Are there Multiple Bubbles in the Ethanol-Gasoline Price Ratio of Brazil?[#]

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Abstract: This paper presents an analysis of ethanol-gasoline price ratio in Brazil from 2000 to 2012. Since 2008 Brazilian Government has artificially frozen gasoline prices while prices of ethanol to the consumer were still liberated. Considering that annual inflation in Brazil is around 5% per year and increase in costs is transferred to ethanol prices this explain why ethanol consumption decays while gasoline consumption boosts. In Brazil, consumers are often told that ethanol is more advantageous for refueling cars when such price ration is below 0.70. In this paper, we use right-tailed ADF tests, developed recently by Phillips et al., (2013), to check for bubbles in this ratio. The results obtained suggest the existence of two bubbles: one has already collapsed and the other is still on course since 2010. Policy implications are also derived.

JEL Codes: C15, C22, Q16, Q21

Keywords: Brazil; Bubbles; Ethanol-Gasoline Price-ratio; Right-tailed ADF tests.

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1. Introduction

This paper has the purpose to analyse the formation of a bubble in the ethanol-gasoline price ratio in Brazil, from 2000 to 2012. The difficulty in testing for the presence of bubbles lies in modeling its explosivity and labeling its occurrence. Traditional unit root and co-integration tests aimed at identifying such periods may not bear out the existence of bubbles when they are periodically collapsing. To overcome this problem, Phillips et al., (2013) developed a recursive right-tailed Generalized Sup Augmented Dickey-Fuller (GSADF) testing procedure to detect and date stamp mildly explosive pricing behaviour. This technique provides an efficient and consistent basis for identifying periods of mildly explosive departures from a unit root Data Generating Process (DGP), followed by reversion back to a martingale process. Such periods would then be labeled as bubbles. There are a few previous studies in Brazilian ethanol, including market related aspects as Goldemberg et al. (2004), Walter et al. (2008), Figueira et al. (2010), and Bastian-Pinto et al. (2010). Moreover, there are also other similar studies in US ethanol as Marzhoughi and Kennedy (2012), Du and Hayes (2012) and Anderson (2010). Therefore, this paper innovates because it analyses the Brazilian Government pricing policy for gasoline as an eventual driver for the formation of a bubble in the ethanol-gasoline price ratio. In addition, this paper uses for the first time right-tailed ADF tests in order to do so. The motivations for the present study are to explain the complex behaviour of the ethanol-gasoline price ratio in Brazil in light of certain governmental actions. Although there are several papers studying ethanol demand and production in the last years none paper uses this kind of statistical tool to explain its pricing to consumers.

The paper is structured as follows. After this introduction, the background on the sugarcane industry in Brazil is presented, discussing not only ethanol production in historical and present terms, but also governmental pricing policies and consumer preferences between ethanol and gasoline. Later the methodology will explain the data and right tailed ADF tests, followed by discussion of the results and the conclusion.

2. Background on the sugarcane industry in Brazil

In Brazil, ethanol for fuel is derived from sugarcane and is used pure or blended with gasoline in a mixture called gasohol (25% ethanol, 75% gasoline). A conjunction of factors in the mid-1970s led Brazil to adopt a large-scale ethanol program: heavy Brazilian dependence on fossil fuels at that time; the military government's concerns about national sovereignty; decreases in oil production by the Organization of the Petroleum Exporting Countries; and low prices of sugar, with the consequent possibility of bankruptcy by sugar industrialists. The series of measures adopted by the Brazilian government included subsides and protection from alcohol imports (Oliveira et al., 2005). There has been extensive research on Brazilian ethanol with a focus on history, economics and possible energy policy and environmental implication. A study draws on 47 published assessments that compare bio-ethanol systems to conventional fuel on a life cycle basis, or using life cycle assessment (LCA). A majority of these assessments focused on net energy and greenhouse gases, and despite differing assumptions and system boundaries, the following general lessons emerge: (i) make ethanol from sugar crops in tropical countries, but approach expansion of agricultural land usage with extreme caution; (ii) consider hydrolysing and fermenting lignocelluloses residues to ethanol; and (iii) the LCA results on grasses as feedstock are insufficient to draw conclusions (Blottnitz and Curran, 2007). Although economic competitiveness is a very frequent argument against renewable energy, the economies of scale and technological advances, achieved through the Brazilian experience with ethanol, lead to increased competitiveness of the ethanol alternative, reducing the gap with conventional fossil fuels (Goldenberg et al., 2004).

