand and supply in competitive markets. However, experts who have investigated the economic repercussion of windbreaks and hurricanes on the timber markets in Germany and Austria have found evidence of little impact of salvage on prices (Bergen et al., 2002; Schwarzbauer, 2007) or no impact on coniferous pulpwood prices (Schwarzbauer, 2007). Therefore, there is no conclusive evidence regarding the relationship between salvage and timber price. The main goal of our research is to shed some light on this topic. Specifically, we check if the amount of timber damaged by fire causes price changes in the eucalyptus timber market in Galicia. For this purpose, we make use of standard statistical methods such as the Pearson´s Correlation Coefficient, the Granger Causality Test and the Cross-Correlation functions. These techniques are commonly applied to discover statistical relationship between variables (Gimeno et al., 2002, Álvarez-Díaz et al., 2010, González-Gómez et al., 2011).

Our analysis is centered on the Eucalyptus timber market in Galicia, a Spanish region located in the Northwest of the Iberian Peninsula, right on the border of Portugal. The eucalyptus harvesting represents approximately 50% of the timber supply in Galicia (Xunta de Galicia, 2013; González-Gómez, 1999). The eucalyptus production has nearly quadrupled from approximately one million cubic meters in 1985 to 4 million in the last years.

Moreover, it is also worth noting that this region is undergoing a large amount of forest fires during the last decades. The number of forest fires rose dramatically from approximately 300 in the 60s to over 10,000 in the 90s. As a consequence the Northwest corner of the Iberian Peninsula became the region with both the highest fire density and the highest burned area in Europe. Despite the intensity of forest fires and the market structure the literature has paid little attention to the effects of forest fire on the eucalyptus timber market. Diaz-Balteiro (2007) emphasizes that more research is required regarding the effects of forest fires on the pulp industry, considered as the most internationally competitive wood industry in Galicia that exports most of the production abroad.

The devastating and recurrent fires have lead to a huge salvage volume of eucalyptus timber. According to the reports of the Spanish Ministry of Agriculture, Food and Environment [1], the annual average of timber salvage was over 2 million of cubic meters, and represented approximately 42 per cent of the total eucalyptus production in Galicia during the period of study. In order to understand what happens in this market we draw into consideration the eucalyptus timber market structure, the development of the growing stock of eucalyptus and the forest fires frequency as possible explanations. The results suggest that there is no need to be aware of the possible undersupply of raw material to the pulp industry (Diaz-Balteiro, 2007).

The remainder of this paper is set out as follows. The next section describes the data and gives brief details of the statistical procedure followed in this study. Section 3 presents the results. Section 4 discusses and explains the main findings. Section 5 concludes and summarizes the main outcomes.

Data and statistical methods

Data description

The two variables used in our statistical analysis are the salvage quantities and the timber price of eucalyptus in Galicia. The volume of timber damaged by fire that has salvageable value (*D*) is measured in cubic meters. This variable is commonly used in the forestry literature to approximate the effect of catastrophes on market timber (Butry et al., 2001, Prestemon et al., 2006). The data were taken from the Coordinating Centre of the National Wildfire Information (CCINIF) at the Spanish Ministry of Agriculture, Food and Environment. This is an official and reliable source of information that is systematically constructed according to a standardized protocol since 1968. Indeed, this is the oldest database of Europe in registering information about forest fires, and it has been frequently used in empirical studies because of its long time length and its methodological rigor in the collection of information (Rego et al., 2013, Prestemon et al., 2012, González-Gómez at al., 2013). More information about how these data were collected can be found at the web page of the Spanish Ministry of Agriculture, Food and Environment[2].

