Modelling Brazilian Export Commodities Using Box-Jenkins Procedure

Maria Emilia Camargo, Gabriela Lain, Eduardo Luis Cardoso, Eduardo da Motta Xavier

ABSTRACT

Background: Currently, Brazil stands out in the international arena to be a global trader in commodity exports, which represent a significant portion of its GDP - Gross Domestic Product. Within this context, this article proposes to analyze by means of the ARIMA model to predict the behavior of monthly exports of major commodities in Brazil. The commodities studied in this article were coffee beans, soybeans, soybean meal, crude soybean oil, orange juice, raw sugar, refined sugar, cellulose, aluminum, swine meat in natura, chicken meat in natura, manufactured iron / steel, rolled leather, leaf tobacco, iron ore, gasoline, fuel oil, crude oil, cotton, corn and ethanol. The behavior of exports of each commodity was analyzed by the application AUTOBOX® software, version 1.2, with data collected between January 2006 to May 2011, obtained from the website of the Ministry of Development, Industry and Trade of Brazil (MDIC). Were considered valid predictive models that had R² above 70%, and the results provide a powerful tool for analyzing the market for commodities, as they show the trend of export values for a short time horizon, serving aid to decision making, especially for the trading agents.

INTRODUCTION

Currently Brazil is characterized by being considered a global commodities trader, especially in the international arena by the export of these products, which constitute a significant source of income for the Brazilian economy. According to Castro and Rossi (2000), the export of commodities worsened since 1999, with the adoption of floating exchange rate regime, which resulted in a trade imbalance in favor of exports. What makes the very important commodities in the economy is the fact that, although primary commodities, have quotation and negotiability global, so fluctuations in the prices of these commodities have significant impact on global financial flows, may cause losses to trading agents and even countries. The derivatives market has emerged as a protection to trading agents against losses caused by volatility in commodity prices (Rios, 2012). Between 2006 and 2009, Brazil lost market share in all product groups except in commodities. That is, in the last three years, the primarization of the country's trade agenda is not just a result of exceptional performance of Brazilian exports of commodities, but also reflects the loss of participation, in other words, the country's competitiveness in international trade in all other groups of products (Corecon-AM, 2011).

Based on the importance of commodity exports to the Brazilian economy and the volatility of the international market, the application of forecasting demand for these products becomes an essential strategy for Brazilian exports. That for agricultural producers, private and state companies meet the requirements of its customers and markets, as these techniques allow to determine the production schedule, as they offer essential information for planning procurement of inputs, implementation and control of resources prior of all departments of organizations. Within this context, this article will analyze the variations of monthly export values in millions of dollars of the main Brazilian commodities through the forecasting model of Box-Jenkins ARIMA, allowing better understand what is happening on the international scene and the trend of Brazilian exports these products. The commodities will be analyzed: coffee beans, soybeans, soybean meal, crude soybean oil, orange juice, raw sugar, refined sugar, cellulose, aluminum, swine meat in natura, chicken meat in natura, manufactured iron / steel, rolled leather, tobacco leaves, iron ore, gasoline, fuel oil, crude oil, cotton, corn and ethanol, using data collected between January 2006 and May 2011, available at http://www.mdic.gov.br, the MDIC.

Corresponding Author: Maria Emilia Camargo, Post-Graduate Program in Administration, University of Caxias do Sul, Brazil.
E-mail: kamargo@terra.com.br

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**Theoretical Framework:**

**The Arima Model of Box-Jenkins:**

A time series data is collected over time and in sequence, so it may provide serial correlation in time. The Box-Jenkins models, commonly known by ARIMA (Auto Regressive Integrated Moving Averages) are stochastic models that try to capture the behavior of serial correlation or autocorrelation between the values of the time series and, based on this behavior, make forward-looking statements. The autocorrelation is used to measure the length and the memory of a process. If the correlation structure is well modeled, with forecasts provide some degree of assertiveness. ARIMA models are the result of the combination of three elements called filters: the component autoregressive (AR) filter integration (I) and component moving averages (MA). A series can be modeled by three filters or just a subset of them, resulting in several models (Fava, 2000).

**Stationary Models:**

Stationary models are ones which assume that the process is in equilibrium. Second order stationary models are those with constant mean and variance in different moments of time.

