SEASONAL PRICE TRANSMISSION IN SOYBEAN INTERNATIONAL MARKET: THE CASE OF BRAZIL AND ARGENTINA[1]

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Resumo: esse trabalho analisou o comportamento sazonal e o relacionamento entre as cotações da soja em grão na Bolsa de Chicago (Chicago Board of Trade – CBOT), e os preços *Cost Insurance and Freight* (*CIF*) do grão de soja no porto de Rotterdam, preços *Free on Board* (*FOB*) no Brasil e Argentina. A principal hipótese é de que os preços no Brasil e Argentina estão mais diretamente relacionados aos preço em Roterdam do que às cotações de Chicago em função do fato de que a União Européia é o principal destino da soja exportada por esses dois países. Espera-se que o comportamento sazonal dos preços *FOB* do grão de soja no Brasil e Argentina seja mais semelhante ao comportamento sazonal dos preços *CIF* em Rotterdam do que às cotações da Chicago.

Palavras-chave: sazonalidade, soja, sistema de transmissão de preços

JEL: C32; F31

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[1] A Preliminary version of this paper was presented in the World Food and Agribusiness Congress X, accomplished in Chicago, in the period from 25 on June 28, 2000.

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Introduction

Brazil and Argentine are two important players in soybean international market in terms of both production and exportation. The traditional and dominant commercialization system has been strongly dependent of Chicago Board of Trade (CBOT) and Rotterdam Port. Prices are set within these centers, which dominate the commercialization of the product and influence the strategies of all chain agents. According to ABIOVE[4], Brazil is responsible for some 20 percent of world's production and the world's second largest exporter. Almost 70% of total Brazilian and Argentine exportation of soybean is destined to European Union. Thus, it is expected that Brazilian and Argentine prices are more associated with Rotterdam than Chicago. The expected result is that the seasonal price behavior in FOB prices of these countries will be more similar to CIF prices in Rotterdam than CBOT quotation. Thus, there is a price transmission system based on this seasonal behavior.

The direction of causality has been showed partially in different cases. AGUIAR and BARROS (1991) and NEVES (1993) use Granger causality test to determine which the direction of Brazilian soybean causality. The main conclusion is that Brazil doesn't set prices in international market. PINO and ROCHA (1994) conclude that Brazilian soybean price is affected by CBOT variations, using ARIMA's models and Box-Jenkins transfer function between 1985 and 1990. MARGARIDO and SOUSA (1998) show that CBOT variations are immediately transmitted from Brazilian prices, using the ARIMA's models developed by HAUGH and BOX (1977) between 1990 and 1998. This approach incorporates a causality test in transfer function. The present paper intends to incorporate more information about the direction of causality in soybean international market.

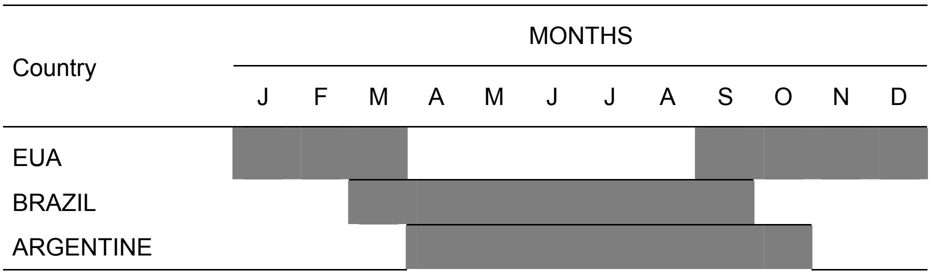
1. Objectives

This paper aims to analyze the seasonal behavior and relationship among soybean price in Chicago Board of Trade (CBOT), CIF prices in Rotterdam and FOB prices in Brazil and Argentine. In particular, it is expected that the amplitude of seasonal standard is

[4] Brazilian Association of Vegetable Oil Industries

more accentuated in USA off-season period in Brazil and Argentine. On the other hand, the seasonal standard in Rotterdam must be less accentuated than another series, due to the fact that supply in European Union is constant during all year. These results are according to the expected for this market, due to USA, Brazil and Argentine crops occur in distinct periods of the year (Table 1). Another expected result is that the seasonal price behavior in FOB prices of Brazil and Argentine will be more similar to CIF prices in Rotterdam than CBOT quotation. Thus, there is a price transmission system based on this seasonal behavior.