In our specific study, the information about the salvaged timber comes from the 197,781 forest fires registered in Galicia from 1985 to 2008, which is the period with

1 Available at www.magrama.gob.es/es/biodiversidad/estadisticas/Incendios_default.aspx

2 www.magrama.gob.es/es/biodiversidad/estadisticas/Incendios_default.aspx#para3. The questionnaire that forest fire employees fill in for every fire event to collect the data can be downloaded from www.magrama.gob.es/es/biodiversidad/estadisticas/impreso_parte__IF__v_tcm7-212274.pdf .

the most recent information available. It is also remarkable that the quantity of salvaged timber represents an important percentage of the total timber supply in Galicia. In particular, during the 24 years included in our analysis, the salvaged timber represented a 65 per cent of the eucalyptus standing timber of the 3rd National Forest Inventory.

On the other hand, the market price of eucalyptus (*P*) is measured in Euros per cubic meter, and was obtained from the Yearly Agricultural Statistics published by the Galician regional government, Xunta de Galicia [3]. As is common in time series analysis, all variables were taken in logarithms to reduce the variability of the data. Finally, the sample period object of analysis has an annual periodicity. Most empirical studies that analyze the timber market use annual data (Moog, 1991). In our case, it was also possible to carry out our analysis using monthly data, and disaggregating the data for each one of the three Galician coastal provinces that produce eucalyptus timber. In all cases, both the spatial and the temporal disaggregation did not alter the results and conclusions obtained using annual data. For sake of brevity, the disaggregated results are not reported here, but they can be sent upon request. Figure 1 depicts the evolution of both variables, and Table 1 shows the main descriptive statistics.

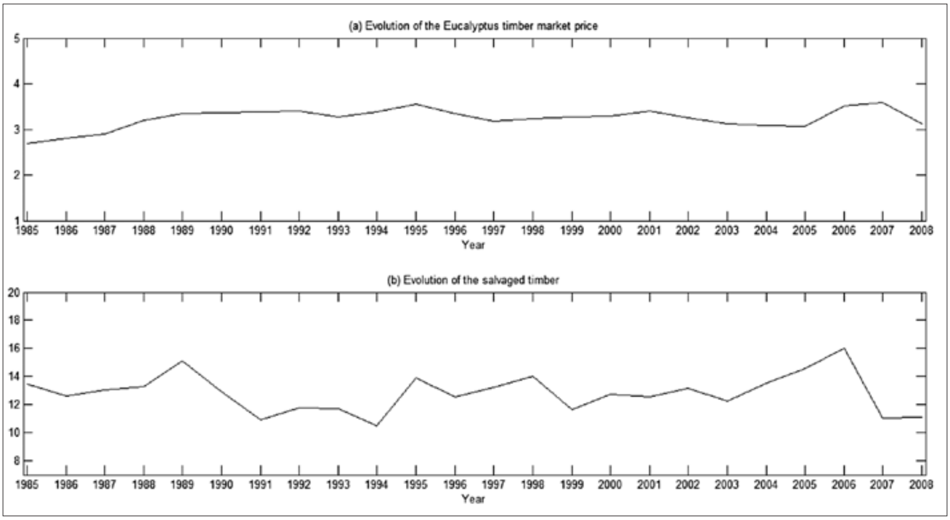

Figure 1: Evolution of the variables eucalyptus timber market price (P) and salvaged timber (D)

3 The data can be downloaded from www.medioruralemar.xunta.es/institucional/estatisticas/anuario_de_estatistica_agraria

Table 1: Descriptive Statistics

	P	D
Mean	3.23	12.80
Median	3.26	12.82
Maximum	3.58	16.02
Minimum	2.69	10.48
Std. Dev.	0.22	1.35
Jarque-Bera (P-value)	2.55 (0.27)	0.52 (0.76)

Statistical methods

In this study we use three alternative and complementary statistical methods to analyze the relationship between eucalyptus salvage (D) and the eucalyptus timber price (*P*). The first one is the well-known Pearson's correlation coefficient ($r_{P,D}$). This coefficient measures the proportion of the covariation of both variables with respect to the product of their standard deviations (DeLurgio, 1998). Analytically the coefficient can be calculated by the expression

$$r_{P,D} = \frac{Cov(P,D)}{\sqrt{Var(P)}\sqrt{Var(D)}} \tag{1}$$

where *Cov(P,D)* is the covariance between *P* and *D*, and *Var(P)* and *Var(D)* are the variances of the variables. The values of the coefficient range from -1 and 1; and it gives us information about the intensity and direction of the relationship between both variables. Specifically, a value of zero means no-relationship, a value close to -1 implies a strong negative relationship, and a value near to 1 involves a strong positive relationship.

