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The Chilean wheat market and its price support mechanism: a spatial market integration analysis

El mercado chileno de trigo y su mecanismo de protección de precios: un análisis de integración espacial de mercados

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ABSTRACT

This research investigates the spatial market integration of the Chilean wheat market in relation with its most representative international markets by using a vector error correction model (VECM) and how a price support policy, as a price band, affect it. The international market was characterized by two relevant wheat prices: PAN from Argentina and Hard Red Winter from the United States. The spatial market integration level, expressed in the error correction term (ECT), allowed concluding that there is a high integration degree among these markets with a variable influence of the price band mechanism mainly related with its estimation methodology. Moreover, this paper showed that Chile can be seen as price taker as long as the speed of its adjustment to international shocks, being these reactions faster than in the United States and Argentina. Finally, the results validated the "Law of the One Price", which assumes price equalization across all local markets in the long run.

RESUMEN

Este trabajo investiga la integración espacial del mercado chileno de trigo en relación con sus principales mercados internacionales, mediante el uso de un modelo de corrección de error (VECM) y cómo este parámetro es afectado por la utilización de una política de estabilización de precios. Los mercados internacionales fueron caracterizados a través de dos precios relevantes: PAN de Argentina y Hard Red Winter de los Estados Unidos. En este sentido, el nivel de integración espacial del mercado chileno, expresado en el coeficiente de corrección de errores, permitió concluir que existe un alto grado de integración entre los mercados considerados, con una influencia variable del mecanismo de protección de precios debido principalmente a su metodología de estimación. Además, este trabajo demostró que Chile puede ser considerado como un tomador de precios internacionales equivalente a la velocidad

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Keywords

co-integration analysis • price band • wheat • cereal prices • international market of *commodities* • Vector Error Correction Model

Palabras clave

análisis de cointegración • bandas de precio • trigo • precios de cereales • mercado internacional de *commodities* • Modelo de Corrección de Errores

de ajuste a los impulsos provenientes de Argentina y los Estados Unidos, los cuales debido principalmente a su tamaño, reaccionan más lentamente a los "shocks" provenientes del mercado internacional. Finalmente, los resultados permitieron validar la "Ley del Precio Único", la cual asume ecualización de precios en el largo plazo para los mercados espacialmente vinculados.

INTRODUCTION

The world exports of wheat are concentrated in five countries or regions, the United States, the European Union, Australia, Canada and Argentina, involving nearly 75% of the world supply. It is relevant to consider that three of these countries are in the North hemisphere and two in the South hemisphere, since the counter seasonal nature and its impact on the world trade (4).

Chile has historically been a net wheat importer, being Argentina and the USA its most important suppliers with 22% and 39% for the total Chilean imports in 2007 respectively (19). The condition of net importer in addition to being a small market, exposes the Chilean domestic wheat prices to the international market fluctuations (14).

Given the importance of the wheat chain, several studies using time series were performed to analyze the formation of the Chilean wheat prices and its price protective mechanism in order to reduce its volatility, concluding that in general terms, it was acted in fact as a protective measure, increasing in average the wheat domestic prices (6, 17, 24).

The Chilean price supporting mechanism, called price band, is calculated yearly based in historical international prices of a set of reference markets and published in the Chilean official newspaper at the beginning of the agricultural season, prior the sowing period (18).

These reference markets were from 1984 to 2003 the Hard Red Winter N° 2 FOB price (Gulf of Mexico) and from December 2003 to present the Argentinean PAN wheat FOB price for the first semester and the Soft Red Winter N° 2 wheat FOB price (Gulf of Mexico) for the second semester (3). Since for the price band estimation is used historical price series, the first step is to express all these prices in real terms.

Then, these monthly averages prices registered in the reference markets are converted to U$ dollars December-based of the previous year to the calculation and deflated by the domestic inflation index. Second, the real prices are sorted on upward

order. Then is eliminated the 25% higher and 25% lower of the values, that is to say, from the 60 prices considered are eliminated the 15 higher and 15 lower, with this information are defined the extreme values, that is, the base and the ceiling of the band (24).

For the purpose of this research oriented to analyze the difference between the prices on two external markets with respect to a domestic situation, the concept utilized is "spatial price transmission". For a market called integrated, is required that a set of locations share both the same traded commodity and the same long run information (1). In a co-integration framework, this second condition requires the existence of one and only one integrating factor that is commons to all price series (8).

