Market integration and price leadership in selected sugar markets. The case of Colombia, Brazil and the world

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Abstract

M. Bugueiro, B. Brümmer, and J. Diaz. 2010. Market integration and price leadership in selected sugar markets. The case of Colombia, Brazil and the world. In the present empirical study we used the Johansen Maximum Likelihood procedure to evaluate spatial market integration for raw sugar among the Colombian, Brazilian and World markets. The Johansen (1988) cointegration approach allowed relating the three market sugar prices in a multivariate cointegrated vector error correction model. The law of one price and the general patters of influence were tested. To support the study monthly sugar price series for the three markets ranging from 1998 to 2007 were used. The overall empirical results revealed that the null hypothesis of perfect market integration cannot be rejected, which implies that raw sugar prices from the three markets move proportionally in the long-run following the law of one price. In addition, for the world sugar price the null hypothesis of weak exogeneity cannot be rejected, evidencing that the World sugar market has the price leadership, whereas the Brazilian and Colombian markets are price followers.

Key words: market integration, cointegration, law of one price, vector error correction models.

INTRODUCTION

The aim of the present work is to provide an econometric method to evaluate, in a broad perspective, spatial market integration for raw sugar among the Colombian, Brazilian and World markets by the examination of sugar price relationships. The econometric procedure consists in the application of three hierarchical hypothesis tests; the first is to test the presence of cointegration between the sugar price series, then the law of one price hypothesis which reveals whether perfect market integration prevails, is tested, and the last one is to determine whether a cointegrated price variable drives or lead the other prices in the possible common market.

The study of price relationships not only provides essential information about the degree of integration between markets, but rather also how they perform and how their dynamic structure is. The empirical work defines indicators that explain by statistical means about *"the extent and speed to which shocks are passed through, and the strength of the interdependence among prices"* (Sanjuan and Gil, 2001).

As pointed by Barrett (2001) it's important to not confuse the increment of trade with the concept of market integration. Specifically, in agricultural markets, the concept of market integration refers to the accomplishment of the "*Law of One Price*" hypothesis which states that commodity arbitrage activities ensure that prices in spatially separate markets tend to the uniformity. Thus, the study of market integration has a relevant importance for governments, policy makers and international organizations because allows to assess whether specific policies, bilateral and multilateral agreements enhance or increase the efficiency of interacting markets. A high degree of integration implies that prices are perfectly transmitted, and therefore, accurate resource allocation occurs avoiding this way distortions of production and marketing.

The paper is organized as follows. In the next section we described the theoretical econometric framework in which this study is based. Following this, the main empirical results are presented. This section consists of four stages; the first one corresponds to the presentation of the data, then the ADF test is used to obtain the order of integration and unit root. In the third step the Johansen's Trace Joint Test is used to test for cointegration. Lastly, once the VECM is specified, restrictions on the loading matrix α and the cointegration space β are applied in order to test LOP and weak exogeneity. Finally, the paper concludes with the discussion and conclusions section.

THEORETICAL FRAMEWORK

When two or more integrated time series, denoted $Y_t \sim I(d)$, share a common trend they have a long-run equilibrium relationship, in this situation we say they are cointegrated or statistically related. The economic theory defines forces which push the elements of Y_t towards to the equilibrium path whenever these economic variables wander separately. In such case, opportunities for international commodity arbitrage take place leading to an equalization of commodity prices (Keele and De Boef, 2004). The foundations behind the theory of cointegration follow the Engle and Granger (1987) definition. Two equally integrated stochastic processes of a vector Y_t are cointegrated, denoted $Y_t \sim CI(1)$ if their linear combination generates a stationary process $z_t \sim I(0)$. The univariate quantity z_t is defined as the equilibrium error and we say that the system is in equilibrium when z_t is equal to zero.

According with Hendry and Juselius (2001) "*cointegration analysis is inherently multivariate, as a single time series cannot be co-integrated*". Thereby, if k nonstationary prices series, $y_1, y_2, \cdots, y_k$, collected in a vector Y_t, are cointegrated with a cointegration rank r, the aim is to find out a statistical description of the linear relations between them. Vector error correction models (VECMs) allow to describe the DGP[1] in a multivariate setting and they also allow the analysis of the cointegration structure present in the system.