The second method applied in our study is based on the test of causality developed by Granger (1969). This test allows us to check whether lagged values of the variable D have some statistical capacity of explaining P. This approach assumes that the current price can be explained by the following econometric model

$$P_t = \alpha_0 + \alpha_1 \cdot P_{t-1} + \ldots\ldots + \alpha_p \cdot P_{t-p} + \beta_1 \cdot D_{t-1} + \ldots\ldots + \beta_p \cdot D_{t-p} + \varepsilon_t \tag{2}$$

where $\{P_{t-1},\ldots,P_{t-p}\}$ and $\{D_{t-1},\ldots,D_{t-p}\}$ are the lags of the variables P and D, respectively; $\{\alpha_i\}^p_{i=0}$ and $\{\beta_i\}^p_{i=0}$ are the parameters of the model and ε_t is the disturbance term that is assumed to be an independent and identically distributed (*i.i.d*) variable. The definition of causality in the sense of Granger implies that D_t is causing P_t if and only if it is rejected the null hypothesis H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_0 = 0$. That is, some parameter β_i

is statistically nonzero. The statistical test used to contrast this hypothesis is the conventional F-statistic.

The third approach is based on the cross-correlation function ($\rho_{e,u}(l)$). This method is usually applied in natural science research to detect connections between different variables (Álvarez-Díaz et al., 2010). It is important to underline that if each one of the analyzed series has a very high degree of autocorrelation, then the nonzero values of the cross-correlation function do not necessarily imply a true relationship between the two time series (Katz, 1988). This means that the presence of autocorrelation can generate a spurious relationship between the variables and, therefore, the cross-correlation analysis would not be a valid tool of analysis. In order to avoid possible fictitious cross-correlations, it is necessary to remove all of the autocorrelation in each time series and then cross-correlate that which remains. If the identical method of removing autocorrelation is applied to each variable, the true cross-correlation between variables is preserved (DeLurgio, 1998). The procedure followed in this study to remove autocorrelations is similar to that one explained in Katz (1988). That is, we start by assuming that each one of the time series under study follows an autoregressive process with additive Gaussian noise. Consequently, the method involves the fit of a p-order autoregressive model (AR(p)) for P_t of the form

$$P_t = \alpha_0 + \alpha_1 P_{t-1} + \ldots\ldots + \alpha_p P_{t-p} + e_t \tag{3}$$

and a q-order autoregressive (AR(q)) for

$$D_t = \mu_0 + \mu_1 D_{t-1} + \ldots\ldots + \mu_p D_{t-q} + u_t \tag{4}$$

where P_t and D_t are the original time series that show autocorrelation, $\{P_{t-1},\ldots,P_{t-p}\}$ and $\{D_{t-1},\ldots,D_{t-p}\}$ are the delays or lags of the time series $\{P_t\}$, and $\{D_t\}$, $\{\alpha_i\}_{i=0}^{p}$ and $\{\mu_j\}_{j=0}^{q}$ are the coefficients that must be optimally estimated in order to get non-autocorrelated residuals $\{e_t\}_{t=0}^{T}$ and $\{u_t\}_{t=0}^{T}$. The order p and q of the autoregressive models will be those that minimize the Akaike Information Criterion (AIC) (Akaike 1973). Finally, the residuals e and u are the filtered series to be cross-correlated. The sample cross-correlation at lag l between these two series is calculated using the expression

$$\rho_{e,u}(l) = \frac{C_{e,u}(l)}{\sqrt{C_{e,e}(0)} \cdot \sqrt{C_{u,u}(0)}} \tag{5}$$

where

$$C_{e,u} = \begin{cases} \sum_{t=1}^{T} (e_t - \bar{e})(u_{t+l} - \bar{u}) \big/ T & \text{if } l = 0, 1, 2, \ldots \\ \sum_{t=1}^{T} (u_t - \bar{u})(e_{t-l} - \bar{e}) \big/ T & \text{if } l = 0, -1, -2, \ldots \end{cases} \tag{6}$$

and T is the sample size.

