A Study of the Brazilian Business Cycles (1900 – 2012)*

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Abstract

This paper studies the Brazilian business cycles in the period of 1900 to 2012. Since the quarterly series of the real GDP only starts in 1980 we had to build the series for the period of 1900 to 1979, using the structural time series model with temporal disaggregation for the first period. After that, a Markov Switching Model is estimated in order to build a chronology of the business cycles. The chosen model has two separate regimes with different regimes for expansion and recession, and the dating carried out in this paper is compared with other studies on the theme, and characterizations for the growth phases that can support studies of the economic history in Brazil are proposed.

Keywords: Quarterly GDP, Brazilian Business Cycles, Markov Switching, Structural Time Series Model, Temporal Disaggregation.

JEL Codes: C22, E32, N16.

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1. Introduction

The importance of research on business cycles has been established in Economics for many years, and at the start of the 1990s, a new methodology proposed in the paper by Hamilton (1989) started to be used. This author carries out a study on the business cycle of the American economy, using a time series model with Markov Switching. The present study adopts the same class of models to propose a quarterly dating of the Brazilian business cycle starting in the year 1900.

In his paper, Hamilton (1989) considers that the American GDP series does not follow a linear process, that is, it is subject to discrete changes in its data generating process. In practice, the series is characterized by a dynamics in which there are somewhat frequent changes between the recession and growth regimes. A series of studies indicate evidences of non-linearity in important macroeconomic variables, signaling, according to this author, the relevance of testing this methodology to date the Brazilian cycles.

The author applies this methodology to study the actual American GDP in the period of 1951:II to 1984:IV, in the quarterly frequency. The results are similar to the dating of the business cycle published by the National Bureau of Economic Research (NBER). Thus, Hamilton signals that this methodology can be used for predicting the business cycles and in constructing their chronology.

Krolzig (1997) evaluates the German GDP from 1960 to 1994 using quarterly data and, for that end, introduces changes in the Hamilton (1989) methodology. Krolzig (1997) allows not on the top of changes in mean, but also changes in the variance according to each estimated regime. This is especially important for this paper, since there is evidence that the series of the Brazilian GDP presents heteroscedasticity.

Céspedes et al. (2006) evaluate the Brazilian real GDP on a quarterly basis from 1975:1 to 2002:2. The paper suggests that the non-linear models are superior to the linear models in predictive terms. The authors present a chronology of the Brazilian business cycle, allowing a comparison with the results of this paper, at least for part of the period studied.

Chauvet (2002) uses models with changes in regime in Brazil´s GDP annual data from 1900 to 1999 for dating the business cycles in Brazil. The results, although obtained from annual data, are over a long historical period and allow comparisons with the results from this paper.

Also for the Brazilian economy, Araújo et al. (2008) studied some cyclical and growth properties of the Brazilian per capita GDP from 1850 to 2000. More specifically, the authors evaluated the question of recessions and expansions dating. This paper is important because it deals with a long historical period, thus allowing comparisons, despite its annual frequency.

It is important to note that throughout the 20th century and the beginning of the 21th century, there were several stabilization plans, adverse international shocks, financial and supply crisis, wars etc., on top of a greatly differentiated inflationary dynamic. Therefore, the use of a non-linear model for business cycle dating seems to be adequate to represent the phases of Brazilian economic growth.

The aim of this paper is to evaluate the same theme adopting the time series class of models with Markov Switching, and, in this sense, it is closely related to the papers by Céspedes et al. (2006) and Chauvet (2002). However, this paper differs by allowing the variance to be different in each regime. The present paper studies the historical period from 1900 to 2012 and the data frequency is quarterly. For that end, we have carried out a temporal disaggregation of the data between 1900 and 1980. In this aspect the present paper is different from the ones by Chauvet (2002) and Araújo et al. (2008).

Therefore the present paper seeks to make contributions in two ways. First, to elaborate a long quarterly series for the Brazilian GDP since 1900. Second, to propose quarterly dating for the Brazilian business cycle. These points produce information that allows us to consider short and long term themes. For example, it is possible to evaluate the political influence in the Brazilian economy in sub periods of our history or identify the secular empirical pattern of Brazilian growth.

The methodology used in this article also allows us to evaluate the volatility of the Brazilian growth since 1900. For example, one result found is that the volatility increases after the Second World War. In this manner, it is possible to establish comparisons with other papers such as Ellery and Gomes (2005) which evaluated the properties of the Brazilian cycle. Backus and Kehoe (1992) have also studied the theme of economic cycles and carried out a comparison among several developed countries, creating a reference for results in ten other countries.

The next section presents the econometric models to be applied; the third presents the data set and the main estimations performed. And the fourth, and last, section presents our results compared with the papers mentioned above to motivate economic interpretations.

2. Methodology

As stated in the previous section, this study faces two main problems: first, making the Brazilian GDP series compatible, since before 1980 the series' frequency is annual and from 1980 to 2012 the frequency is quarterly. Second, proposing a chronology for the economic cycles in Brazil from 1900 to 2012.