The analysis suppose that wheat markets are well integrated under the "Law of the One Price (LOP)" (16) and to quantify the price adjustment is used a vector error correction model (VECM) which is considered appropriate to non-stationary time series with common trend on the long run and very useful on several market integration studies (8, 22, 25).

Previous research focused on considering the impact on the surplus transfers and wheat demand. Nevertheless, they did not study in depth the dynamics among the different markets that interact with a domestic situation. The results of this exercise would allow us to predict future prices fluctuations and to support the design of agricultural policies for public and private components of the Chilean wheat market.

THE CO-INTEGRATION CONCEPTS

When the variables are defined and the existence of unit roots are confirmed, it is possible to formulate a test for co-integration vectors, that is, the long run equilibrium relations. In general terms, in the presence of two variables y_t and x_t which are I(1) the residuals will be I(1). However, if this variables are I(0), y_t and x_t are called co-integrated.

On the other hand, according to the Granger Representation Theorem -Engle and Granger 1987, cited by Pillai (20)- if two variables y_t and x_t are I(1) is possible to represent it as an error correction mechanism. In this kind of representations, the variations in almost one of the variables are explained, not only by short run variables but also by the observed error term (e_t) of the previous period, in which e_t represents the long run relation deviation*.

According to that, in the long run, the variables "x" and "y" are under equilibrium and any variation will be compensated on the next period, in the opposite direction, with the final purpose to maintain the equilibrium (10).

* et = yt-λxt, in which λ represents the coefficient, estimated by OLS for the long run relation among "x" and "y".

The existence of co-integration among two or more integrated variables can be analyzed with uniequational or multiequational approaches. The uniequational approach admits that the dependent variable is explained by one or more exogenous variables and the existence of only one stationary linear combination (one co-integration relation) (11). The multiequational approach allows the possibility of simultaneous influence among the different variables and the existence of multiple co-integration vectors linearly independent, therefore is less restrictive (21).

The most generic formulation of a multiequational equation is called VAR (Vector Autoregressive) and its specification is:

$$\underset{(nxl)}{z_t} = \underset{(nxn)}{A_1}\ \underset{(nx1)}{z_{t-1}} + \underset{(nxn)}{A_2}\ \underset{(nx1)}{z_{t-2}} + \ldots\ldots + \underset{(nxn)}{A_p}\ \underset{(nx1)}{z_{t-p}} + \underset{(nx1)}{CD_t} + \underset{(nx1)}{e_t}$$

where z_t represents the vector of "n" variables I(1), A_i is a matrix which contains the the associated parameters to each vector z_{t-1}, D_t represents the deterministic variables vector -constant, tendency, seasonal, impulse or shift binary variable- and C represents the vector coefficients associated to each deterministic components. The VAR models are equivalents to the equation systems in which each variable is function of the lagged phases of itself. The element e_t represents the residual component, that is, a random variable vector with a normal distribution (21).

The vector error correction model (VECM) is a transformation from the original formulation of the VAR. It allows to distinguish the long and short run relations. The VECM assumes the existence of a stable long run relation between the two variables of the zt vector, and for that, does exists equilibrium situations which address to converge in each moment; this formulation can be expressed as:

$$\Delta z_t = \prod z_{t-1} + \Gamma 1 \Delta z_{t-1} + \Gamma 1 \Delta z_{t-2} + \ldots. + \Gamma 1 \Delta z_{t-2} + CD_t + e_t$$

where Δz_t , represents the first differences vector of z_t, $\Gamma i = I + A_1 + A_2 + \ldots + A_i$, with i=1,2,...,p-1 and $\prod = -I + A_1 + A_2 + \ldots + A_p$. Accepting the existence of one co-integration vector for a efficient uniequational model estimation is necessary that almost "n-1" inherent variables with respect to the vector z_t be exogenous (23).

MATERIAL AND METHODS

Data sources

Three time series with monthly observations of real prices were created: Chilean wheat (DOM_CH), Argentinean PAN wheat (PAN_ARG) and USA Hard Red Winter wheat (HRW_USA), from December 1986 to December 2007, generating a total of 253 observations.

In addition to the price series, two binary variables were created to represent the impact of the price band established in 1977 and its change of regime in January 2004.

Since all variables were used in logarithmic form, the coefficients can be directly read as elasticity's.