**Autoregressive Model (AR):**

In an autoregressive model, a series of historical data $Z_t$ is described by its past values and regressed by random noise $\varepsilon_t$. Thus, a model AR (p) is given by:

$$Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + ... + \phi_p Z_{t-p} + \varepsilon_t$$

where:

$$Z_t = Z_t - \mu$$

$\phi$, parameter that describes how $Z_t$ relates the value $Z_{t-i}$ to $i = 1, 2, ..., p$.

The model AR (p) given by equation (1) can be rewritten by equation 2 using the lag operator $L$ (applying the lag operator $Z_{t-1}$ have $L Z_t$).  

$$(1 - \phi_1 L - \phi_2 L^2 - ... - \phi_p L^p) Z_t = \phi (L) Z_t = \varepsilon_t$$

The autoregressive model of order 1 or AR (1) is the simplest model in this class, with the following algebraic presentation:

$$Z_t = \phi_1 Z_{t-1} + \varepsilon_t$$

For the model to be stationary it is necessary that $| \phi_1 | < 1$ (stationarity condition) and that the autocovariance $Y_k$ are independent. In the case of AR (1), the autocovariance are given by:

$$Y_k = \phi_1^k Y_0$$

and autocorrelations are given by the equation:

$$\rho_k = \frac{Y_k}{Y_0} = \phi_1^k$$

**Moving Average Models (MA):**

In a model of moving averages, the series $Z_t$ results from a combination of white noise current period to those in prior periods occurred. Thus a moving average model of order q or MA (q) is given by:

$$Z_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + ... + \theta_q \varepsilon_{t-q}$$

Where:

$$\varepsilon_t = Z_t - \mu$$

$\theta$, a parameter which describes how the value $Z_t$ relates $\varepsilon_{t-i}$ for $i = 1, 2, ..., q$.

The model MA (q) given by equation 6 can be rewritten as in 7, using the lag operator $L$.

$$(1 - \phi_1 L - \phi_2 L^2 - ... - \phi_q L^q) \varepsilon_t = \theta(L) \varepsilon_t = Z_t$$
The model MA (1) is the simplest version of this class of models. The presentation is given by the algebraic equation 8:

$$Z_t = \varepsilon_t + \theta_1 \varepsilon_{t-1}$$  \hspace{1cm} (8)

The autocorrelations $\rho_k$, where autocovariance are divided by the variance, have the following representation:

$$\rho_k = \frac{\gamma_k}{\sigma^2} = \frac{-\theta_1^k \sigma^2}{(1+\theta_1^2)\sigma^2} = -\frac{\theta_1^k}{1+\theta_1^2} \quad \text{for } k > 1$$  \hspace{1cm} (9)

**Models autoregressive Moving Averages (ARMA):**

The processes autoregressive moving average ARMA (p, q), mixing characteristics of the processes AR (p) and MA (q). Any stationary series can be modeled as a process ARMA (p, q), requiring a smaller number of terms autoregressive moving average, and can be expressed in the following equation:

$$Z_t = \phi_1 Z_{t-1} + \cdots + \phi_p Z_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \cdots - \theta_q \varepsilon_{t-q}$$  \hspace{1cm} (10)

The simplest model is ARMA (1,1) given by:

$$Z_t = \phi_1 Z_{t-1} + \varepsilon_t - \theta_1 \varepsilon_{t-1}$$  \hspace{1cm} (11)

The autocorrelation function of the ARMA (1,1) takes the form:

$$\rho_k = \frac{(1 - \phi_1 \theta_1)(\theta_1 - \phi_1)}{1 + \theta_1^2 + 2 \phi_1 \theta_1} \quad \text{for } k > 1$$  \hspace{1cm} (12)

**Models non-stationary:**

When you get a series non-stationary, it is necessary to adjust it prior to a stationary model (MA, AR, ARMA) and make it stationary by removing non-stationary patterns (for example, trend and seasonality) time-series analysis. Thus, the series must be transformed to become stationary relative to its mean and variance (Makridakis et al. 1998). Filtering is repeated as many times as necessary until you get off a process with the necessary characteristics to represent the non-stationary process smooth. A necessary condition for implementing the ARIMA model is that the process is second order stationary, that is, that their mean and variance are constant in time.

