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Heterogeneity, Aggregation and Long Memory in Lottery Sales: Some Empirical Evidence for Brazil*

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Abstract

The paper investigates the prevalence of long memory in terms of ARFIMA (p,d,q) models for lottery sales, as previous results in the econometric literature have suggested that aggregation of heterogeneous agents can potentially lead to a fractional differencing parameter consistent with highly persistent processes. Applications are considered for sales of 7 different lottery modalities in Brazil and also disaggregated at the level of federative units. The selected estimated models considered controls in terms of dummy variables for prize rollovers, special draws and weekends´ draws. The effects of rollovers and special draws on lottery sales are typically positive and non-negligible with an exception for the latter variable. In contrast, the effect of draws that take place at weekends are mixed and not always positive. As for the prevalence of long memory, with aggregate evidence for Brazil as a whole, it occurs only in the case of one modality. The evidence by federative units, on the other hand, is mixed and indicates contrasts that suggest heterogeneities across regions and lottery modalities. At a more exploratory level, the evidence obtained with a stacked sample suggest relevant effects accruing from income inequality and main lottery modalities on the probability of prevalence of highly persistent lottery sales, taking into account controls for regional heterogeneities. The initial evidence suggests that positional concerns may be relevant in the case of Brazil.

Keywords: lottery sales; long memory; Brazil

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1. Introduction

A salient phenomenon pertains to the fast expansion of gambling and prediction markets, as acknowledged, for example, by Paton et al (2009) in the context of the UK and Resce et al. (2019) in the case of Italy where an exponential growth has been recently observed following less restrict regulations.

In the case of lotteries, such tendency appears to prevail in different countries with a rapid dissemination of various modalities of lotteries that are likely to be facilitated by modern technologies. A growing econometric literature has emerged in connection to different aspects of demand as documented by Walker (1998), Ariyabuddhiphongs (2011) and Grote and Matheson (2012). However, the evidence mostly concentrates on developed countries, especially on the U.K. and on the U.S., with exceptions exemplified by Lima and Resende (2006) and Cardoso and Resende (2018) in the case of Brazil.

The literature on time series studies for lottery demand comprises studies in two basic strands. First, more traditional approaches focus on the expected value of the ticket, and the related effective price, as a key-variable with representative studies provided by Farrel et al. (1999) and Forrest et al. (2000a,b). Second, there are studies that conceive that sales and lottery demand cannot, given other control variables, be essentially related to the effective price of the lottery ticket. In fact, successive rollover of prizes can give rise to large jackpots and reduce the adherence of the lottery sales´ trajectory relative to the effective price ticket path. Those episodes are described, for example, in Beenstock and Haitovsky (2001) and Matheson and Grote (2004) in terms of abrupt increases of sales in the context of very large jackpots. However, Peel (2010) raised the necessity of

being cautious on assuming the prevalence of lotto mania, where in the limit, applied analyses would solely focus on the role of jackpots in demand estimations. In fact, the author argues that a more general utility setting, based on the cumulative prospect theory by Tversky and Kahneman (1992), could raise doubts on irrationality episodes associated with substantial jackpots. The analysis relied on simulated data generated upon a specific parameterization of the utility function and suggested that significance of jackpot size in the reduced form lottery sales equations reported in the literature may not reflect lotto mania. A general message is that betters´ rationality needs to be assessed upon more general utility structures.[1]

The previous remark does not rule out the relevance of proposing departures from analyses based on the expected value of the lottery ticket, even though one should not necessarily suggest as an alternative, the exclusive focus on the jackpot size for explaining lottery sales. A departure from the traditional analysis , centered around the expected ticket value, is provided by Forrest et al. (2002) who defend the plausibility of expanding the usual empirical models for lottery demand, so as take into account disruptive effects of large jackpots, following successive rollovers, on the demand pattern. Thus, one could postulate that the purchase of a lottery ticket could operate as an option for temporarily dreaming and therefore the purchase of a lottery ticket would mean “buying a dream”. Such remark can be relevant as one could envisage that different lottery modalities can potentially attract consumers with different profiles. In fact, it is not uncommon to observe that some groups of consumers appear to regularly engage in the purchase of several lottery modalities even with small jackpots involved and apparently addiction effects may be taking place and the short-run

[1] Conlisk (1993), for example, conceives an expected utility function that embodies a component that captures the pleasure of merely participating in a gambling activity that adds to the components that reflect probabilistic concerns.

perspective of potentially becoming a winner, despite the magnitude of the jackpot, appears to provide an enduring incentive for betting. In the limit, severe situations involving pathological gambling can emerge as overviewed in Lesieur and Rosenthal (1991) but even less severe conditions can prevail as indicated in the economic literature pertaining to rational addiction [see Becker and Murphy (1988)]. Thus, different persistence patterns by betters might be associated to different lotteries´ modalities. Such aspect has been scarcely addressed in the literature. An exception is provided by Lima and Resende (2006) that identified consistency with rational expectations only for the main number lottery modality in Brazil (*Mega-Sena*) but not for the second most important one (Quina).[2] Therefore, different persistence effects associated with distinct lottery modalities, that have demand more or less aligned with the effective price of the ticket, warrant additional investigations.

At first, it is possible to detect persistent effects in lottery sales and make the case for the existence of habits in lottery purchase decisions by means of significant coefficients for lagged sales as exemplified by Beenstock and Haitovsky (2001) for Israel and Forrest et al. (2000) for the UK. Furthermore, it is possible to detect relevant roles for some lagged sales in the instrumental variable procedures in the case of Farrel et al. (1999) for the UK and Cardoso and Resende (2018) for Brazil. Those results are suggestive in indicating habits in lottery purchases. However, even if one intuitively supposes that sort of behavioural pattern for individuals, it does not necessarily follow that aggregate sales would display strong persistence patterns. Byers et al. (2007) note that the aggregation of individual time series can lead to a fractionally differencing parameter that is consistent with long memory and illustrates with an application

[2] The paper followed the approach by Forrest et al (2000a) that only considered one major lottery modality in the UK.

for television audience data. The underlying motivations follow from technical results provided by Granger (1980) and Taqqu et al. (1997). In the former, the aggregation of individual time series with very heterogeneous weights can result in a fractionally differencing parameter, associated with long memory even if the individuals series are stationary I(0) series, whereas in the latter, aggregation upon binary individual series can lead to persistent patterns.

McHale and Peel (2010) were motivated by the aforementioned studies and investigated the prevalence of long memory for aggregated lottery sales in the UK. ARFIMA(p,d,q) models were estimated with a rollover dummy variable that captured situations when there were no winners for the main prize in the previous draw. The evidence indicated that the obtained fractional differencing parameters d were consistent with a long memory process. The study, however, focused only on the main lottery modality and with aggregate data from all the UK. Thus, the consideration of more spatially disaggregated data and also different lottery modalities can be potentially informative on the role of aggregation on long memory in the case of lottery sales.

The present paper aims at contributing in at least two aspects:

a) By testing for the presence of long memory in Brazil in terms of disaggregated data at the level of federative units and yet attempting to identify different patterns across 7 different lottery modalities. Moreover, this study intends to take advantage of the great heterogeneity observed in the Brazilian economy, that is plagued with one of the worst income inequalities in the world;
b) At an exploratory level, attempt to discern any pattern that relates persistence in sales with income distribution inequality at the federative units;

The remainder of the paper is organized as follows. The second section provides some basic background on lotteries in the case of Brazil. The third section provides a brief discussion on fractionally differenced ARFIMA models and their connection to long memory processes. The fourth section discusses the data sources and used variables and discusses the empirical results for different modalities of lotteries and different regions in Brazil. The fifth section discusses the possible role of positional concerns in the context of lotteries and undertakes an initial econometric estimation for Brazil. The sixth and final section brings some final comments.

2. Lotteries in Brazil: a Brief Background

State-managed lotteries have a long history in Brazil. In April 1970, the public bank *Caixa Econômica Federal* introduced a lottery modality based on football matches (*Loteria Esportiva* that would become popularly known as *Loteca*). Specific cases of single winners of large jackpots received large media coverage during the 70s, what was somewhat expected given the substantial income inequality in that economy. Since its outset, official lottery in Brazil became a significant form of voluntary taxation where some resources have pre-defined destinations (for example, to support sports).

Later, that referred modality would experience a steady decline in popularity since the 80s, following journalistic materials that had raised fraud possibilities.[3] Furthermore, the creation of number lotteries, similar to those existing in other countries, has largely substituted football bets. Variants of those earlier modalities do still exist but the involved money amounts and public interest are less

[3] In particular, it is worth mentiniong reportages from an influential sports´s magazine [see e.g. *Placar* no. 1.032-A, Editora Abril, March 1990, page 55].

significant.[4] The main modality of number lottery in Brazil is the *Mega-Sena* that initiated in March 1996 and given the larger prizes involved still attracts media coverage. In fact, when successive prize rollovers take place and a large jackpot emerges, it is common to observe TV interviews in streets asking what one would do in the case of winning the prevailing large jackpot. Table 1 summarizes the main characteristics of 7 lotteries´ modalities that are investigated in the present study, Over time some adjustments have taken place in different modalities and involved, for example, the creation of special draws in specific dates.[5]

INSERT TABLE 1 AROUND HERE

As previously mentioned, a central issue in the present paper is the assessment of the degree of persistence in lottery sales of different modalities and of the evidence on the prevalence of long memory processes, The next section briefly outlines the basic conceptual aspects on the related statistical models.

3. **Long Memory: Basic Aspects**

Persistence is often a salient feature in various economic settings. The class of Fractional ARIMA models (ARFIMA) naturally accommodates that feature by allowing a slower decay in the autocorrelation function. The ARFIMA (p,d,q) model advanced by Granger and Joyeux (1980) and Hosking (1981) can be summarized as:

$$\phi(L)(1-L)^d y_t = \theta(L)\varepsilon_t \ , \ \varepsilon_t \sim WN(0,\sigma_\varepsilon^2) \qquad (1)$$

where L denotes the lag operator, d the potentially fractional integration parameter, $\phi(L) = 1 - \phi_1 L - \phi_2 L^2 - ... - \phi_p L^p$, $\theta(L) = 1 - \theta_1 L - \theta_2 L^2 - ... - \theta_q L^q$.

Following a binomial expansion one has:

[4] The decline of the Brazilian dominance in the world scenario and the fact that the main players no longer play in Brazilian clubs may also have some role in the aforementioned trend,
[5] In particular, the special draw related to new year´s eve was created only in 2006.

$$(1-L)^d = 1 - dL + \frac{d(d-1)}{2!}L^2 + \frac{d(d-1)(d-2)}{3!}L^3 + \ldots \qquad (2)$$

One needs d < 0.5 for stationarity and d > - 0.5 for invertibility and a long memory process is characterized by d ≠ 0 and as indicated by Brockwell and Davis (1987) give rise to two possibilities: (i) for - 0.5 < *d* < 0 the process is antipersistent; (b) for 0 < *d* < 0.5 the process is persistent. Useful overviews on long memory processes are provided by Lardic and Mignon (1997) and Guégan (2005). The exact maximum likelihood estimation of such class of model is addressed in Sowell (1992) and Doornik and Ooms (2003). The estimator of the former work is implemented, for example, at the Eviews software that is used for the estimations in the present paper. The ARFIMA (p,d,q) models, discussed in the next section, are estimated for the log of sales for each lottery modality and considered dummy variables for prize rollovers, special draws and weekends´ draws.

The aforementioned effects of aggregation on long memory can be complex and significant heterogeneity on weights might be required.[6]

Finally, beyond a conceptual interest on the possible role of heterogeneity and aggregation in association to habit petterns in lotteries, more practical aspects may be relevant. In fact, the identification of a fractional parameter d consistent with long memory, could further motivate the use of fractional cointegration methods in de context of lottery sales estimation and forecast [see e.g. Davidson (2002) and Souza et al. (2018) for discussions on fractional cointegration].