Empirical results

The Pearson's correlation coefficient between the explanatory variables P and D for our sample is calculated to be $\rho_{P,D} = -0.087$, which is a relatively low value. This indicates that apparently there is no relationship between the two variables. Nevertheless, we must corroborate the statistical significance of this result. That is, we must test the null hypothesis H_0: $\rho_{P,D} = 0$. (non existence of relationship), against the alternative hypothesis H_1: $\rho_{P,D} \neq 0$ (there are statistical arguments that confirm a relationship between the variables). In order to carry out this hypothesis testing, we make use of a specific inferential nonparametric method called "bootstrapping" (Efron and Tibshirani 1998). The bootstrap method allows us to construct confidence intervals for $\rho_{P,D}$ without assuming a particular statistical distribution for this parameter. This estimated interval includes the correlation values that verify the null hypothesis at a specific level of confidence. In our case, the bootstrap confidence interval at 95 percent of confidence is (-0.24, 0.30). The value zero is inside of this interval. Consequently, we can accept the null hypothesis H_0: $\rho_{P,D} = 0$ and conclude that the variables salvaged timber and timber price are orthogonal and, therefore, uncorrelated. In other words, the Pearson's correlation coefficient reveals that the variables P and D are not statistically related.

In order to apply the Granger causality test, it is necessary to verify that the variables are stationary (*I(0)*); otherwise, the method could provide spurious results (Granger, 1969; Granger and Newbold, 1974). This is the reason why we must analyze first the order of integration of the variables considered in our study. This analysis has been usually done using the ADF (Dickey and Fuller, 1981) and P-P (Phillip and Perron, 1988) unit root tests. However, these tests have been strongly criticised because of its low power in distinguishing between unit root and a near unit root process when the span of the data is not long enough (DeJong et al., 1992). An alternative test that has superior properties in small samples is the KPSS unit root test (Kwiatkowski et al., 1992).

Table 2: KPSS Unit Root Test

Null hypothesis: Salvaged Timber (D) is stationary		
	KPSS Test	**Critical value (5%)**
Equation with constant and trend	0.06 (1)	0.15
Equation with constant	0.07 (1)	0.46
Null hypothesis: Timber Price (P) is stationary		
	KPSS Test	**Critical value (5%)**
Equation with constant and trend	0.14 (2)	0.15
Equation with constant	0.24 (2)	0.46

Note: The critical values were calculated following Kwiatkowski et al. (1992). The number of lags are shown in brackets according to the Newey-West Criterion using Bartlett Kernel

Table 2 shows the results of the KPSS unit root test. As we can observe, the test provide clear evidence that the variables P and D are stationary (they are *I(0)*). Therefore, we can apply the Granger Causality Test in our analysis. Table 3 reports the results of the Granger causality test. As we can see, the F-statistic show a value of 1.25, and the corresponding p-value is 0.25. This indicates that it is not possible to reject the null hypothesis H_0: $\beta_1 = \beta_2 = ... = \beta_p = 0$.. As a result, the application of this test also confirms statistically that D is not related with P.

