STUDY OF MARKET EFFICIENCY IN AGRICULTURAL FUTURES: A COMPARATIVE ANALYSIS BETWEEN FUTURES MARKETS OF BUENOS AIRES AND CHICAGO, SPECIFICALLY FOR THE CULTIVATION OF SOYBEAN AND WHEAT

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This paper aims to study and compare the efficiency in futures markets for soybean and wheat crops between the markets in Buenos Aires (MatBa) and Chicago (CME-CBOT) for the years 2000 through 2015. There are numerous studies that analyze this phenomenon independently, but none of them have done a comparative analysis between these two countries using these specific crops. Therefore, the main objective of this research - in addition to individually analyzing the efficiency in futures markets in each country, for each crop - is to be able to detect the existence of a relationship between the two markets. In other words, the intention is to show whether the individual efficiency of any of these markets is linked to the efficiency of the other

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1. Objectives

Efficiency in futures markets [1] for the selected cases will be based on the existence - or lack - of at least one cointegrating relationship between the price of futures contracts and the spot price, as has been done by numerous authors (Ali and Gupta, 2011; Delgado and Lema, 2001; Fama, 1970, 1987 and 1991; Mckenzie and Holt, 1998). In this way, we will be able to confirm that markets have operated under efficient conditions for the period analyzed if there is a cointegrating relationship between the price of futures contracts and spot price.

In the second place, a study will be done based on a cointegration approach in order to test whether there is a relationship between the efficiency in futures markets in Buenos Aires (Argentina) and Chicago (The United States). Since the futures markets in Buenos Aires has a significantly lower volume of operations than Chicago, a situation that can lead to market inefficiencies, the intention is to see if the price changes of the second determine the first. Thus, relevant market information is transmitted from one case to another, allowing for efficient markets to exist despite low trading volume[2].

Through this analysis, it will be possible to demonstrate i) the efficiency - or inefficiency - of futures contracts as an instrument to forecast spot prices, and ii) if the efficiency in a futures market derives from the efficiency in the other. Through the first objective, it will be possible to ensure - or deny - that markets operate under conditions in which available information for all the agents is sufficient so that there are no individual gains or losses over time. In other words, efficiency in futures markets for soybean and wheat contracts would imply that, in the long run, statistical evidence confirms that the prices at which futures contracts are traded reflect the spot price. On the other hand, under the second objective, it will be possible to conclude how both markets interact so that the efficiency in one leads to efficiency in the other - or vice versa -.

2. Antecedentes

2.1. Literature review

There is a vast amount of literature that addresses, through a cointegration approach, the study of efficiency in commodity futures markets and the existing relationship between trade volume and price volatility - in the case of the works mentioned below. However, nothing was found that directly links both analytical schemes together.

Kumar (2004) studied the efficiency of futures markets for diverse commodities in India, concluding that futures prices are not a good indicator of the expected spot price.

Wang and Ke (2005), researched the efficiency for wheat and soybean crops in China, finding a long-term balance between the price of the futures contracts and the spot price of soybean, but no such balance was found with wheat.

[1] Future market efficiency is defined as the degree of precision by which the spot price of a certain commodity - in this case soybean and wheat - is forecasted by the price of a futures contract (Fama, 1970, 1987 and 1991; Mckenzi and Holt, 1998).

[2] The annually traded volume in futures agricultural markets in Argentina represent a third of the total harvest, while in the United States this number is about eighty times the harvest.

Watkins and McAleer (2006), found a cointegrating relationship between the future price, the spot price, stock level and the interest rate for multiple metal commodities.

Mckenzie and Holt (1998) conducted an extensive analysis for different commodities - including soybean and corn, for the period between 1966 and 1995, validating the hypothesis of market efficiency in all cases on the CBOT.

The literature available on the Argentine market is much scarcer. The work of Delgado and Lema (2001) discovered the existence of a cointegrating relationship in the wheat futures market of Buenos Aires between 1995 and 2000. On the other hand, Grignafini (1998) reached the same conclusions for the futures markets of soybean, corn and wheat crops in the city of Rosario. At the same time, Lachman (2016) highlights the efficiency of the futures market in Buenos Aires in the case of soybean, considering three different time lags between the future contracts and the spot price.

Furthermore, Malliaris and Urrutia (1998) conducted an extensive literature review on the relationship between trade volume carried out in futures markets and prices. In turn, they obtained a positive relationship between the absolute value of changes in price and the absolute value of futures trading in the Chicago market.