**Models autoregressive integrated moving average (ARIMA):**

The most common transformation to become stationary in a series, is to consider the successive differences of the original series (Morettin; Toloi, 1987). The first difference

$$\Delta Z_t = Z_t - Z_{t-1}$$  \hspace{1cm} (13)

and the second is given by:

$$\Delta^2 Z_t = \Delta [\Delta Z_t] = \Delta [Z_t - Z_{t-1}] = Z_t - 2Z_{t-1} - Z_{t-2}$$  \hspace{1cm} (14)

The authors add that, in normal situations, it is enough to take one or two differences to transform the series into stationary. The required number of differences D is called the order of integration, where the inclusion ARIMA model (p, d, q) is given by the following equation:

$$w_t = \theta_1 w_{t-1} + \cdots + \theta_p w_{t-p} + a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q}$$  \hspace{1cm} (15)

where in: $w_t = \Delta^d Z_t$

Using a lag operator L, it is possible to rewrite the equation as:

$$(1 - \theta_1 L - \cdots - \theta_p L^p)w_t = (1 - \theta_1 L - \cdots - \theta_q L^q) a_t$$
with \( w_i = (1 - L)^d Z_t \delta(L)(1 - L)^d Z_t = \theta(L)u_t \) 

(16)

The authors add that, in normal situations, it is enough to take one or two differences to transform the series into stationary. The required number of differences \( D \) is called the order of integration, where the inclusion ARIMA model (p, d, q) is given by the following equation:

The ARIMA model has the lowest error. In this model it is considered historical series of sales, in chronological order in which they perform analysis of autocorrelations and partial autocorrelations, to calculate an estimate of the parameters by minimizing the squared error. The great advantage of this model is the diagnosis of residues such that the estimated parameters have the least squares error. However, a tool is accurate and costly, requiring much time for analysis (Lin, 2000; Mudie 1997).

According to Box and Jenkins (1970), the intervention models are generalizations of the methods used for data analysis, not often expressed in the form of time series describing a large number of simultaneous effects. The time series on the economic variables are more susceptible to exogenous events of character that should be considered when studying the structural relationship between variables, not to run the risk of wrong estimation models. The goal of the analysis of the intervention is to assess the impacts of exogenous events (input variables). These input variables, when deterministic in nature, are called operations where the time of occurrence is known a priori (Box and Jenkins, 1970). Examples of interventions can be cited: political decisions, climatic disturbances, strikes, economic crises, etc. Due to these exogenous events, the same cannot be ignored when studying the structural relationship between the variables, because it runs the risk of estimating models distorted.

To use the model input intervention is required a detailed knowledge of interventions and their effects on the series studied. When the dates of the events that influence the behavior of the series are not known a priori, the inputs are called outliers. Once found outliers, these variables are included as intervention (impulse and step), as proposed by Box and Tiao (1975). Be \( Z_t \) a time series for which it was identified an ARIMA model and its parameters estimated at some moment where an event occurs regardless of the factors that act normally, causing the phenomenon that gave rise to series. This event is called external intervention. The proposed model for intervention analysis interprets the way to incorporate the effects of the model series, given by equation (17):

\[ Z_t = \sum_{k=1}^{p} v_i(B)X_{t+k} + \eta_t \]

(17)

where: \( Z_t \): variable-response model, \( k \): number of interventions in the series; \( u_i (B) \) and transfer function value, \( X_{it} \): binary variable; \( \eta_t \): noise model, represented by an ARIMA model. If some of the variables \( X_{it} \) are binary, the intervention model plays the same role that the variables dummy in regression. The purpose of the intervention analysis is to assess the impact of such an event in the series behavior. These indicators of intervention can be represented by two types of binary variables:

- **S – Step**
  \[ X_{it} = S^{(T)}_{it} = \begin{cases} 0, & t < T \\ 1, & t \geq T \end{cases} \]

(18)

- **I – Impulse**
  \[ X_{it} = I^{(T)}_{it} = \begin{cases} 0, & t \neq T \\ 1, & t = T \end{cases} \]

(19)

- **IS - Impulse seasonal**
  \[ X_{it} = S_{it}^{(ST)} = \begin{cases} 0, & t \neq ST \\ 1, & t = ST \end{cases} \]

(20)

In function (18), the effect is permanent intervention after the time \( T \), and the functions (19 and 20) the effect is temporary. The effect of intervention is characterized by changing the level or slope of the series. There are three sources of noise that can obscure the effect of the intervention: trends, seasonality and random error.

