BRAZILIAN BUSINESS CYCLES AND GROWTH FROM 1850 TO 2000*

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Abstract: We studied the cyclical and growth properties of Brazilian per capita output from 1850 to 2000. Contrary to the experience of some developed countries, we did not find large changes in the volatility of per capita output. However, we obtained evidence that the oscillations in economic activity became more persistent after World War II.
Keywords: Brazilian per capita GDP, business cycle, growth.
JEL Classification: C22, E32 , N10.

Resumo: Analisaram-se neste artigo as propriedades do produto interno bruto (PIB) per capita do Brasil de 1850 a 2000. Contrariamente ao observado em alguns países desenvolvidos, não se obteve evidência de alterações expressivas na volatilidade do PIB per capita. Contudo, verificou-se que as oscilações na atividade econômica se tornaram mais persistentes após a II Guerra Mundial.
Palavras-Chave: PIB per capita brasileiro, ciclo de negócios, crescimento.
Classificação JEL: C22, E32 , N10.

ÁREA 3
MACROECONOMIA, ECONOMIA MONETÁRIA E FINANÇAS

* The authors acknowledge the financial support from the Brazilian Council of Science and Technology (CNPq).

Introduction

The reporting of empirical regularities of economic has a long tradition in the study of business cycles and economic growth. For instance, Burns and Mitchell (1946) documented several features of the economic cycles in the United States. Kaldor's (1961) summary of the growth evidence became widely known as Kaldor's stylized facts.

Recently, there have been several studies aimed at documenting the statistical properties of business cycles. Backus and Kehoe (1992) and Hodrick and Prescott (1997) are typical examples of this research line. The same is observed in the field of economic growth. For instance, Barro and Sala-I-Martin (1995) devoted several chapters of their book to the empirical regularities of economic growth.

While the international literature on the statistical regularities of business cycle and economic growth is very large, its Brazilian counterpart is relatively incipient. One of the reasons is that a lack of available data restrains studies on Brazilian business cycles to the period after the World War II, as in Ellery, Gomes and Sachsida (2002).

In this paper we construct a per capita gross domestic product (GDP) series for the Brazilian economy that covers the period 1850-2000. We then evaluate some of the statistical properties of its cyclical component as well as of its growth rates.

We evaluate some basic business cycle features, such as volatility, persistence, and turning points. We assess some of these features over distinct sub-periods of the whole sample and compare our findings to some international evidence. Our main findings are that, contrary to the evidence Backus and Kehoe (1992) presented for several industrialized nations, the volatility of Brazilian business cycles does not appear to vary greatly over the sub-periods of our sample. However, we obtain evidence that the cyclical component of the per capita output became more persistent after 1945.

We evaluate the volatility and persistence of the growth rates of per capita GDP. We show that volatility may be characterized by three phases. There is an initial low volatility period from 1850 to 1875. Then, an intermediate period lasting up to 1975 displays higher volatility. Finally, the most recent period is characterized by low volatility. We do not find a significant statistical relationship between the growth rate and its volatility. In addition, we find that there is a change in the series dynamics when we compare pre and post World War II periods. This change is due to an increase in persistence rather than to any abrupt change in volatility.

This paper is organized as follows. Section I describes our data set and evaluates its reliability. Section II studies the business cycle properties of Brazilian per capita GDP. Section III assesses the volatility trend and the empirical relationship between volatility and growth and verifies whether the dynamics of per capita GDP pre and post World War II are different. Section V contains concluding remarks.

I – The data set

As usual, we obtained the per capita GDP series by taking the ratio of a GDP series to a population one. This motivates our approach in this section. First we discuss and comment on our GDP series. Then, we take the same steps for the population data. Finally, we discuss some of the properties of our per capita GDP series.

I.1 – The GDP series

Goldsmith (1986) contains a real GDP series from 1850 to 1900 (Table II.1, pages 22 and 23 and Table III.1, pages 82 and 83). Haddad (1978) provides data for the same variable from 1900 to 1947 (Table 3, page 15). The data CD that accompanies IBGE (2003) is the source for the sub-period 1948-2000. The files '1_2_scn_consolidado.xls' and '1_3_nscn.xls', both located in the folder 'economia\contas_nacionais' of that CD, contain real GDP growth rates from 1948 to 2000. We combined these three sources to obtain a real GDP index from 1850 to 2000.

We now discuss some issues related to the reliability of our GPD series. As usual, the older the period, the less reliable the data are. In the particular case of our GDP series, the 1850-1900 sub-period deserves more attention. We further elaborate on this topic next.

