

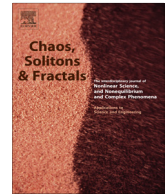


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## Effects of monetary policy on the long memory in interest rates: Evidence from an emerging market <sup>☆</sup>

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### ABSTRACT

We study the presence of long memory in a variety of interest rates in Turkey by time-varying generalized Hurst exponent. We reveal that adopting inflation targeting cause a sudden and considerable decrease in the long memory in interest rates. The improvement lasts till the collapse of Lehman Brothers in 2008 which is followed with an increased persistence in interest rates. Moreover, degree of long memory increases with maturity which is in contrast to economic theory.

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### 1. Introduction

The analysis of long memory in interest rates plays an important role in macroeconomics. Economic agents include the interest rates as a key parameter when they make investment decisions. On the other hand, the monetary authority usually implements its policy by setting the short term interest rates and expects it to influence the rates with longer maturity. Moreover, Peel [1] state that the most consistent forecasting of changes in real gross domestic product (GDP) is established when the term structure of interest rates is included in the models hence analyzing the long memory in interest rates is also essential for modeling and forecasting.

We study the presence of long memory in a variety of Turkish interest rates. Since 1993 to 2001, political and economical instability went hand in Turkey. High inflation and budget deficits were two main problems causing the severe recessions of 1994, 1999 and 2001. Recessions forced the government to make major policy reforms. In 2002, exchange rate was allowed to float and inflation tar-

geting was adopted. The result was a decade of high and broadly stable economic growth. Moreover, in recent years, Turkey has become one of the most important emerging economies in the world and plays a significant role in global trade and finance.

This is the first study that investigates the time-varying long memory in interest rates for the Turkish economy and it uses a rolling generalized Hurst exponent (GHE) approach [2] in that manner. GHE combines sensitivity to any type of dependence in the data and simplicity. Furthermore, since it does not deal with max and min functions, it is less sensitive to outliers than the popular R/S statistics [3]. Besides, it is a stylized fact that the financial asset returns are not normally distributed and are heavy-tailed. Barunik and Kristoufek [4] studies how the sampling properties of the Hurst exponent estimate change with fat tails by comparing the R/S analysis, multifractal detrended fluctuation analysis, detrending moving average and the generalized Hurst exponent approach in estimating the Hurst exponent on independent series with different heavy tails. They show that GHE is robust to heavy tails in the underlying process and provides the lowest variance.

Many researchers have reported long memory in a variety of markets [5–16]. However, only a few studies have focused on interest rates [17–22], in particular, monetary policy effects on the long memory. For example, Cajueiro and Tabak [23] show that with changes in the conduct of monetary policy in the 1980s, significant long memory in

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interest rates was not present anymore in the US. In other papers, Cajueiro and Tabak [24,25] study the dynamics of Brazilian interest rates for different maturities and revealed that the strong long memory has decreased over time due to changes in monetary policy.

In this study, by using dynamic generalized Hurst exponent, we show that the adoption of inflation targeting produce an instantaneous and substantial decrease in the long memory in interest rates. Moreover, in addition to the previous literature, we reveal that the degree of long memory increases with maturity which is in contrast to economic theory.

## 2. Methodology

We use  $H(q)$  to measure the long memory of a given stochastic process  $S(t)$  with  $t = (1, 2, \dots, \Delta t)$  defined over a time window  $\Delta t$ .<sup>1</sup>  $H(q)$  is a generalization of the approach proposed by Hurst [26] and it may be evaluated using the  $q^{\text{th}}$ -order moments of the distribution of increments [2],

$$K_q(\tau) = \frac{\langle |S(t+\tau) - S(t)|^q \rangle}{\langle |S(t)|^q \rangle} \quad (1)$$

where  $\tau$  can vary between 1 and  $\tau_{\max}$  and  $\langle \dots \rangle$  denotes the sample average over the time window.<sup>2</sup>  $H(q)$  is then defined for each time scale  $\tau$  and each parameter  $q$  as

$$K_q(\tau) \propto \tau^{qH(q)} \quad (2)$$

The relation (2) leads to  $\ln K_q(\tau) = qH(q) \ln \tau + C$ .  $H(q)$  is then computed through a linear least squares fitting using a set of values corresponding to different values of  $\tau_{\max}$  in Eq. (1).<sup>3</sup> For any value of  $q$ ,  $H(q) = 0.5$  means that  $S(t)$  does not exhibit long memory, while  $H(q) > 0.5$  and  $H(q) < 0.5$  implies that  $S(t)$  is persistent and mean-reverting respectively.

