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Fluctuation Dynamics in US interest rates and the role of monetary policy

Daniel Oliveira Cajueiro* Benjamin M. Tabak †

Abstract

This paper presents empirical evidence suggesting that the degree of long-range dependence in interest rates depends on the conduct of monetary policy. We study the term structure of interest rates for the US and find evidence that global Hurst exponents change dramatically according to Chairman Tenure in the Federal Reserve Board and also with changes in the conduct of monetary policy. In the period from 1960's until the monetarist experiment in the beginning of the 1980's interest rates had a significant long-range dependence behavior. However, in the recent period, in the second part of the Volcker tenure and in the Greenspan tenure, interest rates do not present long-range dependence behavior. These empirical findings cast some light on the origins of long-range dependence behavior in financial assets.

Generalized Hurst exponent; long-range dependence; monetary policy.

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1 Introduction

In the past decades the US economy has experienced low inflation and little variation in real activity if compared to the 1970's. These improvements have been largely attributed to a change in the way the Federal Reserve conducts monetary policy. A number of research papers have suggested that a structural break in the conduct of monetary policy has occurred since Paul Volcker became chairman of the Federal Reserve in August 1979 (see Clarida et al., 2000). However, there is little consensus as whether a change in the conduct of monetary policy has indeed occurred and if it has what would be the dates of these changes (Boivin, 2006).

This paper has three main contributions. First, we present evidence of a structural break in long-range dependence for long-term interest rates. The break seems to be related to the conduct of monetary policy. Second, we employ a non-parametric technique to analyze long-range dependence, which is robust to short-term dynamics misspecification. Third, we also test for long-range dependence for inflation and find that the degree of long-range dependence has decreased substantially in the post-1982 period.

We contribute to the debate on monetary policy by studying changes in persistence in interest rates for different maturities for the US. We investigate 1, 3 and 5 year maturity interest rates and present overwhelming evidence that a structural break has occurred in the dynamics of these interest rates. We employ methods recently developed in statistical physics and show that interest rates' persistence has decreased substantially in the post-1982 period, while there is evidence of strong long-range dependence in the pre-1982 period. Therefore, the evidence in this paper is in line with the reasoning that a structural break has occurred in the conduct of monetary policy in the early 1980's.

This paper proceeds as follows. In section 2, a brief review of the literature is presented. In section 3, the methodology to estimate generalized Hurst exponents is reviewed. In section 4, the data used in this work is described. Section 5 presents the empirical results. Finally, in section 6, this paper is concluded.

2 Brief Literature Review

Researchers have documented a substantial change in macroeconomic variables for the US in the past decades. From the late 1960s through the early 1980s, the United States economy experienced high and volatile inflation along with several severe recessions. Since the early 1980s, however, inflation has remained steadily low, while output growth has been relatively stable[1].

An important question that recent literature has been trying to answer is why in the recent decades monetary policy in the US has been successful in controlling inflation whereas in the mid-1970's inflation was high. Several papers have documented that major changes occurred in the way monetary policy is conducted by the Federal Reserve (Clarida et al., 2000; Duffy and Engle-Warnick, 2006; Boivin, 2006; Boivin and Giannoni, 2006; Sims and Zha, 2006) following changes in the Federal Reserve chairman. These papers in general use parametric models and estimate reaction functions. They test for changes in the reaction function (Taylor rule) of the Federal Reserve to inflation expectations. There seems to be a consensus that major changes have taken place, although that the precise timing of when these changes have occurred is not consensual.

Another strand of the literature has studied long-range dependence in interest rates and has found evidence of it in different periods (Backus and Zin, 1993; Tsay, 2000; Barkoulas and Baum, 1998; McCarthy et al., 2004, Cajueiro and Tabak, 2005a). The study of long-range dependence in interest rates is important for three main reasons: 1. If there is long-range dependence in interest rates then there is some degree of predictability; 2. It is crucial to assess the persistence in interest rates as it has important implications for the evaluation of economic models. For example, if we wish to evaluate whether covered interest rate parity holds we have to take long-range dependence into account employing an ARFIMA model rather than the usual ARMA; 3. It is not clear what the cause of persistence in interest rates is. Although a few papers have documented this stylized fact, so far it is difficult to ascertain its causes. Therefore, if the persistence of interest rates changes due to changes in the conduct of monetary policy we have identified that policy making can be an important cause of long-range dependence.