As a matter of fact, the sugarcane industry has experienced significant production growth cycle in Brazil in the last decade. The acceleration of investments in new plants, mainly from 2003, was driven by growth in sugar demand in the international market, especially after the reform of the European policy for the product, and the increasing use of ethanol, from the development of vehicles with Flex Fuel engines in the country. Moreover, there was the perspective of exporting the product to a growing number of countries that had chosen to add biofuels in their energy matrixes, primarily the United States and Europe, with the establishment of a biofuel policy in 2005. In response to such strong demand stimulus, the production of sugarcane has experienced a significant increase in the last decade, mainly in the period between cycles 2001/2002 and 2008/2009 year of global economic crisis. In this interval, the crop grew at a rate of 10.6% per year, reaching 573 million tons. From 2009/2010 until the harvest 2012/2013, there was not only a break with the pace presented so far, but also production has been negatively vary by 1% a year. After the global financial crisis of 2008, investments in the sector ceased and the expansion of sugarcane has been compromised, especially by the abrupt reduction of credit, which was abundant until then. As a result, most companies found themselves heavily indebted, a scenario that was enhanced by increased world supply of sugar. Notwithstanding, the costs of production in Brazil rose and, even with the recovery in prices of sugar and ethanol in 2009/2010 harvest, the unfavourable financial situation of most companies was far from being resolved. The sector began to experience a strong movement of mergers and acquisitions, while part of the milling sugarcane capacity increased to multinational companies, factors that significantly changed their profile. Furthermore, some of the companies that made acquisitions of highly indebted groups were surprised by a sequence of crops with serious weather problems. Adds to the unfavourable scenario the policy gap in gasoline prices practiced by the Brazilian Government in relation to the international market, which led to the deactivation and failure of a large number of plants. Since the 2008 crop, the industry lost a milling sugarcane capacity of 48 million tons of cane in the balance between the entry into operation of new units and the closure of others. Thus, this ability came in 2013, about 600 million tons in the South Central Region. The yield losses caused by the reduction in dealings with the sugar plantations, the age of the crop, mechanization and climate problems, began to be reversed in 2013/2014 harvest (Novacana, 2014).

In a universe of 435 ethanol and sugar mills in the Country, 44 were closed in the last 5 seasons and other 12 may finish the operations in 2014/2015, extinguishing 100.000 jobs. According to Brazilian Confederation of Agriculture (CNA), the debts of such companies are equivalent to the production value of one entire crop. More than 50 mills are in judicial recovery. The Sugarcane Agroindustry Union (UNICA) complements, saying that "the net average debt of ethanol companies exceeds the annual gross revenues"; in addition, almost 15% of revenue is committed to the payment of interests". This is the panorama from the sugar cane industry - and its main product, the ethanol fuel - has been neglected in energy policies. According to UNICA, biggest companies have already indicated the intention of leave the activity. "What attracts the entrepreneur is the profit, and for that happening again the sector have to resolve the issue of hydrated ethanol. Policies that define and maintain the participation of hydrated ethanol in matrix national fuels would solve 90% of problems of the segment. The anhydrous ethanol market is already regulated and inserted in the matrix of fuels in Brazil. To resolve the issue of hydrated ethanol the first rule is the transparency in the gasoline pricing. In other words, without a clear rule of how gasoline will behave over the coming decades, it is very difficult to invest in this market. From the knowledge of the pricing policy of Petrobras, UNICA defends a tax that differentiates the ethanol from gasoline, as was the case of CIDE (Contribution for Intervention in the Economic Domain). The tribute, which lasted until 2008, inserted BRL 0.28 per liter on selling gasoline by the refinery. The back of CIDE is the main demand of the ethanol sector (Novacana, 2014).