Lütkepohl and Krätzig (2004) defined the following multivariate error correction representation:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

From equation (1) the term ΔY_t is a $(kx1)$ vector of first-differenced endogenous variables, i.e. price series of each market and the vector ε_t holds k independent and normally distributed stochastic processes. So far, the term ΠY_{t-1} is nonstationary as each component, expressed in levels, of Y_t is integrated of order 1, therefore the equation is unbalanced as long as the matrix Π has a full rank, i.e. $r = k$. Due to the fact that the components of ΔY are first difference stationary processes, the equation (1) is balanced if and only if the term ΠY_{t-1}, which contains the cointegrating relations, is stationary. To achieve this condition, the rank of the matrix $\Pi_{(kxk)}$ have to be a reduced rank of $r < k$, then the following decomposition can exists:

$$\Pi_{(kxk)} = \alpha_{(kxr)} B'_{(rxk)} \qquad (2)$$

[1]Data generation process.

Let's consider a three-dimensional econometric system with a cointegration rank $rk(\Pi) = 2$, in such a case two linearly independent cointegration relations $I(0)$, given by $B'Y_{t-1}$, exist, therefore the multivariate system is balanced and stationary. Consequently, the cointegrated VECM where the cointegration space has been restricted for reduced rank can be expressed as:

$$\Delta Y_t = \alpha B' Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \varepsilon_t \qquad (3)$$

$$= \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \\ y_{3,t-1} \end{pmatrix} + \begin{pmatrix} \varphi_{11} & \varphi_{12} & \varphi_{13} \\ \varphi_{21} & \varphi_{22} & \varphi_{23} \\ \varphi_{31} & \varphi_{32} & \varphi_{33} \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \Delta y_{2,t-1} \\ \Delta y_{3,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{pmatrix} \qquad (4)$$

For simplicity we consider only one lagged first difference of the variables, or $p = 1$. Analyzing equation (4), variable changes from period $(t-1)$ to (t) are mainly induced for: a short-run effect represented by previous period changes of the j^{th} variable, with $j = 1, \cdots, k$, with impacts φ_{ij} in the i^{th} equation; an adjustment to a previous disequilibrium between the levels of the variables present in the cointegrating vector, with impacts α_{i1} and α_{i2}[2] respectively in the i^{th} equation; and a random shock represented by the vector ε_t.

As pointed out by Asche *et al*. (2004), two procedures exist in order to test market integration. The first is the two-step Engle-Granger[3] (1987) regression approach and second is the Johansen (1988) maximum likelihood procedure. The former, can only be applied if exists just one cointegrating relation (Kirchgässner and Wolters, 2007), due to its bivariate nature (Sanjuan and Gil, 2001). Additionally, Engle-Granger approach does not reveal information about the long-run component of the system, therefore is not possible to conduct hypothesis tests on the unknown parameters of the cointegration space.

In contrast, the Johansen (1988) ML approach possesses several advantages that make it the appropriate method to evaluate spatial market integration. It has the capacity of deal with models conformed by numerous endogenous variables allowing estimation and testing of multiple cointegrating vectors. Furthermore, the approach has the capability to conduct hypothesis tests on restricted versions of vectors and in the elements of the loading matrix α. Because the present study analyses three raw sugar markets and thus three raw sugar price series in a multivariate cointegration system, the appropriate econometric framework to be used is Johansen (1988) ML approach and VECMs to evaluate spatial market integration in a broad perspective.

Thus, the present econometric framework consists in the application of three hierarchical

[2] α_{i1} and α_{i2} are the components of the *loading matrix* α, each coefficient represents the rate of change towards the long-term equilibrium which is defined by the β's coefficients.

[3] The econometric approach consists on the estimate of the equation $y_t = \alpha + \beta x_t + u_t$ with $y_t, x_t \sim I(1)$, afterwards stationarity test using the ADF procedure is performed on $\Delta u_t = \gamma u_{t-1} + \sum_{i=1}^{p} \delta \Delta u_{t-i} + \varepsilon_t$ and test the null hypothesis $H_0: \gamma = 0$. If the residuals are $I(0)$ implies that x_t, y_t are co-integrated.

hypothesis tests; the first is the Johansen (1988) multivariate co-integration approach used to test the presence of multiple co-integration vectors in the system, allowing us to estimate the co-integrated vector error correction model. Afterwards, the law of one price hypothesis which reveals whether perfect market integration prevails, is tested imposing specific restrictions in the co-integration space β, which follow the form:

$$\beta' = \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \end{pmatrix} \qquad (5)$$

The last hypothesis is conducted in order to determine whether a cointegrated price variable drives or lead the other prices in the cointegration space. Weak exogeneity can be tested with a LR test procedure and consists on the application of restrictions in the α-coefficients of the loading matrix α.