From 1947 onwards, our data source is the official Brazilian national account system. For the 1900-1947 period, the source is Haddad (1978).[1] Despite not constituting an official GDP measure, Haddad's figures are widely accepted today. Thus, for the period 1900-2000, our series is, as far as we know, the most reliable one available.

As we explained before, we linked Haddad's series to Goldsmith's at 1900. We are not aware of any other estimate of Brazilian GDP that covers the period 1850-1900. Thus, a strong reason to adopt the Goldsmith's series is that it is the only one available. The exclusiveness of Goldsmith's GDP series does not ensure its accuracy. So, it is important to check, as far as possible, how accurate that series is. Contador and Haddad (1975) provided yearly estimations of Brazilian GDP from 1861 to 1900. Table 1 compares the GDP growth rates of those two series.

Table 1
Comparison of GDP series: average growth rates

Period	Goldsmith	Contador and Haddad
1862-1900	1.61	1.47
1862-1870	2.63	3.96
1871-1880	1.60	1.98
1881-1890	2.14	2.04
1891-1900	0.19	-1.75

For the period 1861-1900 the two series display similar average growth rates. For shorter periods, the similarity is smaller. Goldsmith emphasized this point. He suggested that the short run oscillations of any GDP series for that period should be used with care.

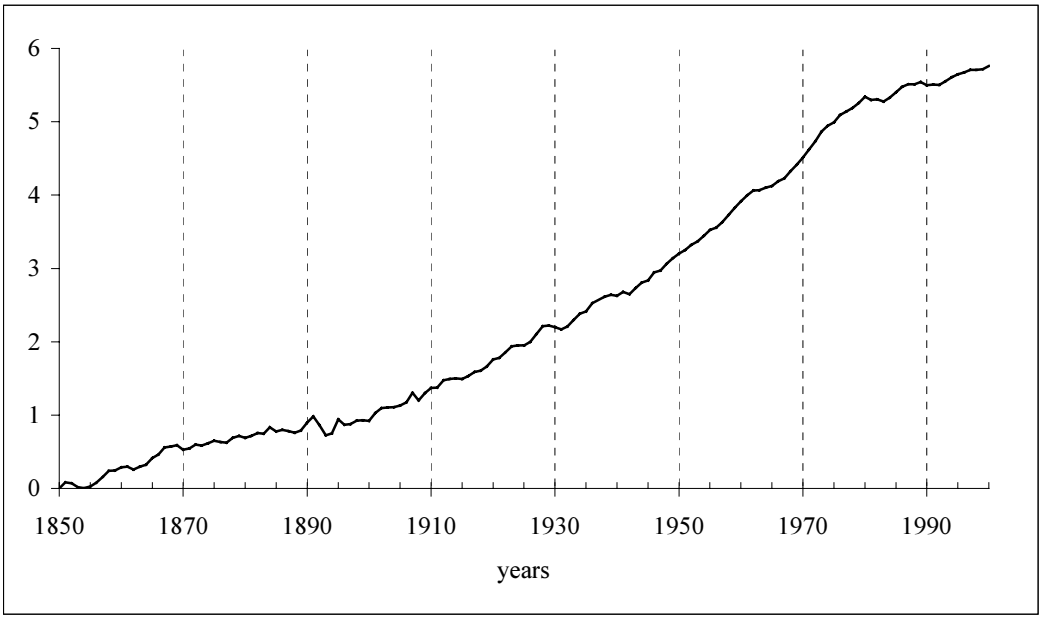
We decided to adopt Goldsmith's series for two reasons. First, as we mentioned before, it is the only one that covers the period 1850-1900. Second, Goldsmith constructed his series using information from labor compensation, money supply, foreign trade and public spending, while Contador and Haddad used only foreign trade from 1861 to 1888 and foreign trade plus installed electricity capacity afterwards.

[1] Note that the Brazilian national account system does not cover the period prior to 1947.

We summarize the discussion on our GDP series as follows. It has four properties. First, it is the only one available for the period 1850-2000. Second, it is very accurate for the period 1900-2000. Third, it provides an accurate description of the long-run evolution of Brazilian GDP. Fourth, its short-term measurement errors should be larger in the 1850-1900 sub-period than later. For this last reason some of the results presented in this paper should be taken with care. To minimize this problem, on several occasions we report results for the whole period 1850-2000 and some selected sub-periods.

We plot the natural logarithm of the real GDP in Figure 1.