**Methodology:**

This research is characterized as quantitative research with data collection time-series data. The methodology used to construct the prediction model for the monthly figures of exports of major commodities in Brazil was based on the steps of (i) identification, (ii) estimation of parameters, (iii) testing, performed. The identification step is to identify the predictive model by discovering which of the various versions of the Box-Jenkins describes the behavior of the time series. According Makridakis et al. (1998), the identification of the model to be estimated is the behavior of the functions of autocorrelations (ACF) and partial autocorrelations function (PACF).

The identification of the prediction model to be used in this article was conducted through AUTOBOX software, version 1.2, and adopted the ARIMA model with intervention, used to forecast the demand of export figures of 15 commodities, which employed 53 samples of each product type. This software automatically analyzed the data variation, considering the significant interventions 5 (steps, impulses and impulses seasonal)
made over time for each commodity. The step estimation of the parameters is to estimate the parameters $\phi$ and $\Phi$ autoregressive component, the parameters $\theta$ and $\Theta$ component moving averages and variance of $\epsilon_t$ waste. The verification step is to assess whether the estimated model is suitable to describe the behavior of the data.

**Brazilian Exports of Commodities:**

Commodity is a word of English origin whose literal translation means merchandise, which is a raw material, in other words, a commodity in its raw state or small degree of industrialization. What differentiates the term from other goods on the market is their primary source of power and its commercial trading in commodities. The commodities are produced on a large scale and by several producers, processors and exporters, have practically uniform quality, these being products grown or mineral extraction that can be stored for a certain period for future sale (MDIC, 2011). In the publication Understanding Brazil in numbers, June 2011, presents data collected until 2010, when Brazil was ranked 22nd in the ranking of the largest exporting countries, gaining two positions compared to 2009 and becomes effective immediately behind countries such as Australia, India and UAE. In 2010, Brazil had exported U.S. $202 billion, an increase of 32% over 2009 and representing 1.3% market share of world exports. Nearly 75% of total Brazilian exports are aimed at four specific markets: Asia, Latin America and the Caribbean, European Union and United States. From 2008 to 2010, the share of these markets in Brazilian exports has changed: Asia jumped from 18.9% to 27.9%. The contents of the other three markets declined: LAC ranged from 25.9% to 23.8%, the EU decreased from 23.4% to 21.4% and the United States decreased from 14% to 9.6%.

Other markets, such as Africa, the Middle East and Eastern Europe, totaling 12.2% of exports, had variations that do not reach 2% (MDIC, 2011). Brazil increased the level of exports of minerals (especially iron ore) compared to 2009, and this product was the main responsible for 51% of total exports in commodities in 2010. Sugar also played a major role in 2010, growing the total, while items like meat and soy had a proportionate share of Brazilian exports less than in 2009 (Corecon-AM, 2011).

**Analysis of Results:**

After implementing the steps of the methodology described above, which was performed by statistics were calculated adjustment: coefficient of determination ($R^2$). The Akaike Information Criterion (AIC) and Criterion Schwarz (BIC), which measure the likelihood of parsimony and parametric models showed acceptable values, because the closer these values become zero, the better the model chosen to forecast.

Based on the analysis of the coefficients of determination $R^2$, it can be seen that the ARIMA model with interventions is the model that has a greater ability to predict the values of exports of most commodities analyzed in compared to the ARIMA model without interventions, except for beef, fuel oil and manufactured iron and steel, which had no interventions over the period analyzed. This is explained because the ARIMA model with interventions that can analyze simultaneous events do not usually occur in the form of time series. Were considered valid ARIMA models that showed an $R^2$ above 70%. Following presents the forecast models with intervention for each commodity in the study and analysis of the interventions.

