Permanent Structural Changes in The Brazilian Economy and Long-Memory: A Stock Market Perspective [*]

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Abstract

The paper assesses long memory patterns in the Brazilian stock market index (Ibovespa) for sub-periods before and after the Real Stabilization Plan. Evidence favours the existence of short memory for both periods despite the so-called reforms the Brazilian economy has been going through in the nineties and, in particular, after the Real Plan.

Sumário

O artigo avalia padrões de memória longa no mercado de ações brasileiro (Ibovespa) para sub-períodos antes e após o Plano Real. A evidência sugere a existência de memória curta para ambos os períodos, apesar das reformas que vem sendo perseguidas no país durante os anos 90 e, mais particularmente, desde o início do plano de estabilização.

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1 – Introduction

An enduring issue in Finance concerns the predictability of stock market returns. There is a vast literature in market efficiency, such as Fama and French(1988), Poterba and Summers(1988) and Lo and MacKinlay (1988). Both anecdotal evidence and a series of studies, which indicated that persistence is an actual feature of stock markets, have challenged this hypothesis.

There is an influential research area consisting of the assessment of long memory in economic time series. In particular, the class of fractional–Arima models (ARFIMA) introduced by Granger and Joyeux(1980) and Hosking(1981), addresses the issue of the existence of long memory. Blasco and Santamaría(1996), Crato(1994) and Crato and Rothman (1994) provided representative applications of the ARFIMA methodology.

The stabilization of the general price level in Brazil after the Real Plan is often regarded as a landmark in terms of the reduction of macroeconomic uncertainty. One would expect as a consequence of this new economic environment that economic agents would hold a longer decision horizon. In fact, government officials have taken this vision forward and contended that agents should be willing, thus, to carry long term financial instruments. However, the National Treasury of Brazil has not been able to issue fixed bonds with maturities longer than one year[1]. It shows us that inflation by itself is just one of the many relevant aspects of macroeconomic stabilization. Additional factors have to be pursued in order to reduce the uncertainty about the future.

The previous discussion is included in a broader subject, namely the trade-off between fixed rules and discretion. In fact, it is well known, at least since Kydland and

Prescott (1977), that the lack of well defined rules may introduce noise in the optimal decisions of economic agents. This problem of time inconsistency indicates that agents' optimal decision rules are not invariant to abrupt changes in economic policies. It appears, thus, that in economies characterized by less stable rules, agents would respond to any shock that would arise in the economy. Then, the agent decision process would display a short memory pattern, which means that recent shocks can play an important rule in decision making.

The Brazilian recent history is especially interesting to test changes in memory patterns as there has been an important economic structural change recently. In fact, the last six years of the Nineties were characterized by a stable inflation after almost twenty years of inflationary turmoil. We chose the Brazilian stock market to evaluate the economic agents memory pattern as stylized facts suggest that stock market reacts rapidly to changes in economic conditions. In this respect, we study the São Paulo stock market return in two sample periods (before and after the 1994 Brazilian economic stabilization plan) in order to verify if there has been a shift in the memory pattern given the observed structural changes in the Brazilian economy. On the other hand, there has been several international crisis after 1994, which, in principle, would benefit a short-memory result.

This paper is organized as follows. The next section presents a brief summary of the ARFIMA models. The third section describes the data and presents the empirical results. The final section summarizes and concludes.

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[1] In fact, in the first week of December, 1999, the National Treasury was only able to issue 3-years bonds

2 – Long Memory in Economic Time-Series

Granger and Joyeux (1980) and Hosking (1981) independently introduced the class of Fractional ARIMA models (ARFIMA)[2]. An important feature of this class of model is its ability to accommodate a higher degree of persistence in time series than traditional ARIMA models. This ability allows a better assessment of the presence of long memory in the data, as we shall see.