4. Empirical Analysis

[6] On the other hand, Dittmann and Granger (2002) investigated the properties of nonlinear transformations of ARFIMA processes and have shown that the prevalence of long memory strongly depends on the stationarity status of the original series.

4.1 - Data

The essential data source for the present paper is the Brazilian public bank *Caixa Econômica Federal* (https://loterias.caixa.gov.br/Paginas/default.aspx) that explores different modalities of lotteries. Historical aggregate information on different modalities can be found with information on draws´ results, number of winners, rollovers and jackpots. For example for the main modality given by the *Mega-Sena* can be found as indicated below and analogous path can be found for other modalities by changing the name at end:

http://loterias.caixa.gov.br/wps/portal/loterias/landing/megasena/

The purpose of the present paper is to assess the existence of long memory processes for lottery sales highlighting the role of spatial aggregation and of different lottery modalities. However, disaggregated sales data by draw and federative units is not available at the site. Therefore, it was was necessary to request the data to the responsible segment (*Loterias Caixa*) through the information access law (*Lei de Acesso à Informação-LAI*). The description of the samples´s composition for the 7 studied modalities appears in Table 2.

INSERT TABLE 2 AROUND HERE

The sample period precedes the possibility of online betting that only started in 2018 and is still partially limited to clients that possess a bank account at *Caixa Econômica Federal*.

The general historical information available at the site allows to construct different dummy variables that assume value 1 under the referred event and 0 otherwise:

. ROLL: if in the previous draw no major win took place, and rollover occurred;

. WK: if the draw takes place in weekends;

And a series of dummy variables for special dates or situations:

. D05: if the draw number ends with 0 or 5 [*Mega-Sena*];

. DMV: if the draw takes place at new year´s eve (*Mega da Virada*) [*Mega-Sena*];

. DSJ: if the draw takes place at São João´s day (*Dia de São João*) [*Quina*];

. EASTER: if the draw takes place at easter (*Páscoa*) [*Dupla-Sena*];

. DIND: if the draw takes place at independence day (*Dia da Independência*) [*Lotofácil*];

A complementary data source is provided by the Brazilian statistical bureau [Instituto Brasileiro de Geografia e Estatística-IBGE] that allows to obtain data on income inequality based on household surveys [Pesquisa Nacional por Amostra de Domicílios (PNAD-IBGE)]. The last issue took place in 2016 with data for 2015. Then, it was substituted by the *PNAD Continua Anual* that is currently active. Data of the Gini inequality index for each federative unit can be found on an annual basis for 2012-2020 period at Table 7453 [see https://sidra.ibge.gov.br/tabela/7453]. [7]

4.2 – Empirical results

The empirical estimation results for the different selected models are reported in Tables A1 through A7 in the appendix. All estimations were carried out in Eviews and given a total of 27 federative units (26 states and Federal District), Brazil as a whole, 7 lottery modalities and ARFIMA models (for p and q ranging from 0 to 4), a total of 4900 models was estimated. The usual selection procedure based on Akaike´s information criterion (AIC) was considered for selecting the optimal autoregressive (AR) and moving average (MA) orders of

[7] Gini index for the average real income of people aged 14 years and over, usually received in all jbs, at average prices at the given year for the different federative units.

the model.[8] In a few cases, the minimization of the AIC statistic led to misbehaved models.[9] In those cases, to avoid invertibility violation, the second lowest AIC statistic was considered for selecting the orders of the ARFIMA model. Furthermore, it is important to preclude the possibility of serial correlations in the residuals of the selected models. However, usual test statistics like Box-Pierce or Ljung-Box [10], would be inappropriate not only for the presence of lagged dependent variable bur also due to the inclusion of dummy variables in the different estimated models of this paper [see Dezhbakhsh (1990)]. Thus, in order to gain additional confidence on the estimated results, residual autocorrelations were estimated for the selected models with orders up to 10. The evidence indicated very low values at most at the second decimal place and often at the third decimal place and therefore serial correlation of the residuals does not seem to be an issue.[11]

The complete disaggregated tables presented at the appendix display different AR and MA coefficients that will not have immediate interpretation. Thus, the focus of the inspection of the different tables will be on the identification of possible patterns of the coefficients related to the different dummy variables and on the presence of long memory as associated with the fractional differencing parameter d.

Table 3 summarizes the proportion of significant coefficients in different categories of dummies variables and also the prevalence of long memory, across different lottery modalities. All the analyses take as a reference a 5 % significance level

INSERT TABLE 3 AROUND HERE

[8] See Akaike (1974).
[9] Lotofácil (for Pará), Loteca (for Espírito Santo and Mato Grosso) and Lotogol (for Mato Grosso, Rio de Janeiro, Rio Grande do Sul, São Paulo and Brazil).
[10] Box and Pierce (1970) and Ljung and Box (1978).
[11] The obtained residual autocorrelations can be provided upon request.

When one considers the relevance of prize rollovers, the evidence is strong and indicates positive and significant effects in all federative units across all lottery modalities.

In the case of special draws, the evidence is similar to the previous variable with the sole exception of the *Dupla Sena* modality for which no significant effects on sales where observed during the Easter holiday, as indicated for some states in the Southeast and South regions in Brazil in accordance to Table A3.

In the case of the dummy variable for weekends, the effect is heterogeneous across federative units and lottery modalities. The effect is completely positive for the main modality (*Mega-Sena*) whereas smaller effects are observed for the *Quina* and *Dupla Sena* with more negligible effects in the latter modality. A closer inspection of the corresponding disaggregated tables A2 and A3 shows that no specific regional patterns appear to prevail and one can observe cases where negative and significant effects on lottery sales relate to weekend draws. In principle one could think that weekend draws could facilitate the participation of betters as for those that are active workers could have more available time at weekends. However, it is worth mentioning that is not uncommon to observe the presence of retired individuals in lottery stores that regularly place bets in several modalities in different week days and also some anticipated bets are possible with repetition of numbers for different draws. Moreover, the sample periods of the present study precedes the introduction of online bets in 2018.

Having commented on the significance of the coefficients associated with different control variables, one should focus on the central issue of this study in terms of the prevalence of long memory in lottery sales. First, consider the aggregate summary provided in Table 3. Even if one considers aggregate evidence for Brazil as a whole, evidence of long memory only appears for the

Dupla Sena modality. As for regional evidence, long memory prevails at most in approximately half of the federative units in the case of the *Quina*, *Dupla-Sena* and *Lotofácil* lottery modalities. Additional evidence on long memory at the regional level only emerged, at a smaller proportion, for the *Loteca* and *Lotogol* modalities. Thus, even though the evidence on long memory is mixed, the results are suggestive. In fact, region-specific and modality-specific patterns may suggest that different modalities may attract betters with different profiles that can relate, in part, to some salient regional characteristics. In particular, Brazil is plagued with one of the worst income distributions in the world and regional contrasts are not negligible. In the next section, the possible relevance of positional concerns in the case of lotteries is discussed at an exploratory level.

5. Positional Concerns and Lotteries: some Remarks

5.1- Related literature

In economies that are characterized by substantial income inequality, like in Brazil, it is plausible to conjecture the relevance of positional concerns by the agents. Thus, relative income standing can affect agents´ decision making in different contexts. At a more general level Pingle and Mitchel (2002) investigate relative-income concerns by means of a survey that asked hypothetical questions on labor market situations. The referred research method is not immune to criticisms of artificiality, but nevertheless it attempts to address some confounding aspects that may emerge in the assessment of positional concerns. Specifically, most of income would reflect a time allocation process directed towards labour at the expense of leisure and therefore some confusion could emerge between positional concern for income and positional concern for leisure. The survey evidence suggests that

a “follower behavior” would be more likely when confusion between positional concerns for income and leisure are possible than when only positional concern for income is possible, Therefore, effort for keeping current income status would partially reflect motivation for keeping current leisure status. The evidence, based on a logit regression, indicated that a positional concern for income was more likely among younger, more competitive, non-Caucasian, that express lower satisfaction with respect to perceived acceptance, and that are more satisfied with their religious achievement and yet by those who gambled more frequently. The latter aspect can pose a possible compensatory role for gambling when relative income concerns do prevail. Furthermore, it is worth mentioning that in an era of social media, positional concerns may be amplified as a stronger need for social acceptance may lead to stronger positional concerns for income.

Friehe et al. (2018) attempt to uncover more specific aspects related to positional income concerns. The authors take advantage of a detailed survey in terms of the 2008–2010 pretest modules of the *German Socio-Economic Panel* (SOEP) that includes information on the importance of income comparisons in terms of seven reference groups (coworkers, occupation, friends, age group, partner, parents and neighbours). The comparative question established an ordinal scale ranging from 1 to 7 in the degree of importance in terms of relative labour income. The main goal of the study was to relate the importance of particular reference groups to individual personality as approximated by the so-called *Big Five personality traits* (openness, conscientiousness, extraversion, agreeableness and neuroticism).[12] The respondents were requested to self-assess adjectives that would describe their personalities in accordance to an ordinal scale ranging from 1 to 7 in the degree of trueness. The five variables

[12] See Specht et al. (2014) for an overview.

pertaining to personality traits were constructed upon the standardization of the sum of the dimension-specific questions and intended to capture the intensity of the particular trait. The empirical analysis investigated the impact of the personality traits on the prevalence of positional income concerns. Additional demographic controls were included (gender, age and being a foreigner). The evidence indicated significant heterogeneities across different reference groups. Most respondents attributed some importance of other people in the same occupation as a relevant reference group in strong contrast with the reference group "neighbours" for which no relative income perception appeared to be pertinent. As for underlying personality traits, one can highlight agreeableness, conscientiousness and neuroticism as important correlates for positional income concerns, though the direction of the effect depends on the particular reference group. The results are suggestive if one considers, for example, the possibility of positional concerns in the context of gambling as it could be the case of modality-specific effects, as the different types may attract betters with distinct profiles and therefore more disaggregated analyses may be timely.

Haisley et al. (2008) investigated the role of relative-income concerns on the purchase of lottery tickets by considering two field experiments targeted at low-income participants. Respondents were approached at the Greyhound Bus Station in downtown Pittsburgh, PA and invited to participate in a short survey in exchange for a $ 5 payment. After initial questions about the city, there were random assignments of participants to different survey questions. In the sequence a lottery betting opportunity is offered upon the paid amount for responding the survey and the participants´ decisions are observed and demographic information is collected from all participants for control purposes and an ordered probit estimation is considered for assessing the effect of the experimental treatment.

Experiment 1 attempted to capture relative income induction as the random assignment could lead to a survey with less extreme income brackets (control group) or to extreme income intervals that would highlight the relative precarious income condition of the poorer (experimental group). The participants were more prone to purchase lottery tickets under a scenario with perceived low relative-income taking an implicit standard as a reference.

In experiment 2, that considered a different sample of participants, had the intention of assessing the potential role of lottery as a social equalizer. In the experimental condition, the survey asked questions on perceived relative advantages in the case of 8 different hypothetical outcomes interms of a rich person, middle class person, or poor person. In particular, the inclusion of a question on the chances of winning playing a slot machine aims at emphasizing an equal chance across diffferent income groups for that outcome and thus establish a contrast with other outcomes where some income groups are likely to possess relative advantages. The evidence from the econometric estimation, that considered demographic controls, indicated that participants purchased more lottery tickets when subject to situations in which rich people or poor people are perceived as having advantages.