The standard errors of the  $H(1)$  estimates are found by employing a pre-whitening and post-blackening bootstrap approach of Grau-Carles [27]. Methodology can be summarized as follows:

1. Do the pre-whitening by estimating an  $AR(p)$  (autoregressive model of order  $p$ )  $r_t = \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + \dots + \alpha_p r_{t-p} + \epsilon(t)$  for interest rates  $r_t$  with  $p$  sufficiently high (we take  $p$  from 1 to 30). The order  $p$  is estimated through the Akaike information criteria.
2. Obtain the residuals  $\epsilon(t)$  of the  $AR$  model from the historical sequence.
3. Obtain the simulated innovations by bootstrapping  $\epsilon(t)$  using the circular block bootstrap [28], where the choice of block length is given by the rule provided in [29] (we use the choice of block length that is corrected in 2009).

<sup>1</sup> Following Di Matteo et al. [3], we take  $S(t)$  to be the interest rate series themselves.

<sup>2</sup> For  $q=1$ , Eq. (1) describes the scaling behavior of the absolute increments and it is expected to be closely related to the original Hurst exponent  $H$ , therefore, we focus on the case  $q=1$ .

<sup>3</sup> We let  $\tau_{\max}$  vary between 5 to 22 days.

4. The post-blackening is made, adding the innovations series generated by bootstrap to the model whose parameters were generated in the pre-whitening, to obtain the synthetic interest rate series.
5. Generalized Hurst exponent  $H_b(1)$  is estimated for each synthetic series ( $b$  stands for *bootstrapped*).

We run 100 bootstrap samples and estimate  $H(1)$  for them (which gives us a hundred number of  $H_b(1)$ ). Then the standard deviation  $S(H_b(1))$  of these estimates are taken as a proxy for the standard error of generalized Hurst exponents. This process generates the Wald statistic  $W$  given by  $W = \frac{(H(1)-0.5)^2}{S(H_b(1))}$  which has a  $\chi_1^2$  distribution and it tests the null hypothesis of “long memory does not exist”.

## 3. Data and results

We consider the daily interest rates with 1, 4, 6, 9 and 12 months to maturity.<sup>4</sup> The time interval of the study is from 02/01/1993 to 13/01/2012. We proceed as follows: we choose a 4 year time-window<sup>5</sup> that shift 22 point (business month) at a time. For each window, we calculate  $H(1)$  and its standard errors then obtain the Wald statistic  $W$ . We call a window *significant* if null hypothesis of “long memory does not exist” is rejected.

For all interest rate series, Fig. 1 presents the time-varying  $H(1)$  with a black curve. Fig. 1 also displays the dynamic status of long memory by blue and red markers denoting the presence of long memory at 5% and 1% significance levels respectively.

In Fig. 1, notice that before the adoption of inflation targeting, series are mean reverting, in particular between two recession of 1999 and 2001. Starting with 2002, degree of long memory decreases in each series and interest rates mostly display weak form efficient behavior between 2002–2008. However, this changes during the global financial crisis of 2008 and it seems to be triggered by the collapse of Lehman Brothers.

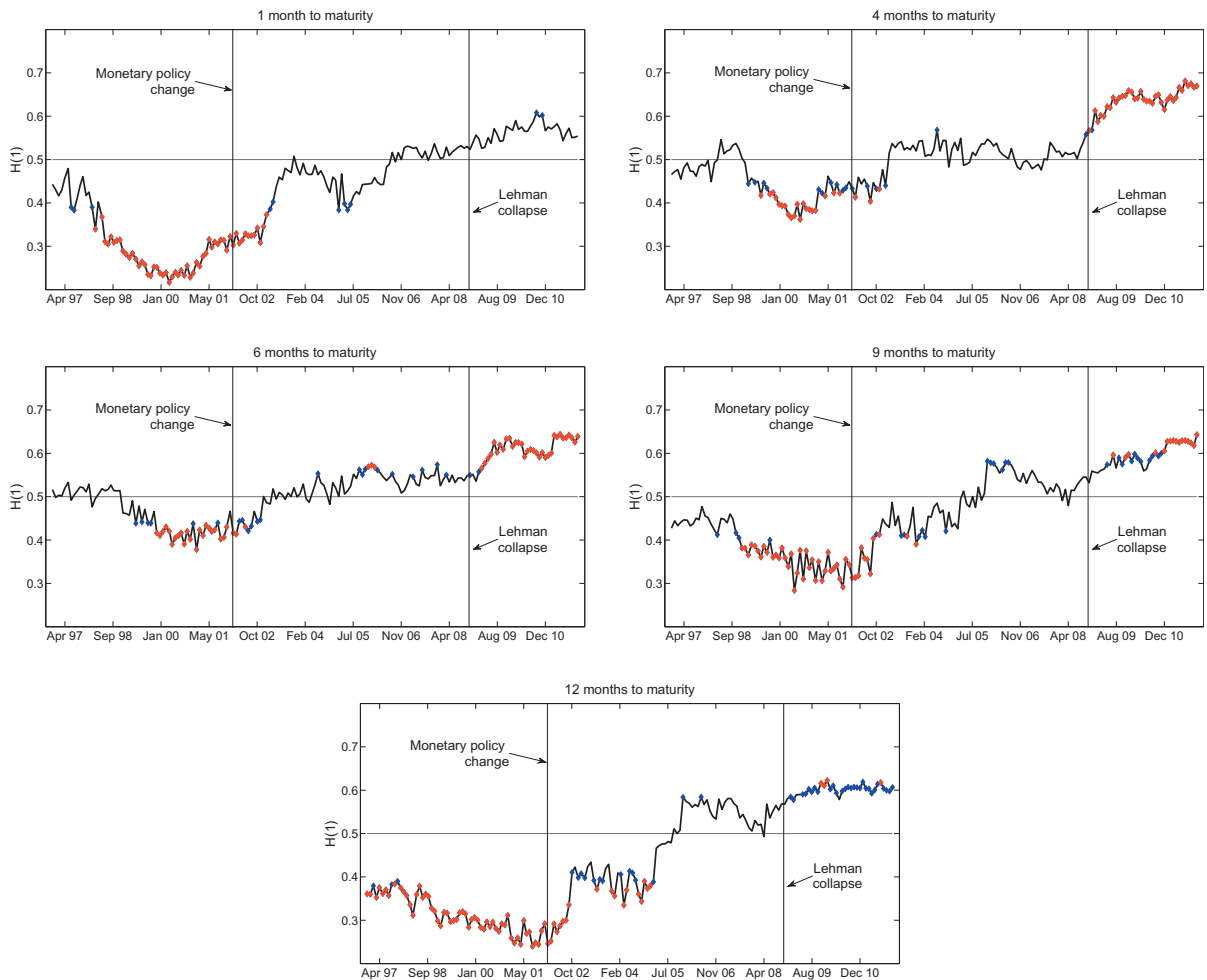
The rolling window approach also reveals how often the null hypothesis is rejected by the selected test statistic, and hence the percentage of sub-samples with a significant test statistic (which we call *long memory ratio*) can be used to rank the interest rate series with different maturities according to their degree of long memory. For both 5% and 1% significance levels, rankings are given in Table 1 and they show that the degree of long memory increases with the maturity.