The ARIMA model with intervention of iron ore is shown in equation 21. Figure 1 presents statistics adjustment.

$$Z_t = 4,3400I_{29} - 2,7600I_{39} - 3,3000I_{61} - 2,9900I_{41} - 3,3400I_{66} + \epsilon_t$$

$$(4,12) (-3,71) (-3,14) (-2,84) (3,17) \quad (21)$$

<table>
<thead>
<tr>
<th>Model without intervention</th>
<th>Model with intervention</th>
</tr>
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<tbody>
<tr>
<td>$R^2$</td>
<td>86,83%</td>
</tr>
<tr>
<td>AIC</td>
<td>$-3,8450$</td>
</tr>
<tr>
<td>BIC</td>
<td>$-3,7650$</td>
</tr>
<tr>
<td>AIC</td>
<td>$-4,4274$</td>
</tr>
<tr>
<td>BIC</td>
<td>$-4,2573$</td>
</tr>
</tbody>
</table>

**Fig. 1:** Model of Iron Ore.

The five interventions significant detected at 5%, 4 is the step type and one impulse-type in the analyzed period. According to the MDIC (2011), Brazil is the 3rd largest producer and 2nd largest exporter. The mining industry is one of the most important on the agenda of Brazilian exports, accounting for 22% of total exports. The main buyers of iron ore are China, Japan, Germany, South Korea, Bulgaria, France, Cyprus, Belgium, United States, Finland, Canada and Ireland. In analyzing data on exports, there is a slight drop in steady export growth from March 2008.

The fall continues until April, and from May 2008, the largest peak starts exports reached in September of the same year. This peak had two causes. According IBRAM (2012), the first is related to the increase of the extraction and export by the state of Pará which grew 43% over 2007 and the second is due to the appreciation.
in the price of iron ore in markets before the 2008 financial crisis. The ARIMA model with intervention for leather, is shown in equation 22. Figure 2 presents statistics adjustment.

\[
Z_t = 7.3068 + 1.0170Z_{t-1} + 4.6178Z_{t-2} - 5.5957Z_{t-3} + 6.0940Z_{t-12} - 1.3206I_{31} + \epsilon_t
\]

(22)

<table>
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<tr>
<th></th>
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<th>Model with intervention</th>
</tr>
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<tbody>
<tr>
<td>(R^2)</td>
<td>87.34%</td>
<td>90.91%</td>
</tr>
<tr>
<td>AIC</td>
<td>-6.9803</td>
<td>-9.8804</td>
</tr>
<tr>
<td>BIC</td>
<td>-5.0499</td>
<td>-7.5639</td>
</tr>
</tbody>
</table>

**Fig. 2: Model of Leather**

There was a significant intervention, detected at 5%, and an impulse. The products for export are basically leather from cattle with a varied value. There are four kinds of leather for export that goes from gross to more finished, named: salted, wet-blue, crust and finished. The export is complemented by leather and soles of sheep and goats. According to the MDIC (2011), Brazil is the 2nd largest producer of leather in the world and 4th in export country. The data showed export surveyed 2006 until early 2008, growth in exports. From 2008, the export decreases and reaches the minimum rate in January 2009. Between 2009 and 2010, there is a growth in exports shy and quite markedly from 2011, reaching the highest peak in the last month analyzed. This decrease in 2008 is due to two reasons: (a) U.S. housing crisis that also affected the demand of the American market for leather furniture and (b) drop in exports of 44% in wet-blue leather type in function unrealistic value that remained too expensive. In addition, China, a big buyer of leather, saw the U.S. market to reduce their purchases of footwear.

The ARIMA model with intervention of chicken meat, is shown in equation 23. Figure 3 presents statistical adjustment.

\[
Z_t = -5.2433Z_{t-1} - 3.2024I_{13,25} - 7.9978I_{35} + 6.7400I_{29} + \epsilon_t
\]

(23)

<table>
<thead>
<tr>
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<th>Model with intervention</th>
</tr>
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<tbody>
<tr>
<td>(R^2)</td>
<td>77.29%</td>
<td>88.44%</td>
</tr>
<tr>
<td>AIC</td>
<td>1.9165</td>
<td>1.2736</td>
</tr>
<tr>
<td>BIC</td>
<td>2.0194</td>
<td>1.4108</td>
</tr>
</tbody>
</table>