Table 1 – Soybean crop and trade time



Source: Brazilian Vegetal Oils Industry Association (ABIOVE)

2. Materials and methods

2.1. Materials

The paper focuses on the period between January/91 and September/99, containing 105 observations. The data for soybean quotations were obtained in Chicago Stock Market (January/91 to October/98) and in Vegetal Oil Industry Brazilian Association, ABIOVE, (November/98 to September/99). The Brazilian and Argentine Free on Board (FOB) prices and the Rotterdam Port Cost Insurance and Freight (FOB) prices were founded in Oilseeds publication (several numbers).

The seasonal index of each series and the ARIMAs models were obtained from Statistical Analysis Software (SAS, version 6.12), using the methodological framework developed by the U.S. Bureau of the Census and SAS Institute (1993, 1994). For the causality test was used Econometric Views (Eviews, version 2.0)

2.2. Methods

2.2.1. ARIMA X-11 method

The X-11 approach is a methodological framework developed by the U.S. Bureau of the Census and SAS Institute. The method is based on decomposition of original series (Ot) in four components: seasonal (St), cycle tendency (Ct), trading-day (Dt) and residual (It). The first component catches modifications that it is repeated constantly during a year. The second includes long run variations of tendency, business cycles and other long run cycle factors. The third shows variations related with the composition of the calendar ("calendar effects"). The last represents all information not explained by the other components. Thus, the seasonal component is separated and the comparison among successive monthly data is facilitated. There are two kinds of adjustment models: addictive (1) and multiplicative (2).

$$O_t = S_t + C_t + D_t + I_t \qquad (1)$$

$$O_t = S_t * C_t * D_t * I_t \qquad (2)$$

The X-11 process uses symmetric moving average to estimate all components. However, this symmetric weighing can't be applied in the last observations. The ARIMA X-11 method was developed to solve this problem that compromised the model results. According to SAS Institute (1993, p.897), this "method adjust a ARIMA model for a original series, and so it uses a forecast model to lengthen the original series. At last, the lengthen series will be modified in X-11 seasonal adjust". The ARIMA X-11 method uses an automatic selection method, which chooses the best model among five predefined Autoregressive Integrated Moving Average Models (Table 2). The selection of these models was based in tests applied on a large number of economics series. Dagum (1988) maintains that these pre-defined models provide good forecasts for the majority of economic series. Box-Jenkins and Reinsel (1994) developed the best systematic approach to understand the ARIMA models.

Table 2 – ARIMA X-11 models

ARIMA MODEL	Specification	Multiplicative Model	Addictive Model
1	(0,1,1) (0,1,1) s	With log transformation	Without log transformation
2	(0,1,2) (0,1,1) s	With log transformation	Without log transformation
3	(2,1,0) (0,1,1) s	With log transformation	Without log transformation
4	(0,2,2) (0,1,1) s	With log transformation	Without log transformation
5	(2,1,2) (0,1,1) s	Without log transformation	Without log transformation

Source: Adapted from SAS Institute (1993, p. 924)

The main idea of Box-Jenkins approach consists in to extract the predictable movements from the observed data, using primarily three linear filters: the autoregressive, the integration, and the moving average filter. Equation (3) represents a general form of the ARIMA models.

$$\tilde{y}_t = \frac{\theta(B)\Theta(B)}{\phi(B)\Phi(B)} a_t \qquad (3)$$

where: $\tilde{y}_t = y_t - \mu$; e $\tilde{y}_t$ is the differenced variable (y_t) centred in relation of your mean (μ), while the differenced variable is represented by: $y_t = \nabla^d \nabla_s^D Y_t$, where ∇^d is the difference operator ($\nabla Y_t = Y_t - Y_{t-1}$), ∇_s^D is the seasonal difference operator, so that $\nabla_s Y_t = Y_t - Y_{t-s}$, while Y_t is the level variable, and *B* is the backward shift operator so that $B^j y_t = y_{t-j}$. Finally, $\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - ... - \phi_p B^p$ is the *p order* autoregressive operator, $\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - ... - \theta_q B^q$ is the *q order* moving average operator, $\Phi(B^S) = 1 - \Phi_1 B^S - \Phi_2 B^{2S} - ... - \Phi_p B^{PS}$ is the seasonal autoregressive operator and

$\Theta(B^S) = 1 - \Theta_1 B^S - \Theta_2 B^{2S} - \ldots - \Theta_Q B^{QS}$ is the seasonal moving average operator.