Actually, the ARFIMA (p,d,q) model can be described as:

$$f(L)(1-L)^d y_t = q(L)e_t, \qquad e_t \sim WN(0, s_e^2)$$

where L is the lag operator, d represents the integration parameter, which is potentially fractional, $f(L) = 1 - f_1 L - f_2 L^2 - ... - f_p L^p$ and $q(L) = 1 - q_1 L - q_2 L^2 - ... - q_p L^q$. The previous polynomials are outside the unit circle to guarantee stationarity and irreversibility. Then, $(1-L)^d$ denotes the fractional differencing operator, which can be defined by the binomial expansion:

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

where $d < 0.5$ is a requirement for stationarity and $d > -0.5$ is the respective requirement for invertibility.

The asymptotic autocorrelation function follows:

$$g(h) \sim C\, h^{2d-1}, \qquad as \quad h \to \infty$$

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linked to the change of the general price index.

where h denotes the displacement in time.

When $d \neq 0$ the process has a long-memory characteristic, and follows one of the two possible cases, as shown in Brockwell and Davis (1991):

. for $-0.5 < d < 0$ the process is antipersistent; and

. for $0 < d < 0.5$ the process is persistent.

According to Brockwell and Davis(1991), the spectral density for $d \neq 0$ is given by:

$$f(l) = \frac{\left|q\left(e^{-ih}\right)\right|^2}{\left|f\left(e^{-ih}\right)\right|^2}\left|1-e^{il}\right|^{-2d}\frac{s^2}{2\Pi} \sim \left|\frac{q(1)}{f(1)}\right|^{-2} l^{-2d}\frac{s^2}{2\Pi}, \quad for \ l \to 0$$

Both equations suggest that ARFIMA models are indeed capable of accommodating a higher degree of persistence in time series than traditional ARIMA models. The autocorrelation decay of ARFIMA models is slower than the related decay for the ARIMA models. Moreover, ARFIMA spectral density at the zero frequency is higher than the ARIMA one.

3 - Empirical Results

3.1 - Dataset

We consider the São Paulo stock market returns (constructed upon the IBOVESPA) on a weekly basis from 01/10/1986 to 12./31/1999. The choice of weekly data is consistent with the bulk of the international literature on long memory which is mentioned throughout the paper. The referred data was deflated by different price indices for the sake of robustness. Specifically we consider the General Price Index (IGP-DI) and the Producer Price Index (IPA), both from Getulio Vargas Foundation, and the National

[2] For general surveys on ARFIMA models, see Baillie(1996) and Lardic and Mignon (1997).

Consumer Price Index (INPC) from the National Department of Statistics and Geography (IBGE). We consider two sub-periods: the first from 01/10/1986 to 06/30/1994 and the second from the beginning of the stabilization plan (07/01/1994) to 12/31/1999. The basic motivation for deflating the original series has to do with the intention of abstracting the memory pattern from the inflation reasoning [3]. Instead of deflating the weekly Ibovespa index with the corresponding monthly price index, we built weekly price indeces through the exponential transformation of the corresponding monthly data series.[4] We intend to assess to which extent the memory horizon has changed due to the new economic environment excluding the inflation reduction obtained after the stabilization plan.

Stock market prices are known to quickly respond to new information. We argue that it is well suited to distinguish long memory from short memory patterns in volatile economies such as the Brazilian one. The subsequent figures depict the evolution of the stock market index and different real returns.

[Insert Figure 1 here]

[Insert Figure 2 here]

[Insert Figure 3 here]

[Insert Figure 4 here]

3.2 – Empirical Results

[3] Fava e Alves (1998) considered the estimation of ARFIMA models for a Brazilian inflation rate between January of 1974 and June of 1994. The results obtained by that study indicated a long memory pattern.

[4] This procedure eliminates a bias that arises when the whole monthly inflation is carried only on the following month.