All series were obtained from the price databases of ODEPA (2007). The data was analyzed using the econometric software Jmulti Version 4.22, available on www.jmulti.de, designed for univariate and multivariate time series analysis and with a Java graphical user interface that uses an external engine for statistical computations. The table 1 presents a description of the variables.

Table 1. Description of the variables used in this paper.
Tabla 1. Descripción de las variables utilizadas en este artículo.

Type	Variable description	Variable description	Measure unit
Real Prices	DOM_CH	Natural logarithm of the Chilean price of wheat	Price in USA dollars per ton
Real Prices	HRW_USA	Natural logarithm of the Hard Red Winter N. 2 wheat (FOB price)	Price in USA dollars per ton
Real Prices	PAN_ARG	Natural logarithm of the Argentinean PAN wheat (FOB price)	Price in USA dollars per ton
Binary Variable	D_BAND	Binary variable for the Chilean price band application	0 = without the application of specific rights or tariff reductions 1 = with the application of specific rights or tariff reductions
Binary Variable	D_MECH	Binary variable for the change in the price band mechanism	0 = January 1984 to December 2003 1 = January 2004 to December 2007

Source: prepared by the authors (2008).

Definition of the models

As explained above, the VECM is the appropriate modeling approach when series follows a I(1) process and are co-integrated into a trend system (15). Moreover, it is useful to estimate the long run relationship among the variables included in the model and its adjustments to the long term equilibrium.

Prior to the model estimation, the regular test and analysis for time series were performed as follows:

1. Augmented Dickey-Fuller Test (ADF) with the purpose of determine the non-stationary character and degree of integration of the series (9).
2. Lag order test (7).
3. Johansen test for co-integration to test the number of co integrating vectors in the system (7).

After estimating a VECM, the analyses performed to the results were the following:

1. Granger and Instant causality tests for determine whether one time series is useful in forecasting another (10).
2. Residual analysis for autocorrelation (LM test for autocorrelation), heteroskedasticity (VARCH-LM test) and normality (Jarque-Bera, 1980) in order to test possible shortcomings (10).

RESULTS

Analysis of the time series

We begin the analysis by examining the stationary properties of the variables using the Augmented Dickey-Fuller (ADF) Test (5). The optimal lag is chosen carefully by the Bayeasian of Akaike, Final Prediction Error, Hannan-Quinn and Schwarz Criterium. The results confirm that both variables in the model showed an unit root at all significant levels (table 2); therefore, are suitable for estimating a VECM.

Table 2. Results from the Augmented Dickey-Fuller test for each variable.
Tabla 2. Resultados de la prueba Dickey Fuller Aumentado para cada variable.

Variables	Augmented Dickey Fuller Test		Asymptotic Critical values	
	Test statistic	1%	5%	10%
DOM_CH	0.9434	(-) 2.56	(-) 1.94	(-) 1.62
HRW_USA	1.1174	(-) 2.56	(-) 1.94	(-) 1.62
PAN_ARG	0.789	(-) 2.56	(-) 1.94	(-) 1.62

Source: prepared by the authors (2008).

Since the variables are integrated of the same order (I(1)), the next step is to carry out a co-integration analyses of the variables (table 3). We first try to identify the long-run relationship between our measures and then its causal relationships by using the Johansen procedure (1988). In order to determine the optimal numbers of lags for the models were used the Bayesian of Akaike, Final Prediction Error, Hannan-Quinn and Schwarz Criterion.

Table 3. Johansen co-integration test results.
Tabla 3. Resultados del test de cointegración de Johansen.

Variables	Rank	LR	p-value		Critical	
Included		Statistic			Values	
				90%	95%	99%
DOM_CH, HRW_USA,	r=0	60.29	0.0001	38.85	41.76	47.66
PAN_ARG	r=1	20.34	0.1846	22.66	25.01	29.82
D_MECH	r=2	7.20	0.2951	10.4	12.15	16.24
DOM_CH, HRW_USA,	r=0	54.21	0.0001	32.25	25.07	40.78
PAN_ARG	r=1	15.35	0.1927	17.98	20.16	24.69
D_BAND	r=2	4.70	0.5210	7.60	9.14	12.53

Source: prepared by the authors (2008).

The results suggested for all series one degree of co-integration with a 10, 5 and 1% of confidence, which turn possible to apply the VECM. This statement means that if "n" markets were integrated would be one common factor of integration among these markets, which imply the existence of n-1 co-integration factors with respect to a reference market (8).

