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Fractional dynamic behavior in ethanol prices series

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ABSTRACT

Commodities have an increasing importance in international financial markets due to the cross effects between their equity patterns and their volatility. Brazil is one of the world's largest producers of ethanol that represents an important energy commodity. In this paper, several tools for investigating the Brazilian ethanol pricing mechanism are adopted, namely the Auto Regressive Integrated Moving Average, Auto Regressive Fractional Integrated Moving Average, Detrended Fluctuation Analyses, and the Hurst and Lyapunov exponents. The data series cover the period from 2010 up to the end of 2014, for the spot price composition, and 2015 for the future price prediction. The results suggest that the ethanol prices series is anti-persistent which implies that a low price level has a tendency to be followed by a high price level and vice versa. Furthermore, the effect of shocks to the price system dissipates in the long run.

1. Introduction

Brazil is an important international player in the ethanol market. Having in mind that fact, in this study we analyze the Brazilian ethanol pricing mechanism.

Knowing the importance of this product not only in the Brazilian economy, but also for the agents of the international chain, improving the methods of forecasting is of major relevance for economic and financial planning.

The use of renewable energies is a solid strategy to achieve sustainable development. The sources of renewable energies are undergoing a large-scale development and reliable technologies are already implemented. The Brazilian sugarcane ethanol is fully competitive with gasoline and its use was consolidated in Brazil by means of flex-fuel cars (i.e., gasoline/ethanol).

In the late 1970's, the Brazilian Federal Government defined the obligatory use of a mixture of anhydrous ethanol in gasoline (blends up to 25%) and encouraged car makers to produce engines running on pure hydrated ethanol (100%). The motivation was to reduce oil imports that was consuming one-half of the total amount of hard currency from exports. The decision was well accepted by the civil society, agricultural sector and car manufacturers and created a market for ethanol leading to a fast production growth [1].

In the end of 1990's, the Brazilian economy was affected by a large devaluation of its currency, the Brazilian Real, increasing the price of imported goods, such as the petroleum. At the same time, there was a significant decrease of the vehicles production propelled by ethanol and a stabilization of the demand. Under this scenario, the government created a company to acquire the oversupply of ethanol in the market, and tried to stimulate its consumption [2].

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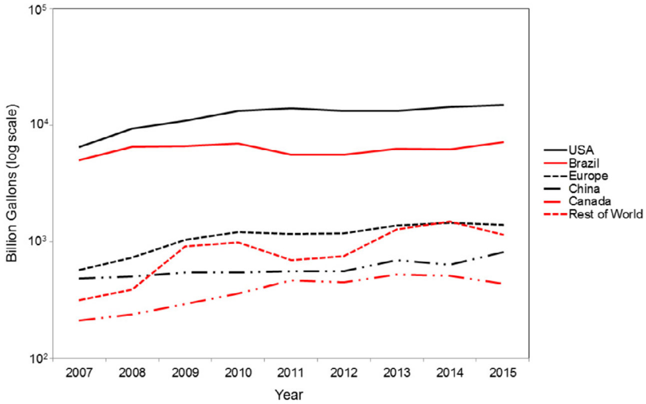

Fig. 1. Global fuel ethanol production by country.

In the 2000's, the sector experimented a considerable technological evolution. The flex-fuel technology allowed consumers to choose between the fuel to use in their vehicles. Such choice was now based on the relative price at the gas station and not only when buying the vehicle, as previously. This fact raised the ethanol production in this decade [3].

In the last years, the National Bank for Social and Economic Development (BNDES—Brazil) provided specific credit lines for the sugar, ethanol, and bioenergy industries, not only to support the investments on sugarcane production and the expansion of industrial capacity for sugar and ethanol, but also to promote the adoption of cogeneration, logistics, and multimodal transportation. The total ethanol production for 2016 in Brazil was approximately at 8.023 billion gallons, similar to the revised volume for 2015 (8.026 billion gallons). Together, U.S.A. and Brazil produce 85% of the world's ethanol, as illustrated in Fig. 1.

Most of the Brazil ethanol is produced from sugarcane. One of the main characteristics of agricultural activity is its inherent price instability, due to the price inelasticity of demand and the rigidity of short-term supply. This effect is related to the time lag between the decision of producing and the actual production.

According to [4], the spot price of ethanol in Brazil has a seasonal pattern. In the off-season, spanning the months from December to March, prices are high. As the year stretches and production gains force, prices tend to fall by mid-year, and from there begin to resume uptrend until the end of the season.

The price volatility of ethanol in consecutive years is associated primarily to the following factors: (i) quantity of production of sugarcane; (ii) percentage of sugarcane for the production of ethanol, that is, for the production mix; (iii) consumer income; (iv) number of the light commercial fleet vehicles; and (v) price of gasoline in view of the compulsory mixture of such kind of ethanol in gasoline sales.

To track this problem, we adopt several mathematical tools, namely the Auto-Regressive Fractionally Integrated Moving Average (ARFIMA), Detrended Fluctuation Analysis (DFA), and the Hurst (H) and Lyapunov (λ) exponents. This strategy will lead a novel perspective for analyzing the behavior of the Brazilian ethanol price series. The well known Auto-Regressive Integrated Moving Average (ARIMA) model is also considered for comparing results.

This paper is organized as follows. In Section 2, the time series (TS) is introduced and the adopted methods are presented. In Section 3, the results are discussed. Finally, in Section 4, the main conclusions are outlined.

2. The dynamics of financial time series

The market dynamics requires an accurate modeling for understanding its complex behavior [5–10]. Financial TS can present non-linear and non-Gaussian characteristics. The nonlinearity is due to the accumulated long-range dependence in the TS and a typical non-Gaussian modeling is the smoothing of a TS that has mean value in spite of exhibiting both abrupt and gradual changes [11–13]. Several tools have been adopted in the study of TS, namely the DFA [14], Lyapunov exponents [15,16], time frequency analysis (e.g., wavelets and Fractional Fourier Transform (FrFT)) [17,18], among others [19,20].

The analysis of commodities attracted considerable attention, due to the growth of its volatility in the international markets [21,22]. Statistical methods involving the fractional integration were used to investigate spot and futures prices [23,24]. However, energy commodity prices have some specificities such as temporary supply and demand imbalances. Besides, they are mean reverting [25] to the marginal cost of production and are affected by supply and demand shocks, as well as changes in the expectation of agents and unanticipated macroeconomics policy [26].

Real-world TS exhibit long-range dependence or persistence in their observations [27]. Besides, long-range dependency in a TS is indicative of non-stationarity because of persistence in the volatility [13]. The decision to model a TS either as stationary, or as non-stationary entails important consequences. A spurious result arises if a non-stationary series is modeled

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