In this paper we fill the gap between these two literatures and examine

[1]See Romer and Romer (2003) for a discussion on why monetary policy has been so much successful under some Federal Reserve chairmen than others.

whether there is a structural break in the long-range dependence of interest rates for different maturities according to Federal Reserve chairman tenure. Therefore, we are able to test whether changes in the conduct of monetary policy are related to changes in the persistence of interest rates. Furthermore, most of the literature so far has employed parametric techniques to estimate reaction functions, such as Taylor rules, and to estimate long-range dependence. These methods are subject to important caveats as the results rely on the short-term dynamics specification. We employ a novel estimation non-parametric technique, which is robust to short-term dynamics misspecification.

3 Measures of Long-Range Dependence

Several methods have been introduced to take the long-range dependence phenomenon into account[2]. This literature can be actually divided in two different strands: (1) an approach whose focus is to determine the degree of long range dependence based on the parameter well-known the Hurst exponent or a parameter related to it (see, for example Geweke and Porter-Hudak (1983), Hosking (1981), Hurst (1951), Barabasi and Vicsek (1991), Robinson (1995) and Cajueiro and Tabak (2005b)) and (2) an approach that aims at developing statistics to test, through a hypothesis test, the presence of long-range dependence (see, for example, Giraitis *et al.* (2003), Lee and Schmidt (1996) and Lo (1991)).

In this paper, we follow the former branch of the literature where one is interested to determine the degree of long range dependence of a given stochastic process $X(t)$. Our measure of long range dependence is the Generalized Hurst exponent introduced in Barabasi and Vicsek (1991) and considered recently by Di Matteo *et al.* (2005) to study the degree of development of financial markets. The generalized Hurst exponent is a generalization of the approach proposed by Hurst (1951). It may be evaluated using the q-order moments of the distribution of increments, which seems to be a good characterization of the statistical evolution of a stochastic variable $X(t)$[3],

[2]A survey of these methods may be found in Taqqu *et al.* (1999).

[3]In financial applications the variable $X(t)$ is the time series of asset prices (in logarithmics).

$$K_q(\tau) = \frac{\langle |X(t+\tau) - X(t)|^q \rangle}{\langle |X(t)|^q \rangle}, \tag{1}$$

for each time-window τ. Therefore, using equation (1), the generalized Hurst exponent can be defined for each time scale τ and each moment parameter q as

$$K_q(\tau) \sim \tau^{qH(q)}. \tag{2}$$

In order to find the value of $H(q)$, one has to choose a value for q and to evaluate $K_q(\tau)$ for different time scales τ. The determination of $H(q)$ is obtained by the the best straight line of a log-log plot of $K_q(\tau) \times \tau$.

For the case that a given stochastic process $X(t)$ is a monofractal[4], the exponent $H(q)$, for any value of q, is useful to discriminate stochastic processes in terms of the presence of long range dependence (Hurst, 1951). In this case, for any value of q, $H(q) = 1/2$ means that $X(t)$ does not present long range dependence. If $H(q) > 1/2$ the process $X(t)$ is persistent in the sense that an increasing trend in the past implies in an increasing trend in the future, whereas if $H(q) < 1/2$ the process $X(t)$ is anti-persistent. For more complex processes, $H(q)$ is dependent on the value of q[5].

An important issue in the estimation of long-range dependence measures is how to calculate standard errors for the estimates. We follow Grau-Carles (2005 and 2006) and employ a post-blackening bootstrap approach.

The post-blackening bootstrap methodology may be exemplified as follows[6]:

1. Fit a default AR(1) to asset returns $r_1, r_2, \cdots, r_3$

$$\epsilon_t = r_t - \hat{\alpha} r_{t-1} \tag{3}$$

2. Estimate the autoregressive parameter $\hat{\alpha}$ and form the residuals from the historical sequence

[4] A monofractal is a stochastic process whose its scaling behavior is determined from a unique constant H that coincides with the Hurst exponent.

