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Multiresolution Analysis of the Wheat Production in Brazil Using Wavelets

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Abstract: *Currently wheat production in Brazil is concentrated in the states of Paraná (PR) and Rio Grande do Sul (RS), which together total more than 90% of production. However, the states of Goiás (GO), Minas Gerais (MG), São Paulo (SP) and Santa Catarina (SC) are also responsible for the supply of wheat. The geographical extent of crop distribution and the different climatic, edaphoclimatic and cultural practices, originate products with different technological quality standards. The domestic commercialization of wheat flour is made in a 1 kg package of paper or plastic and is used for the preparation of cakes and other homemade confectionery products. It is noteworthy that in recent years the consumption of wheat flour is increasing in Brazil. In this work the analysis of multiresolution of wheat production in Brazil (annual) will be done, totaling 86 observations between the years 1931 and 2016, in order to verify the information that each level brings. By means of this analysis, the most gentle decomposition level corresponding to the series (area harvested from wheat in Brazil) was identified and the energy concentration at each analyzed level was verified.*

Keywords: *Wheat consumption, Wavelets, Daubechies*

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I. Introduction

According to Biotrigo [1] the brazilian population is incorporating other ingredients into their diet, fleeing a little from traditional beans and rice. It is noteworthy that another grain that has been gaining ground in the table of Brazilian families is wheat, the raw material of our daily bread, pasta, biscuits and one of the strategic products that fight hunger of humanity, according to FAO (Food and Agriculture Organization). In the last 40 years, the average per capita consumption in Brazil has more than doubled, according to IBGE projections (Brazilian Institute of Geography and Statistics). In the current scenario, each person consumes 60 kg of wheat in a year, an average considered ideal by the WHO (World Health Organization).

In a survey carried out by IBGE, it was verified that the consumption is concentrated, in the majority, in the South and Southeast regions. According to experts in socioeconomics at Embrapa wheat, this is credited to the "downward habits of italians and germans and the highest income per capita". In both regions, the product that leads in sales is the bread roll Biotrigo [1].

Other countries are still far ahead of Brazil in the consumption of wheat: Azerbaijan consumes 212 kg, Tunisia 204.2 kg and Argentina today faces 103.4 kg. For Embrapa wheat, the consumption profile of a population is determined by a series of factors. Among them: distribution of rural and urban population, culture (ethnicity and belief), income per capita and local industrialization can define the success or failure of a product. In the case of Brazil, there is still the edaphoclimatic aspect, which characterizes the supply profile and variety of products available in the region, which are also capable of affecting consumption Biotrigo [1].

In this work the use of wavelets in the analysis of multiresolution of agriculture data will be highlighted. A wavelet function is the interpretation of a short wave with rapid growth and decay. His theory is based on the representation of functions in different scales and different resolutions (time-scale), being considered one of its main characteristics Daubechies [2].

Wavelets are a relatively new way of analyzing for example time series, where formal data date back to 1980, but in many respects wavelets are a synthesis of older ideas with new elegant mathematical results and efficient computational algorithms. In some cases, wavelet analysis is complementary to existing analysis techniques (correlation and spectral analysis) and, in other cases, it is able to solve problems for which there was little progress before the introduction of the wavelets Persival and Walden [10].

The wavelets are intrinsically linked to the notation of multiresolution analysis, that is, objects (signals, functions, images) can be examined using different levels of resolution Odgen [9] and Kaiser [6].

The concept of representing a multiresolution signal allows one to draw interesting conclusions about wavelet transformations as well as a deeper understanding of its connection to filter banks Diniz et al. [3].

The objective of this work is to analyze the multiresolution of the series referring to the area harvested from wheat in Brazil, using the discrete non-decimated wavelet transforms, in order to verify the level of the smoother level, verifying the information that each level brings and identifying the energy at each level. The wavelet used in this work will be Daubechies with 4 null moments.

II. Material And Methods

The series to be studied corresponds to the area harvested from wheat in Brazil (annually), referring to the years between 1931 and 2016, obtained from the ipeadata website. Totaling 86 observations.

To perform the analyzes, the R program was used with the waveslim package.

The number of levels analyzed in the series must be less than or equal to log (length (x), 2), where x corresponds to the series to be analyzed.

In the analysis of a wavelet, the window is oscillating and is called the mother wavelet. There are arbitrary translations and dilations. In this way the mother wavelet gives rise to other wavelets Hernandez and Weiss [5].