Figure 1
Log of real Brazilian GDP



The period 1890-1895 has some striking features. There was a strong boom from 1890 to 1892, a deep recession in 1893 and 1894 and a strong recovery in 1895. This period corresponds to the well-known *encilhamento*.

The industrial machinery and equipment imports data in Table 7.6 of IBGE (1990) provides additional information on real economic activity for the *encilhamento* period. These data display positive growth in 1890 and 1891, a fall in 1892, virtual stagnation in 1893 and 1894 and a recovery in 1895. The amount of imports was so high in 1891 that only in 1907 did the economy reach that level again. In the case of GDP, this happened a little earlier, in 1901.

Other conspicuous features of the GDP series are an acceleration that took place around 1895 and a slowdown at the beginning of the 1980s. The latter is widely known. It corresponds to the beginning of the *lost decades*. We discuss next the former feature.

The aforementioned GDP acceleration happened close to 1895. Both Baer (1996) and Prado Jr. (1979) stated that an industrial surge started in the 1880s. Additional evidence on that industrial take-off is provided in Table 7.6 of IBGE (1990). The industrial machinery and equipment imports display a boom after 1880. It is well known

that industrialization is often accompanied by a rise in GDP's growth. For evidence on this growth stylized fact, see Baldwin, Martin and Ottaviano (1998).

I.2 – The population series

To our surprise, we did not find any population series for the entire period 1850-2000 suited to this paper. All series we had access use (at least for some sub-period) geometric interpolation for years between censuses. We explain next why such estimations are not appropriated for our purposes.

One of our goals in this paper is to document the cyclical properties of Brazilian per capita GDP. The use of population data based on geometric interpolation would introduce spurious breaks in per capita GDP. For instance, consider the sub-period 1960-2000. During these years, the Brazilian population grew at decreasing rates. Had we used geometric interpolation for the years between 1960 and 1970 and 1970 and 1980, the population growth rate would have a decrease in 1971 and be constant up 1980. That would have introduced a spurious break in the per capita GPD series exactly in 1971.

To overcome the problems mentioned above, we constructed a population series using cubic spline interpolation. This method has the advantage of generating a series that has a smooth growth rate and exactly matches the original figures for the interpolation nodes. Thus, the resulting series exactly matches the long run evolution of the Brazilian population.

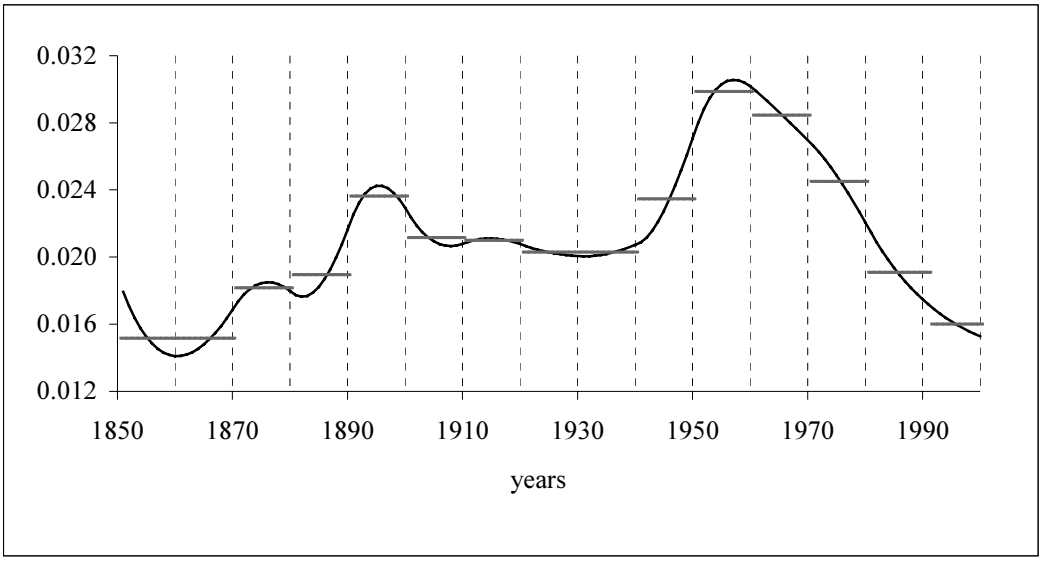
We detail next how we constructed our population series. Our basic source for population figures is the data CD that accompanies IBGE (2003). The file 'populacao_a1952aeb_32.xls' located in the folder 'populacao\1952' contains population estimations for each year in the period 1851-1950. We selected the years 1851, 1860, 1870, 1880, 1890, 1900, 1910, 1920, 1930, 1940 and 1950 as interpolation nodes.[2] The file 'populacao2000aeb_s2_002a_a_002b.xls' in the folder 'populacao\2000' contains the results of several population censuses. We took the results of 1960, 1970, 1980, 1991 and 2000 as interpolation nodes as well.