2.1 Basic structural time series models (BSTSM)

In order to solve the first problem, we can, for example, follow the methodology that uses Unobserved Component Model. The class of models used is part of the structural time series models. The basic formulation of a structural time series model (BSTSM) allows us to extract from an observed series the unobserved components, trend, cycle , seasonality and irregular. This formulation follows the one proposed by Harvey (1993):

$$y_t = \mu_t + \psi_t + \gamma_t + \varepsilon_t \tag{1}$$

where μ_t, ψ_t, γ_t and ε_t are respectively the components of trend, cycle, seasonality and irregular.

The Stochastic Linear Trend component is composed by the level (μ_t) and the slope (β_t) that are described by the following components:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \tag{2}$$

$$\beta_t = \beta_{t-1} + \xi_t \tag{3}$$

where η_t and ξ_t are mutually independent white noise. Observe that if the variance of the level disturbances, σ^2_η, and the slope, σ^2_ξ are zero, then the trend is deterministic. The formulation of the Cycle Component is given by:

$$\begin{pmatrix} \psi_t \\ \psi_t^* \end{pmatrix} = \rho \begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \begin{pmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{pmatrix} + \begin{pmatrix} \kappa_t \\ \kappa_{t-1}^* \end{pmatrix} \tag{4}$$

where ψ_t, ψ_t^*, are the cycle components where the second captures the second order autoregressive structure from the reduced form of the model (see Harvey, 1993). The other parameters $\rho, \lambda, w, k_t, k_t^*$ are respectively, the damping factor that varies from zero to one, the period, the frequency and the disturbances that are also white noise with the same variance and mutually independent.

The cycle can be deterministic or stochastic, in the same way as the trend component. It is deterministic if the variance of the disturbance is zero.

The seasonal component, is that when the seasonal effects in the forecast function sum zero over s consecutive time periods, where s is the period of seasonality. For example, if $s = 4$ it can be written as such:

$$\gamma_t = -\sum_{j=1}^{3} \gamma_{t-j} + \omega_t \tag{5}$$

where ω_t is the disturbance of this component, which is also white noise.

Observe that the all disturbances are mutually independent.

The transition equation is given by:

$$\underbrace{\begin{pmatrix}\mu_t\\ \beta_t\\ \psi_t\\ \psi_t^*\\ \gamma_t\\ \gamma_{t-1}\\ \gamma_{t-2}\\ \gamma_{t-3}\end{pmatrix}}_{\alpha_t}\underbrace{\begin{pmatrix}1&1&0&0&0&0&0&0\\ 0&1&0&0&0&0&0&0\\ 0&0&\rho\cos\lambda&\rho\sin\lambda&0&0&0&0\\ 0&0&-\rho\sin\lambda&\rho\cos\lambda&0&0&0&0\\ 0&0&0&0&-1&-1&-1&0\\ 0&0&0&0&1&0&0&0\\ 0&0&0&0&0&1&0&0\\ 0&0&0&0&0&0&1&0\end{pmatrix}}_{T_t}\underbrace{\begin{pmatrix}\mu_{t-1}\\ \beta_{t-1}\\ \psi_{t-1}\\ \psi_{t-1}^*\\ \gamma_{t-1}\\ \gamma_{t-2}\\ \gamma_{t-3}\\ \gamma_{t-4}\end{pmatrix}}_{\alpha_{t-1}}\underbrace{\begin{pmatrix}\eta_t\\ \xi_t\\ \kappa_t\\ \kappa_t^*\\ \omega_t\\ 0\\ 0\\ 0\end{pmatrix}}_{\varepsilon_t} \qquad (6)$$

the hyperparameters, the variances of the disturbances for the components, can be estimated by maximum likelihood and as a sub-product the unobserved components are estimated at each period of time using the Kalman Filter.

Because the quarterly real GDP series begins in 1980 and before this date we only have annual data, we can use the structural time series models to reconstruct the quarterly series for the period of 1900 to 1979. This can be done by observing that the annual real GDP, that is if y_t^+ represents the annual actual GDP that is observed for $t = 4, 8, 12, \ldots$ and if y_t represents the real GDP observed series for each quarter we have:

$$y_t^* = \begin{cases} y_t & \text{for } t = 1900.Q4, 1901.Q4, \ldots, 1979.Q4 \\ 0 & \text{for } t \neq 1900.Q4, 1901.Q4, \ldots, 1979.Q4 \\ y_t & \text{for } t = 1980.Q1, 1908.Q2, \ldots, 2012.Q4 \end{cases} \qquad (7)$$

The state space representation of this model has a state vector

$$\alpha_t' = (y_t, \mu_t, \beta_t, \psi_t, \psi_t^*, \gamma_t, \gamma_{t-1}\gamma_{t-2}, \gamma_{t-3}) \qquad (8)$$

and the observed equation is given by:

$$y_t = \begin{cases} (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)\alpha_t & \text{for } t = 1900.Q4, 1901.Q4, \cdots, 1979.Q4 \\ (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)\alpha_t & \text{for } t \neq 1900.Q4, 1901.Q4, \cdots, 1979.Q4 \\ (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)\alpha_t & \text{for } t = 1980.Q1, 1908.Q2, \cdots, 2012.Q4 \end{cases} \qquad (9)$$

and the transition equation is given by:

$$\begin{pmatrix} y_t \\ \mu_t \\ \beta_t \\ \psi_t \\ \psi_t^* \\ \gamma_t \\ \gamma_{t-1} \\ \gamma_{t-2} \\ \gamma_{t-3} \end{pmatrix} = \begin{pmatrix} 0 & 1 & 1 & \rho\cos\lambda & \rho\sin\lambda & -1 & -1 & -1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho\cos\lambda & \rho\sin\lambda & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\rho\sin\lambda & \rho\cos\lambda & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & -1 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ \mu_{t-1} \\ \beta_{t-1} \\ \psi_{t-1} \\ \psi_{t-1}^* \\ \gamma_{t-1} \\ \gamma_{t-2} \\ \gamma_{t-3} \\ \gamma_{t-4} \end{pmatrix} \quad (10)$$

$$+ \begin{pmatrix} \eta_t + \kappa_t + \omega_t + \varepsilon_t \\ \eta_t \\ \xi_t \\ \kappa_t \\ \kappa_t^* \\ \omega_t \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad \text{for } t = 1900.Q4, \cdots, 2012.Q4$$

the estimation of this model will be presented in subsection 3.1.

In the next section we present the Markov Switching Autoregressive models (MS-AR) such as presented in Hamilton (1989), but with the changes proposed by Krolzig (1997), allowing both the mean and the variance to be different for each regime and changing conditionally to the state of the Markov process.

2.2 Regime Switching Models

Time series models with regime switching are characterized by two processes that describe the data generating process: the time series itself, generally an autoregressive model, and a stochastic process to describe the state subjacent to the regime of the time series.

The time series model with Markov switching regime is a dynamic model, with parameters that are time varying , according to the state in which the process is. An autoregressive model of order $p, AR(p)$, for k states for the regimes, $S_t \in \{0, 2, \ldots, k\}$, denoted by $MS(k) - AR(p)$ is given by:

$$y_t = \upsilon_{s_t} + \alpha_{1,S_t} y_{t-1} + \alpha_{2,S_t} y_{t-2} + \cdots + \alpha_{p,S_t} y_{t-p} + \varepsilon_t \quad (11)$$

where $\varepsilon_t \sim NI(0, \sigma^2_{S_t})$.

In this class of models the change between regimes is determined by an unobserved variable, named state. This variable follows a Markov chain. In this chain the state changes from one regime to the next according to the transition probabilities given by:

$$Pr\left(S_t = i | S_{t-1} = j\right) = p_{ij} > 0 \tag{12}$$

where $i, j = 0, 2, \ldots, k$ and k is the number of possible states. Because (12) represents the probability of transition between the instants $t-1$ and t it satisfies the following relation:

$$\sum_{i=0}^{k} p_{ij} = 1 \tag{13}$$

These transition probabilities can be represented by a matrix, called transition matrix, M, given by:

$$M = \begin{bmatrix} p_{00} & \cdots & p_{0k} \\ \vdots & \ddots & \vdots \\ p_{k0} & \cdots & p_{kk} \end{bmatrix} \tag{14}$$

Using the transition probabilities we can calculate the mean duration of each regime. For example, for a given regime j¸ this duration is given by:

$$\frac{1}{1 - p_{jj}} \tag{15}$$

Time series model with regime change is very flexible and we can consider it as regime dependent parameters: the mean μ_{S_t};[1] the intercept term, υ_{S_t}, the autoregressive coefficients, α_{i,S_t} and variance $\sigma^2_{S_t}$ (see, for example, Krolzig, 1997). Usually in empirical applications some parameters of the present model vary with regime while other components do not.

Since we are interested in the business cycle, the variable to be modeled will be the fourth order difference of the real quarterly GDP for the period of 1900 to 2012. The model can have the following specifications, assuming an autoregressive of order four model with Markov switching:

$$y_t = \upsilon_{S_t} + \alpha_{1,S_t} y_{t-1} + \alpha_{2,S_t} y_{t-2} + \alpha_{3,S_t} y_{t-3} + \alpha_{4,S_t} y_{t-4} + \varepsilon_t \tag{16}$$

where $y_t, \upsilon_S, \alpha_i, (i = 1, \ldots, 4), \varepsilon_t$ and S_t are, respectively, $\triangle_4 \ln(real\_GDP_t)(= \ln(real\_GDP_t) - \ln(real\_GDP_{t-4})$, mean of the process, autoregressive coefficients, disturbance and state. Since heteroscedasticity could be present, the disturbance is given by $\varepsilon_t \sim NI(0, \sigma^2_{S_t})$. Therefore the conditional mean and the variance can

[1] In the analysis of the regime change models there is a relation between mean and intercept. The autoregressive model of the first order adjusted by the mean is given by: $(y_t - \mu_{S_t} = \alpha_{1,S_t}(y_{t-1} - \mu_{S_{t-1}}) + \varepsilon_t$, and the intercept model's form is given by $y_t = \upsilon_{S_t} + \alpha_{1,S_t} y_{t-1} + \varepsilon_t$. Therefore $\upsilon_{S_t} = \mu_{S_t} - \alpha_{1,S_t}\mu_{S_{t-1}}$. The dynamic of adjustment for the model with switching regime in mean is abrupted, after the regime transition, while the model with regime switching in the intercept implies in a more smooth adjustment.

changed according to each regime, even though the variance is constant within regimes.