**Fig. 3: Model of Chicken meat.**

There were three intervention significantly detected at the 5% level, being 2 of the step type, 1 impulse type seasonal. According to the ABEF (2012), in 2010, Brazil registered an increase in exports of 5.1% over the previous year, setting a record and consolidating this product as the major Brazilian poultry product. Inside of the item chicken meat, export encompasses some types of product variations in cuts such as chicken, whole frozen and industrialized. Major markets buyers are formed, in order, by the Middle East, Asia, Africa and the European Union. According to the Ministry of Development, Industry and Foreign Trade, Brazil is the 3rd largest producer and 1st in exports. In analyzing the data provided by the MDIC (2011), 2006-2011, there is a fall between the months of November 2008 that extends through April 2009, resuming growth after. This decrease is due to reflections of the global financial crisis where countries buyers of Brazilian chicken meat as Venezuela, Russia and Japan decreased their purchases. As 40% of the country's production is destined for the export market, the output for producers was the product available to the market with large price reduction.

The ARIMA model with intervention of tobacco leaves is shown in equation 24. Figure 4 presents statistics adjustment.

\[
Z_t = 3.1570Z_{t-1} + 3.1533Z_{t-3} + 3.2613Z_{t-12} + 6.0063I_{42} + 6.1494I_{34,46} - 3.6939I_{14} + \epsilon_t
\]

(24)

<table>
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<tr>
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<th>Model without intervention</th>
<th>Model with intervention</th>
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</thead>
<tbody>
<tr>
<td>(R^2)</td>
<td>74.35%</td>
<td>85.86%</td>
</tr>
<tr>
<td>AIC</td>
<td>1.7463</td>
<td>1.2730</td>
</tr>
<tr>
<td>BIC</td>
<td>1.8621</td>
<td>1.5046</td>
</tr>
</tbody>
</table>

**Fig. 4: Model of Smoke on leaves.**
There were three significant interventions, detected at 5%, being 2 pulses and 1 pulse seasonal. According to the Observatory of the National Tobacco Control (2012), exports of tobacco indicate growth in the analyzed period tending to remain in growth. Brazil is the 2nd largest producer after China, and is the 1st in world exports. Its main destinations are the European Union, the Far East, Africa and the Middle East. In addition, the tobacco leaves is exported in two ways: pre-processing (not manufactured tobacco) and post-processing. According to the website of the Observatory of the National Tobacco Control (2012), Brazil exports most of its production without processing. It is necessary to note that the seasonal cycle of smoking in Brazil takes two years. And it is in the phase between May and December which happens 90% of exports, precisely where the peaks happen informed by data from MDIC (2011). Looking at the data provided by the MDIC (2011), no pulses to be posted. Three of them occur respectively in October 2008, 2009 and 2010 indicating moments seasonal sale of the commodity.

The ARIMA model with intervention of corn is shown in equation 25. Figure 5 presents statistics adjustment.

\[
Z_t = 7.1926 + 1.2606Z_{t-1} - 1.4547Z_{t-2} + 7.9340Z_{t-3} - 5.816Z_{t-3} - 5.1300I_{01} + a_t \\
(0.82) \quad (-9.90) \quad (-17.32) \quad (-7.34) \quad (-4.80) \quad (3.50)
\] (25)

<table>
<thead>
<tr>
<th>Model without intervention</th>
<th>Model with intervention</th>
</tr>
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<tbody>
<tr>
<td>R²</td>
<td>80.42%</td>
</tr>
<tr>
<td>AIC</td>
<td>1.6908</td>
</tr>
<tr>
<td>BIC</td>
<td>1.8595</td>
</tr>
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</table>

