International Temperate Rice Conference

7 ITRC

SCIENCE & INNOVATION

FEEDING A WORLD OF 10 BILLION PEOPLE

FEBRUARY 09-12 . 2020

PELOTAS . BRAZIL

PROCEEDINGS

ISBN 978-65-00-00331-4

Is Brazilian rice immune to shocks?

W.A Silva Neto[1] and Wander, A. E[2]
[1] Postgraduate Program in Economics – PPGECON/UFG, Goiânia-GO, Brazil, netoalcan@ufg.br
[2] Embrapa Rice and Beans, Santo Antônio de Goiás-GO, Brazil, alcido.wander@embrapa.br

ABSTRACT
This paper aimed to analyze the behavior of the Brazilian rice market in the face of exogenous shocks. Therefore, time series of exports, imports and prices received by farmers in Brazil from January 1997 to October 2019 were used to estimate the fractional differentiation parameter Gaussian Semiparametric Estimator (GSE), based on the frequency domain Whittle Function. Brazilian rice market is persistent to external shocks, with the presence of long memory in exports, imports and prices received by farmers.

Key words: Rice market, rice exports, rice imports, rice prices, long memory.

1. Introduction

Brazil is among the largest producers and consumers of rice worldwide. In addition, it has a large consumer market and rice is an essential and widely consumed staple food among Brazilian families. Average per capita consumption of the Brazilians is approximately 36 kg per year. Per capita consumption varies regionally and has declined over time in Brazil (Wander and Chaves, 2011).

Given this, the objective of this paper is to analyze the behavior of the Brazilian rice market in the face of exogenous shocks. In other words: is this market susceptible to shocks coming from the international or national market? Is it a mature or still consolidating market? Specifically, it seeks to test the presence of long memory in the series, to verify the existence of structural break in the data and to identify if there is heterogeneity in the behavior of the import, export and producer price series.

The contribution of this paper is based on two pillars: i) the applied methodology (fractional integration analysis: long memory test or shock persistence) has become an alternative method for understanding time series and has not been used in time series of export, import and producer prices of rice; and ii) the contribution to the understanding of the Brazilian rice market dynamics.

2. Material and Methods

2.1 Method

To achieve the objectives proposed by the present paper, each of the rice export, import and price series is denoted by y_t and its behavior will be described using the following model:

$$y_t = \beta^T Z_t + x_t, \qquad t = 1, 2, \ldots \qquad (1)$$

where β is a vector of unknown coefficients $(k\,x\,1)$, Z_t is a set of deterministic terms that may include an intercept ($Z_t = 1$), an intercept with a linear time trend ($Z_t = (1, t)^T$), or any other kind of deterministic processes and x_t are the regression errors.

According to Barros et al. (2012), the time series x_t ($t = 1, 2, \ldots$) is fractionally integrated in order *d* and follows a model $I(d)$ represented by:

$$(1-L)^d x_t = u_t, \qquad t = 1, 2, \ldots \qquad (2)$$

where $(1-L)^d$ is the fractional difference operator, L is the lag operator (i.e., $Lx_t = x_{t-1}$), d is the process integration order and can be any real number and u_t is a stationary process $I(0)$, with zero mean and spectrum $f_u(\lambda)$.

The polynomial $(1-L)^d$ on the left side of Equation (2) can be expressed in terms of binomial expansion for any real number d:

$$(1-L)^d=\sum_{j=0}^{\infty}\psi_j L^j=\sum_{j=0}^{\infty}\binom{d}{j}(-1)^j L^j=1-dL+\frac{d(d-1)}{2}L^2-\ldots, \text{ i.e.,}$$
$$(1-L)^d x_t=x_t-d\,x_{t-1}+\frac{d(d-1)}{2}x_{t-2}-\ldots$$

Barros et al. (2011, 2016) point out that parameter d, represented by equation (2), plays a crucial role in data analysis, because it is an indicator of the degree of dependence of the series. The higher the value of d, the greater the level of association between observations that are increasingly distant in time.

In the case of $d=0$ in (2), the stochastic process x_t has a stationary covariance. If the fractional parameter assumes a value of $d=1$, x_t is a non-stationary process with a unit root, that is, the model contains a stochastic tendency. Thus, fractional integration arises when d assumes positive rather than integer values, $0<d<1$. If the value of d is restricted to the range $0<d<0{,}5$, x_t is mean reversal and remains a steady-state covariance process, but with the decay of the autocovariance function slower than in the steady-state case, $I(0)$. If $0{,}5\leq d<1$, x_t is non-stationary but reversed to mean and its self-covariance function exhibits greater persistence (Apergis and Tsoumas, 2011, 2012). However, if $d\geq 1$, x_t is non-stationary and not mean-reversed (Gil-Alana, 2008).