Friehe and Mechtel (2017a.b) conceived a simplified utility setting where positional concerns are highlighted in terms of a separable total utility function for the representative household as indicated in the expression below:

$$T = u(x) + v(y) + gw(S) \qquad (3)$$

where x and y respectively denote the household's consumption levels of the positional and the nonpositional, whereas S represents relative standing. The marginal utility from an improvement in relative standing (w´(S)) is assumed to be positive and may be either decreasing or increasing. Furthermore, $g \geq 0$, in

the above expression, captures the intensity of positional concerns. The relevant distance is defined as a deviation to some mean reference $S = x - \bar{x}$ in line with some previous literature.[13] In the case of a fixed income with expected winning state probability given by (*1- p)* and B composing the winning scenario, and assuming a negative expected payoff, one can consider the following maximization problem for the household:

$$\max_{y_j, l} ET = p[u(I_N - y_N) + v(y_N) + g\,w(I_N - y_N - \bar{x})]$$
$$+ (1-p)[u(I_M - y_M) + v(y_M) + g\,w(I_M - y_M - \bar{x})] \qquad (4)$$

Note that the authors distinguish two different levels of available income left for consumption expenditures, depending on the particular state that emerges (the winning state M or the no win state N) and consider $x_j = I_j - y_j$ for j = M, N and assume that the consumption levels of the positional and non-positional goods can be determined conditional on the state of the nature. Under that setup, it is possible to obtain two salient results with interesting testable hypotheses. First, households who link more importance to relative standing are more likely to participate in gambling. Second, households' gambling expenditures will be the higher, the more importance they link to relative standing, when status utility w is sufficiently convex. Thus, the propositions indicate an relevant role of positional concerns in determining the likelihood of participation and the intensity of participation in gambling activities. An empirical application is considered with a consumer expenditure survey for Germany. The strength of households' positional concerns is proxied by expenditures in conspicuous consumption that, according to the authors, should be readily observable, leave the impression that those who consume more of them are, on average, better off regarding wealth than individuals who consume less of them, and portable

[13] See, for example, Card et al; (2012), Falk and Knell (2004) and Konrad and Lommerud (1993).

across a variety of interactions.[14] The econometric analyses consider demographic controls for the households (or the head of it) related to age, gender, educational level, number of children and adults, nationality, location (urban or not and yet if the location is in East Germany or not) and wealth-related (income, savings, wealth formation and whether is homeowner or not). The evidence appears to be consistent with both of the aforementioned propositions, as both the discrete choice logit model for gambling participation and the OLS econometric estimation referring to the intensity of gambling, *ceteris paribus*, appear to be positively associated with proxies reflecting positional concerns.[15] Possible shortcomings of the referred studies relates to the reliance on the household as the relevant decision unit and the consideration of gambling in general instead of specific modalities.

The previous mentioned studies either undertake a more aggregate approach for assessing gambling or focus on a particular lottery modality. However, a comparative perspective may be relevant if one expects that different types of lotteries may attract betters with different characteristics. Worthington (2001) analysed the role of demographic aspects on gambling expenditures that included household income, family composition, welfare status, gender, age, occupation, and ethnicity, by considering estimations from tobit models. The study, that had focused on a state lottery in Australia, suggested lottery-specific patterns. Furthermore, the incidence of gambling-type expenditures, *coeteris paribus*, indicate income regressivity of gambling expenditure. In particular, Lotto and Instant Lotto are the most regressive of the main lottery modalities

[14] Different expenditures within various goods´categories could fit that concept and refer to categories within motor vehicles; apparel; jewelry and watches; skin and body care; hosiery goods/headpieces; dental treatments and prostheses; furniture; valuable electronic household appliances; phones, TVs, radio sets, cameras; optical instruments; collections, art objects, music instruments; sporting and other leisure goods; food and drinks in restaurants and holidays.

[15] A two-step procedure takes into account sample selection does not appear to have been applied.

with regressivity patterns that would be stronger than similar modalities in the US. Worthington et al. (2007), undertook a similar approach to examine gambling expenditure patterns in connection to the aforementioned demographic aspects but now including a geographic location control, as the study does not concentrate on a state lottery. The main categories of gambling in Australia are considered and include also less traditional modalities [lottery tickets, lotto-type games and instant lottery (scratch cards), TAB (pari-mutuel betting) and related on course betting, and poker (slot) machines and ticket machines]. The contrasts across lottery modalities were significant and a salient result indicated that the source of household income is more important than the level of income and that household composition and regional location are both significant in explaining gambling expenditure.

Resce et al. (2019) undertake a disaggregated analysis on the income-related inequality in gambling. Even though no direct investigation is undertaken with respect to the role of positional income concerns, the disaggregated analysis by types of gambling can be informative. The authors make use of a detailed data source from the 2014-2017 waves of the *Italian Population Survey on Alcohol and other Drugs* (IPSAD) which also has information on different modalities of gambling. The starting point of the analysis relies on the rank-dependent inequality measure proposed by Erryegers (2009) and by taking as a reference three categories of gambling [traditional games (Scratchcards, Instant Lottery, Lotto, and Bingo); Betting (Football pools and Sport betting); New generation games (Slot machines and Texas hold'em - a poker variant)]. The initial, more descriptive, results indicate that traditional lotteries are concentrated among the richest individuals, whereas betting and new generation games tend to be modalities preferred by lower income betters. Furthermore, the study considers a regression-based decomposition procedure that suggest that pro-rich

inequality observed in traditional games is mostly determined by gender, age, and working condition. In contrast, the pro-poor inequality observed in betting and new generation games come are essentially explained by income and age. The authors emphasize that the rapid growth of gambling in Italy is largely associated with less traditional modalities for which the high addiction potential (for example in online gambling) can be especially deleterious in terms of less favoured income segments that can imply in significant financial difficulties and even in psychological disorders.

The brief summary of the related literature suggests that income inequalities can potentialize positional concerns. Thus, a possible natural step is assess whether those concerns for relative standing are more intense in some specific gambling modality.

5.2 – Long memory in lottery sales and income inequality: an empirical analysis

The present study intends to move further and consider, yet at an exploratory level, the aforementioned aspects by means of disaggregated data at the spatial level and by type of lottery. The Brazilian case is especially interesting as it is plagued with one of the worst income distributions in the world. Also, the analysis disaggregated by lottery modality might highlight different profiles for betters as associated with income distributions patterns that can influence persistence behaviors.

The empirical evidence in the preset study so far has relied on lottery-specific samples with a reduced number of spatial units (27 federative units). In principle one could conceive multi-level stacked models that intend to assess a global sample upon regional and lottery modality models. Those exist even in the case of non-strictly hierarchical setups [see Rasbash and Browne (2008)]. However, collinearities in the present data set at more disaggregated

levels and the aggregated level of the main control would obstacle the joint estimation of random and fixed effects associate to the different levels. [16]

Thus, at a more exploratory level, a stacked sample is considered for associating the prevalence of long memory in lottery sales at different federative units in different lottery modalities (LMEM assumes value 1 if so and 0 otherwise) to the income distribution inequality (as measured by the Gini index for the average real income at each federative unit level in terms of averages between the years of 2014 and 2017 that compose the samples).

Additionally, ore aggregated controls for the aforementioned levels of the data are considered in terms of dummy variables for macro-regions in Brazil [North (DNO), Northeast (DNE), Midwest (DMW), Southeast (DSE) and South (DSO)]. Furthermore, an aggregate dummy variable (DMQ) aims at establishing a contrast between the main modalities [*Mega-Sena* and *Quina*] with the remaining 5 modalities considered in the present study [the variable assumes value 1 in the case of those 2 modalities and 0 otherwise]. The inclusion of this dummy variable can also be motivated on the basis that those different groups of lottery modalities can, in principle, be associated with distinct levels of lottery sales persistence. In fact, it is plausible to conceive that betting as an option for "buying a dream" is more likely to prevail in the face of modalities where more substantial jackpots may emerge after prizes´ rollovers than in the case of systematically lower jackpots that would not sustain those temporary dreams. In the case of minor lottery modalities, such is not the case and probably the betting would seek short run thrills that not rarely can involve addiction and more persistent behaviors by betters.

[16] See Guo and Zhao (2000) for an overview of those models in the context of binary response data.

The corresponding results for the estimated probit model, with estimations carried out in Stata 16, are reported in Table 4.

INSERT TABLE 4 AROUND HERE

The evidence suggests a relevant role for regional heterogeneity and suggests that income inequality positively affects the predicted probability of observing highly persistent lottery sales and therefore can be consistent with the conjecture that the greater the income inequality, the greater can be the prevalence of positional concerns. Therefore, more significant inequalities (as approximated by a higher Gini index) could be inversely related to the probability of observing less persistent processes. The negative and significant coefficient of DMQ is suggestive as may indicate that the two major lottery modalities im Brazil (*Mega Sena* and *Quina*) could be associated with a smaller probability of observing highly persistent lottery sales as the larger jackpots accruing from successive rollovers could indicate different betters´ profiles in comparison to other types of lotteries that regularly provide smaller jackpots.

6. Final Comments

The paper aimed at testing for the existence of long memory in lottery sales in Brazil. The previous literature pointed out that the referred feature could emerge when one considers aggregated sales data upon heterogeneous agents. This study pursued a detailed analysis considering more spatially disaggregated data for different lottery modalities at the level of federative units in contrast with McHale and Peel (2010) that had only considered the UK as a whole for the main lottery modality.

The empirical analysis of the present paper, disaggregated at the level of federative units and by lottery type, allowed to detect heterogeneous patterns

associated with lottery sales. The most salient results and main focus of the paper related to the prevalence of long memory. Such pattern does not emerge uniformly across spatial units and lottery modalities and indicates that distinct types of lotteries may be attracting betters with different profiles. In particular, one cannot rule out the possibility that modalities, where substantial jackpots would occasionally emerge following successive rollover, should be contrasted with modalities that systematically provide smaller jackpots that would not be consistent with the idea of "buying a dream". Thus, different levels of heterogeneity of betters could, in principle, exert a role on the persistence of lottery sales. The tentative evidence based on the estimation of of a probit model upon the stacked sample indicates that the higher the income inequality within a federative unit (that could suggest positional concerns aspects), the lower the probability of prevalence of long memory in lottery sales and the main modalities appear to be associated with less persistent processes, Altogether, the preliminary evidence may be capturing the relevance of positional concerns and the role of the main lottery modalities as an attempt to leapfrog in status that would not be feasible with the other minor modalities.

The present study was a large scale and data-intensive study but clearly additional investigations are warranted. In Brazil, significant income inequality prevails even within municipalities. Thus, an avenue for future research could involve a similar study at the municipality level and therefore form samples with thousands of observations. However, beyond the gigantic task, it would be restricted by the Gini index that only would be available for that level of aggregation at the census year, should also the data on lottery sales at the

municipality level be made available.[17] An hypothetical study of that nature would allow univariate estimations of probit models by type of lottery with a large number of observations without relying on a stacked sample and potentially enable more precise conclusions.

Furthermore, it is worth mentioning that the present study investigated a time period that preceded the possibility of online betting and in addition to that, the increased diffusion of different forms of social media may potentially exacerbate the role of positional concerns in the context of lotteries. Therefore, the study of the role of social media in relation to lotteries might raise different research questions.

Finally, it is worth noting that beyond the academic interest on lottery sales, one cannot disregard possible negative aspects that may be associated with persistent behaviors. In particular, Resce et al. (2019) had warned about possible addicting patterns especially in connection with more recent online gambling modalities following the recent rapid expansion in Italy. Given the possible negative social costs involved, one needs to exercise care in terms of regulatory design in the case of the creation of new lottery modalities.

[17] Last census took place in 2010.