Table 3: Granger causality test

Null Hypothesis	F-Statistic	p-value
Salvaged Timber (*D*) does not Granger Cause Timber Price (*P*) (lag=1)	1.42	0.25

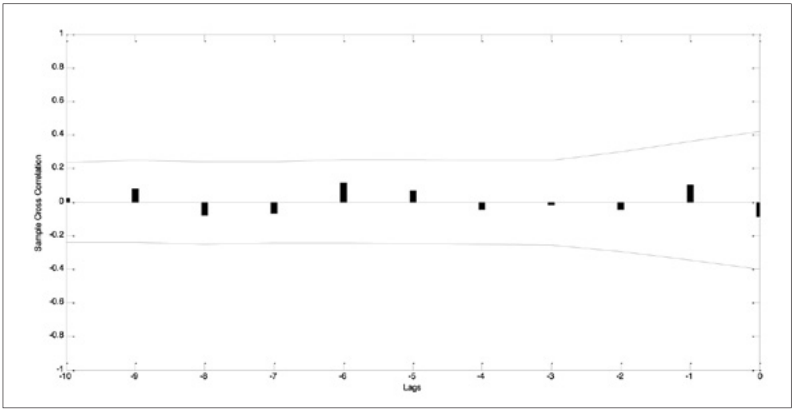

Figure 2: Sample cross-correlation between the filtered series of the salvaged timber of eucalyptus, and the filtered series of the eucalyptus timber price

Finally, the results of the sample cross-correlation function between the filtered series *e* and *u* are shown in Figure 2. The figure also displays the confidence intervals necessary to examine the statistical significance of the cross-correlation coefficients (H_0: $\rho_{u,e}$ (l)= 0). The intervals were empirically constructed by means of a Montecarlo simulation (Mooney 1997). Technically speaking, we generate randomly 5,000 time series with the same characteristics as a random white noise variable and with the same standard deviation as the filtered Salvaged Timber variable (*u*). Then, each one of these artificial variables was cross-correlated with the filtered variable Timber Price (*e*). An empirical distribution of each cross-correlation coefficient for each lag was computed. Using this empirical distribution, a confidence interval was determined at a significance level of 95 percent. As we can see, the cross-correlation coefficients are all of them within the bounds of the interval. Therefore, we can assert that lags of the variable Salvaged Timber are not a significant factor to explain changes in the Timber Price.

Discussion

The Pearson's Correlation Coefficient, the Cross-Correlation Function and the Granger Causality Test allow us to conclude that the quantity of eucalyptus timber damaged by fire in Galicia (Spain) does not cause price changes. This result seems to be inconsistent with the economic law of demand and supply for competitive markets. However, our findings are in line with the work of Schwarzbauer (2007), who did not find a statistical relationship between salvage and coniferous pulpwood in Austria. Moreover, the following explanatory factors offer support for the absence of a causal relationship between salvage and eucalyptus timber price in our study.

(i) the eucalyptus timber market structure is not competitive. It is likely that the salvaged timber affects prices in a competitive market as it was found in some previous studies. However, the eucalyptus timber market in Galicia (Chas-Amil, 2007b; Diaz-Balteiro, 2007; González-Gómez, 1999) is characterized by an imperfect market (specifically, a monopsonic structure). There are many and weak sellers and, conversely, the demand is very concentrated in one pulp company. The eucalyptus cuts are not completely determined by the price since the buyer can use its strategic timber stock to influence the market price. As a consequence, an increase in the eucalyptus timber cuts caused by high quantities of salvaged timber increases the timber supply, but this not necessarily means an alteration in the level of market prices. On the other hand, the pulp company can use its timber stock in case of possible supply shortages of timber in the open market without driving the price in the market upwards (Kuuluvainen, 1986).

(ii) development of eucalyptus growing stock. Eucalyptus is not considered a scarce resource in Galicia. This fact also contribute to break the salvage-price dynamic; that is, the destruction of timber growing stock due to a catastrophe increases the resource scarcity and it raises the timber price. The development of both the volume of timber harvested and the growing stock of eucalyptus show an abundant resource in spite of the continuous forest fires. The destruction of the stock caused by the forest fires and by increasing cuts has not led to a shortage of the eucalyptus timber in the market. This result seems initially paradoxical since one could expect a priori that a destruction of the resource caused by forest fires would imply problems of non-availability of eucalyptus timber. However, we do not observe supply problems. On the contrary, the eucalyptus stock increases. Table 4 provides information about volume and number of trees in the Second (2NFI), Third (3NFI) and Fourth National Forest Inventory(4NFI). The National Forest Inventories are published by the Spanish Ministry of Agriculture, Food and Environment. It provides data at the regional and national levels of the growing stock (volume and number of trees) and the extent of the forest area. The collection of data in Galicia started in 1986 for the 2NFI , 1997 for the 3NFI and 2008 for the 4NFI.