Model results

Two models were estimated in order to capture the impact of the price band and its change on the domestic prices. The first model, denominated A, includes the binary variable D_BAND that capture the periods where tariff reductions or rights were implemented; and the second model, denominated B, includes the binary variable D_MECH, which indicates the change in the price band mechanism with respect to the periods involved in this research (1984-2003 and 2004-2007) .

The VECM for both models were estimated using one lagged variable as suggested by the Akaike, Hannan Quinn and Schwarz Criteria. The equations are presented on the tables 4 and 5.

Table 4. Estimation results for the vector error correction model with the D_BAND variable.
Tabla 4. Ecuaciones del modelo de corrección de error com la variable D_BAND.

Variables	MODEL A					
	Equation		Equation		Equation	
	DOM_CH		HRW_USA		PAN_ARG	
	Estimate	t-value	Estimate	t-value	Estimate	t-value
ect model A	(-) 0.005	(-) 1.331	0.005	0.987	(-) 0.032	(-) 5.111
Ä DOM_CH $_{t-1}$	-	-	-	-	-	-
Ä HRW_USA$_{t-1}$	-	-	(-) 4.695	(-) 5.022	-	-
Ä PAN_ARG$_{t-1}$	-	-	-	-	4.415	5.735
D_BAND	0.004	0.017	0.004	0.017	0.004	0.017
D_MECH	-	-	-	-	-	-

Source: prepared by the authors (2008).

Table 5. Estimation results for the vector error correction model with the D_MECH variable.
Tabla 5. Ecuaciones del modelo de corrección de error com la variable D_MECH.

Variables	MODEL B					
	Equation		Equation		Equation	
	DOM_CH		HRW_USA		PAN_ARG	
	Estimate	t-value	Estimate	t-value	Estimate	t-value
ect model B	(-) 0.004	(-) 1.143	0.008	1.755	(-) 0.029	(-) 4.928
Ä DOM_CH $_{t-1}$	-	-	-	-	-	-
Ä HRW_USA$_{t-1}$	-	-	(-) 5.794	(-) 5.637	-	-
Ä PAN_ARG$_{t-1}$	-	-	-	-	4.847	6.152
D_BAND	-	-	-	-	-	-
D_MECH	0.696	2.252	0.696	2.252	0.696	2.252

Source: prepared by the authors (2008).

The next step was to execute the Granger causality test. The results are presented on the table 6 (p. 54).

Table 6. Results from the Granger causality test.
Tabla 6. Resultados de la prueba de causalidad de Granger.

Variables Included	Ho	Granger p-value	Instant p-value
DOM_CH, HRW_USA, PAN_ARG, D_BAND	DOM_CH do not cause HRW_USA, PAN_ARG	0.1993	0.0005
	HRW_USA do not cause DOM_CH, PAN_ARG	0.1553	0.0000
	PAN_ARG do not cause DOM_CH, HRW_USA	0.1064	0.0000
DOM_CH, HRW_USA, PAN_ARG, D_MECH	DOM_CH do not cause HRW_USA, PAN_ARG	0.1978	0.0005
	HRW_USA do not cause DOM_CH, PAN_ARG	0.0163	0.0000
	PAN_ARG do not cause DOM_CH, HRW_USA	0.1037	0.0000

Source: prepared by the authors (2008).

According to these results, variations in the Argentinean and USA prices Granger causes variation in the domestic prices, moreover, the domestic prices does not Granger causes variations on both international markets, results which were expected. Additionally, was detected a direct causality among USA prices with respect to the Argentinean and Chilean markets. These results were not the same for the case of the Argentina and the markets considered in this research.The last step of the analysis was check the residuals, which were tested for autocorrelation (LM test for autocorrelation), heteroskedasticity (VARCH-LM test) and normality (12), considering five lags (table 7). The null hypothesis were:

- Autocorrelation, *Ho = No autocorrelation*
- Heteroskedasticity, *Ho = No heteroskedasticity*
- Normality, *Ho = Normality*

Table 7. Residual analysis for both models.
Tabla 7. Análisis de los residuos para ambos modelos.