By definition: a wavelet is a function $\psi(t) \in L^2(\mathbb{R})$, such that their family of functions is given by Equation 1:

$$\psi_{j,k} = 2^{-j/2}\psi(2^{-j}t - k), \tag{1}$$

wherein j and k are arbitrary integers on an orthonormal basis in Hilbert space $L^2(\mathbb{R})$ Wojtaszczyk [11]. The characteristic of the discrete non-decimated wavelet transform is to keep the same amount of data in the even and odd decimations on each scale and continue to do the same on each subsequent scale. Be D_0 the dyadic decimation, D_1 the odd decimation, H the high-pass filter and L the low-pass filter. Consider, for example, an input vector $(y_1,...,y_n)$. Then apply and keep both D_0H_y e D_1H_y, even and odd indexed of the observations filtered wavelets. Each of these sequences is length $n/2$. Thus, in total, the number of wavelets coefficients in both decimals on the finer scale is $2 \times n/2 = n$ Nason [8].

The scalogram is a very useful tool for interpreting the sign of the wavelet. It is defined as a graph of the sum of squares of the wavelet coefficients at the different levels. In the context of discrete transformation, it represents a decomposition of the energy of a function in the time-frequency (scale) Liò and Vannucci [7].

The energy E (j) for the coefficients, d_{jk}, of the wavelet on each level j, is given by:

$$E(j) = \sum_{k=0}^{n} d_{j,k}^2 \qquad j = 1, \dots, J. \tag{2}$$

The Equation 2 corresponds to the calculation of the energy in the discrete non-decimated wavelet transform on level j Gençay et al. [4].

III. Results And Discussion

Analyzing Figure 1 it is shown that the first series of the graph corresponds to the original series of the harvested area of wheat in Brazil. From w1 to w6 we have the decomposition levels of the studied series, which in this case were analyzed 6 levels. The last series represented by v6 corresponds to the approximation of the last level of decomposition. It is noticed that the level of detail of the series increases from level 5, where the softer level corresponds to level 6 (w6). In the first levels (w1, w2, w3 and w4) one does not have a detail of the series.

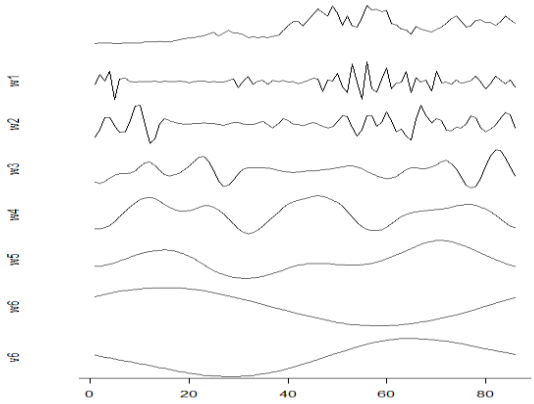

Figure 1: Decomposition of the series.

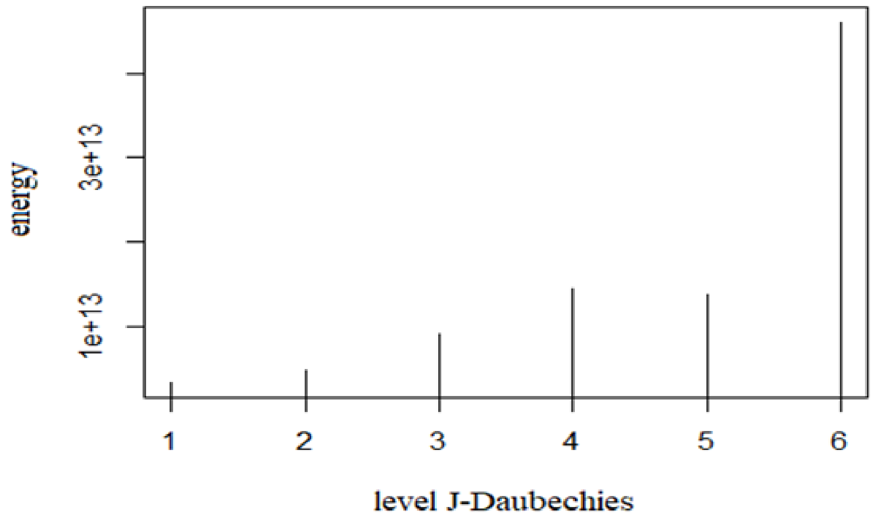

Figure 2: Energy in each level.