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Table 1

Description of the different modalities of lotteries in Brazil

Modality	Description
Mega-Sena	One can choose from 6 to 15 numbers upon a total of 50 numbers. Six numbers are drawn and there are prizes for 6, 5 and 4 correct numbers. In the event of no main prize, rollovers are accumulated for later draws with specific rules for draws ending in numbers 0 or 5. Draws take place twice a week, typically on wednesdays and saturdays (with exceptions of occasional holidays). A special draw takes place at new year´s eve
Quina	One can choose from 5 to 15 numbers upon a total of 80 numbers. Five numbers are drawn and there are prizes for 5, 4, 3 and 2 correct numbers. When there is no winner there is a rollover to the respective range in the next draw. However, if that occurs at all prize ranges, there will be a rollover only for the first range (5 correct numbers). Also, a proportion is reserved for a special date draw (*São João*). Draws take place six times a week, from monday to saturday.
Dupla Sena	One can choose from 6 to 15 numbers upon a total of 50 numbers. There are prizes for 6, 5, 4 or 3 numbers. When there is no winner t is a rollover to the range of 6 correct numbers in the next draw. Moreover, a proportion is allocated to a special draw (*Easter*). Draws take place three times a week on Tuesdays, thursdays and saturdays
Lotofácil	One can choose from 15 to 18 numbers. Fifteen numbers are drawn and there are prizes for 15, 14, 13, 12 or 11 correct numbers. When there is no winner there is a rollover for the first range (15 correct numbers) of the next draw and yet a proportion is reserved for a special draw (*Lotofácil da Independência*). Draws take place three times a week, on mondays, wednesdays and fridays.
Timemania	One can choose 80 numbers and football team that will benefit. Seven numbers and a football team are drawn. There are prizes for 7, 6, 5, 4 or 3 correct numbers or for the correct team. When there is no winner the value is accumulated as a rollover to the next draw to the 7 numbers´ range. Moreover, a proportion is allocated to draws ending in number 0 or 5, Draws take place three time a week on tuesdays, thursdays and saturdays
Loteca	One faces 14 football matches and must indicate the winning team or the occurrence of a draw. In the most basic bet it is possible to select two options in one of the 14 matches. Similarly, it is possible to have extra double or triple choices by means of more expensive bets. There are prizes for 14 and 13 correct results. When there is no winner there is a proportion that is carried as a rollover to draws ending in numbers 0 or 5. Draws take place once a week.
Lotogol	One can choose the results of 5 football matches with the indication of 0, 1, 2, 3 or more goals. There are prizes for 5, 4 and 5 correct results. When there is no winner, the amount is accumulated to the respective prize range in the next draw. Draws take place once a week in accordance with the specified days of the matches.

Source: author´s elaboration upon information from Caixa Econômica Federal

Table 2

Samples for different lottery modalities

Modality	**Total number of draws**	**Time period**
Mega Sena	327	03/09/2014-12/08/2017
Quina	893	01/09/2014-30/08/2017
Dupla Sena	376	02/09/2014-29/08/2017
Lotofácil	455	07/09/2014-28/08/2017
Timemania	455	04/09/2014-29/08/2017
Loteca	141	06/10/2014-28/08/2017
Lotogol	280	03/09/2014-30/08/2017

Table 3

Estimated coefficients´ significance for different lottery modalities – summary results

Significant coefficients	**Lottery modality**						
	Mega Sena	**Quina**	**Dupla Sena**	**Lotofácil**	**Timemania**	**Loteca**	**Lotogol**
% across federative units (rollover)	100	100	100	100	100	100	100
Brazil (rollover)	yes	yes	yes	yes	yes	yes	yes
% across federative units (special draws)	100	100	77.78	100	does not apply	does not apply	does not apply
Brazil (special draws)	yes	yes	yes	yes	does not apply	does not apply	does not apply
% across federative units (weekends)	100	70.37	18.52	100	51.85	does not apply	does not apply
Brazil (weekends)	yes	no	no	yes	no	does not apply	does not apply
% across federative units (for which long memory prevails)	0	48.15	48.15	44.44	0	25.93	3.70
Brazil (long memory)	no	no	yes	no	no	no	no

Table 4

Probit model with stacked sample (N =189), dependent variable: LMEM

Variable	Coefficient	Marginal Effect
GINI	-0.645 (0.046)	-0.199 (0.044)
DNO	-0.322 (0.029)	
DNE	-0.607 (0.000)	
DMW	-0.214 (0.012)	
DSE	-0.252 (0.537)	
DSO	-0.371 (0.000)	
DMQ	-0.027 (0.028)	

Notes: p-values presented in parentheses; underlying standard errors clustered by taking as a reference the lottery modality in terms of DMQDS

Appendix

Table A1

Estimation results for the ARFIMA (p,d,q) model – Mega Sena

Federation	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	WK	D05	DMV	d
Acre	10.778 (0.000)	-0.297 (0.073)	0.528 (0.000)	-	-	0.946 (0.000)	-	-	-	0.607	0.444 (0.000)	0.111 (0.000)	0.168 (0.000)	3.221 (0.000)	0.076 (0.609)
Alagoas	12.280 (0.000)	-1,254 (0.000)	0.330 (0.240)	0.632 (0.000)	-	1.984 (0.863)	1.000 (0.931)	-	-	0.474	0.401 (0.000)	0.163 (0.000)	0.113 (0.001)	3.229 (0.000)	-0.019 (0.903)
Amapá	10.649 (0.000)	-0.931 (0.000)	0,828 (0.000)	0.863 (0.000)	-	2.147 (0.000)	1.462 (0.000)	0.292 (0.009)	-	0.665	0.445 (0.000)	0.121 (0.000)	0.136 (0.000)	3.337 (0.000)	-0.538 (0.000)
Amazonas	12.418 (0.000)	-1.210 (0.000)	0.301 (0.295)	0.580 (0.000)	-	1.897 (0.000)	0.966 (0.000)	0.050 (0.642)	-	0.709	0.494 (0.000)	0.190 (0.000)	0.143 (0.000)	3,298 (0.000)	0,010 (0.950)
Bahia	13.972 (0.000)	0.701 (0.000)	-0.049 (0.748)	-0.811 (0.000)	0.520 (0.001)	-0.068 (0.993)	0.029 (0.997)	0.952 (0.988)	-	0.634	0.401 (0.000)	0.136 (0.000)	0.122 (0.001)	3,673 (0.000)	0.028 (0.865)
Ceará	13.260 (0.000)	0.709 (0.000)	-0.060 (0.728)	-0.797 (0.000)	0.532 (0.001)	-0.079 (0.984)	0.033 (0.993)	0.944 (0.976)	-	0.618	0.437 (0.000)	0.136 (0.000)	0.143 (0.000)	3.268 (0.000)	-0.015 (0.930)
Espírito Santo	13.390 (0.000)	0.702 (0.000)	-0.080 (0.489)	-0.785 (0.000)	0.501 (0.000)	-0.070 (0.991)	0.022 (0.997)	0.954 (0.986)	-	0.660	0.456 (0.000)	0.116 (0.000)	0.177 (0.000)	3.277 (0.000)	0.053 (0.742)
Goiás	13.775 (0.000)	0.716 (0.000)	-0.071 (0.581)	-0.808 (0.000)	0.522 (0.000)	-0.067 (0.987)	0.028 (0.994)	0.953 (0.978)	-	0.561	0.431 (0.000)	0.082 (0.000)	0.143 (0.000)	3.484 (0.000)	0.031 (0.850)
Maranhão	12.624 (0.000)	0.864 (0.000)	-0.099 (0.404)	-0,785 (0.000)	0.641 (0.000)	-0.062 (0.987)	0.019 (0.996)	0.960 (0.977)	-	0.744	0.416 (0.000)	0.116 (0.000)	0.113 (0.008)	3.525 (0.000)	-0.181 (0.373)
Mato Grosso	13.100 (0.000)	1.431 (0.035)	-0.454 (0.450)	-	-	-	-	-	-	0.504	0.425 (0.000)	0.049 (0.022)	0.135 (0.000)	3.403 (0.000)	-0.706 (0.299)
Mato Grosso do Sul	13.099 (0.000)	0.688 (0.000)	-0.080 (0.510)	-0.808 (0.000)	0.504 (0.000)	-0.059 (0.291)	0,026 (0.643)	0.947 (0.000)	-	0.563	0.430 (0.000)	0.090 (0.000)	0.134 (0.000)	3.250 (0.000)	0.095 (0.532)
Minas Gerais	14.960 (0.000)	0.672 (0.000)	-0.069 (0.558)	-0.806 (0.000)	0.488 (0.000)	-0.067 (0.893)	0.023 (0.858)	0.955 (0.985)	-	0.477	0.385 (0.000)	0.095 (0.000)	0.134 (0.000)	3,301 (0.000)	0.080 (0.591)
Pará	13.110 (0.000)	-1.286 (0.000)	0.173 (0.545)	0.531 (0.000)	-	1.912 (0.000)	0.991 (0.000)	0.056 (0.632)	-	0.651	0.434 (0.000)	0.136 (0.000)	0.112 (0.002)	3.509 (0.000)	0.072 (0.594)

Paraíba	12.302 (0.000)	-1.317 (0.000)	0.136 (0.657)	0.529 (0.001)	-	1.929 (0.000)	1.024 (0.000)	0.065 (0.580)	-	0.420	0.395 (0.000)	0.156 (0.000)	0.104 (0.001)	3.212 (0.000)	0.102 (0.466)
Paraná	12.148 (0.000)	1.468 (0.378)	-0.528 (0.671)	-	-	-0.766 (0.563)	-	-	-	0.543	0.432 (0.000)	0.070 (0.006)	0.135 (0.001)	3.445 (0.000)	-0.083 (0.822)
Pernambuco	13.337 (0.000)	0.703 (0.000)	-0.062 (0.676)	-0.807 (0.000)	0.509 (0.001)	-0.075 (0.985)	0.025 (0.995)	0.951 (0.977)	-	0.554	0.386 (0.000)	0.140 (0.000)	0.125 (0.000)	3.334 (0.000)	0.021 (0.894)
Piauí	12.159 (0.000)	0.681 (0.000)	-0.048 (0.632)	-0.827 (0.000)	0.536 (0.000)	-0.052 (0.985)	0.014 (0.996)	0.967 (0.977)	-	0.700	0.420 (0.000)	0.070 (0.003)	0.136 (0.001)	3.449 (0.000)	-0,010 (0.951)
Rio de Janeiro	14.963 (0.000)	0.542 (0.001)	-0.058 (0.711)	-0.805 (0.000)	0.364 (0.013)	-0.088 (0.980)	0.032 (0.992)	0.941 (0.973)	-	0.587	0.412 (0.000)	0.086 (0.000)	0.137 (0.000)	3.077 (0.000)	0.202 (0.106)
Rio Grande do Norte	12.318 (0.000)	0.719 (0.000)	-0.097 (0.590)	-0.767 (0.000)	0.501 (0.001)	-0.091 (0.987)	0.047 (0.993)	0.932 (0.982)	-	0.478	0.372 (0.000)	0.143 (0.000)	0.117 (0.001)	3.282 (0.000)	0.020 (0.906)
Rio Grande do Sul*	14.358 (0.000)	-0.315 (0.028)	0.543 (0.000)	-	-	0.962 (0.000)	-	-	-	0.328	0.386 (0.000)	0.113 (0.000)	0.125 (0.000)	2.936 (0.000)	0.114 (0.390)
Rondônia	12.245 (0.000)	0.669 (0.000)	-	-	-	-	-	-	-	0.615	0.444 (0.000)	0.063 (0.005)	0.146 (0.000)	3.546 (0.000)	0.054 (0.754)
Roraima	10.642 (0.000)	0.603 (0.000)	-	-	-	-	-	-	-	0.544	0.396 (0.000)	0.045 (0.041)	0.106 (0.002)	3.375 (0.000)	0.114 (0.446)
Santa Catarina	13.973 (0.000)	-1.374 (0.000)	-0.013 (0.966)	0.538 (0.004)	-	1.988 (0.000)	1.169 (0.000)	0.154 (0.186)	-	0.323	0.394 (0.000)	0.135 (0.000)	0.126 (0.000)	3.160 (0.000)	0.170 (0.147)
São Paulo	15.988 (0.000)	-1.333 (0.000)	0.171 (0.482)	0.525 (0.001)	-0.021 (0.752)	1.984 (0.895)	1,000 (0.947)	-	-	0.533	0.455 (0.000)	0.132 (0.000)	0.138 (0.001)	3.325 (0.000)	0.140 (0.278)
Sergipe	11.973 (0.000)	0.690 (0.000)	-0.084 (0.667)	-0.777 (0.000)	0.479 (0.002)	-0.092 (0.896)	0.051 (0.944)	0.929 (0.456)	-	0.545	0.399 (0.000)	0.130 (0.000)	0.126 (0.000)	3.472 (0.000)	0.083 (0.593)
Tocantins	11.731 (0.000)	-0.549 (0.450)	1.290 (0.096)	0.521 (0.307)	-0.388 (0.510)	1.983 (0.000)	0.999 (0.000)	-	-	0.628	0.462 (0.000)	0.079 (0.000)	0.132 (0.000)	3.531 (0.000)	-0.689 (0.340)
Distrito Federal	13.929 (0.000)	-1.772 (0.000)	-0.181 (0.646)	1.215 (0.000)	0.577 (0.000)	2.737 (0.000)	2.607 (0.000)	0.857 (0.000)	-	0.700	0.522 (0.000)	0.106 (0.000)	0.187 (0.000)	3.169 (0.000)	0.189 (0.313)
Brazil	17.188 (0.000)	0.665 (0.000)	-0.082 (0.526)	-0.794 (0.000)	0.469 (0.001)	-0.073 (0.987)	0.031 (0.994)	0.948 (0.980)	-	0.518	0.418 (0.000)	0.105 (0.000)	0.138 (0.000)	3.270 (0.000)	0.108 (0.447)