We observe that the volume of eucalyptus growing stock has increased by 284% from 1986 to 2008. González-Gómez et al. (2011) provide two possible explanations for this increase. First, there are better investment and institutional conditions for the plantation of eucalyptus than for other species (growing rate, low maintenance and regeneration costs, and subsidies). Therefore, the owners expand eucalyptus plantations, transforming bare land, substituting other forest species for eucalyptus, or reforesting land previously devoted to agricultural use. The second explanation is that eucalyptus is a species that expands rapidly without active intervention of the forest owners. Indeed, we observe that the continuous abandonment of land dedicated to agricultural in rural areas of Galicia is usually occupied by plantations of eucalyptus (2NFI, 3NFI and 4NFI, and Chas-Amil, 2007a). Additionally, we must also keep in mind that the eucalyptus is a species that has easy vegetative reproduction from stumps, which favors fast regeneration after a clear-cut or a forest fire.

Table 4: The growing stock in Galicia

Diametric class (cm)	**Million of m³**			**Million of trees**		
	2nd NFI	3rd NFI	4th NFI	2nd NFI	3rd NFI	4th NFI
<10	–	–	–	87.3	237.5	241.1
>10	15,998	35,537	61,525	69.3	94.4	262.8
Increase from the 2nd (1986) to the 4th NFI (2008)	45,527 million of cubic meters or 284%			346.7 million trees or 221%		
Source: Ministry of Agriculture, Food and Environment						

(iii) the high risk level of forest fires. The literature has focused on the effect of a unique catastrophic event. Nevertheless forest fires are very frequent in Galicia. Despite the fact that Galicia represents 6% of the Spanish geographical area, concentrates approximately 50% of the wildfires outbreaks in Spain. Therefore, Galicia belongs to the regions with the highest density of forest fires and burned area in the Southern European countries (San-Miguel and Camia, 2009). This high forest fire risk leads to a continuous presence of fires and can explain that the harvesting behavior of the forest owners is different as it was reported in some of the previous literature (Prestemon and Holmes, 2000), where wildfires were rare catastrophes. The quantity of damaged timber caused by forest fires every year is high and both variables, number of forest fires and salvage, show certain stabilization along time. As a result of this, salvage is not an unpredictable shock, but it is permanent, predictable and "expected" by the agents. The pulp industry buys every year a quantity of salvage and can hold a stock of raw material or pulp. Consequently, forest owners do not have reasons for postponing felling in order to avoid the flooding of market with damaged timber and wait for higher prices in the future.

Conclusions

We have analyzed the relationship between salvage and price in the eucalyptus timber market in Galicia. The findings obtained in our study allow us to conclude that there is no statistical relationship between these variables. It means that the large quantities of salvaged timber of eucalyptus do not push prices down in the short-run, nor the losses of standing inventory lead to price increases in the long-run. The absence of a statistically significant relationship differs with some previous studies, but is in line with the evidence found in the pulpwood market in Austria (Schwarzbauer, 2007). The results obtained in our study can be explained as a consequence of the specific characteristics of eucalyptus timber market in Galicia, the development of the growing stock and the permanent occurrence of forest fires. The market is not confronted with large shocks caused by an unique or extraordinary events that occur infrequently but with the continuous presence of salvage in the market that is caused by a persistent and high number of annual ignitions. Therefore, forest fires seem not to represent a threat causing a supply shortage that pushes the price up. Our conclusions suggest that there is no need to be aware of the possible undersupply of raw material to the pulp industry, considered as the most internationally competitive wood industry in Galicia that exports most of the production abroad. On the contrary, despite the quantity of killed and salvaged timber the growing stock has nearly tripled during the period of analysis and guarantees the supply to the pulp industry.