Processes with $d>0$ in equation (2) exhibit the "long memory" property, so-called because of the strong degree of association between observations that are very distant in time (Barros et al., 2016). Impulse responses are also affected by the magnitude of d, according to Barros et al. (2011), the higher the value of d, the higher the answers. In the case of $d<1$, the series is reversed to average, with shocks of temporary effects and disappearing over the long term. However, if $d\geq 1$, the shock will have permanent effects unless strong policy measures are taken.

In the context of fractional processes, Gil-Alana (2008) points out that occasionally neglecting structural breakdowns can lead to the discovery of spurious long memory. Therefore, this paper examines the possibility of fractional integration in the presence of a single structural break at an unknown point within the sample. Thus, each of the series, y_t, which presents break is represented according to the following model:

$$y_t=\beta_1^T+x_t; \qquad (1-L)^{d_1}x_t=u_t, \qquad t=1,2,\ldots,T_b \tag{3}$$
$$y_t=\beta_2^T+x_t; \qquad (1-L)^{d_2}x_t=u_t, \qquad t=T_b+1,\ldots,T \tag{4}$$

where β's are the coefficients corresponding to the deterministic terms, d_1 and d_2 are real numbers, u_t is a stationary process $I(0)$, with zero mean and spectrum $f_u(\lambda)$ and T_b is the unknown break point.

The methodology used in the present study to estimate the fractional differentiation parameter is the method proposed by Robinson et al. (1995), the Gaussian Semiparametric Estimator (GSE) based on the frequency domain Whittle Function. Also the test proposed by Andrews and Ploberger (1994) is applied, with p-value using the Hansen (1997) approximations, which is recommended for testing a single structural break at an unknown point within the sample and identifying the break date, T_b. Also. Subsequently, new estimates of parameter d are made in the presence of breakage[1].

2.2 Data

Monthly export and import amount data from January 1997 to October 2019 (N=274) were obtained from Comex Stat (MDIC, 2019). Time series is presented in Figure 1.

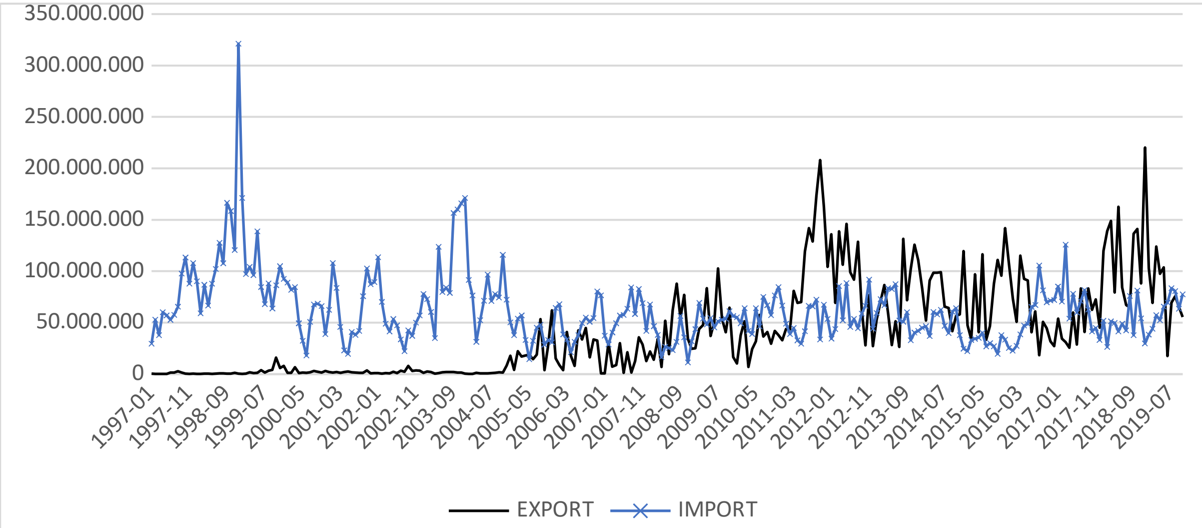
Monthly rice prices received by farmers from January 1997 to October 2019 (N=274) were obtained from Instituto de Economia Agricola (IEA, 2019). Time series is presented in Figure 2.

Yearly data on production amount, harvested area and yield from 1996/1997 to 2018/2019 (N=23) were obtained from IBGE (2019a, 2019b).

1 The econometric software used to perform the statistical procedures of this study is the Regression Analysis of Time Series (RATS 9.2) and its complement, the Cointegration Analysis of Time Series (CATS).