Previous applications have been concentrated on the estimator by Geweke and Porter-Hudak (1993). These authors suggested a semi-parametric estimator of the fractional differencing parameter d which relies on a regression of the ordinates of the log spectral density on trigonometric function. The process $1-L^{d}(y_t)=u_t$, where $u_t \sim I(0)$ can be written as:

$$f(w)_y = \left[1-e^{-iw}\right]^{-2d} . f(w)_u \qquad (3.1)$$

where $f(w)_y$ and $f(w)_u$ denote the spectral densities of *y* and *u*. Then, equation (3.1) can be expressed as:

$$\log\left[f(w)_y\right] = \left[4\sin^2\left(\frac{w}{2}\right)\right]^{-d} + \log\left[f(w)_u\right] \qquad (3.2)$$

$$\log\left[f_y(w_j)\right] = \log\left[f(0)\right] - d\,\log\left[4\sin^2\left(\frac{w_j}{2}\right)\right] + \log\left[\frac{f_u(w_j)}{f_u(0)}\right] \qquad (3.3)$$

Geweke and Porter-Hudak consider estimating d from a regression upon equations (3.2) and (3.3) using spectral ordinates $\omega_1, \omega_2, ..., \omega_m$ from the periodiogram of y_t , that is $I_y(\omega_j)$. Then, for j=1,2,...m,

$$\log\left[I_y(w_j)\right] = a + b\,\log\left[4\sin^2\left(\frac{w_j}{2}\right)\right] + v_j \qquad (3.4)$$

where

$$v_j = \log\left[f_u\left(\frac{w_j}{f_u(0)}\right)\right] \text{ and } v_j \sim i.i.d\left(0, \frac{p^2}{6}\right)$$

Baillie (1996) in an extensive survey, pointed out several shortcomings on the Geweke and Porter-Hudak (1993) methodology. For example, Hurvich and Ray (1995) pointed out a bias in the Geweke and Porter-Hudak estimator when the true data generating process is a non-stationary ARFIMA process with d > 0.5. Therefore, w follow

Baillie by considering the estimation of ARFIMA models in terms of exact maximum-likelihood estimators as developed by Sowell(1992)[5].

Table 1 summarizes the main results:

[Insert Table 1 here]

The results for the two sub-periods are similar as what concerns the memory features. In fact, we cannot reject the null hypothesis that d (the fractional integrating parameter) is equal to zero. In other words, our estimation and test procedures favours the existence of short memory in both sub-periods.

Given the previous results we decided to proceed with a final robustness check by considering the Ibovespa returns denominated in US dollars as shown in figure 5. The results thus obtained corroborate our previous analysis and were already presented in table 1.

[Insert Figure 5 here]

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The evidence signals that the observed structural changes in the Brazilian economy have not been strong enough to induce a long memory feature of economic agents. The result is not totally surprising as the Brazilian economy has been subjected to important external shocks in the last three years[6].

4- Final Comments

[5] We performed the estimations with the ARFIMA package developed by Doornik and Ooms (1999).

In the present paper, we investigate the relationship between long memory and stable economic environment. In particular, we consider two sub-periods: one before and the other after the Brazilian Real Plan. The evidence indicated the presence of a short memory pattern in the São Paulo stock market index (IBOVESPA) for both sub-periods.

Brazil has been going through several structural reforms since the beginning of the Nineties. The major turning point was the implementation of the Real Plan in July of 1994. One would expect agents to move from a short memory pattern to a long memory one after a couple of years of reforms and the prevalence of low inflation rates. In other words, agents would have long memory within a couple of years after the implementation of several structural reforms in a low inflation environment. A long memory by itself would mean that a shock in the economy would persist for a long period of time. However, our results showed that agents kept a short memory despite ongoing structural reforms in a low inflation scenario since the Real Plan. Therefore, investors remained quite sensitive to the information arrival rate, altering their allocation decisions frequently. In fact, we believe that the short memory and the associated continuous change in the economic environment constitutes one of the main reasons for the high volatility of stock market returns we have been observing in the Brazilian market in the last two decades.

Despite the significant reforms the Brazilian economy has been going through, there is much more to be done. We believe that the so-called institutional reforms, such as the tax and legal system ones, have to pass Congress before an environment with low economic uncertainty and longer decision horizon can be reached permanently[7]. Our

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[6] In the last three years, we observed significant shocks in the world economy: the Asian crisis in 1997; the Russian crisis in 1998; and the Brazilian currency devaluation in 1999.