The results are based on the past development in the eucalyptus timber market. When the study is being carried out the timber markets are undergoing significant shifts, for instance, the increasing demand from the energy sector (Schwarzbauer et al., 2009; Mantau et al, 2010). The higher demand for wood energy could have increased the level of scarcity in the eucalyptus timber market, which could have changed the relationship between salvage and timber price. Further analysis will be needed in order to consider these changes.

References

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. In B. Petrov & F. Csake (Editors.), Second international symposium on information theory. Springer-Verlag.

Álvarez-Díaz, M., Otero-Giráldez, M.S. and González-Gómez, M. 2010. Statistical relationships between the North Atlantic Oscillation and international tourism demand in the Balearic Islands, Spain. Climate Research 43: 207–214. doi:10.3354/cr00931

Bergen, V., Löwenstein, W. und Olschewski, R. 2002 Forstökonomie. Volkswirtschaftliche Grundlagen. Verlag Vahlen München

Butry, D.T., Mercer, D. E., Prestemon, J.P., Pye J.M. and Holmes, T.P. 2001. What is the price of catastrophic wildfire. Journal of Forestry 99 (11): 9-17.

Chas-Amil, M. L. 2007a. Forest fires in Galicia (Spain): threats and challenges for the future. Journal of Forest Economics 13:1-5. doi:10.1016/j.jfe.2007.02.001

Chas-Amil, M. L. 2007b. Forest fires in Galicia (Spain): a reply. Journal of Forest Economics 13: 211-215. doi:10.1016/j.jfe.2007.09.001

DeJong, D. N., J. C. Nankervis, N. E. Savin and Whiteman, C. H. 1992. The power problems of unit root tests in time series with autoregressive errors. Journal of Econometrics 53: 323–43. doi:10.1016/0304-4076(92)90090-E

DeLurgio, S. A. 1998. Forecasting principles and applications, Irwin/McGraw-Hill, New York.

Dickey, D. A. and Fuller, W.A. 1981. Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica 49: 1057–1072.

Díaz-Balteiro, L. 2007. Letter to the Editor. Journal of Forest Economics 13: 291-292. doi:10.1016/j.jfe.2007.06.002

Efron, B., and Tibshirani, R. 1998. An introduction to the bootstrap. Boca Raton, Fla: Chapman & Hall/CRC.

Gimeno, L., Ribera, P., Iglesias, R., Torre, L., García R. and Hernández, E. 2002. Identification of empirical relationships between indices of ENSO and NAO and agricultural yields in Spain. Climate Research 2: 165-172.

González-Gómez, M. 1999 . Beispiel Galicien/Nordspanien: Herausforderungen einer Plantagenforstwirtschaft. Allgemeine Forstzeitschrift-Der Wald 4/99: 195-198.

González-Gómez, M., Otero- Giráldez, M. .S and Álvarez-Diaz, M. 2011. Explaining wood stock increases in times of decreasing profitability: a statistical analysis. Forest Policy and Economics 13: 176-183. doi:10.1016/j.forpol.2010.11.008

González-Gómez, M., Álvarez-Diaz, M. and Otero-Giráldez, M. S. 2013. Estimating the long-run impact of forest fires on the eukalyptus timber supply in Galicia, Spain. Journal of Forest Economics 19 (2): 149-161. doi:10.1016/j.jfe.2012.12.002

Granger C.W.J. and Newbold P. 1974. Spurious regressions in econometrics, Journal of Econometrics, 2: 111-120

Granger, C. 1969. Investigating causal relations by econometric models and cross-Spectral Methods, Econometrica 37: 424-438.