RESULTS, EMPIRICAL ANALYSIS

The time series data used in the present analysis correspond to monthly raw sugar prices for the period from 1998 to 2007. All prices are measured in U.S. cents per pound and the nomenclature of the variables to be used is shown in the Table 1. Price series from the selected sugar markets -Colombia, Brazil, and the World- were obtained from different sources. In the case of Colombia the data correspond to raw FOB sugar price collected from the Trade Statistical Service[4] (SIEX) of the Colombian Customs Service. The data from Brazil, raw FOB sugar price, was obtained from the Foreign Trade Information System ALICE-Web[5] of the Foreign Trade Secretariat belonging to the Ministry of Development, Industry and Trade (MDIC). World raw sugar price correspond to the Contract No11- FOB stowed Caribbean port spot price and was collected from the Economic Research Service[6] (ERS) of the U.S Department of Agriculture (USDA).

The data plot representing the three markets is summarized in Figure 1 on a log scale. Monthly raw sugar prices of Colombia, Brazil, and the World are shown for the period 1998-2007 where the total number of realizations for each time series is 120.

The first step in the study of the spatial market integration is to establish individual stationary properties of each sugar market's price time series data defined as the logarithm of the levels of the variables. Further empirical analy-

[4]Available online: http://websiex.dian.gov.co - revised, 03/02/2009.

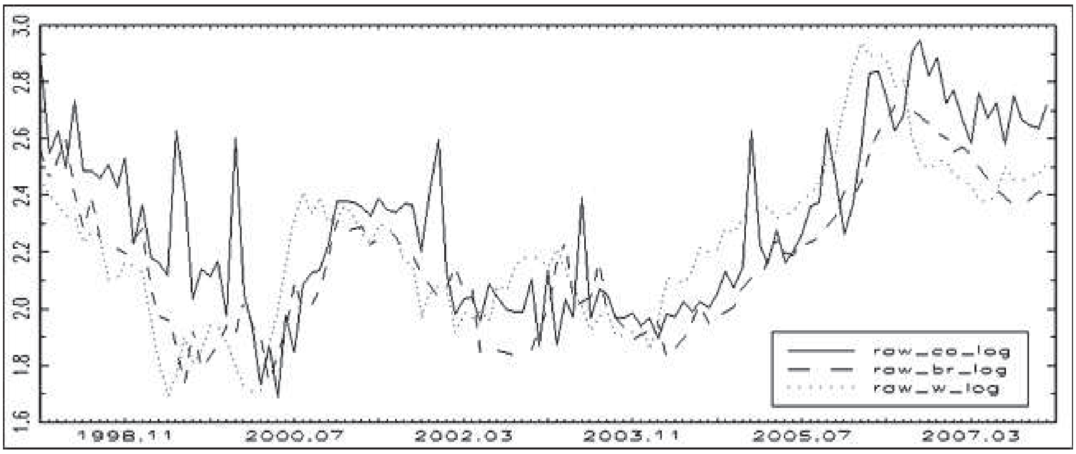
[5]Available online: http://aliceweb.desenvolvimento.gov.br - revised, 03/02/2009.

[6]Available online: http://www.ers.usda.gov/Briefing/Sugar/Data.htm - revised, 03/02/2009.

Table 1. Raw sugar price nomenclature for the selected markets.

Time series	Denotation	Units	Data span
Colombia raw sugar price	raw_co	US cents/pound	January 1998 - December 2007
Brazil raw sugar price	raw_br	US cents/pound	January 1998 - December 2007
World raw sugar price	raw_w	US cents/pound	January 1998 - December 2007

Note: the time series were transformed in log levels.



Source: *JMulTi4 software.*

Figure 1. Plot of time series 1998.01 – 2007.12. T=120.

sis, i.e. cointegration approach, requires that the economic variables must be nonstationary. To investigate the series' univariate properties the Augmented Dickey-Fuller unit root test is used. Moreover, the ADF test seeks to evidence that all variables are integrated of the same order, i.e. integrated of order one or $P_t \sim I(1)$ meaning that the first differences make them stationary.

The results of the ADF test in levels and first differences are summarized in the Table 2. For the variables in levels the null hypothesis of unit root cannot be rejected for each time series. Whereas, at the first differences the nonstationarity is strongly rejected at significance level of 5%, therefore, all time series in first differences are stationary with expected values around a zero mean and a bounded variance, the absence of trend prevails. Overall, we conclude that sugar price series are non-stationary and integrated of order one or $P_t \sim I(1)$ following thus a stochastic trend in levels. For that reason, we proceed with co-integration procedures based on the Johansen's (1988) co-integration approach.