[7] One might expect that the new fiscal legislation that was recently approved in Congress (if it becomes effective) will contribute sharply to the emergence of a turning point in the memory pattern.

results also confirm the perception thatis not uncommon to expect long memory patterns in more stable economies [see Crato (1994) and Crato and Rothman (1994)].

Further research could explore ARFIMA models that allow for regime shifts as recently advanced by Diebold and Inoue (1999). These models would be well suited for analyzing non-stable economies.

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Figure 1: São Paulo Stock Market Index

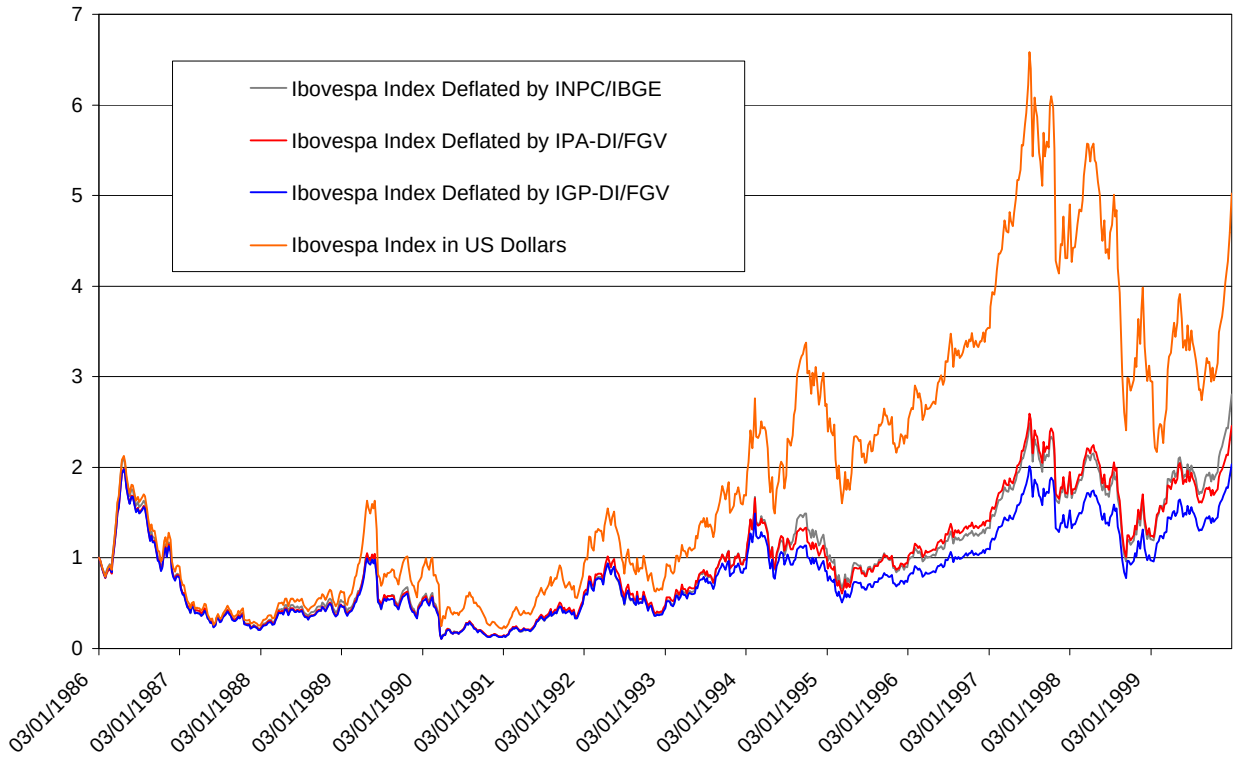

Figure 2: São Paulo Stock Market Weekly Return (Ibovespa Deflated by INPC/IBGE)

