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VOLATILITY AND PRICE INTEGRATION IN COMMODITY MARKET

VOLATILIDADE E INTEGRAÇÃO DE PRECOS EM MERCADOS DE COMMODITIES

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ABSTRACT

The research studied the long-term equilibrium relationship between shrimp produced in Brazil versus the imported, which origins comes from the United States (USA). The motivation came from the fact that both countries maintained an intensive trade relation from 2001 to 2004. Thus, they shared simultaneously the same technologies, productive inputs and other raw materials. It was analyzed the relationship about the shrimp prices volatility from both countries as well tested its co-integration over a period. In order of modeling the volatility price, we considered a multivariate model to test its co-integration and, in addition of that, analyzed their mean through the Vector Auto-Regressive models (VAR) and Vector Error Correction Model (VECM) approach. Evidences pointed that fraction of long-term relationship between the shrimps' prices between Brazil and USA. Although, no co-integration was found, implying in no causal relationship in between them. This application shows a great relevance to the market agents, since demonstrates that the Brazilian inputs production requirement does not reflect on its prices over time.

Keywords: Marketplace, Equilibrium relationships, Causality, Price dynamics.

RESUMO

A pesquisa pretende verificar a existência de relacionamento de equilíbrio de longo prazo entre o camarão produzido no Brasil e importado, produzido pelos Estados Unidos. Tal motivação se deu pelo fato dos dois países terem mantido relações comerciais de 2001 a 2004. Neste período, eles compartilharam tecnologias, insumos produtivos e outras matérias-primas. Pretende-se investigar países a volatilidade dos preços do camarão desses dois países e testar se esses preços se cointegram em algum período de tempo. A volatilidade dos preços foi realizada através de modelagem multivariada para testes de cointegram e por meio do Vetor Auto-regressivo (VAR e VECM). Foram encontradas evidências que apontaram fracos indícios de relacionamento de longo prazo entre os preços dois países. Como não foi achada a cointegração, também não foi encontrada relação de causalidade entre os preços. Para os agentes de mercado esta informação é válida, pois demonstra que a dependência que o Brasil teve dos insumos produtivos não refletiu nos preços da sua commodity ao longo do tempo.

Palavras-chave: Mercado, Relações de equilíbrio, Causalidade, Dinâmica de preços.

1 INTRODUCTION

Among the producers dilemma two mainly risks is well thought-out, production risk, impacted by the effects relating the amount of production given the combinations of input factors used, and price risk, related with the income gain by the amount produced (JUST and POPE, 1978). Most studies about evaluation in aquaculture consider the production risk instead the price risk in order to discriminate and analysis the relevance of its performance.

In 2012, the world' shrimp production estimation was 7,681,661 tons, which 56% (4,328,000 tons) results from the aquaculture and 44% (3,353,661 tons) came from the wild catch (NMFS-NOAA). Between the period, 2006 and 2011, shrimp farming grew at a rate of 4.8%, and then jumped grew to 19% in 2013 and keep on its expansion (ANDERSON; VALDERRAMA, 2014).

The Brazilian shrimp farming supplies around 64% of the shrimp consumed. Play an important socioeconomic role, especially in the north and northeast regions where concentrates 99% of its production (Rocha, 2014, MPA, 2015). Continuing with the authors, the volume reached in 2003 the amount of 90,190 tons, achieving the position among the main world producers, where the first among the small and medium shrimp exporters to the United States. Followed by diseases problems causing changes and especially prices variation related to a production recovered reaching 65,000 tons in 2005. In the subsequent years, its production returned to growing, slowly, but resulting 74,116 tons in 2012.

The antidumping action imposed by the United States on Brazil, Thailand, China, Ecuador, India and other countries in 2003. The Brazilian exports summed up to zero in 2012, forcing the industry, in a first moment, to direct all its exports into the European market and to the domestic market (ROCHA, 2013). Some characteristics in the Brazilian domestic market should be discussed.

In 2005, the Brazilian local market consumed about 50,000 tons of shrimp, where 20,000 tons came from the aquaculture, ascending in 2014, double its consumption where leaded in around 100,000 tons (ROCHA, 2014; NMFS, 2015). Considering the whole period, were consumed in total from 532 to 568 million tons, an increase of 6.7% in this market. Now days, the domestic consumption is supported main by the national production, with the increasing of the “shrimp consumption culture” and a revision of the taxation of 7.05% inside Brazil, add up the anti-dumping action provoked the interest of some exporters from the North American Market.

The shrimp commercial relationship between Brazil and the United States is quite old, which began in the 1960s, when the Brazilian government stimulated the development of this industry by allowing international corporations exchanging the paying taxes into investment of this money in fishing (DORÉ, 1994). This action had a great success bringing investments and technologies to the fishing industry, boosting the production and cultivation of shrimp respectively. Over the years, the Brazilian shrimp production has grown in parallel with the increase of the exportations to the USA and Europe. This caused a great relation in the shrimp prices with the domestic market, therefore strongly influenced by international prices. Especially by the North American market, named as "communicating vessel effect".

Global demand has grown stimulating studies in order to understand and predict trends, in shrimp commodity market, and how certain factors affect its pricing. Those studies focus on exploring aspects such as: i) the use of indicators in the future shrimp market in the USA (MAYNARD, HANCOCK, HOAGLAND, 2001); ii) the market behavior along the supply chain considering the Asian tiger shrimp (LING et al., 1998); iii) effect of shrimp cultivated in Thailand and price formation in South America (BÉNÉ, CADREN, LANTZ, 2000); iv) volume effects on world shrimp prices and shrimp price flexibility (KEEFE and JOLY, 2001); v) stochastic trend between shrimp prices in the United States, the European Union and Japan markets, and whether the single price law is valid (VINUYA, 2007); vi) co-integration analysis of market integration in the US shrimp industry (ASCHE et al., 2012).