## 4. Conclusion

This study investigates the long memory in Turkish interest rates with different maturities in the last two decades. Results reveal that the degree of long memory has decreased substantially in a very short time interval

<sup>4</sup> Due to the high debt/GDP ratio and economic instability, Turkish government could not borrow for longer maturity terms than 12 months until the late 2000s.

<sup>5</sup> Since it corresponds to the duration of political cycle in Turkey and it is large enough to provide satisfactory statistical significance.



**Fig. 1.** Time-varying  $H(1)$  for interest rates with different maturities. Blue and red markers denote the presence of long memory at 5% and 1% significance levels respectively. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

**Table 1**  
Long memory ratios of interest rates with different maturities.

Time to maturity	Long memory ratio (5%)	Long memory ratio (1%)
1 month	38.3%	32.0%
4 months	43.4%	33.7%
6 months	48.6%	34.9%
9 months	51.4%	35.4%
12 months	70.3%	44.6%

1. A significant window ( $\alpha\%$ ) is a window where the hypothesis “does not have long memory” is rejected at  $\alpha\%$  significance level. 2. Long memory ratio ( $\alpha\%$ ) is calculated by dividing the number of significant windows ( $\alpha\%$ ) by the total amount of windows. 3. There are 175 windows in total for each interest rate series.

due to changes in the monetary policy. In particular, this suggests that if a more efficient bond market is desired, policymakers should consider adopting inflation targeting.

Empirical findings also reveal that since the collapse of Lehman Brothers in 2008, interest rates display strong persistence in general (an evidence validating the suggestion

of Morales et al. [30]; using time-varying GHE to monitor unstable periods in financial time series). This situation could be expected as the collapse triggered a financial crisis around the world which is followed by monetary policy expansions in developed economies such as quantitative easing operations of the Fed. The increased liquidity mostly flew to advanced emerging markets. Moreover, in the meantime, monetary authorities in emerging countries also implemented expansionary policies in order to stimulate the economy and prevent a possible recession. Both cases created a downwards pressure on interest rates consistently, thus increasing the predictability.

The most interesting observation is that the degree of long memory increases with maturity. This situation indicates that from 1993 to 2012, short term interest rates are less predictable than long term interest rates which is in contrast to macroeconomic theory. A possible reason for that is due to the increased connectivity and information flow in global financial network. By this way the changes in the short term interest rates are severely affected by noisy circumstances (such as transmission of speculative

information, not supported by economic fundamentals, through several channels) that produce an unpredictable environment. However, long term changes is usually based on politic-economic fundamentals. On the other hand, this reasoning requires further research for justification. Another possible reason is related to the liquidity: Previous studies [31–33] showed that long memory in a return series may be explained by that asset's illiquidity and one can wonder if this is the case here. However, there is no significant difference in the liquidity of short and long term interest rates in our situation.

Finally, the findings imply that policymakers, investors, risk and portfolio managers should take the long-memory in interest rates into account when modeling and forecasting.

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