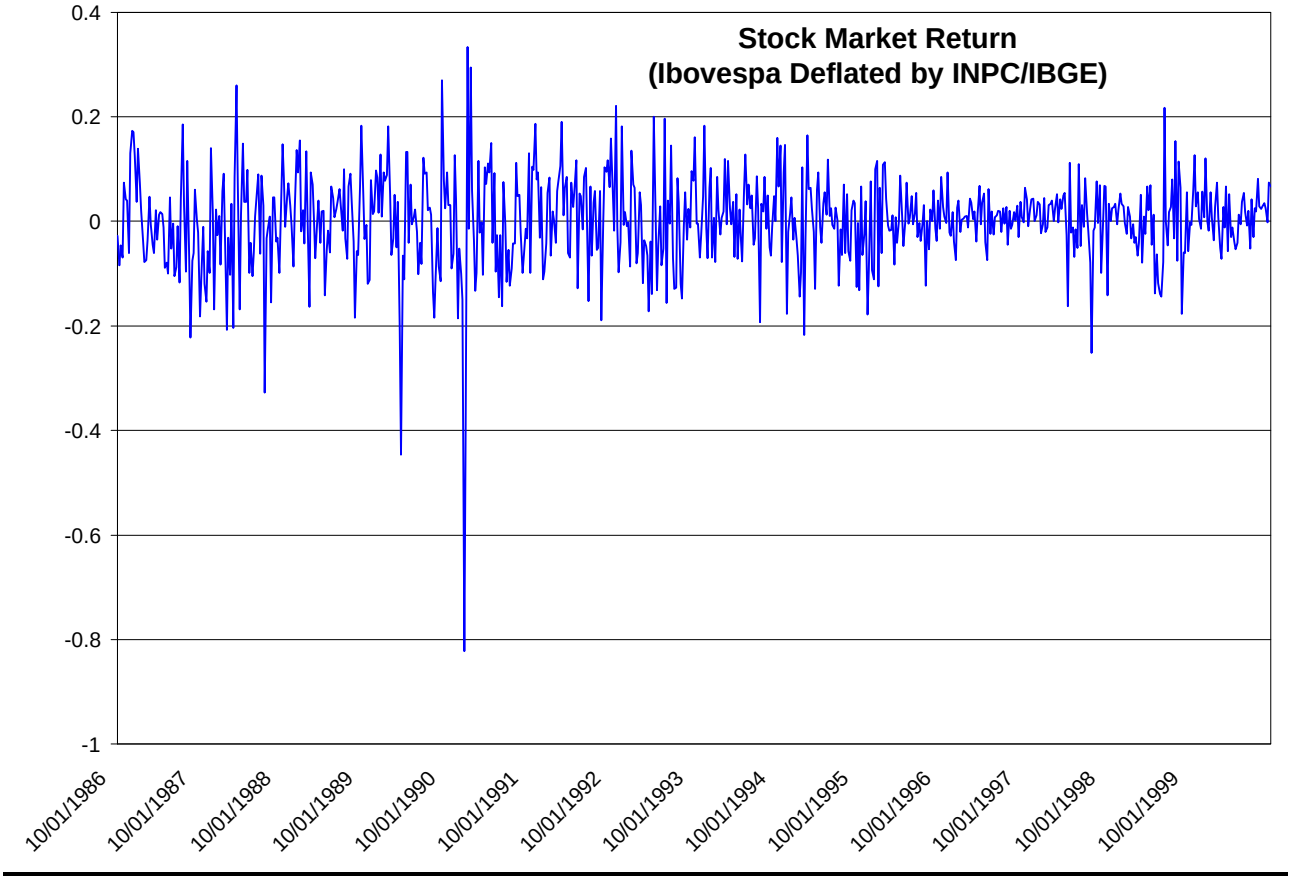

Figure 3: São Paulo Stock Market Return (Ibovespa Deflated by IGP-DI/FGV)