The US market has two sources of time series information on shrimp prices: the Urner Barry publication about future prices and the National Marine Fisheries Service (NMFS) that publishes about the imported volumes and values. From the Urner Barry weekly publication, we considered the stipulated prices by the main importers of shrimp from the United States. From the NMFS monthly reports, we collated the statistics by products, presentations, and sources.

Regarding the Brazilian market, the information collated has the information about the shrimp prices, hence large storage is on the government networks in Rio de Janeiro (CEASA) and São Paulo (CEAGESP), which provide monthly prices for shrimp groups.

The time series modeling adopted focused on price and risk prediction leading on determining the inherent volatility in the formulation of financial strategies applied to the fish commodity market. Through the study of shrimp price series, the manipulation using both univariate and multivariate models incorporated the statistical information obtained for the pricing forecast added by the analysis of causality or long-term equilibrium between the shrimp and other commodities. This study aimed to verify the existence of a long-term equilibrium relationship between Brazilian and American shrimp markets. It also sought to investigate the existence of causal relationship between commodity prices as well.

Commodity prices of the fish market and its risks (BRA and US)

The extractive fishery is not feasible in Brazil, although the country presents a great extension of coast; the same does not have a large quantity of fish on the sea, when compared with the international scenario. According to fisheries regulators, the catch is limited for wild species, and has already reached it capacity, because of the indiscriminate advance of predatory fishing (MENDES and VELOSO, 2012). Although, there is a great opportunity associated with the creation of fish in captivity (known as aquaculture).

Data provided by the Secretary of International Trade (SECEX) indicate the growth of imported fish, especially from China with a growth of 2656% in only 4 years (from 2007 to 2011), and Chile, whose market has grown about 30%, encouraged by the growth of the fish consumption culture. Resulting in 60% of the Brazilians' fish consume are imported from other countries.

Earlier decades three factors had a negative effect on low the Brazilians' fish culture consumption, with *domestic production reduced*, added by *high prices* grating in *lack of habit*. Thus, the biggest factor linked, to its development, is the accessibility in prices that have helped supplied the existed local demand, and supported its increase.

Brazilian aquaculture production is concentrated in four fish types: tilapia, carp, shrimp and tambaqui. Together, these four types of fish accounted 373.6 thousand tons or 78% of national aquaculture production in 2010 according to the Association of Fishing Industry from the São Paulo State (SIPESP). The northeastern region of Brazil concentrates the largest shrimp production as well as the largest exportation amount of fish in the country.

In 2001, it was estimated 507 shrimp farming in Brazil, making a total of 8,500 hectares of flooded area, which 97% are located in the Northeast region, hence responsible for 95% of the country's production. The cultivated shrimp average yield exceeds around 4 tons per hectares annually, summing up to 40,000 tons in 2001, therefore the results are extremely high if compared to the natural area that a species needs to reproduce (ABCC, 2002).

On the other hand, the United States (USA) is one of the highest shrimp consumption countries on the planet, with a high technology in the breeding and reproduction of the same, but almost 90% of its consumption is imported, being much of Asia. Thus, the greatest problem faced in this industry, the common farming methods are unsustainable and harm the environment, causing great amounts of waste especially during the feeding process.

Traditional Shrimps farming is associated with great limitations, the development process is attach with the combination of feed and chemicals added with pumping and aeration of water. During the development, growing process bases on a rich diet with high concentration of nutrients from fishmeal and fish oil extracted from fish caught in the wild. Studies show that the input of fish products is twice to four times greater than the volume of fish production in aquaculture.

Due the dependence on fish caught in the wild, traditional shrimp and salmon farms shrunk rather than fish stocks. Shrimps feed contains about 30% fishmeal and 3% fish oil, and intensive shrimp farming results in net loss of fish protein (NAYLOR et al., 1998). When shrimp yields decline, often the used lagoons are abandoned, in example of that the same authors pointed out the shrimp ponds lifespan in Asia rarely exceeds 5 to 10 years.

The conversion of an extremely degraded pond areas into other agricultural uses is often not economically feasible. Added by the rapid expansion of shrimp farms has caused socio-economic problems, such as the displacement of poor coastal communities, and degraded large coastal areas, including mangroves and other wetlands. These areas provide critical habitat for biodiversity, including marine fish and wild shrimp used to stockpile farms. With about 50 percent of the world's mangrove ecosystems already transformed or destroyed by humans, the incremental cost of mangrove conversion to shrimp ponds is high, creating a great concern.

Shrimp farming technology is a hotspot for the sustainable development of this type of business. Over $20 million has been spent in continuing research over the past 25 years in the US and overseas, working with the company Spirit Sustainable Resources International, with headquarters in Texas, US (McGRAW, 2016).

The dynamics pricing of Shrimp

Figures 01 and 02 show the behavior of the original prices of shrimp, from the Brazilian and USA market, in the time window over twelve years of quotations, from the period of 2000-2012. It is possible to visualize the strong price volatility, which indicates the non-stationary of the series. This instability in prices may have been caused by several factors, including increases and declines in production, price protection measures, and financial speculation of this asset in the physical market.

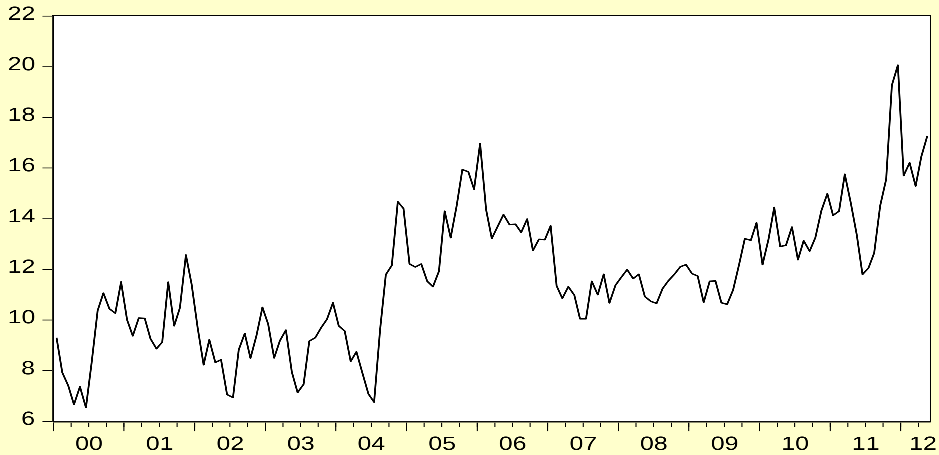

Figure 01. Original series of the Brazilian shrimp prices
Note: x = prices and y = year (Cartesian axis).