2.2. Working hypothesis

In this paper we have two working hypotheses:

1) Both futures markets for the selected crops, within the time period considered, operated efficiently. This is verified by the presence of at least one cointegrating relationship between the series of spot prices and futures contracts.

2) There is a link between the futures markets of Buenos Aires and Chicago, which has been established through a cointegrating relationship between price series of contracts for each market, with each crop. If this relationship exists, it should be given greater influence in the Chicago market over the Buenos Aires market. This would imply that the price of contracts for the Chicago futures market is weakly exogenous in the cointegration relationship.

3. Methodology

Following the analysis of Fama (1991) and Mckenzie and Holt (1998), if we were to consider the existence of a constant arbitration between the operators of futures markets and a behavior of neutrality toward risk, the actual cost of a futures contract will be equal to the expected future price at the moment of the end of the said contract. Thus, the equation would be the following:

$$F_{t-1} = E_{t-1}S_t; \tag{1}$$

F_{t-1} being the price of futures contracts operated in the past, and S_t being the current price of spot transactions. Therefore, on the right side of this equation, we have the expected value as t-1 of the spot price, t, which is equal to the price of futures contracts in t-1. In turn, if it is further assumed that agents have rational expectations, in such a way that they incorporate all available information each time they make a decision, then:

$$E_{t-1}\frac{S_t}{\varphi_{t-1}} + \mu_t = S_t; \tag{2}$$

With φ_{t-1} being the available information in $t-1$ and where μ_t represents the exogenous white noise term to all elements of φ_{t-1}. In this way, the previous equation can be rewritten as follows:

$$\alpha + \beta F_{t-1} + \mu_t = S_t; \tag{3}$$

If the agents were always at neutral risk[3] the last equation would constitute an identity with $F_{t-1} = S_t$, in such a way that $\alpha = 0$ and $\beta = 1$. If this were to happen in a particular futures market, it could be argued that agents can perfectly predict the future spot price based on futures contracts available today.

In order to be able to measure this, we will use the Johansen methodology (1995). This requires building a model of vector autoregression (VAR). This implies a statistical relationship where the variables are explained by lags of themselves and of the other variables. These can be represented as follows for each country and for each crop:

$$S_t = \alpha_1 + \sum_{i=1}^{j} \beta_{1,i} F_{t-1-i} + \sum_{i=1}^{j} \gamma_{1,i} S_{t-i} + \mu_t \tag{4}$$

$$F_{t-1} = \gamma_2 + \sum_{i=1}^{j} \beta_{2,i} F_{t-1-i} + \sum_{i=1}^{j} \gamma_{2,i} S_{t-i} + \mu_t \tag{5}$$

With j= optimal amount of lags

VEC models are a type of VAR model that have variables capable to be cointegrated. Therefore, it is possible to establish a stationary vector, which results from a linear combination of nonstationary variables constituting the VAR. The long-term relationship these variables have with each other, which can be seen in the error correction term of the VEC, must take the following form for each country and for each crop:

$$S_t = \alpha + \beta F_{t-1} + \epsilon_t \tag{6}$$

Recall that the coefficient α represents, in this case, the risk premium to which operators of the future market face, while β is going to signal the efficient levels of the future forecast. Therefore, $\beta < 1$ will be overestimating the future spot price, whereas $\beta > 1$ will be underestimating it. Should $\beta = 1$, futures contracts would perfectly anticipate the spot price. To corroborate the second working hypothesis, a VEC will be built for each crop where the long-term relationship is analyzed will be the following:

$$F_{t;ARG} = \alpha + \beta F_{t;USA} + \nu t \tag{7}$$

In this case, $F_{t;ARG}$ represents the futures contracts for the Argentine market while $F_{t;USA}$

[3]It should be noted that the equality that represents the risk neutral agents is not an assumption for this work. Along the same coefficient value α can be both positive and negative.

represents the futures contract for the Chicago market. If a cointegrating relationship does exist, and the coefficient β is statistically significant, we will be able to say that there is a transfer of information between markets. Additionally, we will proceed to do a weak exogeneity test to see which market has more influence over the other.

4. Data

For this research, we have considered daily information for the time period between 1994 and 2015[4], provided by MatBa (futures market of Buenos Aires) and the CMA-CBOT (futures market of Chicago). The data have been be retrieved from the corresponding websites of both grain stock markets[5]. Two contracts have been used for each year, for both markets and crops: May and November. Meanwhile, the spot price corresponds to the average contract expiration day of the month. Finally, all values were transformed into logarithms, as is usually done in the literature.

