



Energy production in Brazil: Empirical facts based on persistence, seasonality and breaks[☆]



Carlos P. Barros^{a,1}, Luis A. Gil-Alana^{b,*}, Peter Wanke^{c,2}

^a Instituto Superior de Economia e Gestão, Technical University of Lisbon and UECE (Research Unit on Complexity and Economics)

^b University of Navarra, Faculty of Economics, & I.C.S. (NCID), Edificio Biblioteca, Entrada Este, E-31080 Pamplona, Spain

^c COPPEAD Graduate Business School, Federal University of Rio de Janeiro, Rua Paschoal Lemme, 355 Rio de Janeiro, Brazil

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ABSTRACT

This paper investigates the statistical properties of the production of energy in Brazil using long range dependence techniques in monthly data from January 2000 to February 2013. Two important features of the data are analyzed, in particular, its degree of persistence and seasonality. The results indicate first that seasonality is an essential issue in modeling the persistence in energy production. Also, the persistence itself, measured in terms of the differencing parameter is relevant, with orders of integration in the series found to be positive though smaller than 1 and thus implying mean reversion. A single structural break is also found in two of the series. Policy implications of the results obtained are also derived.

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1. Introduction

Developing a strong understanding of the persistence and the seasonality of energy production is directly linked to the success and future energy production policy formulations (Barros et al., 2011). Persistence is a measure of the extent to which short term shocks in current market conditions lead to permanent future changes (Zhou et al., 2003). By a shock we mean an event which takes place at a particular point in the series, and which is not confined to the point at which it occurs. A shock is known to have a temporary or short term effect, if after a number of periods the series returns back to its original performance level (for example, energy production might increase due to energy demand, but drop back after the market demand is withdrawn). On the other hand, a shock is known to have a persistent or long term impact if its short run impact is carried forward to set a new trend in performance (for example, a persistence drop in energy production might result from an economic downturn, inflation, or change in exchange rates). Dekimpe and Hanssens (1995a, b) and Ouyang et al.

(2002) have provided a good summary on the importance of persistence analysis, especially in terms of its direct impact on policy implications. In fact, when energy producers have prior knowledge of the persistence behavior of energy sales they can reap the benefit of positive effects, or avoid the drawbacks of a negative effect. Depending on the degree of persistence, different policy measures can also be adopted, and this degree of persistence is determined by the model associated to the data (Smyth, 2013). For instance, in the case of a unit root, shocks will be permanent and the series will be very persistent. On the other hand, if the series is stationary, shocks will be temporary and the series will be mean reverting and less persistent than in the previous case (Lean and Smyth, 2013). In the context when the shock is positive and the series is mean reverting, strong policy measures must be adopted to maintain the series at the higher level. In the same way, if a shock is negative and the series contains, for instance, a unit root, the effect of that shock will be permanent, and again strong measures should be adopted to bring the series back to its original trend. On the other hand, if the series is mean reverting and the shock is negative, there is no need for strong policy measures since the series will return to its original trend sometime in the future.

In order to obtain accurate measurements of energy production persistence, it is also essential to take into account the seasonality of the series (Apadula et al., 2012). Traditionally, seasonal fluctuations have been considered as a nuisance that overshadow other important components of the series (Herrerias, 2013). If seasonality is not correctly handled, then the persistence of shocks is not correctly determined,

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^{*} Corresponding author. Tel.: +34 948 425 625; fax: 34 948 425 626.

E-mail addresses: cbarros@iseg.utl.pt (C.P. Barros), alana@unav.es (L.A. Gil-Alana), peter@coppead.ufjf.br (P. Wanke).

¹ Tel.: +351 213 016115; fax: +351 213 925 912.

² Tel.: +55 21 2598 98 00.

leading to misperceptions in the consequences of energy policies. Seasonality should be modeled according to the specific characteristics of the data (Bandyopadhyay, 2009). However, there is little consensus on how seasonality should be treated in empirical applications. In fact, as the statistical properties of different seasonal models are distinct, the imposition of one kind when another is present can result in serious bias or loss of information; thus it is useful to establish what kind of seasonality is present in the data (Hyllerberg, 1992). Seasonality can be modeled deterministically or stochastically. In the former case, seasonal dummy variables are employed and the seasonal component is supposed to be fixed across time. Stochastic seasonality usually occurs in economic data, including energy data, and this can be stationary or nonstationary (Chitnis and Hunt, 2012). If it is nonstationary, seasonal unit roots are generally adopted and they are based on the assumption that the seasonal component is changing across time.