The results of a research that analyzed scenarios for Brazilian consumption of ethanol for the period 2006 to 2012, show that if the country's GDP sustains a 4.6% a year growth, domestic consumption of fuel ethanol could increase to 25.16 billion liters in this period. This is a volume relatively close to the forecasted gasoline consumption of 31 billion liters. At a lower GDP growth of 1.22% a year, gasoline consumption would be reduced and domestic ethanol consumption in Brazil would be no higher than 18.32 billion liters. Contrary to the current situation, forecasts indicated that hydrated ethanol consumption could become much higher than anhydrous consumption in Brazil. The former is being consumed in cars moved exclusively by ethanol and flex-fuel cars, successfully introduced in the country at 2003. Flex cars allow Brazilian consumers to choose between gasoline and hydrated ethanol and immediately switch to whichever fuel presents the most favorable relative price (Figueira et al., 2012). Moreover, a research has used a simultaneous equation system to determine the impact of ethanol fuel production on the U.S. motor gasoline market, especially gasoline prices. Based on estimation results, every billion gallon increase in ethanol production decreases gasoline prices by as much as 6 cents (Marzhoughi and Kennedy, 2012).

Despite this attention from policy makers, relatively little is known about household preferences for biofuels or the effect that ethanol mandates will have on gasoline markets. This information is critical for designing, implementing, and evaluating policies to promote ethanol and other biofuels (Anderson, 2011). Ethanol fuel in Brazil (E100) has approximately 34% less energy per unit of volume than gasoline. However, the cost-benefit of ethanol compared to gasoline is not only based on the molecular energy content. Engines using ethanol can benefit from the higher octane rating of this fuel (i.e. higher resistance to explosion), allowing them to perform more efficiently (Thuijl et al., 2003). This raises the performance of ethanol beyond the expected 66% of that of gasoline, which would correspond to the difference in pure energy contents. In average, E100 (pure ethanol) is considered to deliver 70% of the mileage of gasoline, for the same volume of fuel (Goettemoeller, 2007; MME, 2009). Under the already known hypothesis that the consumer decision is based on the cost-benefit of the fuel for a given moment in time, the criterion for choosing ethanol as opposed to gasoline leads to a price-ratio of 0.7. A relative price larger than 0.7 indicates that the usage of ethanol is not advantageous compared to gasoline, in terms of energy content. In this situation, the consumption of gasoline would allow more mileage per monetary unit than ethanol (CEPEA, 2010). Further, the dynamics of gasohol (mandatory blend of gasoline and ethanol) and ethanol prices operate in a symmetric manner over ethanol demand, thereby evidencing the increasing substitutability between these alternative fuels (Freitas and Caneco, 2011).

3. The right tailed ADF tests

The data used in this paper was collected from the Agência Nacional do Petróleo (ANP) website (www.anp.org.br). It provided information on average monthly prices in Brazil for gasoline and ethanol from January 2000 to December 2012. In this research, we used the ethanol-gasoline price ratio to perform right tailed ADF tests in accordance to what was previously explained in the industry background, that is, the decision for the consumer to use one type of fuel to the detriment of the other is based on price-ratio of 0.70.