4.1. Unit root test

Given that in order to construct a VEC model it is first necessary to know the amount of unit roots in each one of the series, the corresponding Augmented Dickey-Fuller test was performed for each one. This test was performed under the Schwartz criteria and with 10 maximum lags. Once proved that the series in levels were not stationary, the test was repeated in each case, but now considering the series with a first difference. The results obtained are summarized in the table 1. This test has a null hypothesis that the variables have a unit root (i.e. they are not stationary), so we can see that at a significant level of 5 %, all of the series are I(1). Therefore, it can be said that the series are stationary in their first difference.

5. Results for efficiency market study

Based on the manifold of literature previously mentioned, the construction of an error correction vector will permit the testing of the market efficiency hypothesis for the case of MatBa and CME-CBOT within the selected period. If the series corresponding to the spot prices and the futures contracts for the three selected periods are not first-order stationary and the VAR model meets the three requirements for the respective errors - normality, not autocorrelation and homoscedasticity -, it is possible to assess the existence of cointegration for each of the armed models. Since, in the previous section, it was demonstrated that all of the series are I(1) and that the required conditions of waste VAR models are fulfilled[6], cointegration tests were performed and the coefficients of the VEC models were estimated.

[4]Given the high volatility detected in the Argentine wheat market from the year 2013, based on the repeated and unannounced closures of wheat exports, was decided to cut the sample for this case until 2012

[5]For the case of CMA-CBOT the data was provided by Reuters

[6]The corresponding results to the tests performed to the VAR models can be found in the annex of this report

5.1. Cointegration test results

From a VAR model, having verified the consistency in its estimation through the waste tests, it is possible to estimate a VEC if a cointegration relationship between the VAR variables is found. The Johansen test was used to detect the long-term relationship between variables. In turn, since the data has a consistent trend and intercept, these aspects should be taken into account when selecting the criteria for the Johansen test[7]. It may be added that, since all of the series used in this paper are I(1), a single cointegration relationship was sought between them. The tables 2 show the test results mentioned for both markets and crops in the three constructed models: with contracts one month, three months, and 5 months from their expiration date As indicated in the results of each one of the tables, through the maximum likelihood method, as through the trace method, all models presented a unique cointegration relationship. It is worth noting that by verifying the cointegration relationship between the series for each one of the models, we can say - given the hypothesis of this paper - that in all cases the markets behaved in efficient conditions for the selected time period.

5.2. VEC coefficients and long-term relationship

Since each one of the VEC models constructed in this paper for the purpose of studying market efficiency show the long-term relationship that exists between the variables considered, it is relevant to elaborate on the continuation of the value and sign of the coefficients obtained for each case[8]. For the values of the coefficients obtained for the models built for soybean and wheat are presented for each market see table 3.

First, it can be noted that in all models, the coefficient "α assumed as the time-varying risk premium - is negative and is also growing (in absolute terms) as we consider time periods more distant from the moment of implementation of the futures contract. This is intuitively consistent given that as we negotiate any given futures contract that is far from implementation, it will have to assume a larger risk premium, because its uncertainty increases. At the same time, the negative sign of the coefficient "α" responds to the fact that there is an inherent risk to the prices negotiated in advance of the distribution of goods. This can be affected by multiple exogenous shocks. It may happen that producers tend to agree on, in statistical terms, the values of the futures contracts. This is what happened in the period analyzed in this paper. On the other hand, in all cases, the coefficient "βïs positive and close to one, which, in turn, also tends to increase - in the majority of cases - as we consider contracts further away from their implementation period. This result is also intuitively expected, because as we consider contracts with a greater time lag with respect to the future spot price, the possibility of erring more on the expected price increases. Therefore, statistically, underestimation of the expected future price spot is higher as we move further away in time.

[7]For this paper, the criteria defined by the software is used on all models as: "linear deterministic trend in data and intercept (no trend) in CE and VAR test".

[8]It's worth noting that these models were established as stable and their coefficients significant. To evaluate the significance of the coefficients obtained, we proceeded to perform a test imposing restrictions, so as to see if these restrictions would break, or not, the cointegration relationship. Therefore, the coefficients were forced to be equal to zero, so that if the cointegration relationship maintained valid, then said coefficient was not significant as it did not provide relevant information.