According to SAS Institute (1993) there are three rules to choose the best predefined model in ARIMA X-11 method. The first rule is the average mean absolute percentage error (MAPE):

$$MAPE = \frac{100}{n} \sum_{t=1}^{n} \frac{|y_t - \hat{y}_t|}{|y_t|} \tag{4}$$

where: y_t are the correspondent last three years values of time series and $\hat{y}_t$ are the estimated value of one step forward forecast. The MAPE decision rule is that the series for the last three years must be lesser than 15,0%. The second is the χ^2 Box-Ljung test, which is applied on model residual. Ljung and Box (1978) define this test as:

$$\chi^2_m = n(n+2) \sum_{k=1}^{m} \frac{r^2_k}{n-k} \tag{5}$$

where: n is the number of residual, m=24 for monthly series and

$$r_k = \frac{\sum_{t=1}^{n-k} a_t a_{t+k}}{\sum_{t=1}^{n} a^2_t} \tag{6}$$

where a_t is a residual sequence. Therefore, the Box-Ljung test allows checking if the ARMA residuals are not autocorrelated using a $\chi 2$ with m-p-q degrees of freedom. If the numerical statistic value is greater than the preselected critical value of $\chi 2$, so there is residual autocorrelation. The third rule is a test about series differencing.

Mills (1990, p.121-122) argued that the series over differencing increase the variance and useless parameters can emerge in the model.

Freitas et al. (1998) obtain, in percentage form, the seasonal coefficient amplitude using:

$$C.A. = \frac{(\acute{I}ndice\ m\acute{a}ximo - \acute{I}ndice\ m\acute{i}nimo)}{(\acute{I}ndice\ m\acute{a}ximo + \acute{I}ndice\ m\acute{i}nimo)}\ X\ 2\ \ X\ 100$$

The seasonal coefficient amplitude permits to verify whether a series is seasonal or not, and what intensity it has.

2.2.2 Causality test

Gujarati (1995) defines the causality concept as "if variable x causes variable y, then changes in x should precede changes in y". A causality test relatively simple was proposed by Granger (1969). This test assumes the information relevant to the prediction of the variables is contained solely in the time series data on these variables. The test estimated of two variables (y e x) is represented by the regression below:

$$\begin{aligned} y_t &= \alpha_0 + \sum_{i=1}^{k} \alpha_i\, y_{t-i} + \sum_{i=1}^{k} \beta_i\, x_{t-i} + \varepsilon_{1t} \\ x_t &= \beta_0 + \sum_{i=1}^{k} \beta_i\, x_{t-i} + \sum_{i=1}^{k} \alpha_i\, y_{t-1} + \varepsilon_{2t} \end{aligned} \qquad (7)$$

where the disturbances term are uncorrelated. One important observation is that the number lagged terms included in regression (7) can affect the direction of causality, because the Granger test is very sensitive to the number of lags used in the analysis. Gujarati (1995) distinguishes four possible results to the regression (7):

Unidirectional causality from *x* to *y* exists if $\sum \beta_i \neq 0$ e $\sum \alpha_i = 0$;

Unidirectional causality from *y* to *x* is indicated if $\sum \alpha_i \neq 0$ e $\sum \beta_i = 0$;

Bilateral causality is suggested if $\sum \beta_i \neq 0$ e $\sum \alpha_i \neq 0$;
Independence or absent causality occurs if $\sum \beta_i = 0$ e $\sum \alpha_i = 0$.

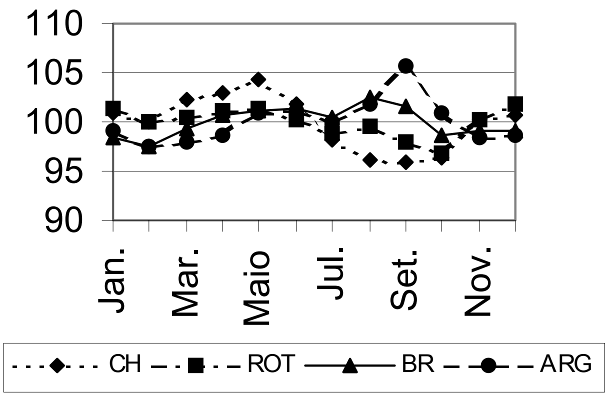
The t test is used to verify the individual statistical relevance of both $\beta_i^{'}$ and $\alpha_i^{'}$ parameters. The joint significance of the complete set of variables is tested using F test.