Table A2

Estimation results for the ARFIMA (p,d,q) model – Quina

Federation	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	WK	DSJ	d
Acre	9.236 (0.000)	1.046 (0.000)	-1.172 (0.000)	0.296 (0.000)	-	-0.734 (0.000)	0.983 (0.000)	-	-	-0.587	0.279 (0.000)	-0.044 (0.003)	2.214 (0.000)	0.241 (0.000)
Alagoas	10.569 (0.000)	1.739 (0.000)	-0.872 (0.000)	-	-	-1.685 (0.000)	0.752 (0.000)	0.044 (0.348)	-	-0.245	0.242 (0.000)	0.053 (0.011)	2.345 (0.000)	0.350 (0.000)
Amapá	8,910 (0.000)	1.785 (0.000)	-0.909 (0.000)	-	-	-1.763 (0.000)	0.866 (0.000)	-	-	-0.134	0.306 (0.000)	-0.046 (0.020)	2.471 (0.000)	0.450 (0.000)
Amazonas	10.674 (0.000)	1.145 (0.000)	-1.217 (0.000)	0.337 (0.000)	-	-0.786 (0.000)	0.976 (0.000)	-	-	-0.115	0.368 (0.000)	0.019 (0.318)	2.405 (0.000)	0.135 (0.066)
Bahia	12.753 (0.000)	-0.929 (0.000)	-	-	-	1.241 (0.000)	0.487 (0.000)	0.283 (0.008)	0.126 (0.033)	-0.390	0.266 (0.000)	0.084 (0.000)	2.324 (0.000)	0.101 (0.096)
Ceará	11.393 (0.000)	-0.426 (0.001)	-0.489 (0.0000	0.468 (0.000)	-	0.865 (0.000)	0.927 (0.000)	-0.042 (0.533)	-	-0.174	0.352 (0.000)	0.018 (0.320)	2.320 (0.000)	0.095 (0.288)
Espírito Santo	11.781 (0.000)	1.399 (0.000)	0.346 (0.008)	-1.386 (0.000)	0.503 (0.000)	-0.910 (0.000)	-0.762 (0.000)	0.946 (0.000)	-	-0.242	0.373 (0.000)	-0.008 (0.668)	2.359 (0.000)	0.083 (0.406)
Goiás	12.373 (0.000)	0.459 (0.000)	-	-	-	-	-	-	-	-0.386	0.330 (0.000)	-0.117 (0.000)	2.251 (0.000)	0.124 (0.122)
Maranhão	11.288 (0.000)	-	-	-	-	0.416 (0.000)	0.240 (0.000)	0.164 (0.000)	-	-0.312	0.274 (0.000)	-0.041 (0.021)	2;232 (0.000)	0.052 (0.225)
Mato Grosso	11.546 (0.000)	1.186 (0.000)	-0.773 (0.000)	1.131 (0.000)	-0.895 (0.000)	-1.132 (0.000)	0.733 (0.000)	-1.171 (0.000)	0.886 (0.000)	-0.138	0.342 (0.000)	-0.138 (0.000)	2.345 (0.000)	0.406 (0.000)
Mato Grosso do Sul	11.423 (0.000)	0.275 (0.000)	0.052 (0.124)	-0.028 (0.565)	-0.075 (0.122)	-	-	-	-	-0.321	0.335 (0.000)	-0.070 (0.000)	2.342 (0.000)	0.264 (0.000)
Minas Gerais	13.518 (0.000)	1.194 (0.000)	0.484 (0.015)	-1.168 (0.000)	0.304 (0.000)	-0.856 (0.000)	-0.742 (0.000)	0.860 (0.000)	-	-0.542	0.288 (0.000)	-0.075 (0.000)	2.266 (0.000)	0.186 (0.017)
Pará	11.491 (0.000)	-0.190 (0.015)	1.577 (0.000)	-0.039 (0.620)	-0.839 (0.000)	0.245 (0.005)	-1.564 (0.000)	-0.063 (0.447)	0.792 (0.000)	-0.187	0.315 (0.000)	-0.043 (0.034)	2.284 (0.000)	0.358 (0.000)

Paraíba	10.667 (0.000)	-0.103 (0.000)	-0.965 (0.000)	-	-	0.373 (0.000)	1.153 (0.000)	0.301 (0.000)	0.170 (0.002)	-0.428	0.285 (0.000)	0.044 (0.009)	2.258 (0.000)	0.148 (0.001)
Paraná	12.742 (0.000)	0.436 (0.000)	-	-	-	-	-	-	-	-0.288	0.364 (0.000)	-0.016 (0.303)	2.422 (0.000)	0.162 (0.021)
Pernambuco	11.547 (0.000)	1.291 (0.000)	0.440 (0.007)	-1.297 (0.000)	0.398 (0.021)	-0.959 (0.000)	-0.718 (0.000)	0.984 (0.000)	-0.047 (0.655)	-0.380	0.295 (0.000)	0.084 (0.000)	2.295 (0.000)	0.159 (0.088)
Piauí	11.059 (0.000)	1.935 (0.000)	-1.182 (0.000)	0.130 (0.041)	-	-1.763 (0.000)	0.887 (0.000)	-	-	-0.408	0.282 (0.000)	-0.098 (0.000)	2.138 (0.000)	0.272 (0.000)
Rio de Janeiro	13.230 (0.000)	0.765 (0.000)	-0.038 (0.636)	0.907 (0.000)	-0.658 (0.000)	0.008 (0.924)	0.122 (0.144)	-0.848 (0.000)	-	-0.109	0.320 (0.000)	-0.019 (0.346)	2.270 (0.000)	-0.374 (0.010)
Rio Grande do Norte	10.610 (0.000)	0.348 (0.000)	0.071 (0.030)	-	-	-	-	-	-	-0.319	0.283 (0.000)	0.058 (0.001)	2.270 (0.000)	0.116 (0.208)
Rio Grande do Sul	12.776 (0.000)	-	-	-	-	0.351 (0.000)	0.217 (0.001)	0.091 (0.157)	-	-0.396	0.291 (0.000)	-0.027 (0.079)	2.002 (0.000)	0.132 (0.023)
Rondônia	10.428 (0.000)	-0.071 (0.711)	0.784 (0.000)	-0.181 (0.000)	-0.082 (0.041)	0.257 (0.976)	-0.743 (0.983)	-	-	-0.043	0.371 (0.000)	-0.121 (0.000)	2.460 (0.000)	0.347 (0.006)
Roraima	12.775 (0.000)	0.153 (0.764)	-	-	-	0.215 (0.650)	0.177 (0.292)	0.070 (0.553)	-	-0.166	0.291 (0.000)	-0.026 (0.088)	2.003 (0.000)	0.104 (0.115)
Santa Catarina	12.128 (0.000)	-0.049 (0,807)	0.935 (0.000)	0.664 (0.000)	-0.555 (0.006)	0.611 (0.036)	-0.584 (0.000)	-0.989 (0.002)	-	-0.391	0.337 (0.000)	-0.064 (0.000)	2.301 (0.000)	0.038 (0.861)
São Paulo	14.406 (0.000)	1.202 (0.000)	-1.252 (0.000)	0.390 (0.000)	0.052 (0.070)	-0.763 (0.000)	1.000 (0.000)	-	-	-0.300	0.326 (0.000)	-0.008 (0.679)	2.363 (0.000)	0.051 (0.628)
Sergipe	10.823 (0.000)	1.458 (0.000)	-1.255 (0.000)	0.223 (0.007)	0.097 (0.002)	-1.112 (0.000)	0.990 (0.000)	-	-	-0.214	0.278 (0.000)	0.044 (0.023)	2.087 (0.000)	0.009 (0.925)
Tocantins	10.462 (0.000)	1.018 (0.000)	-1.148 (0.000)	0.248 (0.000)	-	-0.759 (0.000)	0.994 (0.000)	-	-	-0.320	0.289 (0.000)	-0.169 (0.000)	2;344 (0.000)	0.245 (0.000)
Distrito Federal	12.338 (0.000)	2.769 (0.000)	-2.686 (0.000)	0.912 (0.000)	-	-1.624 (0.000)	0.633 (0.000)	0.140 (0.046)	-	-0.357	0.345 (0.000)	-0.051 (0.003)	2.372 (0.000)	-0.612 (0.000)
Brazil	15.593 (0.000)	1.218 (0.000)	-1.316 (0.000)	0.449 (0.000)	-	-0.759 (0.000)	0,997 (0.000)	-	-	-0.463	0.310 (0.000)	-0.030 (0.060)	2.315 (0.000)	0.097 (0.255)