Table 2. Stationarity test of raw sugar price series, augmented dickey-fuller test.

Variable	Deterministic terms	No. of lagged differences	Test statistic	Critical values	
				10%	**5%**
Levels					
raw_co	constant	7	-1.4690	-2.57	-2.86
raw_br	constant	0	-1.9987	-2.57	-2.86
raw_w	constant	1	-1.7510	-2.57	-2.86
First Differences					
raw_co	constant	6	-4.0355**	-2.57	-2.86
raw_br	constant	0	-11.6595**	-2.57	-2.86
raw_w	constant	0	-8.4079**	-2.57	-2.86

**indicates significance level at 5%. ADF test was performed using *JMulTi4 software.*

The *Johansen's Trace Joint Test* was conducted in order to examine whether a long-run cointegration relationship exists between the economic variables, and to reveal by statistical evidence if the selected sugar markets conform a common market. For the three-dimensional raw sugar system (raw_co, raw_br, raw_w), there is strong evidence for a cointegration rank of two ($r = 2$) at significant level of 5% (Table 3). Consequently, there are two cointegration vectors and one common stochastic trend which is modeled as random walk.

The cointegration results grant strong evidence of market integration or interdependence among the price series. In other words, raw sugar from the three suppliers –Colombia, Brazil and the World- compete in a same common sugar market implying that the commodities are substitutes in some extent. Thereby, the prices of the selected markets don't drift apart in the long-run, but rather they move in tandem along the time being part of a system of raw sugar prices. However, it is too soon to make conclusions about perfect market integration. Additional tests are necessary in order to establish perfect price equalization (law of one price) since spatial linkage can prevails at different price levels.

Table 3. Bivariate and multivariate cointegration tests; sample period: 1998 -2007.

Variables	Deterministic terms	No. of lagged differences	$H_0: r = r_0$	Test statistic[a]	Critical values	
					10%	5%
raw_co, raw_br	c	1	$r_0 = 0$	58.37**	17.98	20.16
			$r_0 = 1$	3.40	7.60	9.14
raw_co, raw_w	c	7	$r_0 = 0$	23.39**	17.98	20.16
			$r_0 = 1$	3.26	7.60	9.14
raw_br, raw_w	c	2	$r_0 = 0$	46.48**	17.98	20.16
			$r_0 = 1$	6.02	7.60	9.14
raw_co,raw_br, raw_w	c	2	$r_0 = 0$	92.38**	32.25	35.07
			$r_0 = 1$	37.47**	17.98	20.16
			$r_0 = 2$	6.34	7.60	9.14

**indicates significance at the 5% level. [a]Trace test. Source: $JMulTi_4$ software.

The next step within the econometric framework is to over-identifying restrictions in the reduced cointegration space and test whether the law of one price prevails; the test is distributed as χ^2 statistic and the restrictions on the cointegration space β follow the design defined in (5). The likelihood ratio statistic obtained is $\chi^2(2) = 0.94684[0.62286]$ (Table 4), therefore there is no reason to reject the null hypothesis of perfect price transmission among the sugar markets. Consequently, all the prices follow the law of one price, in other words, a single price prevails across the three selected markets evidencing that they are perfectly integrated.

Table 4. Likelihood ratio test results.

Hypothesis	$\chi^2 statistics$	$d.f$	p-value	Critical values	
				10%	5%
$H_1{:}\beta_{11} = \beta_{22} = 1; \beta_{21} = \beta_{32} = -1; \beta_{31} = \beta_{12} = 0$	0.94684	2	0.62286	4.605	5.991
$H_2{:}\alpha_{11} = \alpha_{12} = 0$	24.4999**	2	4.78545e-007	4.605	5.991
$H_3{:}\alpha_{21} = \alpha_{22} = 0$	48.2091**	2	3.40035e-012	4.605	5.991
$H_4{:}\alpha_{31} = \alpha_{32} = 0$	0.00704093	2	0.99648	4.605	5.991
$H_5{:}\beta_{11} = \beta_{22} = 1; \beta_{21} = \beta_{32} = -1; \beta_{31} = \beta_{12} = 0$; $\alpha_{31} = \alpha_{32} = 0$	1.07753	4	0.89782	7.779	9.488