In Figure 2 we plot the first difference of the log of our population series. The horizontal lines correspond to the arithmetic means of the first differences for each decennium. Since our population series exactly matches the IBGE data at the interpolation nodes, these averages correspond to both IBGE data and ours.

[2] There exist other population figures available for the period 1851-1950. We selected the one in that file because it was the latest re-estimation carried out by IBGE that fully covered that period.

Figure 2

First difference of the log of the Brazilian population



I.3 – The per capita GDP series

We obtain a per capita GDP series by taking the ratio of GDP to population series. Figure 3 plots the logarithm of real per capita GDP. In Table 2 we present its average growth rate for each decade.

Figure 3

Log of real per capita Brazilian GDP

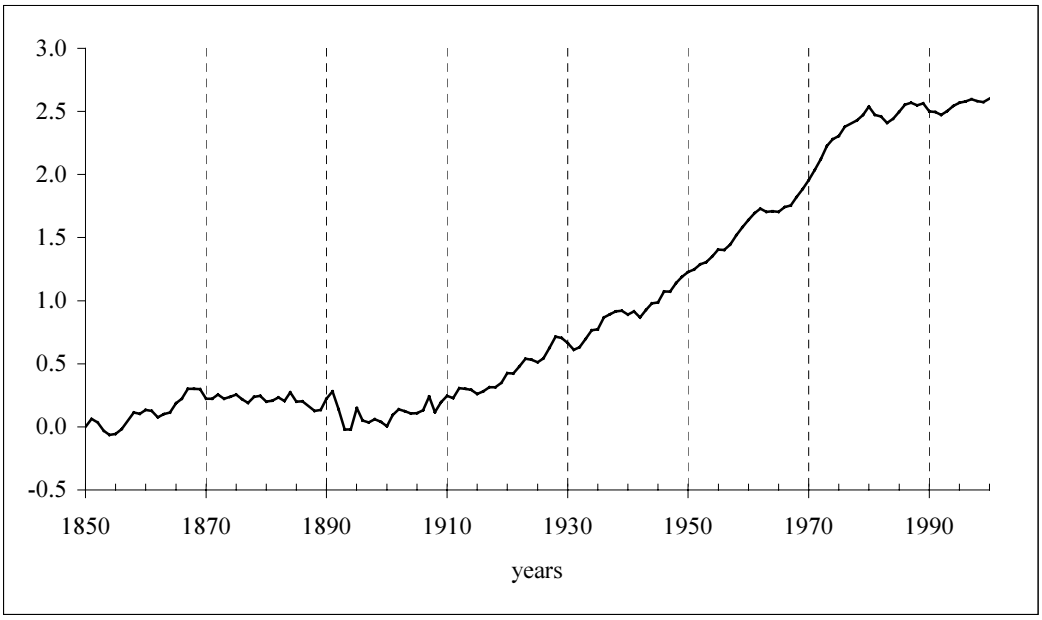


Table 2
Brazilian real per capita GDP – average growth rate (%)

period	rate	period	rate	period	rate
1851-1860	1.35	1901-1910	2.43	1951-1960	4.22
1861-1870	0.89	1911-1920	1.82	1961-1970	3.19
1871-1880	-0.22	1921-1930	2.41	1971-1980	6.00
1881-1890	0.22	1931-1940	2.28	1981-1990	-0.37
1891-1900	-2.15	1941-1950	3.45	1991-2000	1.01

Some selected characteristics of the per capita GDP series deserve a few words. From the end of World War II up to 1980, Brazil experienced higher growth rates. Afterwards, real per capita GPD virtually halted. These facts are widely known. For instance, Abreu (2003) also reported them.

The behavior of the average per capita GDP in the period 1850-1925 has not been studied as often as in the post World War II period. According to Contador and Haddad (1975), per capita GDP in 1910 was about the same as for 1861. Our series also displays this fact. Additionally, we figured out that the real per capita GDP was about the same in 1891 and 1916. The same fact is observed for the years 1885 and 1909. In other words, the average Brazilian was poorer in 1916 than in 1869.

The facts mentioned in the above paragraph are consequences of a major decline in Brazilian per capita GDP during the 1870-1900 period. According to our series, the per capita GDP in 1900 was only 80% of the 1870 figure. Using the series of Contador and Haddad (1975), the equivalent figure is 68%. Therefore, the available evidence suggests that the Brazilian economy suffered a severe decline in the thirty years that followed the end of the Paraguayan War in 1870.