**Fig. 5:** Model of corn.

There was a significant intervention, detected at 5%, and an impulse. Brazil is the 3rd largest producer and 3rd in export grain. The cultivation of grain priority aims to meet domestic consumption, even this segment is the smallest part of his harvest. The main targets are the feed, the surplus being sent for export. Exports are on the rise due to productivity gains of Brazilian agriculture (Ministry of Agriculture, 2011). Brazil is characterized by two planting dates of corn per year. Planting of summer, or first crop, are made in the traditional season during the rainy season, which ranges from late August, in the South, until the months of October / November in the Southeast and Midwest (in the Northeast, this period occurs at the beginning of the year). More recently, it has increased the production obtained in the off-season, or second crop. This refers to the harvest dryland corn planted extemporaneously in February or March, almost always after soybeans early, predominantly in the Midwest and in the states of Paraná, São Paulo and Minas Gerais. It appears the latest harvests, a decrease in the area planted during the first season, but that has been offset by increased plantings for second season and increased farm income of corn (EMBRAPA, 2010). Seasonal variations in survey numbers indicate the time of sale of the grain, considering the Wide spectrum depending on the size of the continental country.

The ARIMA model with intervention of cellulose is shown in equation 26. Figure 6 presents statistics adjustment.

\[
Z_t = 1.1263 + 4.2265Z_{t-2} + 1.7070I_{30} - 4.4033I_{90} + 5.4710I_{90} + 6.8790I_{31} + a_t \\
(17.26) \quad (3.36) \quad (9.16) \quad (-3.53) \quad (5.06) \quad (5.60)
\] (26)

<table>
<thead>
<tr>
<th>Model without intervention</th>
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</tr>
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<tbody>
<tr>
<td>R²</td>
<td>61.09%</td>
</tr>
<tr>
<td>AIC</td>
<td>2.1905</td>
</tr>
<tr>
<td>BIC</td>
<td>2.3636</td>
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</table>

**Fig. 6:** Model of Cellulose.

There were four significant interventions, detected at 5%, being one impulse three steps. Economic development combined with large investments in the pulp industry favored the production of this commodity in the last ten years. The segment has doubled the production of cellulose with average growth of 6.5% per year. In 2008, where there are two peaks and a valley in numbers, the industry reached the fourth position worldwide pulp, behind the United States, Canada and China. This record was obtained during the international financial crisis. The country maintained its position in 2009 and 2010, always increasing production (BRACELPA, 2011). The peaks found in May and July 2008 with a valley in June indicate no drop in exports, but the sudden change is a result of the strike of the IRS tax just as happened with the oil. The main markets are Europe and China. Exports are concentrated primarily in hardwood pulp derived from eucalyptus wood, with over 90% of total exports.

The ARIMA model with intervention of iron ore, is shown in equation 27. Figure 7 presents statistics adjustment.
There were five interventions significant, detected at 5%, being one impulse, two steps and two seasonal pulses. Since early 2007, the price of sugar followed by movements in the stock funds and speculators (Journal Cana, 2007). This fact justifies the Step detected in January 2007. According Jornal Cana (2007), the Brazilian sugar imports from China increased substantially, reaching its peak in August 2010. This fact justifies the step obtained in the simulation in August 2010.

The ARIMA model with intervention of gasoline is shown in equation 28 and figure 8 presents statistics adjustment.

\[
Z_t = 1.9544 + 4.2561z_{t-1} + 2.1386t_{-3} + 1.0870X_{32} - 6.0787X_{36} + 5.7316X_{17} - 7.8641X_{10} - 8.9770X_5 + a_t
\]

(4.29) (3.49) (2.12) (5.89) (-4.56) (3.17) (-3.38) (-3.24) (28)

<table>
<thead>
<tr>
<th>Model without intervention</th>
<th>Model with intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R^2)</td>
<td>30.68%</td>
</tr>
<tr>
<td>AIC</td>
<td>2.3635</td>
</tr>
<tr>
<td>BIC</td>
<td>2.4673</td>
</tr>
<tr>
<td>Model without intervention</td>
<td>62.64%</td>
</tr>
<tr>
<td>AIC</td>
<td>1.5578</td>
</tr>
<tr>
<td>BIC</td>
<td>1.8346</td>
</tr>
</tbody>
</table>

Fig. 7: Refined sugar.

Fig. 8: Gasoline.