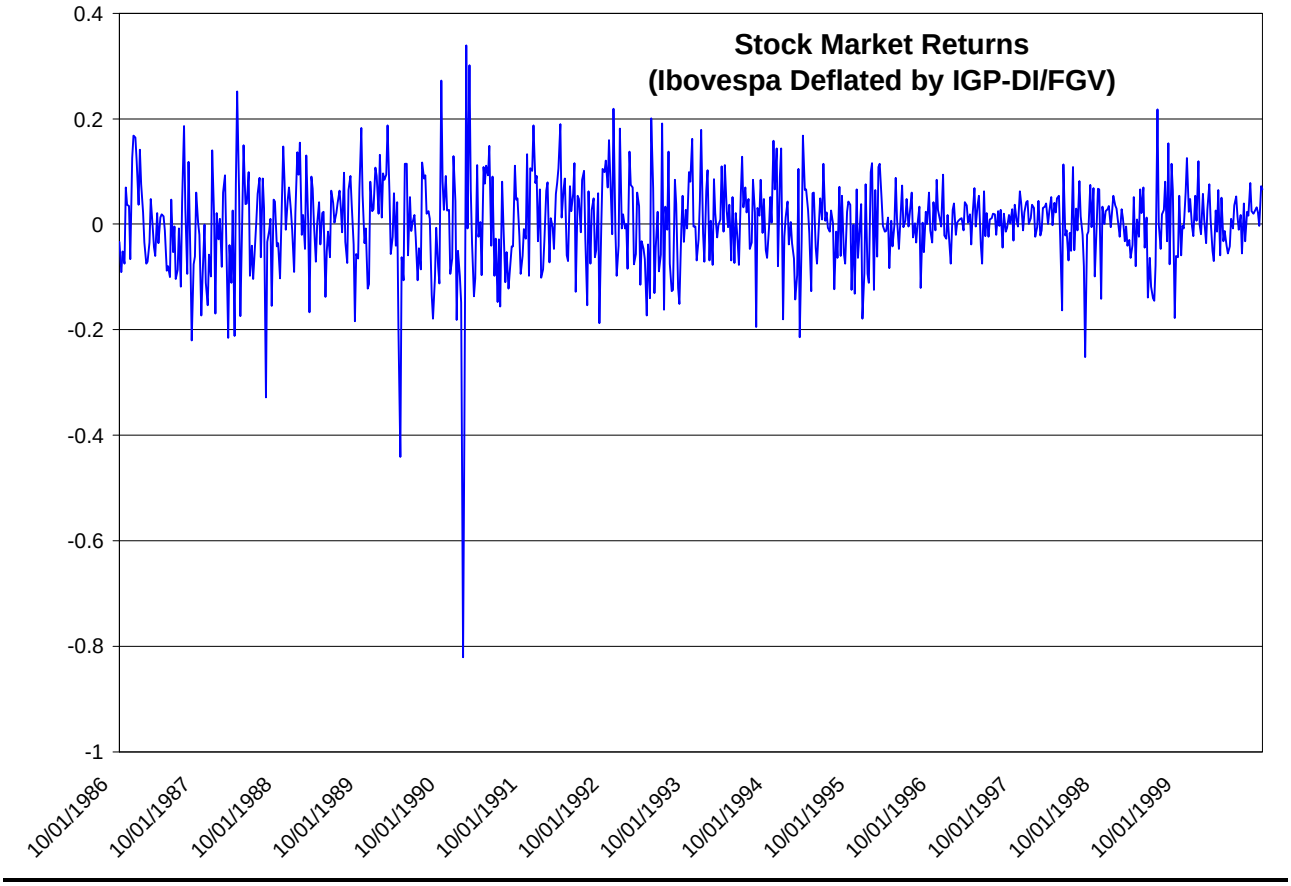

Figure 4: São Paulo Stock Market Weekly Return (Ibovespa Deflated by IPA-DI/FGV)