Phillips, Wu, and Yu (2011, PWY hereinafter), Phillips and Yu (2011, PY hereinafter), Phillips, Shi, and Yu (2012, PSY hereinafter) and Phillips, Shi and Yu (2013) recently developed a convincing series of testing procedures to detect the exact bubble as well as its origination and collapse dates. These authors considered an ADF-type regression in a rolling window. More specifically, we consider an ADF regression for a rolling interval beginning with a fraction r_1 and ending with a r_2 fraction of the total number of observations, and hence the size of the window is $r_w = r_2 - r_1$. The econometric time series model at the root of PWY (2011) testing strategy can be written as follows:

$$y_t = m + \lambda y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \epsilon_t,\ \epsilon_t \sim iid\ N(0, \sigma^2\ ),\ t = 1, \dots., T. \qquad (1)$$

Eq. (1) defines the mildly-integrated root as specified in Phillips and Magdalinos (2007). Thus, PWY (2011) opted for a right-sided test. In more details, the usual null hypothesis $H_0: \lambda = 1$ is to be tested but PSY consider a right sided alternative $H_1: \lambda > 1$. The number of observations taken into account by (1) is $T_w = [r_w T]$ where [.] is the integer part. The ADF statistic corresponding to (1) is noted $ADF_{r_1}^{r_2}$.

As bubbles generally collapse periodically, it is frequently observed that the conventional unit root tests have limited power in detecting them. To overcome this shortcoming, PWY (2011) and PY (2011) suggest to use a recursive sequence of right-tailed ADF-type tests based on a forward expanding sample, and then, they proposed to consider the supremum (sup) of these. While Homm and Breitung (2012) argued that the test has a fairly efficient bubble-detection method in one or two bubble alternatives, PSY (2013) showed that although the PWY procedure consistently estimates the start date of the first bubble in any sample in case of two bubble alternatives, it may fail to identify the second bubble. This implies that in the presence of two bubbles, the second bubble may not be detected if it is dominated by the first bubble. This motivated PSY (2013) to formulate a backward sup ADF test where the endpoint of the subsample is fixed at a fraction r_2 of the whole sample and the window size is expanded from an initial fraction r_0 to r_2. The backward sup ADF statistic is defined as follows:

$$SADF_{r_2}(r_0) = sup_{r_1 \in [0, r_2 - r_0]} ADF_{r_1}^{r_2}. \qquad (2)$$

The generalized sup ADF (GSADF) is then constructed by repeatedly implementing the SADF test procedure for each $r_2 \in [r_0, 1]$. The GSADF can be written as follows:

$$GSADF(r_0) = sup_{r_2 \in [r_0,1]} SADF_{r_2}(r_0). \qquad (3)$$

4. Results and Discussion

Table 1 summarizes the results of the application of the ADF, SADF and GSADF tests on the ethanol-gasoline price ratio. Clearly, we can conclude from this table that this ratio exhibited an explosive behavior. Phillips et al. (2013) noted that the GSADF diagnostic outperforms the SADF test in detecting explosive behavior if there are multiple bubbles in the studied series and seldom gives false alarms, even in relatively modest sample sizes. As we can see from the previous section, the GSADF test covers more subsamples of the data and this justifies its outperformance.

Identifying explosiveness periods is ensured by comparing the calculated GSADF statistics to the corresponding critical values obtained from Monte Carlo replications on the partial sum of 1000 independent standard normal draws. The minimum size of the variable window widths are set to 36. We also used a fixed lag length of zero since PSY (2013) mentioned that considering more lags does not significantly change the results.

To rigorously date-stamp the starting and ending points of the bubbles, we then used the test GSADF which has recorded a bubble that began in June 2006 and which collapsed in March 2007. Also, this test has been able to pick up another bubble which began in June 2010 but which has not collapsed.[1] The results on both bubbles seem to corroborate empirical evidence. More precisely, this second, and more aggressive bubble, starts after the withdrawal of CIDE in 2008, making the price-ratio more favorable to gasoline.

[1] Interestingly, we obtained similar results based on the SADF recursive estimation as well. Further details on the SADF plot is available upon request from the authors. Further, using the Leybourne et al., (2007) test of changes in persistence, we observed that the series became non-stationary (*I(1)*) from stationary (*I(0)*) in November, 2005 or May, 2010 depending on whether we allowed the test to be conducted without trend or with trend. If we identify bubbles as a non-stationary process, as done in the extant literature on bubbles, the test then tends to detect only one bubble, generated earlier than detected by the GSADF test, and also suggests that the bubble has not collapsed yet.