II – Cyclical properties of the per capita GDP

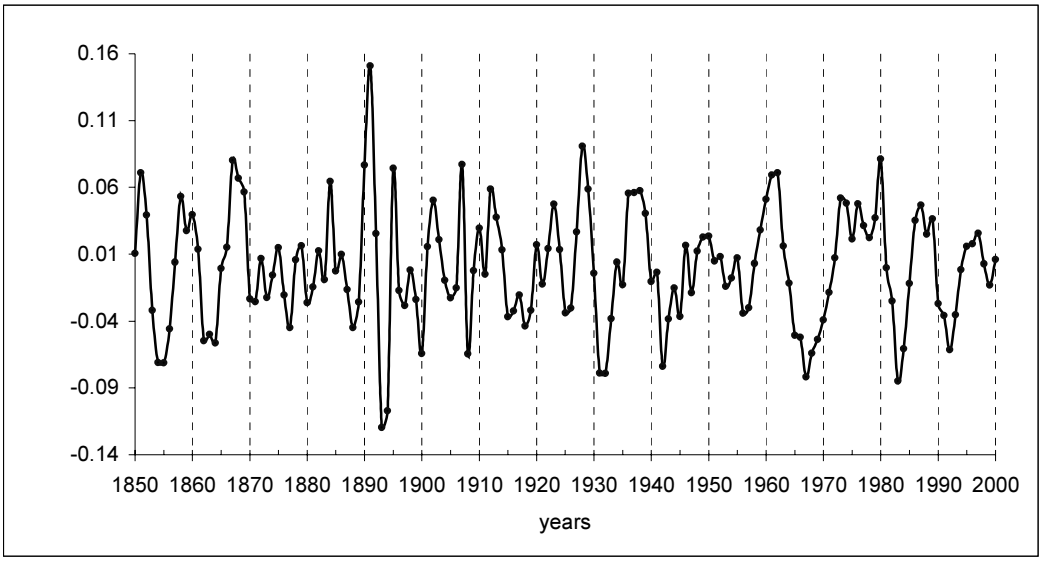
To extract the cyclical component of the per capita GDP series, we detrended the natural logarithm of that series with the well-known Hodrick-Prescott (HP) filter.[3] As usually done when working with annual data, we adopted the value of 100 for the smoothing parameter λ.[4]

We present at Figure 4 the time path of the cyclical component of Brazilian real per capita GDP.

[3] The HP filtering procedure is explained in detail in Hodrick and Prescott (1997).

[4] Ravn and Uhlig (1997) argue that instead of 100, 6.25 would constitute a more appropriate value for λ when working with annual data. We also used that alternative figure. However, except for the fact that the cyclical component became less volatile, we did not find any major difference in the results.

Figure 4
Cyclical component of the log of real per capita GDP



We study next some of the properties of the cyclical component of the per capita GDP. First we will look into its volatility and persistence. Then, we will study its evolution across the cyclical phases (i.e., expansion and recession).

As usually done in the related literature, we used the standard deviation and first order serial autocorrelation of the cyclical component of per capita GDP to measure its volatility and persistence. We report these statistics at Table 3 for the whole sample and some selected sub-periods.[5]

Table 3
Business-cycle volatility and persistence

years	standard deviation (%)	autocorrelation
1850-1889	3.96	0.512
1890-1945	5.11	0.343
1946-2000	3.88	0.715
1850-2000	4.37	0.470

The greatest volatility occurred between 1890-1945. Recall that in 1889 the Republic was proclaimed in Brazil. Hence, the volatility of per capita output fluctuations seems to increase slightly after the fall of Monarchy up to the end of World War II. For the other two sub-periods, 1850-1889 and 1946-200, the volatility was roughly the same. Concerning the autocorrelation, the main conclusion is that an expressive increase in the persistence happened after the World War II.

[5] It is important to explain how we selected the sub-periods in Table 3. The sub-period 1850-1889 corresponds to the Imperial years. Hence, we have 111 Republican years (from 1890 to 2000). The end of World War II in 1945 divides these 111 years into two sub-periods of roughly the same duration.

Backus and Kehoe (1992) studied the output volatility, over a hundred years, of ten countries (Australia, Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States). They focused on three sub-periods, which they labeled as prewar, interwar and postwar. There are slight differences in terms of data coverage for each country, but broadly speaking, the prewar period covers data prior to the beginning of World War I, interwar refers to the period between the end of World War I and beginning of World War II, and postwar deals with data after the end of World War II up to 1985. Their main conclusion was that, except for Australia, all countries in their sample had higher output volatility in the interwar period.