Figure 2 we have the scalogram, which represents the energy at each level analyzed in the decomposition of the series. It is verified that the highest concentration of energy is located at level 6, which corresponds to the last level of decomposition of the analyzed series. And the lowest concentrations of energy are in levels 1 and 2.

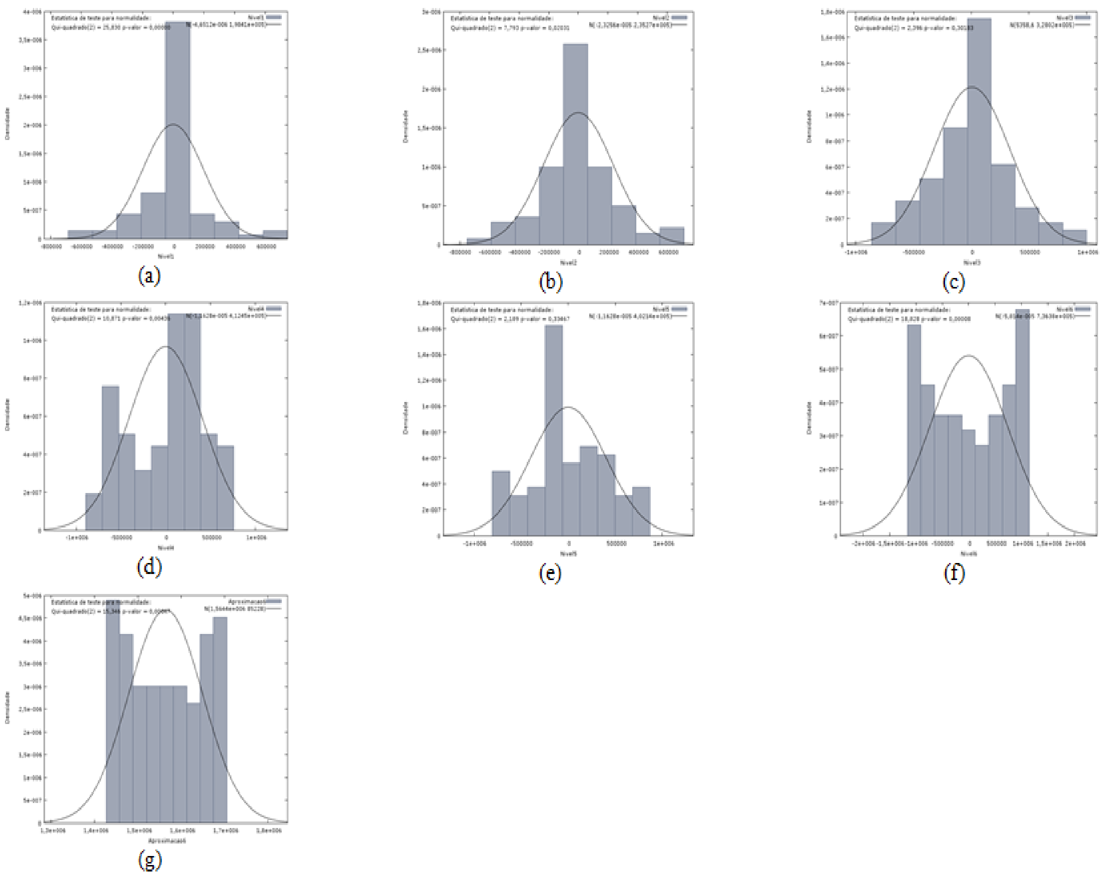

Figure 3: Frequency in each level.

Figure 3 shows the frequency distribution of each level analyzed. Figure 3 (a) represents level 1, Figure 3 (b) represents level 2 and so on up to the next level. Figure 3 (g) represents the approximation of the last level of decomposition. Levels 2 that were closest to the normal distribution were levels 2 (Figure 3 (b)) and 3 (Figure 3 (c)).

IV. Conclusion

The lowest level of the series referring to the area harvested from wheat in Brazil corresponds to level 6 (w6), that is, this level has the largest detail of the series analyzed.
With regard to energy, it was found that the highest concentration is located at level 6 (w6).
Coincidentally in the series (wheat harvested area in Brazil), the softer level is also the level with the highest energy.
All series obtained at each decomposition level are stationary.

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