[5] A good approximation to the Hurst exponent is found when $q = 1$. Therefore, in this work, we evaluate K_q in equation (1) using this value.

[6] The bootstrap is applied to asset returns $(X(t)/X(t-1)$, where $X(t)$ corresponds to the log of asset prices. The price history is recovered recursively from bootstrap samples of returns.

$$\hat{\epsilon}_t = r_t - \hat{\alpha} r_{t-1} \tag{4}$$

3. Obtain the simulated innovations $\epsilon_1, \epsilon_2, \cdots, \epsilon_3$ by bootstrapping ϵ_t using the moving block bootstrap (MBB), where the choice of block length is given by the rule provided in Hall et al. (1996) rule (block size = $N^{\frac{1}{5}}$).

4. The bootstrapped innovation series ϵ_t is then post-blackened by applying the estimated model to the resampled innovations, to obtain synthetic returns r_t

$$\epsilon_t = r_t - \hat{\alpha} r_{t-1} \tag{5}$$

The starting value of r_t is taken to be equal to ϵ_0 itself.

In our case we fit an autoregressive $AR(p)$ model for log changes in interest rates. We choose as 30 lags the maximum p and minimize the Akaike information criteria in order to find the optimal lag length for the AR.

We run 100 bootstrap samples and estimate Hurst exponents for these samples. The standard deviation of these Hurst exponents is used as a proxy for the standard error of Generalized Hurst exponents.

4 Data

The data is sampled daily, beginning on January 2, 1962 and ending on February 4, 2005. The full sample has 10755 observations, collected from the Federal Reserve System. We study the 1,3 and 5-years to maturity interest rates, which are constant maturity treasury rates.

We test for long-range dependence in interest rates for different time periods. We split the sample according to monetary policy and also to Federal Reserve tenure. Table 1 presents the tenure period for each chairman. We do not study the Miller administration because it was too short.

It is worth mentioning that although the central bank is able to control the very short-term interest rate aggregate spending decisions and long-term inflation expectations are closely related to long-term interest rates. Therefore, our interest is on studying the effects of changes in the conduct of monetary policy in the dynamics of long-term interest rates, which affect economic activity and long-term inflation expectations.

Federal Reserve Chairman	Period
W. Martin	Apr. 1951 - Jan. 1970
A. Burns	Feb. 1970 - Jan. 1978
G. Miller	Mar. 1978 - Aug. 1979
P. Volcker	Aug. 1979 - Aug. 1987
A. Greenspan	Aug. 1987 - Feb. 2006

Table 1: This table presents the tenure of each Chairman of the Federal Reserve since the 1950's.

5 Empirical Results

Recent research has documented that a change may have occurred in the way monetary policy has been conducted in the US in the past decades (see Clarida *et al.*, 2000, and Boivin, 2006). Therefore, we study the behavior of interest rates for different maturities and compare generalized Hurst exponents for a variety of time periods.

Table 2 presents generalized Hurst exponents for different time periods. Panel A presents estimates according to Federal Reserve chairman. The generalized Hurst exponents are decreasing with maturity, which suggests that short-term interest rates are more predictable than long-term interest rates. It is striking that these generalized Hurst exponents are close to 0.5 for the Greenspan era for all maturities, and are very high for the Burns era (above 0.62 for all maturities).