6. Results for information transmission between markets

Following the analysis proposed in this paper, the results obtained for the testing of the second hypothesis will be presented next. To that effect, the existence of cointegration between the contract variables and the future of the Matba and CME-CBOT was analyzed, based on each one of the estimated VARs, and VEC models continued to be built (equation number 7) for each crop based on the different lag periods considered[9]. Finally, for these VEC models, the weak exogeneity test was performed in order to evaluate which market has more influence over the other. The latter led to the conclusion about the direction in which information travels between the two selected markets.

6.1. Cointegration test results

As was done in the previous section, having verified the consistency in estimating VARs through waste tests, the Johansen test (1991 and 1995) was used to verify if a cointegration relationship exists between the variables[10]. The tables 4 show the results of the test mentioned that relates to both markets for the soybean and wheat crops based on the constructed models: with contracts one month, three months, and 5 months from their expiration date. As obtained in the previous section, the results indicate that both models, through the maximum likelihood method, as through the trace method, presented one cointegration relationship. In this case, to verify the relationship of cointegration between the futures markets of Chicago and Buenos Aires for the two commodities selected, we can say - given the first part of the second hypothesis of this paper - that a long-term relationship exists between the two said markets in all cases studied.

6.2. VEC coefficients and weak exogeneity test between markets

Having demonstrated the existence of a long-term link between the futures markets of Buenos Aires and Chicago for the case of soybean and wheat, through the presence of a cointegration relationship between them, it is now possible to analyze whether Chicago indeed has a greater market influence over the Buenos Aires market, as suggested in the second hypothesis of this paper. For this, the corresponding associated VEC models are estimated for each model, and, in each case, it is tested if the number of futures contracts of CME-CBOT is weakly exogenous. The results obtained for the estimation are presented in table 5[11]. Given that the coefficient "β" is statistically significant, it can be said that there is a transfer of information between the two markets. Additionally, in all cases, the number of futures contracts that correspond to the Chicago market proved to be weakly exogenous. From these strong results, the influence of the Chicago futures market over the behavior of the Buenos Aires futures market can be seen, in the case of the two selected commodities. Overall, it could be concluded that a 1 % change

[9] The corresponding results to the waste tests performed to the VAR models can be found in the annex of this paper.

[10] The criteria defined by the software used was utilized in all models as: "linear deterministic trend in data and intercept (no trend) in CE and VAR test", since the data has a constant trend and intercept. Additionally, since the series used are I(1), it seeks to obtain a single cointegration relationship between them.

[11] For these models, it was verified that they are stable and their coefficients significant, as was done in the previous section.

in the contracts of the Chicago futures market implicates a 0.8 % change in the prices of the Buenos Aires futures market[12].

7. Conclusion

In the first section of this paper, the efficiency of the futures markets in the case of soybean and wheat in the MatBa and the CME-CBOT were analyzed. The results obtained show that, throughout the period covered, both markets operated under efficient conditions. Thus, the prices of the mentioned commodities obtained from futures markets operated, in statistical terms, as a forecast of spot prices. This was confirmed, having found a cointegration relationship with either one, three, and five months lag. At the same time, the coefficients of the VEC models provided additional information about the way in which the variables are related in the long run. In the second section of this paper, we showed that there is an important relationship between the efficiency of the Chicago futures market and the Buenos Aires futures market, in the case of the selected commodities. First, given that a cointegration relationship was found between all of the estimated models, it can be shown that there is a long-term relationship between the cost-estimate of the contracts for both futures markets in the case of wheat and soybean. Secondly, the results reached also show that changes in the prices of CME-CBOT influence changes in the MatBa prices. This was demonstrated by the existence of weak exogeneity in the error correction model by the Chicago futures market for all cases analyzed. Since this relationship can be demonstrated in all models, it can be concluded that this influence proved to be highly relevant to the efficient operation of the Buenos Aires futures market. In this way, despite the relatively low operational volume carried out by the MatBa, the futures market could operate in efficient conditions thanks to the transfer of information from the CME-CBOT.

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[12] In this case, the coefficient "α" – assumed as the time-varying risk premium for the efficiency analysis of the market of the previous section -, will represent the risk premium associated with the Buenos Aires market. Certainly, its interpretation lacks relevance for the purposes of the objectives of this paper.