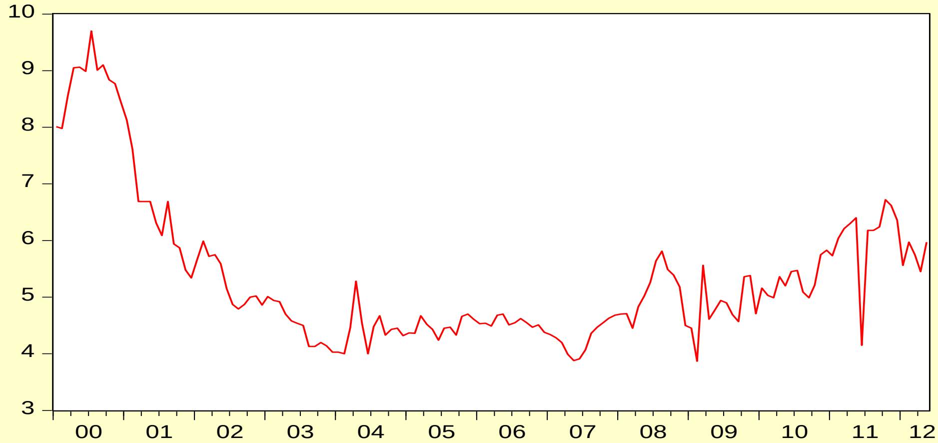

Figure 02. Original series of the US shrimp prices
Note: x = prices and y = year (Cartesian axis).

It is worth mentioning that the relationship between spot and future value in the commodities market is differentiated from other assets because of their primary purpose, ie consumption. This fact makes them part of the consumer goods asset class, which is subject to several shocks that can make complex the interaction relations between supply and demand, inventories, spot price and future. Next, a spectral analysis test was performed for a broader view of price dynamics from a frequency perspective.

Figures 03 and 04 show the spectral behavior of the frequency fluctuations associated to periods in the two price series (BRA and US). According to the Baxter and King (1995) filter, it was possible to isolate certain types of frequencies, for example, high frequency fluctuations associated with the measurement errors and low frequencies associated with the trend. These effects may interfere with the prediction and pricing of any financial asset.