3. Results

3.1. Seasonal indexes

The seasonal indexes of both Brazilian and Argentine soybean FOB prices are more associated with seasonal index of Rotterdam CIF price than with Chicago quotation (CBOT), conform illustrated in Graphic 01. This result confirms a strong dependence of both Brazilian and Argentine prices on the international market. This fact does not happen with EUA soybean complex.

Graphic 1 - Comparative seasonal indices



Source: Primary data from Chicago Board of Trade (CBOT), Brazilian Vegetal Oils Industry (ABIOVE) and OILSEEDS (1991-1999)

The seasonal index of CBOT quotation varied between 95,88 (September) and 104,31 (May), respectively the beginning of crop and the off-season period in the North Hemisphere, with amplitude coefficient 8,41%. These results are consistent because the prices during the crop are smaller than the off-season prices.

In Brazil, the seasonal index of FOB prices varied between 97,42 (February) and 102,46 (September), respectively the beginning of crop and the off-season period in the South Hemisphere, with amplitude coefficient 5,04%. Thus, as in the former case, the indexes seem to capture the market conditions.

Argentina's FOB prices reached minimum value of 97,49 in February and maximum value of 105,596 in September, with amplitude coefficient 7,98%.

The seasonal index of Rotterdam's CIF prices varied from a minimum of 96,90 in October to a maximum of 101,763 in December, with amplitude coefficient 4,89%.

The seasonal amplitude indexes results show that the Rotterdam prices present lower amplitude variation. Probably due to the stability of soybean supply to the European Union along the year. During the South Hemisphere's off-season period, North American crop supplies the EU market; and, in the North Hemisphere's off-season period, South American crop (Brazil and Argentina) supplies the EU market.

3.2.ARIMA Models

The results of ARIMAs models, which were automatically adjusted by the X-11 method, revealed the predominance of moving average parameters in three of the four estimated models. The only model that presented major complexity level was the Brazilian FOB prices model, once it was necessary the introduction of at least two autoregressive parameters, which showed high significance in terms of their respective t tests results (Table 3).

Other aspect observed is that, exception made to the BR variable model, all estimated models are very analogous, with predominance of the moving average parameter of 12 order, in terms of significance level of t test. The presence of this parameter in all of the four estimated models apparently captures the soybean production cycle until its arrival in the market.

Logarithmic transformation was necessary and the respective Box-Ljung tests were significant in all of the estimated models, showing that the residuals autocorrelation was surely eliminated (Table 3).

3.3. Granger causality test

The causality tests results show that the null hypothesis of Brazilian FOB prices not causing Chicago Board Trade prices has 22,91% probability, which means that the probability of true null hypothesis rejection (commit Error type I) is 22,91%. Thus, it can be stated that Brazilian soybean FOB prices do not cause the quotation of soybean in Chicago. Analysing the inverse way, that is, the null hypothesis of soybean quotations in Chicago not causing Brazilian FOB prices, the probability of true null hypothesis rejection is only 12,62% (Table 4). Thus, taking as basis to decision making the commonly adopted significance level of 10,0%, it can be stated that Chicago Board Trade soybean quotations do not cause the commodity's FOB prices in Brazil and vice-versa, that is, there is an absence of causality in both directions.

Analogous results were obtained in the causality test with the CBOT quotations and Argentina's soybean FOB prices, once the probability of true null hypothesis rejection that Argentina's FOB prices do not cause the CBOT soybean quotations (commit Error type I) is 21,67%; while in the inverse way the probability of true null hypothesis rejection that CBOT quotations do not cause the Argentina's soybean FOB prices is 14,11% (Table 4). Thus, taking as basis the significance level of 10,0%, it can be stated that does not exist any causality between Argentina and Chicago's soybean prices.