We would also like to test whether there is an influence of the monetarist experiment conducted in the beginning of the Volcker administration. Panel B shows results dividing the sample in a different way. We see that interest rates were quite persistent in the monetarist experiment in the beginning of the Volcker administration. However, they converge to values similar to the ones seen in the Greenspan administration afterwards. Future research should focus on incorporating these findings in modeling the term structure of interest rates.

	y1		y3		y5	
Panel A: Federal Reserve Chairman						
Martin	0.64	(0.017)	0.59	(0.017)	0.59	(0.017)
Burns	0.64	(0.017)	0.63	(0.017)	0.62	(0.017)
Volcker	0.58	(0.018)	0.58	(0.018)	0.58	(0.018)
Greenspan	0.5	(0.018)	0.5	(0.018)	0.5	(0.017)
Panel B: Monetary Policy						
Pre 1979	0.63	(0.016)	0.61	(0.017)	0.61	(0.017)
Post 1979	0.53	(0.017)	0.52	(0.017)	0.52	(0.017)
Monetarist Experiment	0.6	(0.019)	0.59	(0.019)	0.59	(0.019)
Post 1982	0.5	(0.018)	0.5	(0.017)	0.51	(0.017)

Table 2: This table presents generalized Hurst exponents for 1,3, and 5-years interest rates for different time periods. Standard errors built using the post blackening bootstrap approach are provided between parentheses.

The empirical results obtained suggest that the dynamics of interest rates has changed substantially in the past decades. Long-range dependence seems to be strong in the pre-1982 period, while this evidence practically disappears in the recent period (post-1982), coinciding with substantial changes in the conduct of monetary policy.

The finding of long-range dependence in interesting rates is important for a variety of reasons. First, in many economic models such as the uncovered interest rate parity, Fisher hypothesis, expectations hypothesis of the term structure of interest rates we have to assume an underlying structure for interest rates. If interest rates possess long-range dependence most of these models have to be estimated using fractional integration techniques. An additional problem is when there are structural breaks in the long-range dependence parameter. In this case our results provide some insights on why some models may work better in specific periods, whereas they provide poor predictions in other periods (see Dai and Singleton, 2002; Kozicki and Tinsley, 2005).

The empirical results are important because they imply that a more aggressive policy response to inflation reduces long memory in long-term interest rates. This could be happening due to a change in the dynamics of long-term inflation expectations, which suggests that monetary policy is more effective.

We also test for long-range dependence in the Consumer Price Index for the US employing monthly observations. We split the sample in the pre and post-1982 periods. We have 251 and 269 observations for each period, respectively. The Hurst exponent for the Consumer Price Index (inflation) decreases from 0.72 to 0.58 (bootstrap standard errors equal to 0.024). Therefore, there is a significant decrease in inflation long memory in the post-1982 period. This suggests that part of the inflation process could have been predicted in the pre-1982 period, which is consistent with a Fed´s weak response to inflation forecasts in this period.

Long term interest rates have two main drivers: they can be seen as sums of expected short-term interest rates (Expectation Hypothesis of the Term Structure of Interest Rates) plus some risk premium for expected inflation. In the 1980 period the Fed responded more strongly to inflation expectations and monetary policy has stabilized the economy more effectively. Therefore, our empirical results suggest that these changes in the conduct of monetary policy may have changed the dynamics of inflation itself.

6 Conclusions

Testing for long-range dependence in asset prices has been subject of intense investigation in the financial literature. There are many implications for portfolio and risk management. For example, traditional option pricing models should be modified to incorporate long-range dependence features in asset prices and volatility. Furthermore, if the long-range dependence parameters change over time, then the time series that are being studied possess more information than is given by monofractal models. Therefore, studies that focus on how and why long-range parameters change over time may be particularly useful as they can be used to determine structural breaks or shifts in these time series.

This paper offers a fresh look at the properties of interest rates for the US. The empirical evidence suggests that interest rates had strong long memory in the pre-Volcker administration and that after 1982 this evidence has disappeared. These results suggest a structural break in the dynamics of interest rates. They also imply that careful should be taken when studying long time series as the parameters that characterize them may change over time, which is evidence of multifractality.

It is important to notice that our sample period includes important changes in the macroeconomic environment, as exchange rates become flexible in the mid 1970's and early 1980's. Therefore, in a fixed exchange rate framework shocks to the economy must be absorbed mainly by movements in interest rates, which implies in more persistent interest rates' dynamic. However, in flexible exchange rate regimes policy makers have more degrees of freedom to absorb shocks into the economy, as exchange rates may absorb partially such shocks.

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