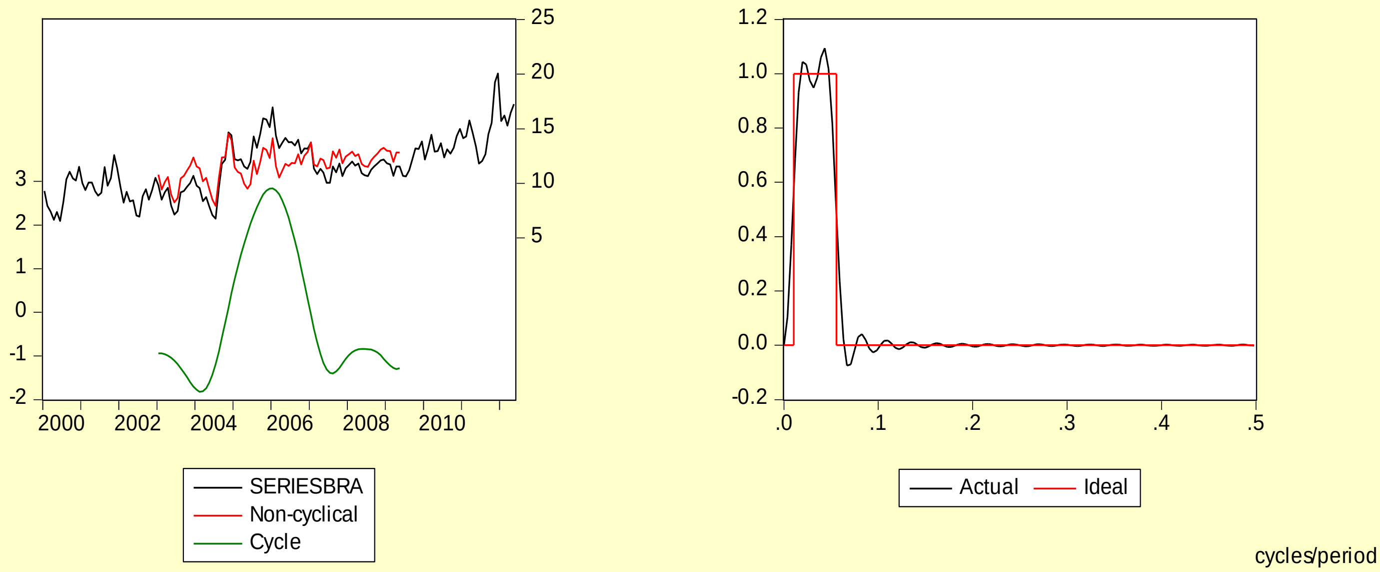

Figure 03. Spectral inspection frequency of Brazilian shrimp prices

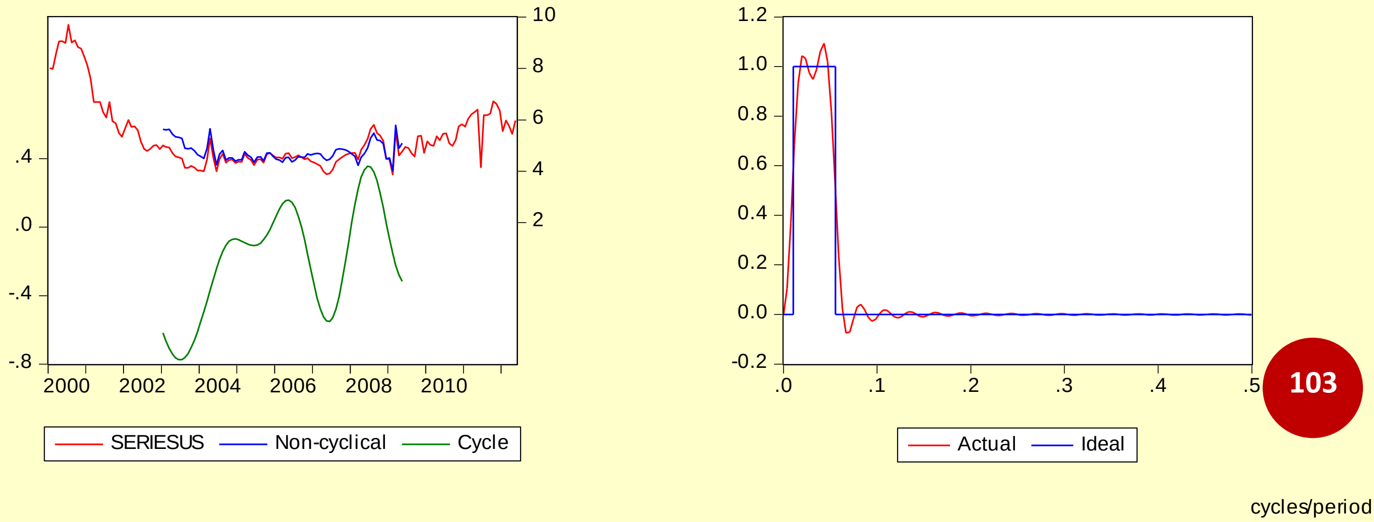

Figure 04. Spectral inspection frequency of US shrimp prices

As shown in the figures, the periods of highest frequency of shrimp prices were from 2002 to 2007 (BRA) and from 2003 to 2009 (US). This information helps in understanding the behavioral dynamics of the prices of these assets and may indicate temporal instability arising from some event outside of prices.

For a better accuracy of the inspection of shrimp prices, deflation of dollar series (to avoid problems of scale) and logarithmic transformation of shrimp price returns was done, $r_t = \frac{L_n P_t}{L_n P_{t-1}}$, as shown in Figure 05.

The graphs below show weak signs of heteroskedasticity and volatility groupings, which represent the no need to model the conditional variance of the price series. The Jarque-Bera (JB) normality test results for both series also confirm this evidence (JB-BRA: 3.64 and JB-US: 91.6).

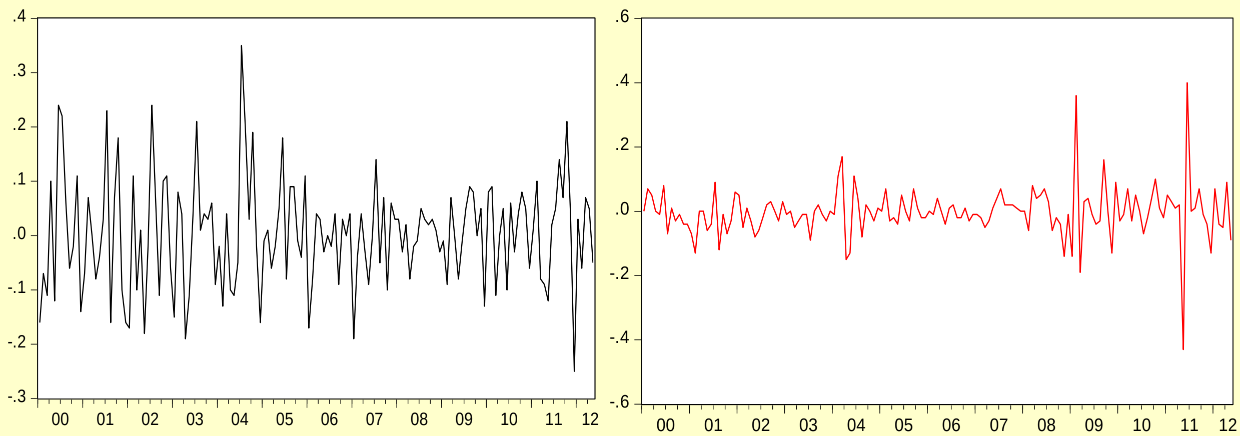

Figure 05. Behavior of dynamics of returns of shrimp (BRA x US)
Note: x = prices and y = year (Cartesian axis).

In order to verify the stationarity of the series the ADF test for the series was performed. The results that Table 01 demonstrates show that at a critical level of 5%, the Brazilian shrimp price series does not present a unit root, while the American shrimp presents, that is, it needs statistical differentiation to stabilize the variance.

Table 01. ADF test for shrimp series (BRA and US)

Shrimp BRA		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.910.854	0.0139
Test critical values:	5% level	-3.440.471	
Shrimp US		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.911.206	0.6437
Test critical values:	5% level	-3.440.471	

*MacKinnon (1996) one-sided p-values.

**H_0 Series has a unit root.

To guarantee that the variances of the two series were matched, the Levene (1960) and Brown and Forsythe (1974) tests of variance were performed. The tests in table 02 confirmed that the standard price variances are different. This information allows the understanding that the highest peaks of volatility are those of Brazilian prices (absolute significance). For market agents, this means that for greater expected profits in Brazil, investors should expect a higher price risk exchange, which is not the case with US prices.