**indicates significance at the 5% level. Own elaboration with *Gretl 1.8.0* software.

The next step is to determine whether the price of a single market drives the prices changes of the other markets. To achieve this, weak exogeneity tests are conducted by defining restrictions on the loading matrix α. The hypothesis tests' results are shown in Table 4, for the Colombian raw sugar price the null hypothesis of weak exogeneity is rejected at the 5% significance level where $\chi^2(2) = 24.4999[4.78545e-007]$, for the Brazilian price the statistic obtained was $\chi^2(2) = 48.2091[3.40035e-012]$, thus the null of weak exogeneity is rejected at the 5% significance level. For the world price the test is conclusive, with a likelihood ratio statistic of $\chi^2(2) = 0.00704093[0.99648]$ there is no reason to reject the null hypothesis. Consequently, the world price is considered weakly exogenous, thus the Colombian raw sugar price (raw_co) and the Brazilian price (raw_br) equilibrium adjust, or follow a common long-run path affected by the world raw sugar price (raw_w) which behaves independent in a nonstationary manner.

Having demonstrated by statistical means that a single price represents the three markets, and that the world is the dominant market meaning that its price is the leader and the other markets are prices followers, we proceed to specify the fully restricted vector error correction model which contains the identified LOP structure in cointegrating space B and the linear restrictions in the

$$\alpha B' P_{t-1} = \begin{bmatrix} -0.53 & -0.17 \\ 0.16 & -0.31 \\ 0.00 & 0.00 \end{bmatrix} \left[\begin{bmatrix} 1.00 & -1.00 & \cdots \\ \cdots & 1.00 & -1.00 \end{bmatrix} \begin{bmatrix} raw\_co_{t-1} \\ raw\_br_{t-1} \\ raw\_w_{t-1} \end{bmatrix} + \begin{bmatrix} -0.13 \\ 0.06 \end{bmatrix} [const.] \right] \quad (6)$$

Therefore, the long-run component of the equation (4) can be expressed by:

$$\begin{matrix} \Delta raw\_co \\ \Delta raw\_br \\ \Delta raw\_w \end{matrix} = \begin{matrix} -0.53ec_{1,t-1} & -0.17ec_{2,t-1} \\ 0.16ec_{1,t-1} & -0.31ec_{2,t-1} \\ \cdots & \cdots \end{matrix} \quad (7)$$

As can be seen in equation (6), there are two cointegrating vectors which contain the error correction mechanism of the variables. The first vector is the equilibrium error representing the long-run relation between the Colombian market and the Brazilian market, and the second one represents the long-run relation between the Brazilian market and the World market. The elements of the loading matrix, the speed of adjustment, and the direction of the granger causality are presented in equation (7). According with the results, the weakly exogenous variable raw_w, i.e. $\alpha_{11} = \alpha_{12} = 0$, Granger causes raw_co and raw_br in a unidirectional manner, therefore there are no feed-back effects onto the world market price from price changes in the Colombian and Brazilian market. In other words, the world is the primary source of information making that the other prices adjust to the imbalances.

In the case of Colombia (Δraw_co), raw_co presents a negative response to perturbations in all the cointegrating vectors, i.e. $\alpha_{11} = -0.53$ *and* $\alpha_{12} = -0.17$. The Colombian price adjusts quite quickly to restore an imbalance between its own price and the price of Brazil, thus if raw_co in $(t-1)$ is higher than the expected value from its long-run relationship with raw_br, the price will fall to a speed of adjustment of 0.53 meaning that approximately 53% of the deviation will be corrected the next month (t). In a similar way, the Colombian price also adjusts to imbalances between raw_br and raw_w, that is, when the Brazilian price is higher than its long-run equilibrium with the world price, raw_co will fall to a speed of 0.17 meaning that about 17% of the deviation is corrected the next month.

Results also show a significant response of the Brazilian price raw_br to movements in both, the Colombian price and the World price, i.e. $\alpha_{21} = 0.16$ *and* $\alpha_{22} = -0.31$. When raw_co in $(t-1)$ is high to its relative long-run relation with raw_br, the Brazilian price will change in a positive way rising at a speed of 0.16, that is, about 16% of the imbalance is corrected in the next month (t). In a similar way, raw_br adjusts to imbalances at a speed 0.31 when its price is higher than the expected value from its long-run relationship with raw_w, thus raw_br will fall 31% of the deviation in the next month (t).