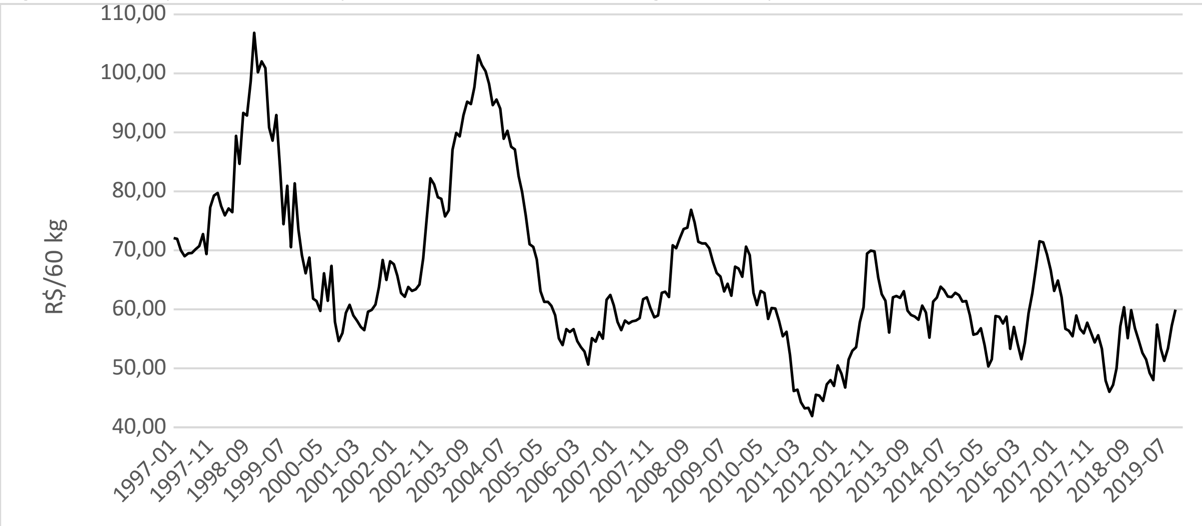
While imports occur over the whole period, export become relevant after 2004, when the Brazilian production reached self-sufficiency level. Rice prices received by farmers show a cyclic decrease tendency over time. Some export peaks occurred in low-prices periods.

Figure 1. Brazilian rice export and import amounts (metric tons), January 1997 – October 2019.



Source: MDIC (2019). Own preparation.

Figure 2. Rice price receive by farmers in Brazil (R$/60kg), January 1997 – October 2019.



Source: IEA (2019). Own preparation.

3. Results and Discussion

Table 1 presents the results of the fractional parameter estimation. The second column contains the *d* parameter estimates by Robinson et al. (1995) for the series of exports, imports and prices paid to the producer. Disregarding the possibility of any structural breakdown, the estimates of parameter *d* of the model given by equations (1) and (2) show that for the import and export series show estimates in the range (0,1), they are fractionally integrated. While for the producer price series has estimate of the parameter greater than 1.

The rice export and import series have a high degree of persistence, $0.5 \leq d < 1$, with less significant oscillations when compared to the lower persistence series, $0 < d < 0.5$. That is, the series have a non-stationary behavior, but with reversal to the mean. Producer prices are higher than 1, indicating that a shock in the series itself will have permanent effects unless strong policy measures are adopted. That is, which shows a non-stationary behavior and no reversal to the mean.

Application of the Andrews and Ploberger (1994) test revealed a structural break in November 2004 for the export and import series and in March 2005 for producer prices. This happened because 2004/2005 was the year where Brazil had the highest domestic rice production. Given this scenario, the *d* parameters were extinguished for the series and there was only one change of behavior: for the export series after the break, which now presents an estimate of the lowest persistence parameter: $0<d<0.5$. This shows that after the break, the export market began to show more significant fluctuations, and it may occur that in one period there is a rise in volume followed by a decrease in the immediately following period.

Table 1. Estimation of the fractional parameter of the series.

	Total sample		Structural Break	Before Break			After Break		
	d	std error		d_1	std error	t_1	d_2	std error	t_2
Export	0.5342	0.0533	10/2004	0.5840	0.0822	93	0.4532	0.0630	174
Import	0.5999	0.0533	10/2004	0.7345	0.0822	93	0.6415	0.0630	174
Price	1.0401	0.0533	03/2005	1.0790	0.0801	98	1.0981	0.0598	175

Source: Research results.

d = fractional parameter of total sample; d_1 = fractional parameter before break; t_1 = observations before break; d_2 = fractional parameter after break; t_2 = observations after break.

Results are coherent with empirical rice market observation in Brazil. Analysis of the degree of persistence to shocks allows us to identify the presence of long memory in all series when considering the complete period. The presence of long memory in the series can be interpreted as a continuity of past values. For the Brazilian rice market that has a large domestic consumption and a practically self-sufficient production, this result is excellent. In other words, it shows that the market does not suffer from world market oscillations (unless they are very strong, such as severe supply shocks) and that it has a good product based on quality and surrounded by strong institutional environment.

Conclusions

Brazilian rice market is persistent to external shocks, with the presence of long memory in exports, imports and prices received by farmers.

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