For comparison purposes, we carried out the same exercise with Brazilian per capita GDP. Table 4 contains the results of that exercise.

Table 4
Brazilian business-cycle volatility

Period	volatility
prewar (1850-1914)	4.80
interwar (1920-1939)	4.64
postwar (1950-1985)	4.35

Brazil did not show the highest variability during interwar era. In fact, volatility reaches its maximum in the prewar period. However, it varied very little across the three periods. This is an important difference from other countries. For instance, in Canada and the United States, the volatility practically halved from the prewar to the postwar.

Another interesting finding is obtained when comparing the data in Table 4 to similar data reported by Backus and Kehoe (1992) for the United States. That country had prewar, interwar and postwar volatilities of, respectively, 4.28, 9.33 and 2.26. So, the Brazilian volatility was similar to the US one in the prewar period and almost double in the postwar.

We now turn to the task of dating recessions, expansions and turning points. We will follow Canova (1994, 1999) and Harding and Pagan (2002) and adopt very simple dating rules.

Let y_t^C denote the cyclical component of the real per capita GDP. We say that a *expansion* takes place at year *t* if $y_t^C - y_{t-1}^C > 0$. Similarly, a *recession* happens whenever $y_t^C - y_{t-1}^C \leq 0$. The last year of an expansion corresponds to a *peak* and the last year of a recession corresponds to a *trough*. A *turning point* takes place whenever the economy hits a peak or a trough.

Our simple dating procedure is in line with the business cycle literature. There are alternative procedures that rely on econometric techniques. Chauvet (2002) and Duarte, Issler and Spacov (2004) adopted some these alternative procedures to create chronologies of the Brazilian business cycle. Despite these distinct approaches, it turned out that our chronology is similar to the one Chauvet constructed using, as we did, yearly data.

We present in Table 5 the evolution of Brazilian per capita GDP over the business-cycle phases. A plus sign means expansion and a minus sign means recession.

Table 5
Cyclical phases of the Brazilian real per capita GDP

year	phase	year	phase	year	phase	year	phase	year	phase	year	phase
1851	+	1876	–	1901	+	1926	+	1951	–	1976	+
1852	–	1877	–	1902	+	1927	+	1952	+	1977	–
1853	–	1878	+	1903	–	1928	+	1953	–	1978	–
1854	–	1879	+	1904	–	1929	–	1954	+	1979	+
1855	–	1880	–	1905	–	1930	–	1955	+	1980	+
1856	+	1881	+	1906	+	1931	–	1956	–	1981	–
1857	+	1882	+	1907	+	1932	–	1957	+	1982	–
1858	+	1883	–	1908	–	1933	+	1958	+	1983	–
1859	–	1884	+	1909	+	1934	+	1959	+	1984	+
1860	+	1885	–	1910	+	1935	–	1960	+	1985	+
1861	–	1886	+	1911	–	1936	+	1961	+	1986	+
1862	–	1887	–	1912	+	1937	+	1962	+	1987	+
1863	+	1888	–	1913	–	1938	+	1963	–	1988	–
1864	–	1889	+	1914	–	1939	–	1964	–	1989	+
1865	+	1890	+	1915	–	1940	–	1965	–	1990	–
1866	+	1891	+	1916	+	1941	+	1966	–	1991	–
1867	+	1892	–	1917	+	1942	–	1967	–	1992	–
1868	–	1893	–	1918	–	1943	+	1968	+	1993	+
1869	–	1894	+	1919	+	1944	+	1969	+	1994	+
1870	–	1895	+	1920	+	1945	–	1970	+	1995	+
1871	–	1896	–	1921	–	1946	+	1971	+	1996	+
1872	+	1897	–	1922	+	1947	–	1972	+	1997	+
1873	–	1898	+	1923	+	1948	+	1973	+	1998	–
1874	+	1899	–	1924	–	1949	+	1974	–	1999	–
1875	+	1900	–	1925	–	1950	+	1975	–	2000	+

Legend: '+' means expansion and '–' means recession.

The longest expansions lasted six years (from 1957 to 1962 and from 1968 to 1973), while the longest recession lasted for five years (from 1963 to 1967).