Katz, R. W. 1988. Use of cross correlation in the search for teleconnections, International Journal of Climatology 8, 241-253. doi:10.1002/joc.3370080303

Kuuluvainen, J. 1986. An Econometric analysis of the sawlog market in Finnland. Journal of World Forest Management 2, (1): 1-19.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., Shin, Y. C. 1992. Testing the null hypothesis of stationarity against the alternative of a unit-root-how sure are we that economic time-series have a unit-root. Journal of Econometrics 54:159-178. doi:10.1016/0304-4076(92)90104-Y

Mantau, U. 1987. Simulation erhöhter Einschlagsmengen infolge neuartiger Waldschäden und ihre ökonomischen Folgen für den Nadelschnittholzmarkt. Forschungsvorhaben „ Folgen der neuartiger Waldschäden für die Holzmärkte der BRD" Institut für Forstpolitik und Raumordnung. Arbeitsbericht Holzmarktlehre an der Universität Freiburg. Freiburg i. Br.

Mantau, U., Saal, U., Prins, K., Steierer, F., Lindner, M., Verkerk, H. Eggers, J. Leek, N., Oldenburger, J. Anttila, P. and Asikainen, A. 2010. Real Potential for changes in growth and use of EU forest. Final Report. Hamburg.

Moog, M. 1991. Wie stark wird das Buchenindustrieholzangebot durch Buchenstammholzmengen und Indsutriholzpreise beeinflusst?. Allgemeine Forst- und Jagdzeitung 162 (5/6):107–111.

Mooney, C. Z. 1997. Monte Carlo Simulation. Sage University Paper series on Quantitative Applications in the Social Sciences, series no. 07-116. Thousand Oaks, CA: Sage.

Phillips, P. C. B. and Perron, P. 1988. Testing for a unit root in time series regression. Biometrika, 75(2): 335-346. doi:10.1093/biomet/75.2.335

Prestemon, J.F. & Holmes, T.P. 2000. Timber price dynamics following a catastrophe. American Journal of Agricultural Economics 82(1): 145-160. doi:10.1111/0002-9092.00012

Prestemon, J.F., Wear D.N., Stewart F.J & Holmes, T.P. 2006. Wildfire, timber salvage and the economics of expediency. Forest Policy and Economics 8: 312-322. doi:10.1016/j.forpol.2004.07.003

Prestemon, J.F., Chas-Amil, M.L., Touza, J.M. and Goodrick, S.L. 2012. Forecasting intentional wildfires using temporal and spatio-temporal autocorrelations. International Journal of Wildland Fire 21; 743-754 doi:10.1071/WF11049

Rego, F., Catry, F.X., Montiel, C. and Karlsson, O. 2013. Influence of territorial variables on the performance of wildfire detection systems in the Iberian Peninsula. Forest Policy and Economics, 29, 26-35. doi:10.1016/j.forpol.2012.11.007

San-Miguel, J. & Camia, A. 2009. Forest Fires at a Glance: Facts, Figures and Trends in the EU. In : J. Sande Silva, F. Rego, P. Fernandes, and E. Rigolot (Editors) , Towards Integrated Fire Management Outcomes of the European Project Fire Paradox. European forest Institute.

Sekot, W. 1989. Motive als Determinanten des Einschlagsverhaltens. Institut für forstwirtschaftliche Betriebswirtschaft und Forstwirtschaft. Universität für Bodenkultur Wien. Wien

Schwarzbauer, P. 2007. Einflüsse von Schadholzmengen auf Rohholzpreise. Eine quantitativ-statistische Analyse am Beispiel Österreich. Allgemeine Forst- und Jagdzeitung, 178. Jahrgang (1), 1-8

Schwarzbauer, P., Huber, W. und Stern, T. 2009. Das Angebotverhalten der österreichischen Forstwirtschaft. Ökonometrische Schätzungen von Angebotsfunktionen. Schriftreihe des Institut für Marketing und Innovation. Universität für Bodenkultur Wien. Wien

Xunta de Galicia 2013. Anuario de Estatística Agraria e Contas Económicas da Agricultura. www.medioruralemar.xunta.es/institucional/estatisticas/anuario_de_estatistica_agraria/