However, the roots of the problem were in the government attempts to artificially hold fuel prices to "control" inflation since 2005. Freezing the price of gasoline at the pumps (in fact the real price fell, considered inflation) worked up until CIDE - the contribution on the importation and marketing of oil and oil products created to compensate Petrobras for price changes abroad - was withdrawn.

Table 1: Tests for Explosive Behavior in ethanol-gasoline price ratio

	Sample 2000 M01- 2012 M12		
	ADF	SADF	GSADF
	1.8928***	4.4806***	7.6041***
CV 1%	0.9551	1.9031	2.2795
CV 5%	0.0102	1.3164	1.8479
CV 10%	-0.3893	0.9396	1.5638

Notes: *** Indicates the significance level at 1%.. Critical values are obtained from Monte Carlo simulations with 1000 replications for the ADF, SADF and GSADF tests.

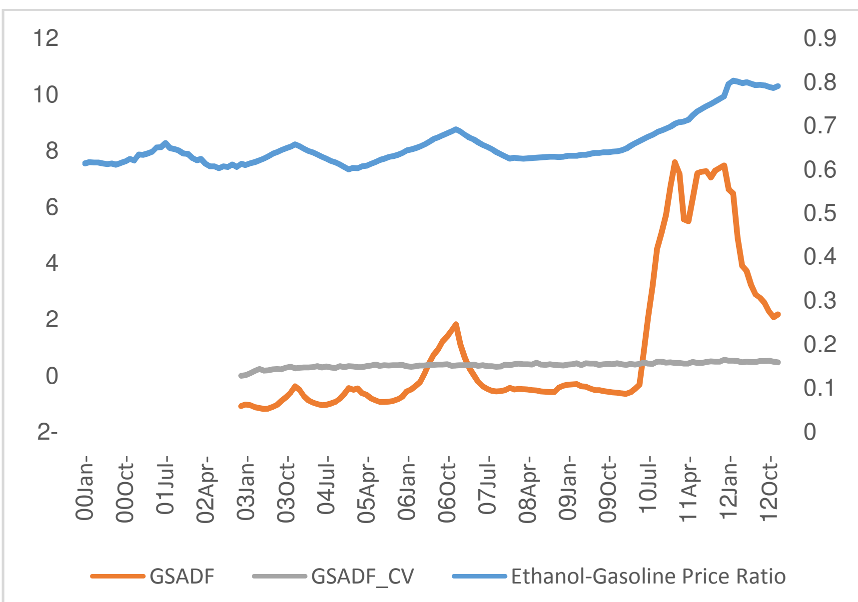

Fig. 1 GSADF statistics of ethanol-gasoline price ratio

Notes: *This graph shows the series of the* ethanol-gasoline price ratio *(blue) and its corresponding sequence of GSADF statistics (orange). The grey line represents the 5% GSADF critical values. The initial window size is set at 36 observations.*

5. Conclusions

This paper analysed the formation of a bubble in the ethanol-gasoline price ratio in Brazil, from 2000 to 2012, using right tailed ADF tests. Results found corroborate empirical and anecdotal evidence in the Brazilian sugarcane industry. The underlying problem, which impacts the entire biofuels sector and not only the ethanol sector, is the governmental policy of freezing prices of petroleum products, especially gasoline and diesel. Freezing gasoline prices not only weakens the Petrobras' investment capacity, but also depresses ethanol prices, depressing investments in new sugarcane crops and distillation plants. However, the restoration of price fluctuation of oil products to international standards does not return structural competitiveness the sugarcane sector. Developments in the global crisis could also download oil prices at lower levels than today, to justify the current level of fuel prices without enabling the business of ethanol.

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