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Table I. Augmented Dickey-Fuller Test of Stationaity

	Level		First Difference		
Variable	t stat	Prob.*	t stat	Prob.*	
Arg_soybean_ 1 month	-2.203454	0.4754	-6.790961	0.0000	I(1)
Arg_soybean_ 3 month	-2.237440	0.4574	-7.358538	0.0000	I(1)
Arg_soybean_ 5 month	-2.613671	0.2766	-9.007198	0.0000	I(1)
Arg_soybean_ Spot	-2.858398	0.1859	-7.904291	0.0000	I(1)
Arg_wheat_1 month	-2.658990	0.2585	-6.426806	0.0000	I(1)
Arg_wheat_3 month	-2.847024	0.1909	-7.708389	0.0000	I(1)
Arg_wheat_5 month	-2.750079	0.2240	-8.329382	0.0000	I(1)
Arg_wheat_Spot	-2595112	0.2846	-6.035213	0.0000	I(1)
USA_soybean_ 1 month	-2.296405	0.4266	-7.624029	0.0000	I(1)
USA_soybean_ 3 month	-2.262407	0.4443	-7.308303	0.0000	I(1)
USA_soybean_ 5 month	-2.412557	0.3681	-7.209227	0.0000	I(1)
USA_soybean_ Spot	-2.305729	0.4218	-7.756206	0.0000	I(1)
USA_wheat_1 month	-2.884579	0.1778	-5.440610	0.0000	I(1)
USA_wheat_3 month	-2.123250	0.5183	-6.393994	0.0000	I(1)
USA_wheat_5 month	-2.397115	0.3757	-7.484948	0.0000	I(1)
USA_wheat_Spot	-2.243739	0.4541	-5.743083	0.0000	I(1)

Note: At the level series for soybean and wheat the test was made with intercept and trend. For the first difference series form soybean and wheat, the test was made with none intercept and trend.

Table 2. Johansen cointegration test results for futures contracs and spot price

	Soybean					Wheat				
	λ_{trace}		λ_{max}			λ_{trace}		λ_{max}		
	H0:	H0:	H0:	H0:		H0:	H0:	H0:	H0:	
Model	r=0	r≤1	r=0	r≤1		r=0	r≤1	r=0	r≤1	
MatBa 1 month	24.85680	2.273786	22.58302	2.273786	cointegrated	43.61489	3.840300	39.77459	3.840300	cointegrated
p-value	0.0015	0.1316	0.0020	0.1316		0.0000	0.0500	0.0000	0.0500	
MatBa 3 months	35.40444	1.455195	33.94925	1.455195	cointegrated	31.95930	2.548972	29.41032	2.548972	cointegrated
p-value	0.0000	0.2277	0.0000	0.2277		0.0001	0.1104	0.0001	0.1104	
MatBa 5 months	40.08220	1.459776	38.62242	1.459776	cointegrated	32.01286	2.423871	29.58899	2.423871	cointegrated
p-value	0.0000	0.2270	0.0000	0.2270		0.0001	0.1195	0.0001	0.1195	
CME-CBOT 1 month	34.03905	3.335877	30.70317	3.335877	cointegrated	54.94073	2.750900	52.18983	2.750900	cointegrated
p-value	0.0000	0.0678	0.0001	0.0678		0.0000	0.0972	0.0000	0.0972	
CME-CBOT 3 months	52.11550	2.674029	49.44147	2.674029	cointegrated	31.83626	1.532544	30.30372	1.532544	cointegrated
p-value	0.0000	0.1020	0.0000	0.1020		0.0001	0.2157	0.0001	0.2157	
CME-CBOT 5 months	70.61452	2.206355	68.40817	2.206355	cointegrated	29.08279	1.569524	27.51326	1.569524	cointegrated
p-value	0.0000	0.1374	0.0000	0.1374		0.0003	0.2103	0.0002	0.2103	

In all the cases it was used the test for "Linear Trend and with Intecept No Trend"

Table 3. VEC models for individual market efficiency

	Soybean		Wheat	
Model	α	β	α	β
MatBa 1 month	-0.203534	1.036357	- 0.041135	1.010689
p-value		(0.02329)		(0.04314)
MatBa 3 months	0.035645	0.996854	- 0.442939	1.086974
p-value		(0.02481)		(0.06358)
MatBa 5 months	-0.216454*	1.043048*	-0.238339	1.038832
p-value		(0.02483)		(0.07822)
CME-CBOT 1 month	0.104972	0.984656	0.147601	0.972478
p-value		(0.01479)		(0.01686)
CME-CBOT 3 months	0.191979	0.970479	-0.013863	1.002434
p-value		(0.03212)		(0.02414)
CME-CBOT 5 months	-0.076488	1.017350	-0.139230	1.022173
p-value		(0.03550)		(0.03012)