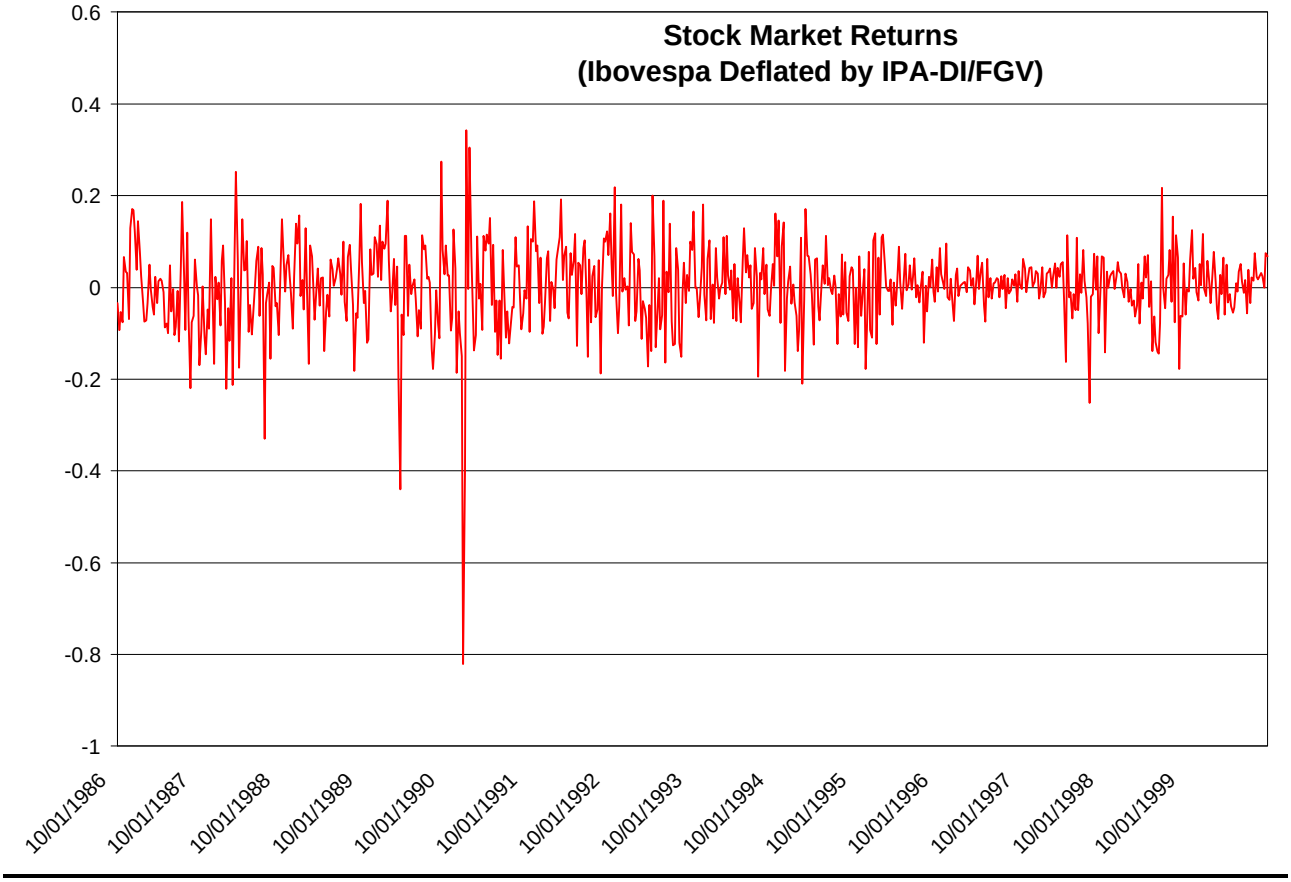

Figure 5: São Paulo Stock Market Weekly Returns (Ibovespa in US Dollars)