Table 02. Test for equality of variance

Method	df	Value	Probability
F-test	(148, 148)	4.025128	0.0000
Siegel-Tukey		0.220504	0.8255
Bartlett	1	66.38326	0.0000
Levene	(1, 296)	53.29488	0.0000
Brown-Forsythe	(1, 296)	54.32706	0.0000

Category Statistics

Variable	Count	Std. Dev.	Mean Abs. Mean Diff.	Mean Abs. Median Diff.	Mean Tukey-Siegel Rank
SERIESUS	149	1.287483	0.953911	0.891007	148.3960
SERIESBRA	149	2.583041	2.032716	2.031074	150.6040
All	298	3.725393	1.493313	1.461040	149.5000

Bartlett weighted standard deviation: 2.040798

Econometric Approach

VECTOR AUTO-REGRESSIVE MODELS (VAR) AND VECTOR ERROR CORRECTION MODEL (VECM)

The co-integration test is a widely used and widespread procedure to analyze long-term relationships between variables. The basic requirement for performing the co-integration test is that the variables are stationary and integrated in the same order. In this way, it is necessary to perform unit root tests in the price series to define the order of integration between the variables (difference of type $x_t - x_{t-1}$, where x_t is the value of the variable *x* perceived at time *t* and x_{t-1} is the perceived value at time $t - 1$).

Engle e Granger (1987) defined that a series without a deterministic component, with ARMA (Autoregressive Moving Average) representation, stationary and invertible, after *d* differences, it is said to be integrated d, denoted by x_t ~ I(d). Therefore, the order of integration concerns the number of times a series needs to be differentiated to become stationary.

Johansen (1988) developed a model to test co-integration for systems composed of more than two series, integrated and of the same order. The Johansen method is a multivariate version of the Engle and Granger (1987) method for the verification of long-term equilibrium relationship for two variables and consists in the use of maximum likelihood estimators to investigate the presence and estimate of co-integration vectors.

This method can be demonstrated from the relationship between the rank of a matrix π and its characteristic roots according to equation (1):

$$X_t = A_1 X_{t-1} + \varepsilon_t \qquad (1)$$
$$\Delta X_t = (A_1 - I)\, X_{t-1} + \varepsilon_t$$
$$\Delta X_t = \pi\, X_{t-1} + \varepsilon_t$$

In the equation (*1*), X_{t-1} and ε_t are vectors (*n x 1*); A_1 is the parameters matrix *(n x n)*; π is defined by $(A_1 - 1)$ and *I* is the identity matrix *(n x n)*.

The number of cointegration vectors is equal to the rank π. If π = 0, as a linear combination of $\{X_u\}$ to be non-stationary, thereby, the variables will not be co-integrated. From the roots of π, it can be verified its significance, since the numbers of co-integration vectors can be known.

For predictions and cointegration studies, several models are used, but for Wooldridge (2010), it makes more sense to make predictions using a model that depends only on lagged values of y and z, as this will save an extra step of having to predict variable on the right side of the equation before the prediction of y. For such reasoning, the author presents the VAR as:

$$y_t = \delta_0 + \alpha_1 y_{t-1} + \gamma_1 z_{t-1} + u_t \quad (2)$$
$$\mathrm{E}(u_t|I_{t-1}) = 0$$

where I_{t-1} contains *y* and *z* given the moment *t-1 and* its passed moments. Therefore, the prediction of y_{t+1} of the moment *t* is specified as $\delta_0 + \alpha_1 y_{t-1} + \gamma_1 z_{t-1}$, but if the parameters are known, can use the values of y_t and z_t. Naturally, in model (2), more lags of y or z and other lags of other variables can be added, especially in the case of forecasting one-step ahead.

The cointegration resulting from the long-term stability between the series can generate an Error Correction Mechanism (ECM) of random short-term deviations that must be considered in the model. The new model to be estimated is a VAR model with Error Correction or simply VEC. The need to use the Error Correction Vector (VEC) is determined by the presence of long-term relationships between the variables of the econometric model to be created, through cointegration analysis (JOHANSEN, 1988).

As demonstrated by Wooldridge (2010), the VEC model can be written in the form:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + \gamma_0 \Delta x_t + \gamma_1 \Delta x_{t-1} + u_t \quad (3)$$

where u_t has zero mean, given as Δx_t, Δy_{t-1}, Δx_{t-1} and additional lags.

Finally, the application of a VAR or VEC model empirically analyzes the participation of each of the variables in the understanding of the changes occurred in the others. The variance decomposition analysis or the analysis of variable response in relation to the occurrence of a given shock or its innovation affecting others components, can also be analyzed by its impulse response functions (BROOKS, 2004; LUTKEPOHL, 1993; SIMS, 1980).

Granger (1969) developed a test, presented as the Granger' Causality in the literature, which assumes that future values can not cause the present or the past, thus:

If the event α happens after β, it is known that α can not cause β. At the same time, if α manifests before β, this does not imply that α essentially causes or provokes β. In practice, one has that α precedes β, β precedes α or α and β occur at the same time. According to Maddala (1992), this is the meaning of Granger's endogeneity.

According to Gujarati (2000) for two time series X_t and Y_t^2, Granger's causality test admits that the relevant information for the prediction of the respective variables X and Y is contained only in the time series on these two variables. Thus, a stationary time series X causes, in Granger's sense, another stationary series Y if the more statistically significant predictions of Y can be obtained by including lagged values of X to the lagged values of Y. Formally, the test involves estimating The following regressions:

$$X_t = \sum a_i Y_{t-i} + \sum b_i X_{t-i} + u_{1t} \quad (4)$$
$$Y_t = \sum c_i Y_{t-i} + \sum d_i X_{t-i} + u_{2t} \quad (5)$$

Considering u_{1t} and u_{2t} being uncorrelated residues.

MATERIALS AND METHODS

This research presents as an exploratory-descriptive research of applied nature with quantitative approach. The price series were extracted from the database of CEAGESP, (Company of Warehouses and Warehouses General of São Paulo).

