Ethanol consumption in Brazil: Empirical facts based on persistence, seasonality and breaks

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ABSTRACT

This paper investigates the consumption of sugar cane ethanol in Brazil for the time period from January 2000 to December 2012. We examine ethanol and gasoline consumption along with the price ratio series. Two important features of the data are analyzed, in particular, its degree of persistence and the seasonality. The results show that the two series of consumption are fractionally integrated with orders of integration smaller than 1 implying that shocks in the series will disappear in the long run. On the other hand, the price ratio series displays an order of integration higher than 1 implying lack of mean reversion behavior. This suggests that strong policy measures must be adopted on prices in the event of shocks since they do not recover by themselves in the long run.

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1. Introduction

This study examines the dynamics of ethanol consumption in Brazil by taking into account two important features of the data: its degree of persistence and the seasonality.

By persistence we mean the time that is required for a shock to disappear completely. In other words, persistence is a measure of the extent to which changes in current market conditions lead to permanent future changes. The direct link between persistence analysis and policy implications is well explained in the literature [1]. In the event of an exogenous shock in the ethanol consumption series, it is important to know if the shock is going to have a permanent or a transitory effect. If the shock is transitory, there is no need for strong policy measures because the series will revert back to its

original trend in the future. On the other hand, if the shocks are expected to have a permanent effect, strong measures must be implemented. The way to discriminate between transitory and permanent shocks is by looking at the statistical properties of the data: if the series is stationary shocks are expected to be transitory, while if it is nonstationary (i.e. containing unit roots) shocks will be permanent. Traditionally, seasonal and non-seasonal unit root tests have been employed for this purpose. Seasonality is another characteristic of the ethanol consumption series which is defined as the repetitive and predictable movement around the trend. In this study, aggregated ethanol consumption data are analyzed in the case of Brazil. Furthermore, the stability of the parameters across the sample period is also investigated.

Previous studies on biofuels – ethanol included – and their regulatory and market-related aspects are rare; they include Refs. [2–5]. Specifically, with respect to the Brazilian case, Silva [2] investigated the market effects of the Brazilian biodiesel law, which made use of biodiesel, blended with petroleum diesel, mandatory in Brazil. Demand curves for diesel fuel (biodiesel and petroleum diesel) and the industry supply curve of biodiesel were also estimated in the paper.

There has been extensive research on Brazilian ethanol with a focus on history, economics, and possible energy policy/environmental implications [6–8]. However, so far, ethanol consumption in Brazil, has attracted little attention from researchers [9].

Research on ethanol consumption dealing with time series analysis includes for example, in the case of Brazil, Figueira et al. [10] who investigated GDP scenarios for Brazilian consumption of ethanol for the period 2006–2012. Their results show that if the country's GDP sustains an accelerated growth, Brazilian consumption of ethanol could reach the forecasted gasoline consumption. On the other hand, Marzhoughi and Kennedy [11] analyzed the impact of the introduction of greater quantities of ethanol in the motor gasoline market, estimating the U.S. gasoline demand and supply price elasticities.

In this paper we use fractionally integrated techniques that will be briefly described in Section 3. Other papers using these techniques in the context of energy-related data are Refs. [12–16]. The contribution of this study therefore, is in analyzing the statistical properties of Brazil ethanol consumption, using fractional integration techniques not previously applied to this particular product. The layout of the paper is the following: Section 2 provides some background information. Section 3 outlines the methodology, which is based on the concept of fractional integration. Section 4 presents the empirical results, while Section 5 contains some concluding comments.

2. Contextual setting

In Brazil, the crisis in the oil sector paved the way for ethanol consumption—a fuel made by fermenting sugar cane—to undergo a marked expansion, driven especially by the Programa Nacional do Álcool (PROÁLCOOL), which was set up in 1975 to replace the use of petroleum-based vehicle fuels with biofuels, thus reducing dependence on gasoline [17].

Specifically, ethanol produced in Brazil has a huge advantage over that produced in other countries and based on other crops: as sugar cane yields much more energy compared to corn or sugarbeet [18–20].

Since then, a range of incentives to use ethanol in motor vehicles have been enacted by the government. These include increases in agricultural production, the modernization and expansion of distilleries, and the construction of new plants. Not to be overlooked is the selective tax relief for reduced CO_2 emissions [21]. Despite the internal consumer market, growing environmental concerns around the world also constitute a strong indication that the external market will also experience growth in ethanol consumption [22–24]. Concerns with preservation of the environment have meant that many countries are looking to replace non-renewable energy sources with renewables. For example, according to Ref. [25], the use of ethanol in Brazil was responsible for 60% of the reduction of the total of carbon credits generated by fuel burning.

Yet, despite being comparatively knowledgeable of the benefits of ethanol, the Brazilian consumer still harbors certain misgivings regarding the replacement of gasoline. That is why in Brazil in the late 1980s, the growth of sugar exports—due to their higher prices on the international market—contributed to the rationing of production and marketing of ethanol and the ensuing price increase [26]. In order to mitigate risks of shortages, measures were implemented to ensure the sustainable expansion of ethanol consumption over the course of the decade [17–20,27]. Internationally, the best known of these are related to the development of vehicles with Flex-Fuel engines, that run on either gasoline or ethanol [28,29]. In parallel, a systematic effort was made to inform the Brazilian population concerning whether to refuel with one fuel to the detriment of another based on energy efficiency: if the price of ethanol exceeds 70% of the price of gasoline at the pump, on average it is more economical to use gasoline, otherwise ethanol is more economical.

As of 2008, however, gasoline prices began to be more rigorously controlled by the Government, the controlling partner of Petrobras. This subtle freezing of gasoline prices—despite the almost always upward fluctuations in the price of oil prices in the international market—has contributed to the systematic decline in the competitiveness of ethanol as an alternative fuel for the Brazilian consumer. That is why the ethanol industry, like the rest of the Brazilian economy, suffers from a chronic costs inflation of the order of 5% per year, on average, and this, sooner or later, is reflected in consumer prices. In this regard it is important to analyze the historical behavior and to assess the potential for future growth of gasoline and ethanol consumption in Brazil.

3. Methodology

Most economic time series have a nonstationary appearance and traditionally, there are two approaches to deal with this issue. On the one hand, the "*trend stationary*" representation assumes that a series can be approximated by a deterministic function of time (usually a linear function) under the assumption that the detrended series is stationary $I(0)$. On the