Table A3

Estimation results for the ARFIMA (p,d,q) model – Dupla Sena

Federation unit	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	WK	EASTER	d
Acre	8.330 (0.000)	0.394 (0.000)	-	-	-	-	-	-	-	-0.242	0.243 (0;000)	-0.019 (0.463)	2.906 (0.000)	0.440 (0.000)
Alagoas	9.524 (0.000)	1.414 (0.000)	-0.848 (0.000)	1.418 (0.000)	-0.984 (0.000)	-0.440 (0.973)	0.440 (0.971)	-1.000 (0.986)	-	-0.320	0.197 (0.000)	5,4E-04 (0.984)	3.390 (0.000)	-0.308 (0.000)
Amapá	7.986 (0.000)	1.489 (0.000)	-1.200 (0.000)	1.310 (0.000)	-0.607 (0.004)	-0.684 (0.000)	0.763 (0.000)	-0.842 (0.000)	-	0.211	0.250 (0.000)	-0.030 (0.391)	3,130 (0.000)	-0.116 (0.665)
Amazonas	9,629 (0.000)	0.601 (0.000)	-	-	-	-0.248 (0.027)	-	-	-	0.033	0.274 (0.000)	-0.008 (0.782)	3.417 (0.000)	0.418 (0.000)
Bahia	11.541 (0.000)	1,246 (0.000)	-0.761 (0.000)	1.343 (0.000)	-0,833 (0.000)	-0.318 (0.041)	0.466 (0.037)	-0.906 (0.000)	-	-0.186	0.205 (0.000)	-0.004 (0.893)	3.486 (0.000)	-0.195 (0.020)
Ceará	10.405 (0.000)	0.170 (0.305)	-0.661 (0.000)	0.601 (0.000)	-	0.203 (0.750)	0.891 (0.738)	-0.243 (0.724)	-	-0.060	0.260 (0.000)	0.014 (0.661)	3.275 (0.000)	0.405 (0.001)
Espírito Santo	11.511 (0.000)	-	-	-	-	0.358 (0.000)	0.186 (0.019)	0.094 (0.211)	-	-0.189	0.242 (0.000)	-0.055 (0.040)	3.313 (0.069)	0.464 (0.000)
Goiás	11.514 (0.000)	0.774 (0.000)	-0.036 (0.002)	1.010 (0.000)	-0.760 (0.000)	0.056 (0.378)	0.091 (0.187)	-0.925 (0.000)	-	-0.199	0.246 (0.000)	-0.056 (0.026)	3.266 (0.561)	0.007 (0.954)
Maranhão	10.296 (0.000)	-	-	-	-	0.182 (0.007)	0.130 (0.061)	0.150 (0.011)	-		0.182 (0.000)	-0.014 (0.708)	3.218 (0.000)	0.439 (0.000)
Mato Grosso	10.818 (0.000)	2.784 (0.000)	-2.766 (0.000)	0.978 (0.000)	-	-1,800 (0.000)	0.999 (0.002)	-	-	-0.173	0.236 (0.000)	-0.068 (0.008)	3,252 (0.000)	-0.264 (0.000)
Mato Grosso do Sul	10.559 (0.000)	-0.858 (0.000)	-0.290 (0.125)	0.491 (0.002)	0.080 (0.170)	1.370 (0.000)	0.999 (0.000)	-	-	-0,184	0.281 (0.000)	-0.040 (0.069)	3.094 (0.000)	0.399 (0.000)
Minas Gerais	12.438 (0.000)	0.077 (0.583)	-0.627 (0.000)	0.647 (0.000)	-	-0.338 (0.449)	0.875 (0.836)	-0.222 (0.917)	-	-0.298	0.218 (0.000)	-0.024 (0.345)	3.374 (0.000)	0.399 (0.001)
Pará	10.496 (0.000)	1.010 (0.000)	-0.007 (0.924)	-0.011 (0.889)	-	-	-	-	-		0.199 (0.000)	-0,021 (0.458)	3.262 (0.000)	-0.337 (0.003)
Paraíba	9.613 (0.000)	0.733 (0.004)	0.161 (0.000)	0.909 (0.000)	-0,808 (0.001)	0.214 (0.456)	0.004 (0.987)	-0.895 (0.036)	-	-0.236	0.242 (0.000)	0,.010 (0.746)	3.115 (0.012)	-0.204 (0.160)

Paraná	11,932 (0.000)	0.450 (0.000)	0.101 (0.028)	-	-	-	-	-	-	-0.220	0.269 (0.000)	-0.001 (0.962)	3,317 (0.234)	0.405 (0.000)
Pernambuco	10.368 (0.000)	1.008 (0.000)	-0.666 (0.000)	1.244 (0.000)	-0.594 (0.000)	0.089 (0.580)	0.712 (0.000)	-0.494 (0.003)	-	-0.232	0.212 (0.000)	0.024 (0;332)	3.251 (0.000)	-0.416 (0.009)
Piauí	9.915 (0.000)	1.365 (0.000)	-0.925 (0.000)	1.373 (0.000)	-0.817 (0.003)	-0.445 (0.953)	0.589 (0.972)	-0.901 (0.982)	-	-0.053	0.180 (0.000)	-0.064 (0.066)	3,281 (0.000)	-0.241 (0.031)
Rio de Janeiro	12.020 (0.000)	-1.271 (0.000)	-0,322 (0.128)	0.528 (0.004)	0.154 (0.019)	1.630 (0.045)	1.000 (0.316)	-	-	-0.219	0.208 (0.000)	-0.003 (0.923)	3,127 (0.000)	0.429 (0.000)
Rio Grande do Norte	9.685 (0.000)	0.370 (0.093)	0.833 (0.000)	0.609 (0.000)	-0,818 (0.000)	0.542 (0.902)	-0,303 (0.899)	-0.902 (0.955)	-	-0.312	0.198 (0.000)	0,013 (0.621)	3,294 (0.000)	-0.185 (0.132)
Rio Grande do Sul	11.733 (0.000)	1,242 (0.000)	-0.162 (0.168)	-0,086 (0.242)	-	-	-	-	-	-0.496	0.192 (0.000)	-0.004 (0.851)	2.976 (0.179)	-0.433 (0.007)
Rondônia	9.843 (0.000)	0.638 (0.000)	-	-	-	-0.250 (0.007)	-	-	-	-0.079	0.252 (0.000)	-0.026 (0.335)	3.428 (0.062)	0.406 (0.000)
Roraima	8.033 (0.000)	0.874 (0.000)	0.108 (0.136)	0.011 (0.885)	-	-	-	-	-	0.124	0.160 (0.000)	-0.107 (0.002)	3.563 (0.002)	-0.344 (0.001)
Santa Catarina	11.339 (0.000)	1.315 (0.000)	-0.236 (0.108)	-0.084 (0.236)	-	-	-	-	-	-0.373	0.239 (0.000)	-0.004 (0.849)	3.448 (0.058)	-0.459 (0.012)
São Paulo	13.306 (0.000)	0.083 (0.554)	-0.625 (0.000)	0.643 (0.000)	-	0.344 (0.803)	0.889 (0.880)	-0.203 (0.906)	-	-0.265	0.244 (0.000)	-0.014 (0.578)	3.383 (0.002)	0.405 (0.001)
Sergipe	9.691 (0.000)	0.164 (0.145)	-0.579 (0.000)	0.739 (0.000)	-	0,091 (0.826)	0.744 (0.818)	-0.462 (0.906)	-	-0.280	0.213 (0.000)	0.024 (0.368)	3.159 (0.000)	0.411 (0.001)
Tocantins	9.718 (0.000)	-0.578 (0.001)	-0.133 (0.498)	0.596 (0.000)	-	0.936 (0.727)	0.509 (0.850)	-0.375 (0.945)	-	0.050	0.159 (0.000)	-0.122 (0.000)	3.619 (0.000)	0.388 (0.002)
Distrito Federal	11.253 (0.000)	1.311 (0.000)	-0.268 (0.029)	-0.049 (0.494)	-	-	-	-	-	-0.179	0.261 (0.000)	-0.024 (0.355)	3.475 (0.000)	-0.452 (0.005)
Brazil	14.540 (0.000)	0.071 (0.613)	-0.632 (0.000)	0.637 (0.000)	-	0.357 (0.501)	0.889 (0.834)	-0.199 (0.915)	-	-0.305	0.233 (0.000)	-0,017 (0.507)	3.338 (0.000)	0.406 (0.000)

Table A4

Estimation results for the ARFIMA (p,d,q) model – Lotofácil

Federation unit	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	WK	DIND	d
Acre	10.658 (0.000)	-	-	-	-	-0.375 (0.003)	-	-	-	-0.470	0.271 (0.000)	-0.219 (0.001)	1.416 (0.000)	0.204 (0.087)
Alagoas	11.874 (0.000)	0.997 (0.000)	-	-	-	-0.812 (0.117)	0.166 (0.321)	0.020 (0.828)	-0.119 (0.102)	-0.541	0.219 (0.000)	-0.294 (0.000)	1.522 (0.000)	-0.464 (0.382)
Amapá	10.434 (0.000)	2.508 (0.000)	-2.155 (0.009)	0.485 (0.488)	0.154 (0.456)	-2.312 (0.004)	1.990 (0.140)	-0.595 (0.424)	-	-0.341	0.277 (0.000)	-0.256 (0.000)	1.398 (0.000)	-0.400 (0,728)
Amazonas	12.341 (0.000)	1.280 (0.000)	-0.333 (0.000)	-0.177 (0.007)	-0.167 (0.028)	-1.766 (0.000)	0.999 (0.002)	-	-	-0.559	0.294 (0.000)	-0.348 (0.000)	1.354 (0.000)	0.176 (0.027)
Bahia	14.140 (0.000)	0.954 (0.000)	-	-	-	-0.427 (0.215)	0.098 (0.004)	-	-	-0.468	0.282 (0.000)	-0.314 (0.000)	1.559 (0.000)	-0,797 (0.057)
Ceará	12.743 (0.000)	1.755 (0.000)	-0.996 (0.000)	-	-	-2.436 (0.000)	2.306 (0.024)	-0.890 (0.076)	0.125 (0.115)	-0.551	0.300 (0.000)	-0.416 (0.000)	1.551 (0.000)	0.331 (0.004)
Espírito Santo	13.128 (0.000)	-0.311 (0.000)	-	-	-	-	-	-	-	-0.384	0.312 (0.000)	-0.245 (0.000)	1.504 (0.000)	0.185 (0.000)
Goiás	13.838 (0.000)	1.235 (0.000)	-0.299 (0.0000	-0.179 (0.000)	-0.180 (0.002)	-1.713 (0.000)	0.968 (0.000)	-	-	-0.657	0.296 (0.000)	-0.362 (0.000)	1.504 (0.000)	0.144 (0.048)
Maranhão	12.737 (0.000)	1.757 (0.000)	-1.000 (0.000)	-	-	-2.357 (0.000)	2.134 (0.000)	-0.742 (0.000)	0.082 (0.002)	-0,510	0.242 (0.000)	-0.461 (0.000)	1.358 (0.000)	0.249 (0.056)
Mato Grosso	13.044 (0.000)	0.537 (0.000)	0.310 (0.000)	0.148 (0.058)	-	-0.958 (0.000)	-	-	-	-0.584	0.313 (0.000)	-0.354 (0.000)	1.547 (0.000)	0.126 (0.369)
Mato Grosso do Sul	12.795 (0.000)	1.410 (0.000)	-0.562 (0.024)	-0.049 (0.443)	-0.165 (0.098)	-2.009 (0.000)	1.445 (0.004)	-0.262 (0.356)	-	-0.639	0.318 (0.000)	-0.339 (0.000)	1.563 (0.000)	0.299 (0.016)
Minas Gerais	14.679 (0.000)	-0.554 (0.000)	-0.217 (0.000)	-	-	-	-	-	-	-0.685	0.287 (0.000)	-0.366 (0.000)	1.668 (0.000)	0.167 (0.009)
Pará	13.014 (0.000)	0.930 (0.000)	-	-	-	-0.362 (0.323)	0.105 (0.007)	-	-	-0.560	0.286 (0.000)	-0.419 (0.000)	1,471 (0.000)	-0.091 (0.059)
Paraíba	12.058 (0.000)	0.968 (0.000)	-	-	-	-0.515 (0.151)	0.059 (0.104)	--	-	-0.620	0.251 (0.000)	-0.328 (0.000)	1.500 (0.000)	-0.735 (0.065)