The series analyzed represent average shrimp prices, ranging from 9g-11g, of the *Litopenaeus Vannamei* type, to be the liquid asset from the point of view of the commercialization of Brazilian fish. The data correspond to the average monthly marketing prices provided by the Company of Warehouses and General Warehouses of São Paulo (CEAGESP) and the prices of US-imported shrimp collected in the National Marine Fisheries Service (NMFS-NOAA) database, on the horizon From January 2000 to May 2012.

The methodological and statistical procedure was the application of the Cointegration tests (VAR and VECM) and Granger' causality, to verify the long-term equilibrium relationships between the series Brazilian and American shrimp prices (both deflated in dollars).

MULTIVARIATE MODELLING (STATISTICAL RELATIONSHIP WITH INTERNATIONAL PRICE)

Table 3 presents the results of the Granger causality test, where the statistical significance indicated that there is no causality between Brazilian and US shrimp. Traders and shrimp producers to formulate their prices, competitive strategies and negotiate with suppliers of productive inputs can use this information.

Table 03. Granger' causality between the price of BRA shrimp (dy) and the American US (dz)

Test-F	0
df1	1
df2	266
p-value	0,9979
Chi-squared	0,9396
Df	1
p-value	0,3324

Note: H_0* there is not causality between (dy and dz) the series analyzed

Thereby, the possibility of cointegrating the Brazilian price with the American price was analyzed, and no evidence of cointegrated vectors was found. Statistical analysis of residues was performed using unit root tests containing modified critical values (Mackinnon, 1991) using the Phillips-Ouliaris and Johansen procedures, presented on the tables 04 and 05.

For shrimp trade, this information is relevant because if there were long-term dependence between national and international fish markets, any positive or negative oscillations in international prices would be passed on to national prices, which could weaken the market due to High marketing prices and the sale of productive inputs.

Table 04. Phillips-Ouliaris Test

Response y3:					Response z:				
Coefficients:					Coefficients:				
	Estimate Std.	Error	t value	Pr(>|t|)		Estimate Std.	Error	t value	Pr(>|t|)
(Intercept)	0.4605	0.20099	2.291	0.0234 *	(Intercept)	0.1962	0.1319	1.487	0.139

zry3	0.8713	0.04019	21.680	< 2e-16 ***	zry3	0.0183	0.0264	0.692	0.490
zrz	0.0453	0.03795	1.193	0.2347	zrz	0.9406	0.0249	37.761	< 2e-16 ***
Adjusted R-squared: 0,8461					Adjusted R-squared: 0,941				
F-statistic: 405					F-statistic: 1174				
p-value: 0,0000					p-value: 0,0000				

Note: '***' = 0, '**' = 0.001, '*' = 0.01, '.' = 0.05, ' ' = 0.1, 1 (y3 = BRA and z = US)

Table 05. Results of Phillips-Ouliaris procedures for the unit root test

Coefficients:				
	Estimate Std.	Error	t value	Pr(>|t|)
(Intercept)	2.50192	0.35730	7.002	8.35e-11***
z[, -1]	0.58079	0.06142	9.456	< 2e-16 ***
Adjusted R-squared: 0,374				
F-statistic: 89,42				
p-value:0,0000				

Note: '***' = 0, '**' = 0.001, '*' = 0.01, '.' = 0.05, ' ' = 0.1, 1

Table 06. Results of procedures Johansen

Values of statistical tests and critical values of tests				
	test	10%	5%	1%
r <= 1	6.81	10.49	12.25	16.26
r = 0	18.96	22.76	25.32	30.45
Eigenvectors normalised: (Cointegration relations)				
	y3.l2	z.l2	trend.l2	
y3.l2	1.00000000	1.00000000	1.0000000	
z.l2	-0.84491727	-4.04751390	3.2499664	
trend.l2	-0.02292897	0.01300728	0.1989435	

The strongest evidence is the lack of cointegration, results confirmed in tables 04, 05 and 06, between the series under study. Then, a VAR analysis was performed (in first differences including seasonal dummies) instead of VECM. However, for information, and given that the expected direction for the forecasting effect is to use the international price as a predictor of the national it was estimated a model of univariate error correction resulting in the equation:

$$\Delta y_t = \underset{(0,05)}{-0{,}02} - \underset{(0,04)}{0{,}12\hat{u}_{t-1}} - \underset{(0,08)}{0{,}11\Delta y_{t-1}} + \underset{(0,13)}{0{,}15\Delta x_{t-1}}$$

where, y is the national price, x is the international and û is the regression residue from y over x. The lagged error coefficient is significant at 5% and negative (expected signal), but the effect of Δx in the forecast of Δy is insignificant unless its effect on û, according to the Table 07.

Table 07. Tests to determine Cointegration

	obs	10%	
ADF (TL)	-3,12	-3,5	
ADF	-2,44	-3,04	
Pu	37,27	27,85	(rejects H_0: nível de 5%)
Pz	31,62	47,58	
Johansen (trace)	6,6	6,5	(rejects H_0: nível de 10%)
Johansen (TL)	6,81	10,49	

Note: H_0 - there is not cointegration
TL - inclusion of the term linear trend

In general, to summarize the VAR modeling, the analysis of the impulse-response function is used. The results of the estimated equations already indicate that there will be no effect of unanticipated shocks (in any sense) and, in fact, the graph of the impulse response function of the national price in the face of a possible impact of the international price has no significant effect, on the Figure 06.