Table 6 contains information on some selected features of the chronology of recessions and expansions of the Brazilian economy. The figures provided there were computed for the 1852-1999 period. That is, we removed from the calculations the two endpoints of the period covered in Table 5. Had we proceeded differently, we would have included in our calculations two one-year expansions that we could not be sure indeed lasted one year. For instance, if the Brazilian economy experienced an expansion in 2001 it would be definitively wrong to compute the expansion in 2000 as a one-year event.

Table 6
Features of expansions and recessions

Feature	Value
years in expansion	79
years in recession	69
number of expansions	35
number of recessions	37
average expansion length (in years)	2.26
average recession length (in years)	1.86

There were 79 years of expansion and 69 of recession. The number of recessions (37) was slightly higher than the number of expansions (35). The average expansion lasted 21% more than the average recession. Thus, expansions were more frequent and lasted longer than recessions.

III – Growth properties of the per capita GDP

In this section we first investigate if the volatility of growth rates has been increasing or decreasing over time. Then, we try to identify whether changes in the volatility of the real per capita GDP impact its growth rate. Finally, we assess if there was a change in the persistence of the per capita GDP growth rate.[6]

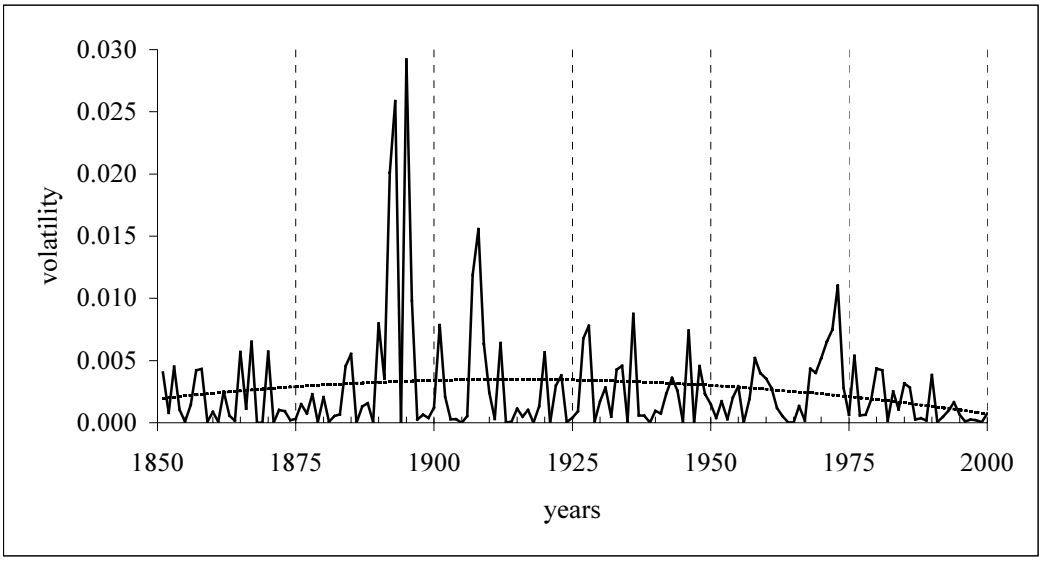
III.1 – Volatility trend and the Fischer Black hypothesis

We carry out two tasks in this subsection. The first one is to find out if per capita output volatility has been changing over time. The second one is to study the impact of volatility on per capita output growth rate.

We measure volatility as the squared growth rate of real per capita GDP. To obtain the trend, we simply fit a quadratic polynomial to the volatility series of per capita output. We plot the volatility and its trend in Figure 5.

[6] We carried out similar exercises for the GDP growth rate. The results were qualitatively similar.

Figure 5
Real per capita GDP growth rates – volatility and volatility trend



The trend shows a low volatility phase approximately from 1850 to 1875, followed by a moderate volatility phase from 1875 to 1975 (a period in which volatility was increasing) and then by another low volatility phase, beginning approximately in 1975. One plausible explanation for the pattern observed is that at the beginning, Brazil had an unsophisticated economic structure and, therefore, faced few macroeconomic shocks. Afterwards, it became an agrarian and an industrialized economy, but without efficient institutions to conduct macroeconomic policies. The last phase may be due to improving institutional arrangements. Still, it is worth noticing that the change in volatility patterns is not abrupt, suggesting a smooth overall pattern rather than breaks.

Interestingly, comparing Table 2 with Figure 5, we observe that periods of high average growth seem to coincide with periods of high volatility. This observation leads us to the second issue we discuss in this subsection.

Black (1987) argued that a positive relationship between output volatility and growth must be observed. The reason is that economies face a positive trade-off between risk (volatility) and return (output growth rates) when choosing their aggregate technologies. This conjecture has become known as the Fischer Black hypothesis.