The next section presents the estimation for the real GDP. The best model chosen have an autoregressive structure, but the variance changes according to the regime and follows a GARCH structure. The specification of the model denoted by MS-GARCH (K) as presented below, was adopted, for example, Almeida and Valls Pereira (2000) and Haas et al. (2004):

$$\varepsilon_t = u_t \sigma_{t,S_t} \tag{17}$$

$$\sigma^2_{t,S_t} = \beta_{0,S_t} + \beta_{1,S_t} u_{t-1} + \beta_{2,S_t} \sigma^2_{t-1,S_t} \tag{18}$$

where $u_t \sim NI(0,1)$.

3. Data Base and the Estimation

3.1 Quarterly real GDP series construction

The series used are from IPEADATA, the real GDP in the annual frequency and in the quarterly frequency.[2] In practice, we have the annual data for all the historical period (1900-2012) and the quarterly data for only part of the period (1980-2012). The structural time series models allow us to obtain the quarterly data from these two pieces of information (see figures 1 and 2). Thus, reconstruct the quarterly GDP series for all the period, which is more suitable for the study of business cycles and for the construction of its chronology.[3] It was possible to reconstructed a series for the Brazilian GDP in the quarterly frequency from 1900 to 2012 (see Table 1).

From the results in Table 1, we can see that the variance of the level (σ^2_η) is zero, indicating that its component is constant over time. The variance of the slope (σ^2_ξ) is, relatively, small, denoting smooth changes in this component. On the other hand, the variance of the cycle component (σ^2_κ) is the greatest of all components.

[2] Accessed in July 2013.

[3] Estimation carried out with OxMetrics 7.0 software, STAMP package for construction of the quarterly series and PcGive for construction of dating.

Figure 1
Actual annual GPD for the period of 1900 to 2012

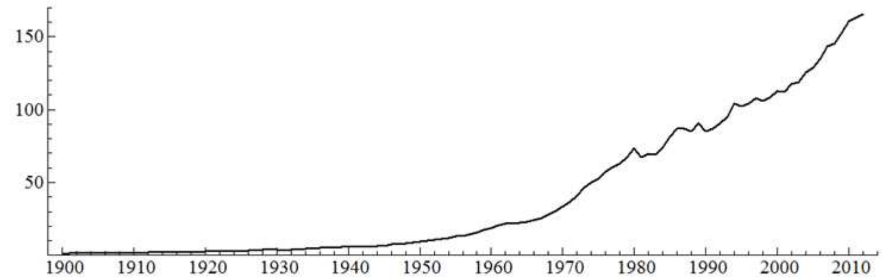


Figure 2
Quarterly GDP for the period of 1980 to 2012

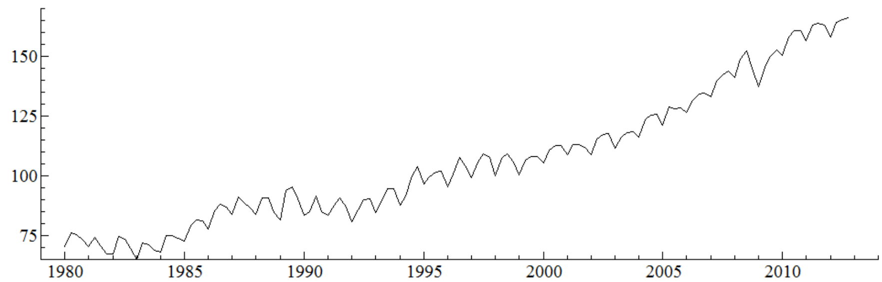


Table 1
GDP Univariate Model

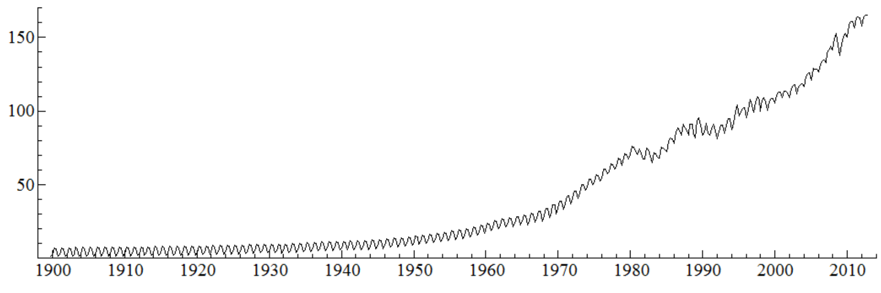
Variance of disturbances	Value	
σ_n^2	0.00000000	
σ_ξ^2	0.00252148	
σ_κ^2	1.04126	
σ_ω^2	0.0487115	
σ_ε^2	0.0000000	
State vector in 2012.$Q4$	Value	p-value
μ_t	166.33381	[0, 0000]
β_t	1.28002	[0, 0000]
Ψ_t	2.03754	[0, 0000]
γ_t	30.52065	[0, 0000]
T	213	
p	7	
R^2	0.5397	

Observation: T - Sample size ; p - number of hyperparameters $R_S^2 - \frac{(T-d)\tilde{\sigma}^2}{SSDSM}$, where $\tilde{\sigma}^2$ is the residual variance and $SSDSM$ stands for sum of squared of the disturbance obtained by subtracting the seasonal mean $\triangle y_t$.

All the components of the state vector in the last period of time in sample were significant different from zero. So, it is adequate to adopt the model formulation with all the components.