Paraná	14.193 (0.000)	-	-	-	-	-0.645 (0.000)	0.128 (0.000)	-	-	-0.662	0.318 (0.000)	-0.353 (0.000)	1.635 (0.000)	0.283 (0.024)
Pernambuco	12.796 (0.000)	-0.282 (0.000)	-	-	-	-	-	-	-	-0.537	0.243 (0.000)	-0.329 (0.000)	1,540 (0.000)	-0.024 (0.564)
Piauí	12.218 (0.000)	0.320 (0.630)	-	-	-	-0.804 (0.147)	0.246 (0.380)	-	-		0.246 (0.000)	-0.577 (0.000)	1.476 (0.000)	0.232 (0.155)
Rio de Janeiro	14.329 (0.000)	-0.462 (0.000)	-0.142 (0.132)	-	-	-	-	-	-	-0.441	0.311 (0.000)	-0.358 (0.000)	1.604 (0.000)	0.179 (0.040)
Rio Grande do Norte	11.910 (0.000)	-0.434 (0.000)	-0.143 (0.162)	-	-	-	-	-	-	-0.591	0.239 (0.000)	-0.311 (0.000)	1.561 (0.000)	0.125 (0.252)
Rio Grande do Sul	13.841 (0.000)	1.346 (0.000)	-0.445 (0.246)	-0.113 (0.216)	-0.168 (0.170)	-1.942 (0.000)	1.312 (0.083)	-0.178 (0.676)	-	-0.851	0.262 (0.000)	-0.296 (0.000)	1.514 (0.000)	0.219 (0.155)
Rondônia	12.080 (0.000)	-	-	-	-	-0.356 (0.000)	-	-	-	-0.184	0.308 (0.000)	-0.270 (0.000)	1,568 (0.000)	0.234 (0.025)
Roraima	10.306 (0.000)	-	-	-	-	-0.491 (0.001)	-	-	-	-0.209	0.243 (0.000)	-0.311 (0.000)	1.476 (0.000)	0.293 (0.040)
Santa Catarina	13.684 (0.000)	1.757 (0.000)	-0.999 (0.000)	-	-	-2.446 (0.000)	2.337 (0.000)	-0.917 (0.000)	0.132 (0.000)	-0.761	0.286 (0.000)	-0.310 (0.000)	1.620 (0.000)	0.264 (0.096)
São Paulo	15.699 (0.000)	0.951 (0.000)	-	-	-	-0.590 (0.095)	0.143 (0.024)	-	-	-0.617	0.310 (0.000)	-0.364 (0.000)	1.675 (0.000)	-0.722 (0.085)
Sergipe	12.248 (0.000)	-	-	-	-	-0.626 (0.000)	-	-	-	-0.580	0.264 (0.000)	-0.308 (0.000)	1.435 (0.000)	0.382 (0.017)
Tocantins	12.094 (0.000)	0.461 (0.000)	0.345 (0.000)	0.187 (0.003)	-	-0.973 (0.000)	-	-	-	-0.437	0.296 (0.000)	-0.433 (0.000)	1.278 (0.000)	0.219 (0.024)
Distrito Federal	13.508 (0.000)	1.741 (0.000)	-0.988 (0.000)	-	-	-2.226 (0.000)	1.933 (0.000)	-0.647 (0.000)	0.086 (0.001)	-0.511	0.358 (0.000)	-0.379 (0.000)	1.718 (0.000)	0.129 (0.427)
Brazil	16.883 (0.000)	-	-	-	-	-0.342 (0.013)	0.091 (0.003)	0,089 (0.131)	-	-0.682	0.300 (0.000)	-0.375 (0.000)	1.648 (0.000)	-0.039 (0.776)

Table A5

Estimation results for the ARFIMA (p,d,q) model – Timemania

Federation unit	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	WK	d
Acre	8.004 (0.000)	-0.196 (0.000)	0.109 (0.028)	0.876 (0.000)	-	0.125 (0.000)	0.872 (0.000)	-	-	-0.438	0.361 (0.000)	-0.002 (0.915)	-0.111 (0.096)
Alagoas	9.332 (0.000)	1.486 (0.039)	-0.286 (0.836)	-0.085 (0.896)	-0.118 (0.182)	0.188 (0.851)	-	-	-	-0.598	0.325 (0.000)	-0.001 (0.925)	-0.898 (0.023)
Amapá	7.866 (0.000)	0.145 (0.452)	0.505 (0.022)	0.192 (0.028)	-	0.0642 (0.005)	-	-	-	-0.120	0.422 (0.000)	-0.061 (0.001)	-0.066 (0.694)
Amazonas	9.528 (0.000)	-0.119 (0.033)	0.011 (0.879)	0.845 (0.000)	-	1.019 (0.000)	0.867 (0.000)	-	-	-0.354	0.393 (0.000)	0.012 (0.480)	-0.072 (0.365)
Bahia	11.444 (0.000)	-0.168 (0.000)	-0.017 (0.623)	0.908 (0.000)	-	1.087 (0.613)	1.000 (0.801)	-	-	-0.543	0.286 (0.000)	0.004 (0.777)	-0.064 (0.184)
Ceará	10.310 (0.000)	-0.134 (0.032)	-0.004 (0.957)	0.830 (0.000)	-	1.021 (0.000)	0.849 (0.000)	-	-	-0.497	0.380 (0.000)	0.037 (0.013)	-0.005 (0.950)
Espírito Santo	10.431 (0.000)	0.067 (0.856)	0.030 (0.797)	0.891 (0.000)	-0.182 (0.484)	1.037 (0.000)	0.918 (0.000)	-	-	-0.458	0.389 (0.000)	-0.017 (0.210)	-0.121 (0.730)
Goiás	11.217 (0.000)	-0.137 (0.007)	0.002 (0.965)	0.858 (0.000)	-	1.005 (0.000)	0.865 (0.000)	-	-	-0.389	0.377 (0.000)	-0.033 (0.038)	-0.041 (0.615)
Maranhão	10.285 (0.000)	0.770 (0.001)	0.134 (0.000)	0.923 (0.000)	-0.856 (0.000)	0.231 (0.911)	0.069 (0.970)	-0.856 (0.913)	-	-0.428	0.319 (0.000)	-0.055 (0.000)	-0.206 (0.164)
Mato Grosso	10.344 (0.000)	-0.154 (0.003)	-8.62E-05 (0.999)	0.838 (0.000)	-	1.016 (0.000)	0.873 (0.000)	-	-	-0.438	0.374 (0.000)	-0.074 (0.000)	0.003 (0.975)
Mato Grosso do Sul	10.055 (0.000)	-0.131 (0.012)	0.005 (0.932)	0.860 (0.000)	-	1.020 (0.000)	0.878 (0.000)			-0.286	0.422 (0.000)	-0.056 (0.000)	-0.038 (0.597)
Minas Gerais	11.979 (0.000)	-0.162 (0.011)	-0.005 (0.948)	0.826 (0.000)	-	1;034 (0.000)	0.868 (0.000)	-	-	-0.539	0.357 (0.000)	-0.028 (0.051)	0.046 (0.624)
Pará	10.413 (0.000)	-0.151 (0.000)	-8.60E-05 (0.998)	0.926 (0.000)	-	1.085 (0.569)	1.000 (0.776)	-	-	-0.396	0.363 (0.000)	-0.046 (0.002)	-0.123 (0.016)

Paraíba	9.582 (0.000)	-0.314 (0.291)	0.569 (0.000)	0.552 (0.016)	-	1.333 (0.000)	0.723 (0.088)	0.152 (0.588)	0.141 (0.132)	-0.478	0.292 (0.000)	0.037 (0.014)	-0.198 (0.496)
Paraná	11.436 (0.000)	1.405 (0.005)	-0.181 (0.862)	-0.095 (0.886)	-0.135 (0.226)	0.333 (0.663)	-	-	-	-0.294	0.356 (0.000)	-0.008 (0.587)	-0.841 (0.064)
Pernambuco	10.370 (0.000)	0.871 (0.000)	-0.007 (0.698)	0.977 (0.000)	-0.868 (0.000)	0.149 (0.938)	0.192 (0.935)	-0.827 (0.836)	-	0.019	0.190 (0.000)	0.024 (0.288)	-0.409 (0.006)
Piauí	9.791 (0.000)	-0.113 (0.243)	0.046 (0.625)	0.826 (0.000)	-	0.994 (0.000)	0.830 (0.000)	-	-	-0,273	0.371 (0.000)	-0.073 (0.000)	-0.142 (0.100)
Rio de Janeiro	11.775 (0.000)	-0.143 (0.019)	0.024 (0.762)	0.844 (0.000)	-	1.046 (0.000)	0.882 (0.000)	-	-	-0.554	0.376 (0.000)	-0.006 (0.694)	-0.024 (0.770)
Rio Grande do Norte	9.739 (0.000)	-0.767 (0.000)	0.633 (0.000)	0.725 (0.000)	0.191 (0.010)	1.616 (0.000)	0.713 (0.000)	-	-	0.018	0.263 (0.000)	0.085 (0.000)	-0.258 (0.054)
Rio Grande do Sul	11.341 (0.000)	-0.117 (0.114)	-0.010 (0.911)	0.807 (0.000)	-	0.968 (0.000)	0.816 (0.000)	-	-	-0.651	0.323 (0.000)	0.017 (0.200)	0.035 (0.715)
Rondônia	9.291 (0.000)	0.866 (0.000)	-	-	-	-	-	-	-	-0.257	0.393 (0.000)	-0.057 (0.000)	0.052 (0.462)
Roraima	7.690 (0.000)	-0.106 (0.689)	0.616 (0.000)	0.371 (0.095)	-	1.075 (0.0000	0.501 (0.004)	0.274 (0.044)	0.258 (0.000)	-0.064	0.318 (0.000)	-0.077 (0.000)	-0.310 (0.048)
Santa Catarina	10.872 (0.000)	-0.177 (0.010)	-0.004 (0.964)	0.808 (0.000)	-	1.036 (0.000)	0.850 (0.000)	-	-	-0.571	0.355 (0.000)	0.009 (0.540)	0.091 (0.356)
São Paulo	12.904 (0.000)	-0.194 (0.000)	-0.046 (0.316)	0.884 (0.000)	-	1.083 (0.613)	1.000 (0.800)	-	-	-0.362	0.401 (0.000)	-0.026 (0.062)	0.033 (0.606)
Sergipe	9.688 (0.000)	-0.435 (0.000)	0.278 (0.000)	0.887 (0.000)	-	1.398 (0.000)	0.990 (0.000)	-	-	-0.607	0.332 (0.000)	0.006 (0.656)	-0.105 (0.028)
Tocantins	9.432 (0.000)	-0.086 (0.213)	0.032 (0.646)	0.856 (0.000)	-	0.989 (0.000)	0.851 (0.000)	-	-	-0.328	0.389 (0.000)	-0.108 (0.000)	-0.139 (0.058)
Distrito Federal	11.083 (0.000)	-0.216 (0.004)	0.012 (0.911)	0.800 (0.000)	-	1.093 (0.000)	0.868 (0.000)	-	-	-0.436	0.427 (0.000)	-0.051 (0.001)	0.075 (0.464)
Brazil	14;217 (0.000)	-0.178 (0.018)	0.002 (0.983)	0.795 (0.000)	-	1.048 (0.000)	0.838 (0.000)	-	-	-0.575	0.370 (0.000)	-0.011 (0.414)	0.082 (0.436)