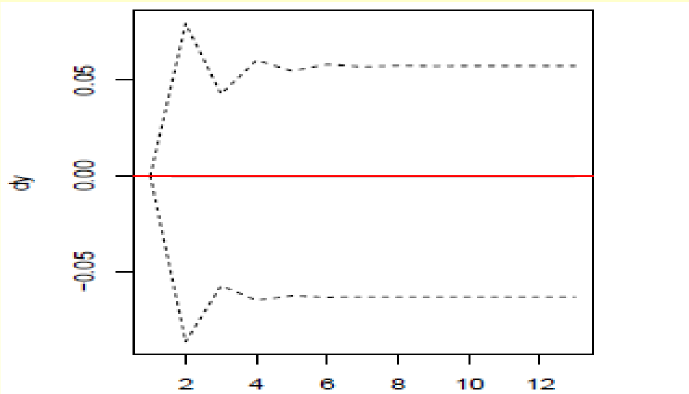

Figure 06. Function Impulse Response (FIR) de y on an unexpected shock at x

Figure 7 illustrates the dynamics of Brazilian shrimp and shrimp prices, both deflated in dollars, where it was possible, through a visual inspection in the impulse response function, to realize that the behavior of the series does not converge over the years.

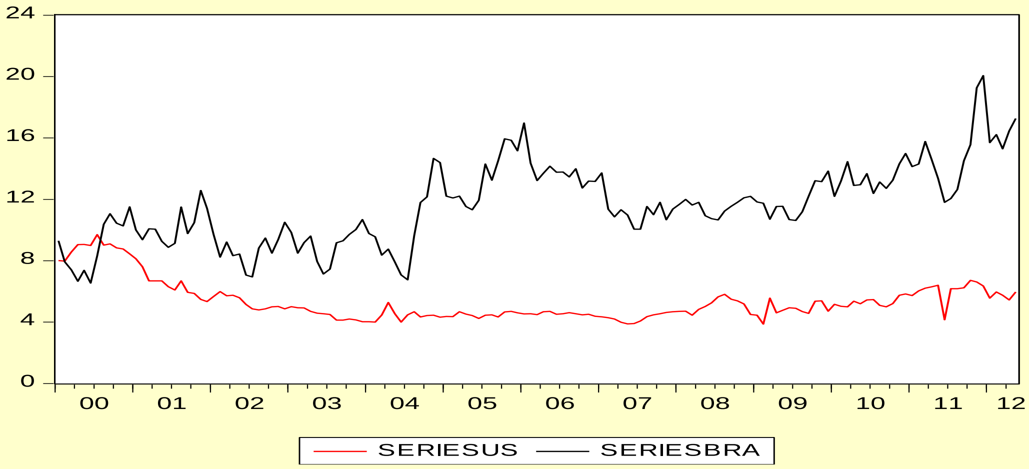

Figure 07. Brazilian price and US

The tests presented in tables 04, 05, 06 and 07 show no strong evidence of cointegration between Brazilian and American shrimp prices, probably there will be no causal relationship between them. In a last verification, the estimates of the equations dy (BRA) and dz (US), presented in the Tables 08 and 09, were made, in which even with the inclusion of dummy variables in the equations of autoregressive vectors there was no improvement in the adjustment Statistic and no significance gains for: dy e dz.

Table 08. Estimation of the VAR results for the equations dy

Log Likelihood: -190.83

dy = dy.l1 + dz.l1 + const + sd1 + sd2 + sd3 + sd4 + sd5 + sd6 + sd7 + sd8 + sd9 +sd10 + sd11

	Estimate Std.	Error	t value	Pr(>|t|)
dy.l1	-0.1057127	0.0856049	-1.235	0.21905
dz.l1	-0.0003325	0.1280197	-0.003	0.99793
const	-0.0168463	0.0496952	-0.339	0.73515

sd1	0.1663869	0.2529299	0.658	0.51178
sd2	0.3860961	0.2452286	1.574	0.11776
sd3	0.4346951	0.2436438	1.784	0.07668 .
sd4	0.2145777	0.2429151	0.883	0.37864
sd5	0.1554164	0.2484306	0.626	0.53265
sd6	0.5808641	0.2484327	2.338	0.02087 *
sd7	1.0334883	0.2523957	4.095	0.000073 ***
sd8	0.5510598	0.2472810	2.228	0.02753 *
sd9	0.5926890	0.2453882	2.415	0.01708 *
sd10	0.7270876	0.2487673	2.923	0.00408 **
sd11	0.6946224	0.2461459	2.822	0.00551 **

Note: Residual standard error: 0.5996 on 133 degrees of freedom, Adjusted R-squared: 0.1117, F-statistic: 2.412 and p-value: 0.005967

Table 09. Estimation of the VAR results for the equations dz

Log Likelihood: -190.83

dz = dy.l1 + dz.l1 + const + sd1 + sd2 + sd3 + sd4 + sd5 + sd6 + sd7 + sd8 + sd9 + sd10 + sd11

	Estimate Std.	Error	t value	Pr(>|t|)
dy.l1	0.01628	0.05662	0.288	0.77415
dz.l1	-0.25625	0.08468	-3.026	0.00297 **
const	-0.03837	0.03287	-1.167	0.24514
sd1	0.04275	0.16729	0.256	0.79870
sd2	0.16010	0.16220	0.987	0.32542
sd3	0.15530	0.16115	0.964	0.33696
sd4	0.05756	0.16067	0.358	0.72074
sd5	-0.21618	0.16432	-1.316	0.19057
sd6	0.30481	0.16432	1.855	0.06581 .
sd7	0.12994	0.16694	0.778	0.43773
sd8	-0.06087	0.16356	-0.372	0.71036
sd9	0.20152	0.16231	1.242	0.21656
sd10	0.13556	0.16454	0.824	0.41150
sd11	-0.10376	0.16281	-0.637	0.52502

Note: Residual standard error: 0.5996 on 133 degrees of freedom, Adjusted R-squared: 0.1117, F-statistic: 2.412 and p-value: 0.005967

Even though the cointegration and causality analysis were not statistically significant, we took differences in the VAR equations of dy and dz. According to the criteria on the Table 10, it shows once again that we do not perceive long-run equilibrium relationships between the series and much less causal relation between them, which can also be confirmed as well in the Figure 08.