We are aware that taking the behavior of an unobserved component of a series to extend the frequency of the data is not a perfect solution, however, considering that the quarterly data is not available; this solution is a relevant one. Thus, using the methodology described in subsection 2.1 we can recover a quarterly series for the Brazilian real GDP from 1900 (available in the Appendix of this paper). This series (Figure 3) will be used to build the chronology of the business cycle in Brazil in the period from 1900 to 2012.

Figure 3
Quarterly GDP for the period 1900 to 2012



3.2 Building the Brazilian business cycle chronology

Once we have the quarterly series, the next step is to estimate Markov switching models, so that the chronology of the business cycle can be proposed. The Estimation is given below.

The dependent variable (Figure 4) for the Markov switching model is the quarterly change in log of real GDP ($\triangle 4 \ln(real\_GDP_t)$. According to Krolzig (1997) we would have, among the several estimated models, the following chosen model: $MSH - GARCH(2) - AR(0)$, which means, Markov Switching models with correction for hetersocedasticity (regime-independent variance) and with two regimes without auto-regressive terms and with the same alpha and beta parameters. Table 2 shows the estimates of this specification. Other specifications were estimated, for example, with autoregressive term, three regimes, and absence of GARCH structure in the variance, GARCH structure varying with regimes, but the results were inferior in their capacity to present adequate interpretations or even not connect to our economic history.

The model chosen, with two regimes, the constants are positive and significant. The volatility, expressed by the variance $\sigma_i^2(i = 0.1)$, is relatively greater in the

Figure 4
$\triangle 4 \ln(Real\_GDP_t)$

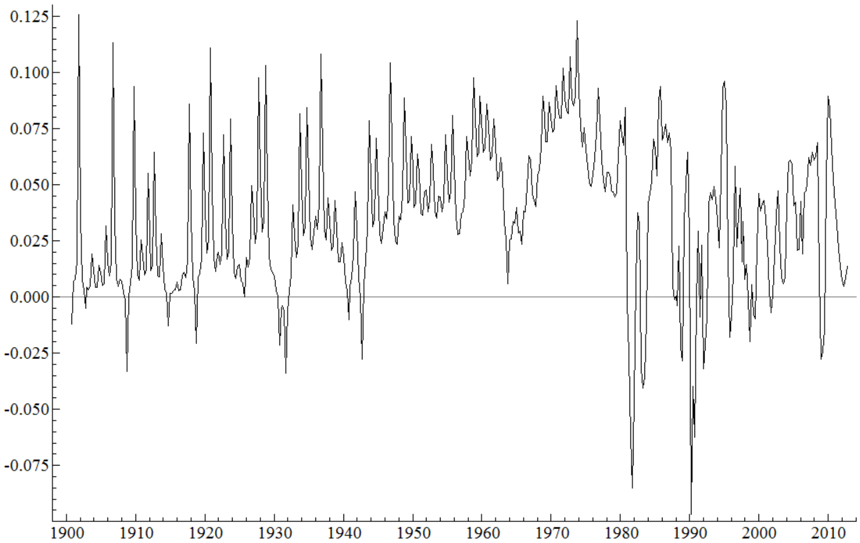


Table 2
$MS - GARCH(2) - AR(0)$

Parameters	Coefficient	Standard error	p-value
υ_0	0.008082	0.001475	0.000
υ_1	0.05461	0.002012	0.000
σ_0^2	0.00991	0.001593	
σ_1^2	0.01457	0.001585	
β_1	0.52923	0.1214	
β_2	0.14583	0.06368	
p_{00}	0.87746	0.03075	
p_{11}	0.91548	0.02243	
N Obs	449		
p	8		
$LogLik$	1020,1291		
AIC	-4.508370		

regime two when compared with regime one. The first regime, from the smoothed probabilities generated in this specification (see Figure 5), is related to recession while the second indicates to economic growth.

Considering the information criterion (available in the appendice) and, mainly, the potential to generate economic interpretation consistent with our economic history, the model estimated with two regimes is, in fact, the most adequate. The models estimated with three regimes, generate, in fact, results that are only slightly different from two regimes, indicating that considering a third regime is not satisfactory. The comparisons, the interpretations and analysis of the Brazilian business cycle will be based on the results obtained using the $MS-GARCH(2)-AR(0)$ model.

This model, among the estimated models, can be considered parsimonious and presents results that allow an interpretation with "economic sense". In the next part we present the graphs that illustrate the smoothed probabilities generated by the selected model. These graphs already give us a general view of the Brazilian business cycle in the period of 1900 to 2012 in the sense that we can have a long term view or even observe short term sub periods of interest to our economic history.

Another important result generated by this class of models is the probability of change from one regime to the other. This probability of change is presented in the transition matrix (see Table 3). This matrix indicates that if the economy is in a recession the probability of the recession continuing is of 88%. And if the economy is growing, the probability of the growth continuing is of 91.5%. It also shows that when the economy is in recession, the probability of changing to a scenario of growth is of 8.5%.