DISCUSSION AND CONCLUSIONS

In the present empirical study we used the Johansen maximum likelihood procedure to evaluate spatial market integration for raw sugar among the Colombian, Brazilian and World markets. Restrictions to the model were applied in order to test law of one price and general patters of influence, the resultant fully-restricted vector error correction model permitted us to analyze markets performance in a broad perspective and also from an economic point of view.

The overall empirical results revealed that raw sugar prices from the three markets move proportionally in the long-run following the law of one price. In consequence, a single market exists as raw sugar buyers consider that the commodities homogeneous and perfect substitutes. International commodity arbitrage activities perform efficiently, ensuring that the prices are perfectly transmitted and tend to equalize when short-term deviations occur in the single market.

In addition, the world raw sugar price drives dynamic adjustments on the Brazilian price which at the same time influences changes on the Colombian price. The World sugar market has the price leadership, whereas the Brazilian and Colombian markets are price followers. Thereby, Brazil price adjusts more quickly to restore an imbalance than the Colombian price. Thus, the Brazilian raw sugar market is more integrated to the World market than the Colombian sugar market.

An especial analysis deserves the Colombian export market. The graphical inspection of the Colombian price series (Figure 1), shows that prices behave with several small volatilities along the studied period. This situation could be explained by the preferential markets and the sugar policy regimes which determine the quantity to be exported. The United States grants access to its sugar market at domestic prices through sugar import quotas, thus in order to maximize export revenues, the Colombian sugar millers prioritize this market as a destine for their exports and only the reaming amount of sugar goes to the world market at lower prices, thus the lower the quantity exported, the higher the average export price. The performance of the Colombian exports is determined by the sugar Price stabilization Fund (FEPA) which fix the amount of the total production that goes to supply the domestic market and in consequence the amount to international markets.

The world price is considered weakly exogenous, thus the Colombian price and the Brazilian price equilibrium adjust, or follow a common long-run path affected by the world raw sugar price. According with that, exports revenues are subject to the prevailing world sugar prices. Admittedly, export oriented developing countries have confronted depressed world market prices characterized by their volatility and levels below average production costs of the most sugar producers. This situation is mainly explained by domestic and trade policies instituted in developed countries with the aim to protect an uncompetitive sugar sector. Producers from these advanced economies supported by export subsidies have increased the quantity of sugar available in the world and in consequence have forced world prices down.

World sugar prices began to rise since 2003 reaching in 2006 a peak of US 19 cents per pound, among the main factors explaining such price levels feature the reforms applied by the EU-27 in their sugar policy regime with the objective of reduce the expenditures in sugar support, in consequence exports decreased drastically in 2007. This provides evidence that efforts to reform sugar policies towards trade liberalization will boost the increase of sugar prices at fair levels and at the same time will reduce the volatility, with direct effects on the export revenues and on the welfare of most sugar exporting countries. In such case, the world market will become more attractive for sugar exporters and preferential markets will be reduced, enhancing thus the degree of market integration among sugar markets.

RESUMEN

El presente estudio empírico provee una metodología econométrica basada en el procedimiento de máxima verosimilitud de Johansen (1988), para evaluar, en una perspectiva amplia, la integración espacial de mercados mediante el análisis de las series de precios FOB de azúcar crudo representando los mercados Colombiano, Brasileño y Mundial. El método de cointegración de Johansen (1988) permitió relacionar los tres precios de mercado en un modelo de vector de corrección de error multivariado. El marco teórico consistió en la aplicación, en forma jerárquica, de tres test de hipótesis; el primero determinó la presencia de cointegración entre las series de tiempo, luego fue testeada la hipótesis de la ley del precio único que revela si una integración perfecta de mercados existe y la última determinó si una variable de precio cointegrada determina o lidera los otros precios en un mercado común. Para apoyar el estudio se usaron series de precios mensuales para los tres mercados en el periodo 1998-2007. Los resultados empíricos revelaron que la hipótesis nula de una integración espacial perfecta de los mercados no puede ser rechazada, lo que implica que los precios de los tres mercados se mueven proporcionalmente en el largo plazo siguiendo la ley del precio único. Adicionalmente, para el precio mundial de azúcar crudo representando el mercado mundial, la hipótesis nula de causalidad de Granger no puede ser rechazada

$\chi^2(2) = 0.94684[0.62286]$, evidenciando que este mercado es líder en precio, mientras los mercados Colombiano y Brasileño son seguidores de precio.

Palabras clave: integración de mercado, cointegración, ley del precio único, modelo de Vector de Corrección de Error.

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