Variables included	Test	p-value
DOM_CH, HRW_USA, PAN_ARG, D_BAND	LM-type for autocorrelation	0.435
	VARCHLM	0.3124
	Jarque-Bera Test	0.000 (u1) 0.002 (u2) 0.000 (u3)
DOM_CH, WGHT_PRICE, D_BAND	LM-type for autocorrelation	0.3421
	VARCHLM	0.2954
	Jarque-Bera Test	0.000 (u1) 0.000 (u2) 0.000 (u3)

Source: prepared by the authors (2008).

The analysis for both models presented the rejection of normality for the residuals hypothesis. The heteroskedasticity and autocorrelation were not presented in both equations. From this point of view, both models were suitable with respect to the final purpose of the analysis (15).

DISCUSSION

The pattern of interdependence among the market locations are mainly related with the price transmission between these countries; in this sense, the ECT coefficients are useful for identify its relations. These coefficients for the Model A showed values of (-) 0.4695 and (+) 4.415, and can be read as the degree of integration among the markets, which means that in the long term the Argentinean and USA alterations will be transferred into the Chilean wheat market according to the speed adjust coefficients. Both values were highly significant with t-values of (-) 5.022, and (+) 5.735 respectively. These results showed strong statistical concordance with the previous analysis of another researches. The ECT coefficients for Model B were (-) 5.794 and (+) 4.847, both higher than the values of the Model A and highly significant.

It was possible to conclude from the result one, first that there is a high integration degree among the markets, regardless the price supporting mechanism applied, second, the higher coefficient in Model B could be explained by the change in the references markets of the new band mechanism and finally, that Chile can be seen as a price taker of the international markets considered in this research.

The theory would suggest that the speed of adjustment for the international price should have been not significant, implying that the international price does not adjust to the Chilean domestic price. Then, to explain these results we pointed out Balcombe *et al.* (2) conclusions that suggest that in cases of concentrated producers and monopsony or oligopsony failures, the price transmission effect could be indirect through a small country to larger producers countries which are geographically separated.

Moreover, the price support policies affects the market integration or not express this relation in linear terms; in this sense, the international prices under the baseline prices does not affect the internal prices, on the opposite, when the international prices are higher than the domestic this will be transferred totally on the internal market.

According to Acosta and Ortega (1) the price transmission elasticity on the long term for aggregate price series could be affected when the estimation of the protectionist measure does not includes the information about all the related markets, situation presented in the price band quantification procedure until December 2003. Moreover, Kilian and Ohanian (13) states that this situation can be absorbed or reduced with ECT coefficients closely to one, highly significant parameters and prices expressed on logarithm terms.

CONCLUSIONS

This work has posed the question of the spatial integration for the Chilean wheat market with respect to its most important wheat suppliers, the USA and Argentina, and the impact of the Chilean price band on the domestic market. The existence of one co-integration vector for the series allowed to conclude the existence of market integration among the USA, Argentina and Chile, in this sense, the Chilean market has been adjusted with respect to the USA and Argentinean markets holding the "Law of One Price". Second, the error correction term (ECM) for both models showed highly significant values, that is, shocks from the USA and Argentina are quickly and intensively transmitted to Chile producing direct and indirect price transmission effects.

The degree of integration was higher on the model with the new mechanism than in the model with the old mechanism, it was mainly due to the calculation procedure for the price band with respect to the reference markets and the impact of the price transmission on the elasticity for integrated markets when the protectionism measures does not includes all the information about its related markets. Additionally, from the results of this research, it was founded two factors to be considered for the improvement of price support policies and its implementation. First, among common factors for both models, can be identified as inaccuracy sources the increasing cost of the energy, the change at global level of the commodities supply and the changes on the emerging economies demand levels.

Also, in the short run, a factor as the weather and temporal restriction to export plays an important role in the markets adjustment results. Second, an increment in the spatial price transmission will be transferred totally on the domestic market if the tariff remains invariable, on the contrary, if the tariff are high or variables across the time, the accuracy of the model will be affected, these situations had been presented the last years by the modification of the Argentinean law 3478-98 with respect to its tariff applications for primary products and the FTA between Chile and USA in 2001. Moreover, the policy oriented to support prices frequently generates a gap from the domestic markets with respect to the international prices or transform its relation to non-linear.

From this point of view, it is very important to improve some aspects of the price support policies, as the definition of the calculation methods for the price band mechanism with relation to the utilization of forecast models for the over-rate tariffs determination by the government (reference prices) by taking in consideration the productive and policy elements described above.

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