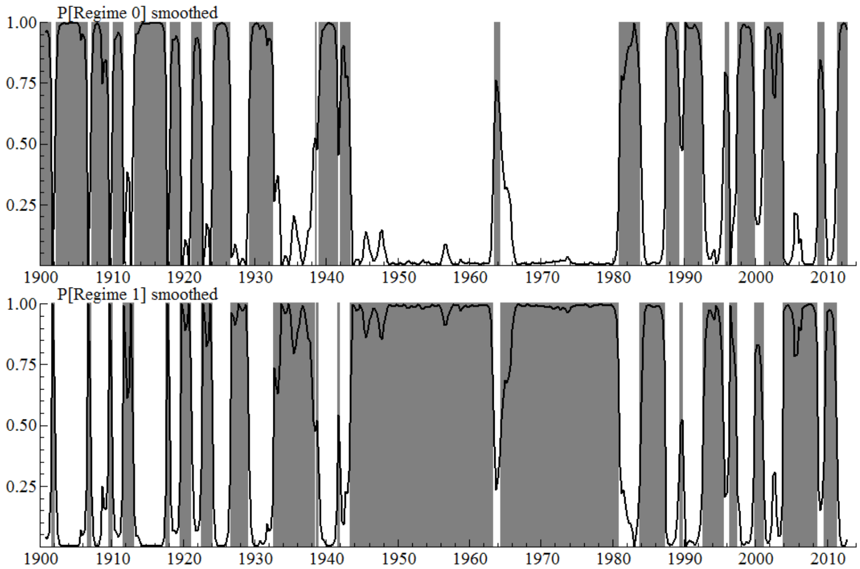
Table 3
Transition matrix

	$\text{Regime}_{0,t}$	$\text{Regime}_{1,t}$
$\text{Regime}_{0,t+1}$	0.87747	0.084513
$\text{Regime}_{1,t}$	0.12253	0.91549

4. Results

From Table 4, the more persistent regimes are of expansions, followed by those of recession. In fact, it can be observed that in the Brazilian economy in the years 1900 to 2012 there is a certain asymmetry in the mean duration of the recession and expansion regimes. The total duration indicates that the expansion moments are, historically, notably more frequent that the regimes of recession, even though this asymmetry may be a valid characteristic for the whole period studied, it would be even more so for the period after the Crash of 1929.

Figure 5
Smoothed Probabilities $MS - GARCH(2) - AR(0)$



We can observe that the Brazilian economy in the period from 1900 to 2012 showed a total of 179 quarters in recession and 270 quarters in expansion. Empirically, we can consider that the recessive periods tend to be shorter than the expansion periods. And when we have an expansion period, greater growth in volatility is to be expected. This information is listed in Table 4.

Table 5 presents the quarterly chronology of the Brazilian business cycle in the years of 1900 to 2012. The longest consecutive periods of recession in the economic history of Brazil were, respectively, the period of World War 1 (18 quarters in recession), the Depression of the 1930's (12 quarters in recession) and the Debt Crisis in 1980 (12 quarters in recession). So, from the point of view of historical perspective, the Debt Crisis of 1980 was as recessive as the period after the Crash of 1929.

Table 4
Volatility, average duration and scenarios

	MS-GARCH(2)-AR(0)	
Regimes	0	1
Scenarios	Recession	Expansion
Total duration*	179	270
Average duration*	8.52	13.5
Volatility	Low	High

Obs.: *ln quarters.

The historical period from the beginning of the 20^{th} century until the end of the 1930's depression is the period with the longest average duration of recession. Empirically, the events of World War 1 and the depression in the 1930's explain this result. Therefore, in average, a recession is more persistent than an expansion until 1932. After that, the expansionary regimes are significantly longer than the recessive ones.

The longest consecutive period of economic growth spans from the year before the end of World War 2 to the beginning of the reforms in 1963, 80 quarters in total. This period is greater than the years that span the phases of the Brazilian economic miracle and of the II PND, 66 quarters in total.

If we characterize the Brazilian economy in periods of recession and expansion, we see that the first decade of the 20^{th} century is the most recessive decade of our history, with 34 quarters in recession. The 1920s can be described as symmetrical in regards to the cycles, with 17 quarters in expansion and 23 quarters in recession. The 1930s, even with two greatly important recessive contexts, the Great Depression and the beginning of World War II, had an increase in the Brazilian GDP in 24 quarters.

From the last years of World War II up until the Debt Crisis in the 1980s, the long period from 1943 to 1980, is one of economic growth when recession is rare, only 4 consecutive quarters between 1963 and 1964 with the abrupt change in the political regime. In this period, the 1950s and 1970s were 100% expansionists.

The 1980s, considered by many scholars as the "lost" decade, presents 24 semesters in recession and 16 in expansion. Therefore, if we consider the historical perspective, the lost decade was in fact the first one of the 20^{th} century.

The 1990s had a perfect symmetry in the division of regimes in Brazil. There were 20 quarters in expansion and 20 in recession. It is worth mentioning that the Plano Collor I, implemented in March 1990, brought about 10 quarters in recession, while the sequence of financial international crisis that happened from 1995 to 1999 brought about 13 quarters in recession.

This period of the 21^{st} century (2001-2013) has, so far, shown the continuation of the symmetry in the Brazilian business cycle. There were 27 quarters of expansion and 21 of recession.