As Caballero (1991) pointed out, there is an alternative view on the relation between growth and volatility. It is often argued that large swings in the economy make investment extremely risky and, as a result, induce less investment, less capital accumulation and consequently less output growth.

Caporale and MacKiernan (1998) tested the Fischer Black hypothesis for the United States from 1871 and 1993 and found that variability significantly increases output growth rates. We carry out a similar exercise with the Brazilian real per capita GDP series. We estimate a GARCH (1,1) in mean model for per capita output.

The GARCH (1,1) is a model for the conditional variance of a time series. In order to capture the effect of volatility on output growth, we introduce the conditional standard deviation in the equation for the mean of the per capita output growth process.

Before presenting the results, some notation is in order. Let y_t be the natural log of the per capita output. As usual, Δ denotes the first difference operator. The conditional variance is denoted by σ_t and ε_t stands for the residual in the mean equation.

The model estimated has a mean equation and an equation for conditional variance, which are, respectively

$$\Delta y_t = \gamma_0 + \gamma_1 \Delta y_{t-1} + \gamma_2 \sigma_t + \varepsilon_t$$

and

$$\sigma_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \ .$$

We report the estimation results in Table 7 .

Table 7
Estimation results – GARCH(1,1) in mean

parameters	estimate	standard deviation	*Z* statistics
γ_0	0.0621	0.0319	1.9452
γ_1	0.1677	0.0863	1.9411
γ_2	-0.9859	0.6863	-1.4364
ω	0.0002	0.0001	1.2941
α	0.1035	0.0568	1.8199
β	0.8214	0.0777	10.5631

The estimation results suggest that volatility does not enter in a statistically significant way in the mean equation. Moreover, the point estimate contradicts the Fischer Black hypothesis. Therefore, that conjecture does not seem to hold for Brazil and if volatility influences growth at all, it is in a negative fashion.

III.2 – Are pre and post World War II per capita GDP growth so different?

Table 3 suggests that business cycles became more persistent after the World War II. In this subsection we fit a simple AR (1) – GARCH (1,1) model, similar to the one in the previous subsection, allowing for a dummy variable, denoted by *d*, associated with observations from 1946 to 2000, in the mean and in the conditional variance equation. The goal is to verify if changes in the dynamics of per capita GDP growth are related to volatility or to persistence.

The dummy is significant in the conditional variance equation only when we specify an ARCH (1) process. With a GARCH (1,1) process, the dummy is not significant, so we drop the variable from the conditional variance equation.

The estimated equations are

$$\Delta y_t = \gamma_0 + \gamma_1 d_t + \gamma_2 \Delta y_{t-1} + \gamma_3 d_t \Delta y_{t-1} + \varepsilon_t$$

and

$$\sigma_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \ .$$

The estimation results are reported in Table 8.

Table 8
Estimation results – GARCH(1,1) with dummy

parameters	estimate	standard deviation	*Z* statistics
γ_0	0.0106	0.0049	2.1605
γ_1	0.0066	0.0117	0.5629
γ_2	0.0032	0.0986	0.0325
γ_3	0.3776	0.2511	1.5133
ω	0.0006	0.0005	1.2338
α	0.1929	0.0983	1.9622
β	0.5276	0.2810	1.8777

The estimation provides evidence that the per capita GDP growth became much more persistent after the World War II. Therefore, the pre and post World War II dynamics of the series are very different. Furthermore, that difference is related to a change in persistence rather than a dramatic change in volatility, since the dummy variable in the conditional variance is not significant.

IV – Conclusion

We constructed a real per capita GDP series for the Brazilian economy that covers the period from 1850 to 2000. We then studied its business cycle and growth features.

Backus and Kehoe (1992) reported the standard deviations of the cyclical components of the outputs of ten developed countries during the period 1861-1985. They found that for most of the countries, the volatility of the economic activity was much lower after the World War II than during the interwar period. We did not identify the same pattern on the Brazilian data. On the other hand, it appears that the cyclical component of the per capita GDP became more persistent after 1945.

We showed that the volatility of the per capita output growth rates could be characterized by three phases: a low volatility period, followed by a higher volatility period, which precedes another low volatility phase, beginning approximately in 1975. Nevertheless, the change in volatility patterns suggests a smooth pattern rather than breaks.

Finally, we empirically modeled the relationship between volatility and output growth, using a GARCH (1,1) in mean, and concluded that the relationship is not statistically significant. However, we found evidence that after the World War II the growth rate of per capita GDP became more persistent.

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