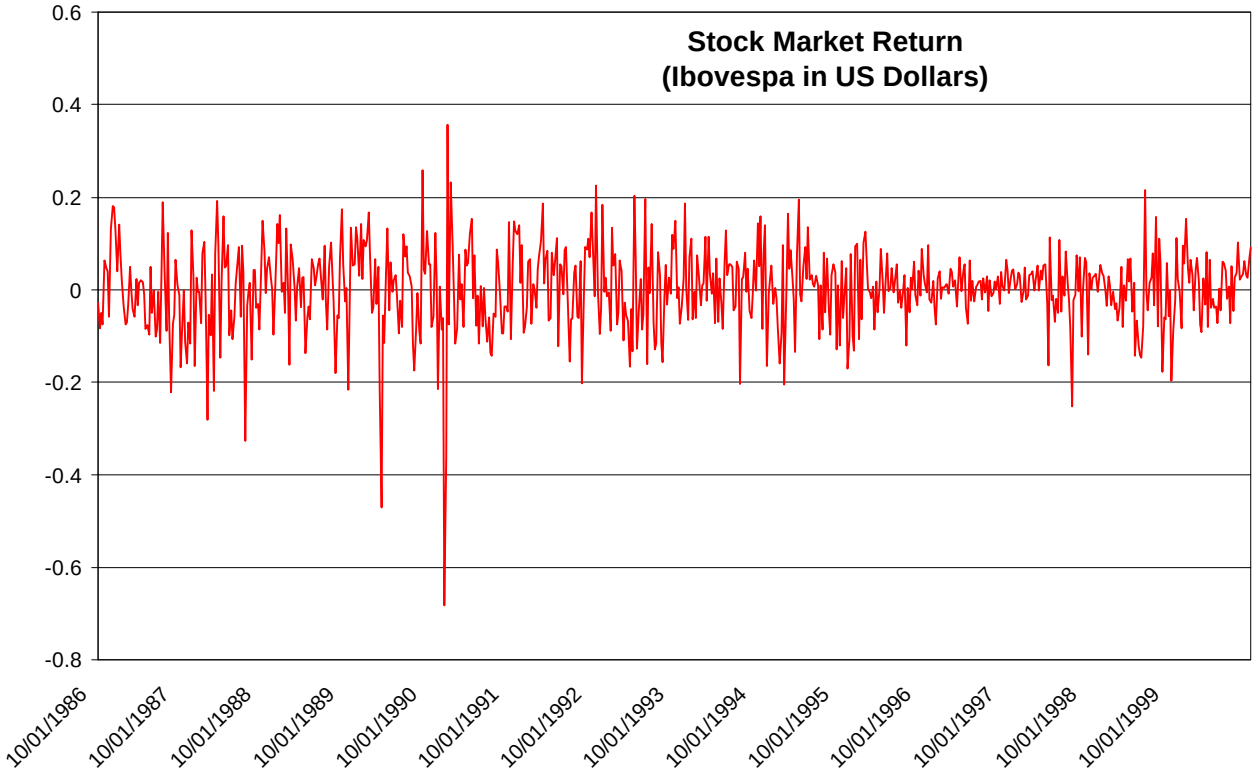

Table I – ARFIMA Model Estimates and Memory

Ibovespa Returns (Deflated by)	Period	Selected Model	d parameter	(t value)	(p-value)	AIC	Log-likelihood
IGP-DI	First	(2,d,4)	-0.096	(-1,42)	0.16	-769.11	392.355
	Second	(3,d,3)	-0.208	(-1,02)	0.31	-814.8	415.4
IPA-DI	First	(2,d,4)	-0.096	(-1,41)	0.15	-768.18	392.09
	Second	(4,d,4)	-0.071	(-1,22)	0.23	-816.08	418.04
INPC	First	(2,d,4)	-0.091	(-1,34)	0.18	-767.25	391.62
	Second	(4,d,4)	-0.058	(-0,96)	0.34	-813.85	416.92
US Dollars	First	(3,d,2)	-0.13	(-1,34)	0.18	-785.31	399.66
	Second	(4,d,4)	-0.042	(-0.79)	0.43	-777.17	398.56