Table 5
General chronology of the economic cycles (Brazil 1900-2012)

Recession		Expansion	
Dates	Quarters	Dates	Quarters
1990(4) 1901(3)	4	1901(4) 1902(1)	2
1902(2) 1906(3)	18	1906(4) 1907(1)	2
1907(2) 1909(3)	10	1909(4) 1910(1)	2
1910(2) 1911(3)	6	1911(4) 1913(1)	6
1913(2) 1917(3)	18	1917(4) 1918(1)	2
1918(2) 1919(3)	6	1919(4) 1921(1)	6
1921(2) 1922(3)	6	1922(4) 1924(1)	6
1924(2) 1926(3)	10	1926(4) 1929(1)	10
1929(2) 1932(3)	14	1932(4) 1938(2)	23
1938(3) 1938(3)	1	1938(4) 1938(4)	1
1939(1) 1941(3)	11	1941(4) 1941(4)	1
1942(1) 1943(2)	6	1943(3) 1962(3)	80
1963(3) 1964(2)	4	1964(3) 1980(4)	66
1981(1) 1983(4)	12	1984(1) 1987(2)	14
1987(3) 1989(2)	8	1989(3) 1989(4)	2
1990(1) 1992(3)	11	1992(4) 1995(3)	12
1995(4) 1996(2)	3	1996(3) 1997(2)	4
1997(3) 1999(4)	10	2000(1) 2001(1)	5
2001(2) 2003(4)	11	2004(1) 2008(3)	19
2008(4) 2009(3)	4	2009(4) 2011(2)	7
2011(3) 2012(4)	6		

Another important aspect to be discussed is the volatility of the Brazilian GDP in this period. Backus and Kehoe (1992) present international evidence, and two of the results found by the authors can be used. First, all the countries researched[4] have greater volatility of their GDP in the period between World Wars. Second, the result of the volatility of the GDP has declined with time.

Araújo et al. (2008), using the same methodology of Backus and Kehoe (1992), present the volatility in Brazil with the following main characteristics: the volatility changes very little in the tree sub periods presented (the years before World War I, the years between World War I and II and the period after World War II), but it is smaller in the period after World War II. However, using a different methodology, Araújo et al. (2008) found different results. There is significant change in the volatility of the sub periods mentioned above, and that it is greater in the period between wars. On the other hand, Ellery and Gomes (2005) show that, differently from other countries, Brazil has greater volatility after the World War II and lower in the period before World War I.

Despite distinct methodologies and data frequency in these papers, and without attaining ourselves to the periodization proposed in Backus and Kehoe (1992), the results obtained in this work can be evaluated in a similar manner.[5] This paper found greater volatility of the GDP for the expansion periods, especially in the period after 1929. The volatility was smaller in the periods of economic recession, especially in the years before the Crisis of 1929.

In general lines, the dating obtained in this article is similar to the paper of Araújo et al. (2008) despite the paper following an annual frequency and using per capita base. Differently, the annual frequency proposed by Chauvet (2002) shows less recessions before the Crisis of 1929. The results obtained by CODACE [acronym in Portuguese that means Business Cycle Dating Committee],[6] which follows the quarterly frequency and studies a much shorter historical period, shows less quarters in recession than the present paper.

5. Conclusions

Chauvet (2002), differently from the present paper, does not consider recessive scenarios in 1902, 1906, 1907 and 1917, second semester of 1921, and first of 1922, 1926 and 1932. Considering Villela and Suzigan (2001), who studies the growth of the Brazilian economy between the years 1889 and 1945 we can consider these

[4]Except in the case of Australia. Besides Australia, the authors studied Canada, Demark, Germany, Italy, Japan, Norway, Sweden, Great Britain and the United States.

[5]Because the results of this paper it is possible to compare the volatility of a given verified scenario, we considered the periods that the expansion regimes are more frequent as periods of greater volatility. And when the recession is more frequent the volatility is lower in that period.

[6]CODACE is the business cycle dating committee of the Instituto Brasileiro de Economia (IBRE) [Brazilian Ecomomics Institute] of Fundação Getulio Vargas (FGV), that following the models of the NBER, establishes the reference chronology of the Brazilian economic cycles. The comparison does not mention Céspedes et al. (2006) because the results are similar to those of CODACE and the chronology extends only up to the year 2000.

differences in a few points. First, it is difficult to evaluate the effect of the growth of the contractionary policy followed from 1898 to 1902. Second, coffee, which was responsible for over half of revenue generated with exports, suffered a reduction in price from 1900 to 1908, expect for 1904. Third, for these authors there is an economic contraction from 1913 to 1918. Fourth, the period of 1920-23 is characterized by a foreign trade crisis and the economic stagnation started in 1924 and lasted until 1926. Fifth, the year of 1932 can still be considered as one with economic depression.

The points mentioned above seem to justify part of the dating differences between the present paper and Chauvet (2002). Thus, especially for the period before the depression of the 1930s, two differences seem to be important. First, the construction of a quarterly series of the GDP for the whole period appears to have been important to better discriminate the regimes. Second, allowing of the variance to change over time seems to provide more adequate dating, considering the historical context mentioned above.

The triennium of 1965, 1966 and 1967 is dated as an expansion in the first four quarters, while in Chauvet (2002) dates 1965 as a recession and Araújo et al. (2008) dates as recession the three years. In these years there were a considerable reduction in the economic growth rate, considering the years just prior and after that triennium, which cannot, necessarily, be considered as a recessive regime, since the economy in Brazil grew 2.7%, 5,1% and 4.8%, respectively, in those years. This way, it seems correct to consider this period as one of expansion.