There were five significant interventions, detected at the level of 5% with one pulse and four steps in the analyzed period. The export of gasoline is very sensitive to various issues such as variations in prices of the real against the dollar, the variation in the content of anhydrous ethanol in gasoline to offset the amount of ethanol in gasoline to maintain the level of octane fuel that allows the internal market, the demand for ethanol, of fluctuations that make up the network of such taxes on the commodity, among others. A simple analysis on export figures reveals that the global financial crisis of 2008 affected Brazilian exports of this commodity. After August 2008, could no longer export the same performance in previous years having retreated about 76% in recent years (Zafalon, 2011). From 2010, there is a widespread low in numbers, a result of the decision of Petrobras to suspend exports of fuel to meet increased domestic demand. The export of gasoline, despite the tendency of deceleration, still supplies markets that do not have alternative fuels like ethanol and ethanol. Some of these countries, such as Japan, begin to add ethanol to gasoline, representing a trend for the coming years (Vigliano, 2006). This fact helps to explain why the numbers exported from fall 2009.

The ARIMA model with intervention Rolled Plans, is shown in equation 29 and figure 9 presents statistical adjustment.

\[
Z_t = 1.1108 + 5.8352z_{t-1} - 3.6165z_{t-2} + 3.9960X_{45} - 3.6992X_{20} - 3.4910X_8 + a_t
\]

(10.70) (4.92) (-2.50) (3.22) (-3.27) (-2.76) (29)

<table>
<thead>
<tr>
<th>Model without intervention</th>
<th>Model with intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>(R^2)</td>
<td>59.57%</td>
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<tr>
<td>AIC</td>
<td>1.2454</td>
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<tr>
<td>BIC</td>
<td>1.3475</td>
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<tr>
<td>Model without intervention</td>
<td>53.01%</td>
</tr>
<tr>
<td>AIC</td>
<td>9.3659</td>
</tr>
<tr>
<td>BIC</td>
<td>1.1407</td>
</tr>
</tbody>
</table>

Fig. 9: Rolled Plans.

There were three significant interventions, detected at 5%, being two impulses and one step. According Andrade et al. (2001), the document Mining and Metallurgy, published by the National Bank for Economic and Social Development - BNDES, steel products are classified into laminates (or finished) long, flat and semifinished. The Flat-rolled segments are the main domestic steel market in volume and value. Account for 50% of total steel exports annually. The plans are produced by large integrated steel plants characterized by large-scale production and use of blast furnaces in the reduction process. Its use covers auto parts, auto parts, construction, packaging, welded pipes, household and commercial mechanical and electronics. A general analysis of the figures of the period informs that exports suffered decline after 2006 and resumed growth only in July 2010.
This fall reinforces meet the demand of both the domestic automobile market, the housing market and packaging.

**Conclusion:**

Por meio da análise do mercado de exportação das commodities brasileiras que obtiveram R² superior a 70%, foi possível analisar os fatores que influenciaram os mercados destes produtos nos períodos que ocorreram cada intervenção apontada pelo modelo de previsão ARIMA com intervenções. A análise demonstrou que todas as intervenções ocorridas no mercado de exportação das commodities realmente são coerentes, conforme mostrado na análise dos resultados realizada. Baseado nesta análise, conclui-se que o modelo ARIMA com intervenções, utilizado para a previsão dos valores de exportação do petróleo bruto, minério de ferro, couro, carne de frango, fumo em folhas, milho, celulose, açúcar refinado, milho e gasolina fornecem uma poderosa ferramenta de análise para o mercado de exportação destas commodities, à medida que demonstram a tendência dos valores de exportação para um horizonte de curto prazo, servindo de auxílio à tomada de decisão para agentes comercializadores, agricultores, grandes empresas privadas, estatais, entre outros.

Through the analysis of the export market of Brazilian commodities that had R² exceeding 70%, it was possible to analyze the factors that influenced the markets for these products in the periods that occurred each intervention aimed at forecasting ARIMA model with intervention. The analysis showed that all interventions occurred in the export market commodities are really consistent, as shown in the analysis of the results accomplished. Based on this analysis, it is concluded that interventions with ARIMA model used to predict the value of exports of crude oil, iron ore, leather, chicken meat, leaf tobacco, corn, cellulose, sugar, corn and gasoline provide a powerful analysis tool for the export market of these commodities, as they show the trend of export values for a short time horizon, serving to aid decision making for trading agents, farmers, large private companies, state among others.

**REFERENCES**