Table 3 – ARIMAs model´s parameters estimates

Serie	Parameter	estimate	t test
Chicago (CH)	Constant = θ_0	-0,0012506 (0,0019487)	-0,64
	θ_1	-0,31788 (0,10135)	-3,14(*)
	θ_{12}	0,88063 (0,06761)	13,03(*)
Model 1 Choice Criterion: (0,1,1)(0,1,1)s, log transformation Box-Ljung test: 27,77 with 22 freedom degrees, Probability=0,18 (Probability>0,05) Over differencing test: MA parameters sum = 0,88 (must be < 0,90) MAPE – three last years : 4,21% (must be < 15,00)			
Totterdam (ROT)	Constant = θ_0	-0,0012506 (0,0013607)	-0,74
	θ_{12}	0,87302 (0,06336)	13,78(*)
	ϕ_1	0,03901 (0,10678)	0,37
	ϕ_2	-0,09682 (0,10844)	-0,89
Model 1 Choice Criterion: (2,1,0)(0,1,1)s, log transformation Box-Ljung test: 11,77 with 21 freedom degrees, Probability=0,95 (Probability>0,05) Over differencing test: MA parameters sum = 0,87 (must be < 0,90) MAPE – three last years : 3,61% (must be < 15,00)			
Brazil (BR)	Constant = θ_0	-0,22079 (0,41655)	-0,53
	θ_1	1,68579 (0,03521)	47,88(*)
	θ_2	-0,99896 (0,03566)	-28,02(*)
	θ_{12}	0,85726 (0,07079)	12,11(*)
	ϕ_1	1,52723 (0,09194)	16,61(*)
	ϕ_2	-0,84942 (0,0955)	-8,89(*)
Model 1 Choice Criterion: (2,1,2)(0,1,1)s, log transformation Box-Ljung test: 10,56 with 19 freedom degrees, Probability=0,94 (Probability>0,05) Over differencing test: MA parameters sum = 0,86 (must be < 0,90) MAPE – three last years : 4,30% (must be < 15,00)			

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Table 3 – ARIMAs model´s parameters estimates

Serie	parameter	estimate	t test
Argentine (ARG)	Constant = θ_0	-0,0024882 (0,0024149)	-1,03
	θ_1	-0,16546 (0,1047)	-1,58
	θ_{12}	0,78325 (0,07204)	10,87

Model 1 Choice Criterion: (0,1,1)(0,1,1)s, log transformation
Box-Ljung test: 21,43 with 22 freedom degrees, Probability=0,49 (Probability>0,05)
Over differencing test: MA parameters sum = 0,78 (must be < 0,90)
MAPE – three last years : 3,86% (must be < 15,00)

(*) Significance at 5,0% level
Source: Primary data from Chicago Board of Trade (CBOT), Brazilian Vegetal Oils Industry Association (ABIOVE) and OILSEEDS (1991/1999)

The analysis of the relationship between Brazilian soybean FOB prices and its respective Rotterdam CIF prices shows that the null hypothesis of ROT not causing BR has probability of 11,79%, that is, there is only 11,79% chances of true null hypothesis rejection. The adoption of the null hypothesis of BR not causing ROT has a probability of 81,57% of true null hypothesis rejection (Table 4). Again, adopting as pattern the significance level of 10,0%, there is absence of causality from ROT to BR, and from BR to ROT. Meanwhile, if adopted the significance level of 12,0%, there is causality from ROT to BR, that is, soybean prices in Rotterdam cause soybean prices in Brasil, while the inverse does not occur.

The analysis of the relationship between ROT and ARG demonstrates that the true null hypothesis rejection of ROT not causing ARG has probability of only 0,94% showing the presence of causality from Rotterdam soybean prices on the soybean FOB prices in Argentina. Analysing the inverse way, the probability of ARG not causing ROT is 99,95%, thus, the possibility of true null hypothesis rejection is 99,95%, indicating that Argentina's soybean FOB prices do not influence the soybean CIF prices in Rotterdam.

Table 4 – Granger causality test (*)

Null hypothesis	F test	Probability
BR not causing CH	1,3253	0,2292
CH not causing BR	1,5686	0,1263
ARG not causing CH	1,3489	0,2168
CH not causing ARG	1,5244	0,1412
ROT not causing BR	1,5955	0,1179
BR not causing ROT	0,6211	0,8158
ROT not causing ARG	2,5210	0,0095
ARG not causing ROT	0,1492	0,9995
CH not causing ROT	0,7991	0,6497
ROT not causing CH	1,2613	0,2656

(*) Montly data were used, requiring 12 lags each case analysed
Source: Primary data from Chicago Board of Trade (CBOT), Brazilian Vegetal Oils Industry Association (ABIOVE) and OILSEEDS (1991-1999)

Finally, the causality test shows that neither Chicago cause Rotterdam nor Rotterdam cause Chicago. This result confirms the assumption that soybean prices are set within these centers.