Table 10. VAR results for the differences of the equation dz and dy

	1	2	3
AIC(n)	-2.7336797	-2.74049817	-2.69895121
HQ(n)	-2.6836295	-2.65708109	-2.58216730
SC(n)	-2.6105046	-2.53520618	-2.41154244
FPE(n)	0.0649805	0.06454172	0.06728614

Note: Selection criteria.

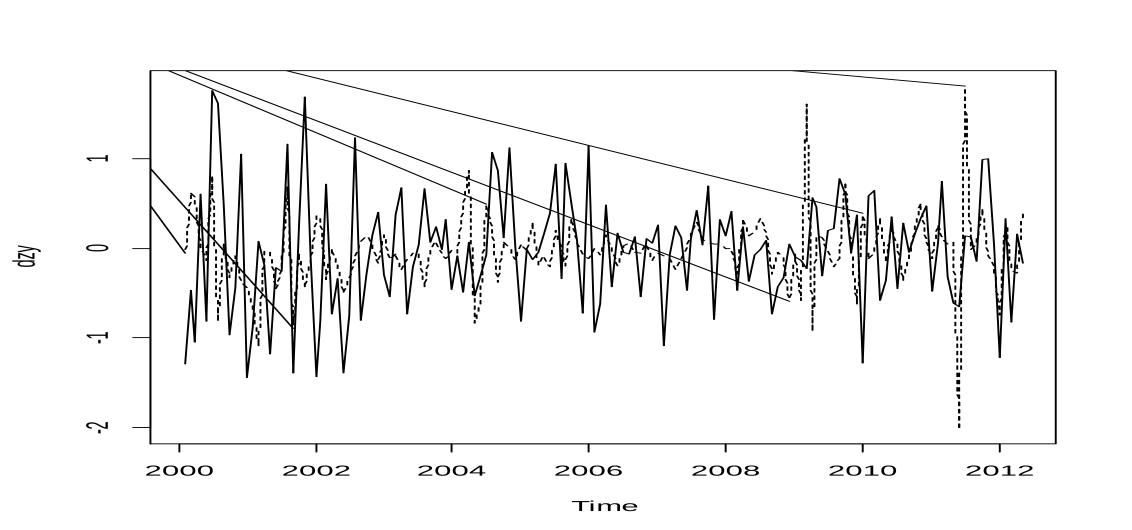

Figure 08. VAR in differences

Finally, we attempted to implement a VAR with univariate ECM or VECM in the Brazilian and American shrimp price series. The initial results, such as presented previously, was not found statistical significance and not a fit VECM model to analysis the series, as presented on table 11.

Table 11. Application of VECM model in price series

Coefficients:	Estimate Std.	Error	t value	Pr(>|t|)
(Intercept)	-0.01551	0.05153	-0.301	0.76392
u.lagged	-0.12108	0.04172	-2.902	0.00429 **
dy31	-0.10664	0.08329	-1.280	0.20248
dz1	0.14529	0.12527	1.160	0.24805

Note: Residual standard error: 0.6225 on 143 degrees of freedom, Adjusted R-squared: 0.0425, F-statistic: 3.16 and p-value: 0.0266

IMPLICATIONS OF THE FINDINGS FOR THE MARKET

Through the results pointed out by the present research, the marketing agents of the shrimp commodity can visualize statistical aspects for a more efficient investment management from the point of view of risk.

It is speculated that, among other factors, after the US government accused Brazilian commerce of selling its products, merchandise and services from Aquaculture/Carcinicultura. In additional of that at prices below their fair value to other countries, prices of shrimp marketed suffered a great reduction, approximately 30%, from 2005 to 2009. With this measure, several market players lost large sums invested in the production, distribution and commercialization of fish.

Added by the fact at the large amount of incident rains and low flows during the dry periods contributed even more to the poor performance of the asset during these four years under discussion. The risk of investing in the shrimp commodity also appears to depend on the producers in relation to the inputs, such as feed and imported drugs, mainly from the United States, Spain and China, that is, even if Brazil has practically no Shrimp export with these countries, there is a productive dependence on inputs.

To minimize the risk and the investment losses in the aquaculture, it is necessary to know the peculiarities of this activity, the productive techniques, the external influences and the economic factors that influence it.

Besides this information, the research also pointed out that the variations in the price of national shrimp are not transmitted to the price of international shrimp and vice versa. Conclusions are, the prices of the two countries (Brazil and USA) are neither cointegrated nor presented relations of Equilibrium in the long term, information that allows the agent greater financial security, since as Brazil consumes all the shrimp production, the risk of interferences of cointegrated external prices to the Brazilian practically nonexistent.

FINAL CONSIDERATIONS

This research aimed to analyze the dynamics of volatility structure in shrimp prices in the Brazilian fish market. For this, multivariate statistical modeling was performed, which presented important results on long - term equilibrium relationship (Brazilian and American imported shrimp) and cause and effect relationship between these price series.

It was verified whether or not there was a long-term relationship between the imported Brazilian and American shrimp prices. The results indicated that there is a weak (almost null) evidence of cointegration between these series, since even though the two countries had been commercially related until 2004, their prices did not coincide. As the long-term relationship between the series was not verified, no cause and effect relationship between the series was also detected.

Future work we suggest to consider on the studies the integration risk, regional causality, price orthogonality, risk valuation and other issues related to the productive aspects of the shrimp, lobster and tilapia market (other assets in contrast to the fish market). Through univariate and multivariate statistical modeling, since there is little research addressing these issues in the financial literature and these commodities present significant economic representativeness in the countries studied.

Based on the information discussed here, it is expected that shrimp traders may have more strategic tools to achieve higher returns for their investments in the fish market (DOS SANTOS FELIPE; MÓL; ALMEIDA, 2013; DOS SANTOS FELIPE; MÓL; DE ANDRADE, 2015). Therefore, this market will continue to foster the economy, generating employment and income in the countries analyzed.

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