Table A6

Estimation results for the ARFIMA (p,d,q) model – Loteca

Federation unit	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	d
Acre	7.908 (0.000)	-0.284 (0.214)	0.822 (0.000)	0.283 (0.024)	-	1,000 (0.968)	-	-	-	0.846	0.405 (0.000)	-0.394 (0.124)
Alagoas	9.504 (0.000)	1,845 (0.000)	-1.650 (0.000)	0.740 (0.000)	-	-1.018 (0.932)	1.000 (0.966)	-	-	0.589	0.270 (0.000)	-0.441 (0.030)
Amapá	8.209 (0.000)	-	-	-	-	0.364 (0.022)	0.188 (0.092)	0.453 (0.000)	0.347 (0.000)	0.944	0.420 (0.000)	0.017 (0.882)
Amazonas	9.206 (0.000)	-	-	-	-	-	-	-	-	0.818	0.372 (0.000)	0.397 (0.000)
Bahia	11.589 (0.000)	0.742 (0.000)	-0.637 (0.000)	-	-	-0.512 (0.931)	0.578 (0.980)	0.442 (0.992)	-	0.618	0.384 (0.000)	0.223 (0.141)
Ceará	10.467 (0.000)	1.659 (0.000)	-1.445 (0.000)	0.646 (0.002)	-	-0.993 (0.862)	1.000 (0.930)	-	-	0.452	0.227 (0.000)	-0.412 (0.195)
Espírito Santo	9.998 (0.000)	0.883 (0.000)	-	-	-	-	-	-	-	0.492	0.322 (0.000)	-0.452 (0.003)
Goiás	11.232 (0.000)	-0.806 (0.000)	-	-	-	0.920 (0.000)	-	-	-	0.461	0.401 (0.000)	0.336 (0.000)
Maranhão	10.112 (0.000)	0.111 (0.630	-0.170 (0.227)	-0.467 (0.001)	-	-0.017 (0.943)	0.124 (0.641)	0.921 (0.023)	-	0.709	0.430 (0.000)	0.265 (0.067)
Mato Grosso	10.206 (0.000)	0.805 (0.136)	-0.258 (0.701)	-0.255 (0.689)	0.518 (0.098)	-0.023 (0.966)	0.325 (0.632)	0.806 (0.252)	-	0.641	0.391 (0.000)	-0.501 (0.088)
Mato Grosso do Sul	10.076 (0.000)	-	-	-	-	-	-	-	-	0.926	0.487 (0.000)	0.369 (0.000)
Minas Gerais	12.264 (0.000)	0.913 (0.000)	-	-	-	-0.030 (0.924)	-	-	-	0.490	0.392 (0.000)	-0.414 (0.362)
Pará	10.448 (0.000)	0.407 (0,064)	-0.190 (0,358)	-0.501 (0.010)	-	-0.240 (0.455)	0.061 (0.844)	0.850 (0,041)	-	0.910	0.421 (0.000)	0.325 (0.006)
Paraíba	9.826 (0.000)	1,122 (0.002)	-0.278 (0.574)	-0.404 (0.408)	0.532 (0.060)	-0.146 (0.836)	0.131 (0.864)	0.860 (0.498)	-	0.517	0.419 (0.000)	-0.524 (0.012)

Paraná	11.549 (0.000)	0.779 (0.000)	-0.775 (0.000)	-	-	-0.535 (0.897)	0.632 (0.968)	0.395 (0.986)	-	0.531	0.335 (0.000)	0.287 (0.014)
Pernambuco	10.341 (0.000)	1.104 (0.003)	-0.237 (0.660)	-0.401 (0.404)	0.502 (0.056)	-0.152 (0.775)	0.144 (0.811)	0.848 (0.314)	-	0,579	0.361 (0.000)	-0.528 (0.009)
Piauí	9.941 (0.000)	0.910 ().000)	-	-	-	-0.008 (0.975)	-	-	-	0.664	0.280 (0.000)	-0.448 (0.249)
Rio de Janeiro	12.015 (0.000)	0.821 (0.000)	-0.721 (0.000)	-	-	-0.510 (0.928)	0.571 (0.975)	0.448 (0.988)	-	0.612	0.385 (0.000)	0.247 (0.102)
Rio Grande do Norte	9.602 (0.000)	-	-	-	-	-	-	-	-	0.692	0.408 (0.000)	0.414 (0.000)
Rio Grande do Sul	11.622 (0.000)	1,632 (0.000)	-1;487 (0.000)	0.712 (0.000)	-	-0.918 (0.967)	1.000 (0.984)	-	-	0.687	0.362 (0.000)	-0.351 (0,148)
Rondônia	9.327 (0.000)	0.927 (0.000)	-0.784 (0.000)	-	-	-0.724 (0.939)	0.701 (0.975)	0.294 (0.989)	-	0.580	0.426 (0.000)	0.179 (0.201)
Roraima	7.059 (0.000)	0.932 (0.000)	-	-	-	0.095 (0.622)	-	-	-	1.120	0.409 (0.000)	-0.575 (0.005)
Santa Catarina	10.836 (0.000)	0.580 (0.183)	0.005 (0.970)	0.220 (0.061)	-	-	-	-	-	1.007	0.555 (0.000)	-0.174 (0;699)
São Paulo	13.079 (0.000)	1.568 (0.000)	-1.500 (0.000)	0.813 (0.000)	-		-0.777 (0.000)	0.967 (0.000)	-	0.576	0.388 (0.000)	-0.362 (0.048)
Sergipe	9.490 (0.000)	-	-	-	-	-	-	-	-	0.847	0.260 (0.000)	0.432 (0.000)
Tocantins	9.267 (0.000)	0.698 (0.000)	-0.628 (0.000)	-	-	-0.576 (0.939)	0.656 (0.980)	0.365 (0.991)	-	0.576	0.375 (0.000)	0.228 (0.169)
Distrito Federal	10.843 (0.000)	1.579 (0.000)	-1.383 (0.001)	0.604 (0.049)	-	-0.957 (0.985)	1.000 (0.992)	-	-	0.504	0.416 (0.000)	-0.250 (0.543)
Brazil	14.285 (0.000)	0.811 (0.000)	-0.732 (0.000)	-	-	-0.588 (0.929)	0.643 (0.976)	0.372 (0.990)	-	0.510	0.418 (0.000)	0.240 (0.151)

Table A7

Estimation results for the ARFIMA (p,d,q) model – Lotogol

Federation unit	Constant	AR(1)	AR(2)	AR(3)	AR(4)	MA(1)	MA(2)	MA(3)	MA(4)	AIC	ROLL	d
Acre	6.022 (0.000)	-0.916 (0.000)	0.414 (0.087)	0.332 (0.000)	-	0,978 (0.000)	-	-	-	0.492	0.152 (0.000)	0.241 (0.126)
Alagoas	7.587 (0.000)	-0.998 (0.000)	-	-	-	0.778 (0.000)	0.107 (0.503)	0.180 (0.121)	-0.117 (0.169)	0.575	0.182 (0.000)	0.433 (0.000)
Amapá	5.973 (0.000)	-0.250 (0.164)	0.889 (0.000)	0.216 (0.096)	-	0.812 (0.000)	-	-	-	0.811	0.068 (0.094)	-0.247 (0.055)
Amazonas	7.141 (0;000)	-0.624 (0.003)	0.945 (0.000)	0.570 (0.008)	-	1.335 (0.000)	0.343 (0.220)	-	-	0.721	0.138 (0.000)	-0.463 (0.000)
Bahia	9.788 (0.000)	-0.534 (0.015)	0.986 (0.000)	0.467 (0.002)	-0.055 (0.718)	0.980 (0.000)	-	-	-	0.463	0.170 (0.000)	-0.250 (0.233)
Ceará	8.256 (0.000)	-0.621 (0.000)	0.923 (0.000)	0.545 (0.000)	-	0.983 (0.000)	-	-	-	0.363	0.156 (0.000)	-0,220 (0.035)
Espírito Santo	8.250 (0.000)	0.218 (0.152)	1.702 (0.000)	-0.224 (0.134)	-0.709 (0.000)	0.494 (0.032)	-0.959 (0.000)	-0.470 (0.012)	-	0.449	0.141 (0.000)	-0.490 (0.000)
Goiás	8.810 (0.000)	-0.049 (0.670)	0.948 (0.000)	-	-	0.669 (0.277)	0.076 (0.909)	0.190 (0.598)	-0.172 (0.560)	0.232	0.140 (0.000)	-0.398 (0.583)
Maranhão	8.396 (0.000)	-0.557 (0.000)	0.895 (0.000)	0.454 (0.000)	-	0.981 (0.000)	-	-	-	0.394	0.145 (0.000)	-0.238 (0.035)
Mato Grosso	7.990 (0.000)	0.345 (0.043)	1.613 (0.000)	-0.350 (0.038)	-0.620 (0.000)	0.332 (0.934)	-0.989 (0.941)	-0.342 (0.947)	-	0.190	0.145 (0.000)	-0.556 (0.000)
Mato Grosso do Sul	7.528 (0.000)	0.196 (0.000)	1.751 (0.000)	-0.203 (0.000)	-0.759 (0.000)	0.570 (0.476)	-0.999 (0.642)	-0.570 (0.771)	-	0.592	0.169 (0.000)	-0.630 (0.000)
Minas Gerais	10.073 (0.000)	-0.623 (0.000)	0.860 (0.000)	0.484 (0.000)	-	0.979 (0.000)	-	-	-	0.287	0.166 (0,000)	-0.162 (0.198)
Pará	8.345 (0.000)	-0.045 (0.717)	0.952 (0.000)	-	-	0.575 (0.492)	-0.121 (0.886)	0.073 (0.818)	-0.193 (0. 495)	0.377	0.135 (0.000)	-0.295 (0.760)
Paraíba	8,021 (0.000)	-0.336 (0.061)	1.100 (0.000)	0.315 (0.045)	-0.123 (0.333)	0.986 (0.000)	-	-	-	0.395	0.138 (0.000)	-0.404 (0.015)

Paraná	9.108 (0.000)	-0.588 (0.000)	0.833 (0.000)	0.422 (0.000)	-	0.982 (0,000)	-	-	-	0.845	0.179 (0,000)	-0.165 (0.294)
Pernambuco	8.182 (0.000)	-0.323 (0.068)	1.146 (0.000)	0.310 (0.052)	-0.162 (0.229)	0.968 (0.000)	-	-	-	0.451	0.149 (0.000)	-0.398 (0.015)
Piauí	7.852 (0.000)	-0.520 (0.006)	0.976 (0.000)	0.463 (0.001)	-0.035 (0.791)	0.985 (0.000)	-	-	-	0.329	0.139 (0.000)	0.256 (0.160)
Rio de Janeiro	9.999 (0.000)	-0.604 (0.000)	0.899 (0.000)	0.495 (0.000)	-	0.978 (0.000)	-	-	-	0.464	0.167 (0.000)	-0,188 (0.100)
Rio Grande do Norte	7.675 (0.000)	-0.629 (0.000)	0.889 (0.000)	0.519 (0.000)	-	0,980 (0.000)	-	-	-	0.525	0.160 (0.000)	-0.204 (0.059)
Rio Grande do Sul	8.576 (0.000)	0.651 (0,070)	1.302 (0.000)	-0.654 (0.066)	0.310 (0.359)	0.145 (0.990)	-0.776 (0.950)	-0.166 (0.967)	-0.203 (0.909)	0.432	0.177 (0.000)	-0.624 (0.000)
Rondônia	7.119 (0.000)	-0.377 (0.000)	0.955 (0.000)	0.334 (0.000)	-	0.970 (0.000)	-	-	-	0.441	0.189 (0.000)	-0.346 (0.001)
Roraima	4.924 (0.000)	-0.054 (0.754)	0.898 (0.000)	-	-	0.499 (0.397)	-0.341 (0.512)	-	-	1.329	0.131 (0.025)	-0.203 (0.786)
Santa Catarina	8.547 (0.000)	-0.677 (0.000)	0.858 (0.000)	0.536 (0.000)	-	0.982 (0.000)	-	-	-	0.584	0.202 (0.000)	-0.113 (0.369)
São Paulo	10.862 (0.000)	-0.642 (0.000)	0.870 (0.000)	0.513 (0.000)	-	0.979 (0.000)	-	-	-	0.324	0.173 (0.000)	-0.180 (0.146)
Sergipe	7.682 (0.000)	-0.448 (0.000)	0.124 (0.009)	0.484 (0.000)	0.800 (0.000)	0.907 (0.662)	0.882 (0.749)	0.204 (0.867)	-0.317 (0.915)	0.535	0.155 (0.000)	-0.279 (0.156)
Tocantins	7.139 (0.000)	-0.502 (0.000)	0.882 (0.000)	0.387 (0.000)	-	0.976 (0.000)	-	-	-	0.515	0.165 (0.000)	-0.285 (0.013)
Distrito Federal	8.665 (0.000)	-0.569 (0.000)	0.894 (0.000)	0.465 (0.000)	-	0.980 (0.000)	-	-	-	0.552	0.185 (0.000)	-0.190 (0.078)
Brazil	12.154 (0.000)	-0.642 (0.000)	0.864 (0.000)	0.507 (0.000)	-0.572 (0.000)	1.128 (0.000)	1.145 (0.514)	-	-	0.314	0.171 (0.000)	-0.155 (0.230)