Note: in all the cases is proved weak exogenity from the spot variable but not in *

Table 4. Johansen cointegration test results between Matba and CME-CBOT

	Soybean					Wheat				
	λ_{trace}		λ_{max}			λ_{trace}		λ_{max}		
	H0: r=0	H0: r≤1	H0: r=0	H0: r≤1		H0: r=0	H0: r≤1	H0: r=0	H0: r≤1	
Future contracs for 1 month	16.27291	1.293770	14.97914	1.293770	cointegrated	20.54450	0.622152	19.92235	0.622152	cointegrated
p-value	0.0381	0.2554	0.0385	0.2554		0.0079	0.4302	0.0057	0.4302	
Future contracs for 3 month	39.44280	2.224316	37.21848	2.224316	cointegrated	24.20252	1.687880	22.51464	1.687880	cointegrated
p-value	0.0000	0.1359	0.0000	0.1359		0.0019	0.1939	0.0020	0.1939	
Future contracs for 5 month	31.20179	2.247242	28.95455	2.247242	cointegrated	16.05292	0.759728	15.29319	0.759728	cointegrated
p-value	0.0001	0.1339	0.0001	0.1339		0.0412	0.3834	0.0343	0.3834	

In all the cases it was used the test for "Linear Trend and with Intecept No Trend"

Table 5. VEC models for information transmition

	Soybean			Wheat		
Model	α	β	Weak exogenity variable	α	β	Weak exogenity variable
Future contracs for 1 month	0.772698	0.856890	CME-CBOT future contras***	1.891154	0.625265	CME-CBOT future contras***
p-value		(0.02896)			(0.07042)	
Future contracs for 3 month	0.704243	0.867871	CME-CBOT future contras*	1.727850	0.660877	CME-CBOT future contras***
p-value		(0.02560)			(0.06307)	
Future contracs for 5 month	0.860947	0.839144	CME-CBOT future contras***	1.094549	0.796708	CME-CBOT future contras***
p-value		(0.03389)			(0.06227)	

Note: * indicates the cointegration relationship persist at a 1%, ** indicates the cointegration relationship persist at a 5%, *** indicates the cointegration relationship persist at a 10% or more

Annex I. VAR structure for soybean and wheat efficiency models

Soybean	VAR Structure		Residual tests results		
Model	Number of lags included	Lags length criteria	Normality by	No Autocorrelation by	No Hetersedasticity by
MatBa 1 month	4		Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
MatBa 3 months	4	LR, FPE, AIC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
MatBa 5 months	4	FPE, AIC, HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 1 month	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 3 months	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 5 months	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)

Wheat	VAR Structure		Residual tests results		
Model	Number of lags included	Lags length criteria	Normality by	No Autocorrelation by	No Hetersedasticity by
MatBa 1 month**	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
MatBa 3 months	2	FPE & AIC	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
MatBa 5 months	2	FPE, AIC, SC & HQ	Cholesky (Lutkepohl)	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 1 month	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl)	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 3 months	3	LR, FPE, AIC, HQ	Cholesky (Lutkepohl)	LM test	White Heteroskedasticity (No Cross Terms)
CME-CBOT 5 months*	3	LR, FPE & AIC	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)

Note: * indicates that was used a dummie for 11/2007, *** indicates that was used a dummie for 11/2007 and for 11/1995.

Annex II. VAR structure for the information transmission between markets models

Soybean	VAR Structure		Residual tests results		
Model	Number of lags included	Lags length criteria	Normality by	No Autocorrelation by	No Heteroskedasticity by
Future contracs for 1 month	5	LR	Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
Future contracs for 3 month*	1	FPE, AIC, SC & HQ	Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
Future contracs for 5 month	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)

Note: * indicates that was used a dummie for 05/2004

Wheat	VAR Structure		Residual tests results		
Model	Number of lags included	Lags length criteria	Normality by	No Autocorrelation by	No Heteroskedasticity by
Future contracs for 1 month	1	SC	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
Future contracs for 3 month	1	LR, FPE, AIC, SC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)
Future contracs for 5 month	3	LR, FPE, AIC & HQ	Cholesky (Lutkepohl) & Doornik-Hansen	LM test	White Heteroskedasticity (No Cross Terms)