In general terms, the results obtained in this paper are closer to the ones obtained in Ellery and Gomes (2005). However, a difference that must be highlighted is that it does not seem appropriate to consider the volatility as constant for the sub periods in our history. In other words, it seems adequate to differentiate between recessive and expansive regimes within a determined sub period and from that determine the volatility regime. For example, the volatility is greater in the years after World War II and this is valid, because in this period there is a predominance of economic expansion scenarios. The volatility is smaller from the beginning of the 20^{th} century until the Crisis of 1929 when the predominant regime is of recession.

Thus, we can say that the empirical pattern of the Brazilian business cycle changes after the end of the depression of the 1930s, and changes again in the decades of 1980 and 1990. This seems to indicate a change in the transition matrix. That is, a limitation of this paper because the transition matrix is no allowed to change over time. For this reason, allowing variation in this matrix over time can be the object of future research.

The greater volatility found in the expansionist regime can be justified. There were, in these periods, from 1950s to 1970, the most important variations in the GDP with some years showing the greatest historical growth and some years when the growth was positive, but relatively smaller. For example, GDP annual growth was 2.9% in 1956 and 10.8% in 1958, 4.2% in 1967 and 9.8% in 1968, 14% in 1973 and 4.5% in 1977 (Baer, 2002).

We can also suggest possible follow up research. One possibility is to go back even further in the historical period, involving decades of the 19^{th} century. Another possibility, notably more important for the first one mentioned, would be searching for primary sources of quarterly data that could help in the construction of indexes that can represent our GDP.

References

Almeida, N. M. C. G. & Valls Pereira, P. L. (2000). Modelos de mudança de regime: Um estudo empírico para regras de mercado. In Sociedade Brasileira de Econometria, editor, *Anais do XXII Encontro Brasileiro de Econometria*, Campinas.

Araújo, E., Carpena, L., & Cunha, A. (2008). Brazilian business cycles and growth from 1850 to 2000. *Estudos Econômicos*, 38:557–581.

Backus, D. K. & Kehoe, P. J. (1992). International evidence on the historical properties of business cycles. *American Economic Review*, 82:864–888.

Baer, W. (2002). *A Economia Brasileira*. Nobel, São Paulo, 2^{nd} edition.

Chauvet, M. (2002). The Brazilian business and growth cycles. *Revista Brasileira de Economia*, 56:75–106.

Céspedes, B. J. V., Chauvet, M., & Lima, E. C. R. (2006). Forecasting Brazilian output and its turning points in the presence of breaks: A comparison of linear and nonlinear models. *Estudos Econômicos*, 36:5–46.

Ellery, R. & Gomes, V. (2005). Ciclo de negócios no Brasil durante o século XX: Uma comparação com a evidência internacional. *Revista Economia*, 6:45–66.

Fundação Getulio Vargas (2009). Comitê de Datação de Ciclos Econômicos Brasileiros (CODACE). Documento de Criação do Comitê, São Paulo.

Haas, M., Mittnik, S., & Paolella, M. S. (2004). A new approach to Markov-switching GARCH models. *Journal of Financial Econometrics*, 2:493–530.

Hamilton, J. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica*, 57:357–384.

Harvey, A. C. (1993). *Time Series Models*. MIT Press, Cambridge, 2^{nd} edition.

Instituto de Pesquisa Econômica e Aplicada (2013a). Acesso em julho de 2013.

Instituto de Pesquisa Econômica e Aplicada (2013b). Boletim de Conjuntura. Disponível em: `http://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=9559:bolede-conjuntura&catid=226:dimac&Itemid=3`. Acesso em: 12 julho de 2013.

Krolzig, H. M. (1997). *Markov-Switching Vector Autoregressions: Modelling, Statistical Inference, and Application to Business Cycle Analysis*. Springer.

Villela, A. & Suzigan, W. (2001). *Política do Governo e Crescimento da Economia Brasileira 1889-1945*. IPEA, Brasília, 3^{rd} edition.

A. Appendix

In this Appendix the link for the real GDP quarterly series and the several estimated models with their respective criteria information for model selection are presented.

https://docs.google.com/file/d/0BxP6WoxNpigQMm5EZDRNQ01PUlk/edit

Table 6
Information criteria

Model	Observations	Parameters	Log-Lik	SC	HQ	AIC
MSH(2)-AR(0)	449	6	984.83023	4.3052	4.3384	4.3600
MSH-GARCH(2)-AR(0)	449	8	1020.1291	4.4352	4.4795	4.5084
MSH(3)-AR(0)	449	12	1024.6122	4.4008	4.4673	4.5105
MSH-GARCH(3)-AR(0)	449	14	1059.7937	4.5303	4.6078	4.6583
MSH-GARCH(2)-AR(0)	449	10	1021.8630	4.4157	4.4711	4.5072
MSH-GARCH(3)-AR(0)	449	17	1064.4140	4.5100	4.6042	4.6652

Nota: GARCH with different parameters between regimes
SC - Schwarz Criteria
HQ - Hannan & Quinn Criteria
AIC - Akaike Criteria