In the present study, we are driven by the persistence and the seasonality in Brazilian energy production, and our aim is to provide a more advanced assessment of the persistence and seasonality of energy production (Wachsmann et al., 2009). We extend the existing literature by adopting fractional integration and autoregressive models to analyze the behavior in energy production previously analyzed by standard methods such as AR(1)MA models (Hanssens, 1998; Turner, 2000; etc.). Our models also incorporate both seasonal and non-seasonal structures in a unified treatment. While previous key studies in the area (Dekimpe and Hanssens, 1995a, b) focus on integer degrees of differentiation (usually 0 or 1), we permit here fractional values, allowing thus for a much richer degree of flexibility in the dynamic specification of the series. This is very relevant in the context of persistence since the fractional differencing parameter will be the indicator of the degree of persistence of series: the higher the value of the differencing parameter is, the higher the level of persistence of the series will be. Moreover, by estimating this parameter in the more flexible fractional range we obtain more precise estimates of the other parameters of the model such as the time trend coefficients and those dealing with the seasonality issue. Our interest is to determine whether energy production experiences heterogeneous persistence and seasonality patterns. This is crucial for policy formulation because in the case of a heterogeneous behavior future policies need to be flexible enough to account for such heterogeneity. The paper focuses on data from energy production in Brazil. Specifically, we proceed as follows: Firstly, we analyze the persistence behavior of energy production. We distinguish between short term and long term by means of the duration of the shocks, which is specified in terms of short memory and long memory processes. Secondly, we examine the univariate behavior of the series in terms of both fractional integration and autoregressions in order to assess whether the series present a persistent pattern over time. Using fractional integration we identify persistence in a continuous range between zero and one or even above 1, also taking into account the seasonality of the series.

The results can be summarized as follows: first we show that seasonality is a relevant issue in the modeling of energy production and its persistence. In fact, the series are found to be highly persistence with orders of integration positive but smaller than 1 implying mean reverting behavior. Thus, in the event of shocks as the recent one with a drop in oil prices, the series of energy production will recover by themselves in the long run, with little need of assistance to recover. The possibility of breaks is also examined and it is found a single break in natural gas and LGN production, but no breaks are found in the oil-related series. This is an interesting finding because differently from natural gas and LGN production, oil prices are strongly regulated by the Brazilian government, and have been kept under control over the last seven years. This, therefore, induces that production levels should remain steady, in order to catch up with increasing demand levels.

The outline of the paper is as follows: Section 2 presents the contextual setting. Section 3 briefly reviews the literature. Sections 4 and 5 describe the methodology and data employed in the paper. Section 6

is devoted to the persistence and seasonality results, while Section 7 contains the discussion and some concluding comments.

2. Contextual setting

Brazil is the ninth largest energy consumer in the world and the third largest in the Western Hemisphere, behind the United States and Canada (CIA, 2013). Total primary energy consumption in Brazil has increased by close to a third in the last decade, due to sustained economic growth. In addition, Brazil has made great strides in increasing its total energy production, particularly oil and ethanol (ANP, 2012). Increasing domestic oil production has been a long-term goal of the Brazilian government, and recent discoveries of large offshore pre-salt oil deposits could transform Brazil into one of the largest oil producers in the world (BRASIL, 2013).

Total Brazilian energy consumption grew to 13.6 quadrillion British thermal units (BTU) in 2010 (MME, 2011). The largest share of Brazil's total energy consumption comes from oil and other liquids (39%, including ethanol), followed by hydroelectricity (29%) and other renewables (21%). The other renewables category consists mostly of biomass, which is used extensively in both the residential and industrial sectors in Brazil. Natural gas represents 7% of the total amount (CIA, 2013).

According to MME (2011), Brazil has 14 billion barrels of proven oil reserves in 2012, the second-largest in South America, after Venezuela (EIA, 2012). The offshore Campos and Santos Basins, located off the country's southeast coast, hold the vast majority of Brazil's proven reserves. In 2010, Brazil produced 2.7 million barrels per day (bbl/d) of liquids, of which 75% was crude oil (ANP, 2012). Average liquid production in Brazil contracted slightly in 2011, with modest gains in crude oil production offset by a decrease in ethanol production stemming from a poor sugar cane harvest.

Most Brazilian oil is currently produced in the south-eastern region of the country in the Rio de Janeiro and Espírito Santo states (ANP, 2012; MME, 2011). More than 90% of Brazil's oil production is offshore in very deep water and consists of mostly heavy grades. Six fields in the Campos Basin (Marlim, Marlim Sul, Marlim Leste, Roncador, Jubarte, and Barracuda) account for more than half of Brazil's crude oil production. These Petrobras-operated fields each produce between 100,000 and 350,000 bbl/d.

Recent offshore exploration efforts in Brazil have yielded massive discoveries of pre-salt oil fields (CIA, 2013). Along with the potential to significantly increase oil production in the country, the pre-salt areas are estimated to contain sizable natural gas reserves as well (ANP, 2012). According to state-owned Petrobras, the Tupi field alone could contain between 5 and 7 trillion ft³ of recoverable natural gas, which if confirmed, could increase Brazil's total natural gas reserves by 50%. Brazil's pre-salt announcements immediately transformed the nature and focus of Brazil's oil sector, and the potential impact of the discoveries upon world oil markets is vast (BRASIL, 2013). However, considerable challenges must still be overcome in order to bring these reserves to fruition. The difficulty of accessing such reserves, given the tremendous depths and pressures involved with pre-salt oil production, represent significant technical hurdles that must be overcome. Further, the scale of the proposed expansion in production combined with strict local-content regulations will stretch Petrobras' exploration and production resources and Brazil's infrastructure.

In 2010 (ANP, 2010), the Brazilian government passed legislation instituting a new regulatory framework for the pre-salt reserves. For these reforms to be implemented, Brazilian legislators must first agree on a system for distributing royalties from the pre-salt oil. Currently, most oil production revenues accrue to the state and municipal governments of the oil-producing states of Rio de Janeiro, Sao Paulo, and Espírito Santo. Other Brazilian states are currently fighting for a greater share of the royalties from the pre-salt oil, and until this happens, Brazil's eleventh licensing round (which will predate the

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