4. Conclusion

The results confirm the existence of strong dependence of the Brazilian and Argentine FOB prices with the CIF prices in Rotterdam, differently of USA prices, that are set within CBOT. Other important result is that the amplitude of seasonal standard is more accentuated in USA off-season period in Brazil and Argentine. On the other hand, the seasonal standard in Rotterdam is less accentuated than another series, due to the fact that supply in European Union is constant during all year. These results are according to the expected for this market, due to USA, Brazil and an Argentine crop occurs in distinct periods of the year. Margarido *et al.* (1999) had obtained similar results to the Granger causality test that confirms the dependency of both Brazilian and Argentine prices to foreign market.

***Abstract**: this paper aims to analyze the seasonal behavior and the relationship among soybean price in Chicago Board of Trade (CBOT), CIF prices in Rotterdam and FOB prices in Brazil and Argentine. The main conjecture is that Brazilian and Argentine prices are more associated with Rotterdam than Chicago, due to the European Union is the main destination of soybean exported by both countries.The expected result is that the seasonal price behavior in FOB prices of these countries will be more similar to CIF prices in Rotterdam than to CBOT quotation. Thus, there is a price transmission system based on this seasonal behavior.*

***Key words**: seasonal; soybean; price transmission system.*

Bibliographic references

AGUIAR, D.R.D.; BARROS, G.S.A.C. - "Causality and asymetry in Brazilian soybean and derivatives prices transmission in 1980's". In : **Estudos Econômicos**, São Paulo, Vol.21, n.1, p.89-103, jan.-abr./1991 (Portuguese).

BOX, G.E.P.; JENKINS, G.M.; REINSEL, G.C. **- Time series analysis: forecasting and control.** New Jersey: Prentice Hall, 3rd Ed., 1994, 598p.

DAGUM, E.B. - **The X-11-ARIMA/88 Seasonal Adjustment Method**. Ottawa: Statistics, Canada, 1988.

EVIEWS - **User Guide - Version 2.0.** Califórnia: QMs, 1994-95, 372p.

FREITAS, S.M.; FERREIRA, C.R.R.P.T.; BARBOSA, M.Z. - "Opportunities and impediments in Brazilian dende culture expansion". In : **Agricultura em São Paulo,** Vol.45, t.2, p.1-16, 1998 (Portuguese).

GRANGER, C.W.J. - "Investigating causal relations by econometric models and cross spectral methods". In : **Econometrica**, Vol.37, p.424-438, 1969.

GUJARATI, D.N. - **Basic Econometrics.** New York: McGraw-Hill, 3rd Ed., 1995, 838p.

LJUNG, G.M.; BOX, G.P.E. - "On a measure of lack of fit in time series models". In : **Biometrika,** Vol.66, p.66-72, 1978.

MARGARIDO, M.A.; SOUSA, E.L.L. - "Soybean prices formation in Brazil". In : **Agricultura em São Paulo**, Vol.45, n.2, p.52-61, 1998 (Portuguese).

MARGARIDO, Mario A ; SOUSA Eduardo L. Leão de; BARBOSA, Marisa Zeferino e FREITAS, Silene Maria. Transmissão de preços no mercado internacional de grãos de soja: uma aplicação da metodologia de séries temporais. In: CONGRESSO BRASILEIRO DE ECONOMIA E SOCIOLOGIA RURAL, 37, Foz do Iguaçu, 1-5 ago. 1999. **Anais**... Brasília: SOBER, 1999.

MILLS, T. - **Time series for economists.** New York: Cambridge University Press, 1990, 247p.

NEVES, L.C. - **Comercialization margins and prices transmission elasticity in the soybean processing industry.** Dissertation, Piracicaba: USP/ESALQ, 1993, Dissertação de Mestrado (Portuguese).

OILSEEDS - **World Market and Trade. Washington**: USDA, 1991/1999.

PINO, F.A.; ROCHA, M.B. - "Soybean prices transmission in Brazil". In : **Revista de Economia e Sociologia Rural**, Vol.32, n.4, p.345-361, out.-dez./1994.

SAS INSTITUTE - **Forecasting Techniques Using SAS/ETS Software** : Course Notes. Cary, NC, 1994.

SAS INSTITUTE - **SAS/ETS user's guide, version 6.** Cary, NC, 2nd Ed., 1993, 1022p.