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Modelling Inflation Dynamics in Mexico

Rim Ammar Lamouchi
Department of Finance, Faculty of Economics and Administration
King Abdulaziz University, Saudi Arabia
Ministry of Education, Tunisia
GEF-2A Laboratory, Higher Institute of Management of Tunis, Tunis University, Tunisia
E-mail: rlamouchi@kau.edu.sa, rim.lamouchi@isg.rnu.tn

Abstract

This paper examines the dynamics of inflation in Mexico from January 1969 to March 2018. We discriminate between long memory and structural breaks in order to identify the process conducting prices in Mexico. The results show evidence for both the long memory and structural breakpoints that correspond to significant events in the Mexican economy. We find evidence in favor of long memory process.

Keywords: Inflation, Long memory, Structural breaks.
JEL: C22, C32, E31

1. Introduction

The statistical features of inflation has attracted a great attention due to the importance of this variable in designing of monetary policy and its implications for the behavior of private agents (Groeneveld et al., 1998; Cogley and Sargent, 2005; Ciccarelli and Mojon, 2010; Canarella and Miller, 2017; Kabukçuoğlu and Martínez-García, 2018). The recent development in the statistical treatment of time series has triggering an increased interest on this topic. As a result, a great number of theoretical and empirical papers have emerged. Despite the important empirical studies, no general agreement has been attained yet about the nature of the process conducting the inflation rate and a range of questions remains unanswered. The fundamental question emerging in this subject: what is the nature of the process driving the dynamics of inflation rate?

Recently, some studies have examined the nature of the inflation rate series process. In fact, the characteristics often quoted in literature are that inflation rate series are conducted by a long memory process which implies a high dependence between distant observations (MacDonald and Murphy, 1989; Delgado and Robinson, 1994; Hassler and Wolters, 1995; Franses and Ooms, 1997; Baum et al., 1999; Batini, 2006; Morana and Bagliano, 2007; Benati, 2008; Bos et al., 2014). This evidence implies that inflation rates are mean-reverting process; it suggests that an inflationary shock persists, and then dissipates eventually. In this vein, Delgado and Robinson (1994) show evidence of persistent dependence in the Spanish inflation rate. Although Hassler and Wolters (1995) examined monthly inflation rates of five industrial countries. They found evidence in favor of long memory. Baum et al. (1999) tested for long memory, or persistence in Consumer Price Index (CPI) based inflation rates for twenty-seven countries. They found a significant evidence of long memory process for developing as well as industrial countries.

In the same case, Gadea and Mayoral (2006) conducted a Fractionally Integrated Approach to test the persistence of inflation in OECD countries. They concluded that the persistence of inflation is very high and they support the existence of a long memory process. In spite of this, other studies relate the long memory of a volatility process to the presence of structural breaks (Boero et al., 2008; Osborn and Sensier, 2009; González et al., 2011; Kouretas and Wohar, 2012; Narayan, 2014). Hence, long memory and structural breaks are considered as two closely issues that can be easily confounded. Baillie and King (1996) and Baillie (1996) show that time dependence is present exists even between distant observations in a series with a long memory. This implies that actual inflation rate may have an influence on future inflation rate for a long period. Granger and Teräsvirta (1999) find that a short memory process among structural breaks gives a biased fractional integration parameter, providing a spurious long memory. Belkhouja and Boutahar (2009) show that accounting for structural breaks and persistence conducts to a lower long memory persistence estimation in the case of the US. In this context, Kang et al. (2009) study the structural breaks in US inflation persistence employing a model with Markov switching parameters and located two sudden structural breaks. Similarly, Diebold and Inoue (2001) show that the long memory can be the consequence of not considered breakpoints.

In their study, Charfeddine and Guégan (2012) demonstrate that the French and US inflation rates expose mutually long memory and structural breaks behavior. Yalama and Celik (2013) suggest that long memory process incorporate a form of structural breaks. Belkhouja and Mootamri (2016) examine the monthly CPI inflation rates of the seven developed economies (G7) between 1955 and 2014. They detect breaks in the inflation dynamics matching economic and political events and highlight that the mistreatment of the structural break in the inflation level and volatility may overestimate the long term dependence. Recently, Ventosa-Santaulària et al. (2017) conduct a Fractional Integration Approach to study the persistence of prices in Mexico. They find that inflation have been seen as a highly persistent process during the early years of study. However, since 2001, the inflation can be recognized as a short memory stationary process with structural breaks. Previous studies are thus inclusive and focus more on the case of developed economies.

From this perspective, understanding the dynamics of inflation is considering as a key component in the monetary policy and has very crucial implications. In this study, we focus on investigating the dynamics of inflation in Mexico. During the last decades, the Mexico economy has faced an important level of inflation. From the 1970s through the mid-1990s, the Mexican economy faced an important level of inflation (Whitt Jr, 1996; Edwards, 1998). Thus, great consideration has been devoted to describing the dynamics of inflation rate series in Mexico (Vogel, 1974; Rogers and Wang, 1993; Baum et al., 1999; Grier and Grier, 2006; Ramos-Francia and Torres, 2008; Capistrán and Ramos-Francia, 2009; Chiquiar et al., 2010; Caporale and Paxton, 2011; Capistrán and López-Moctezuma, 2014).

We are motivated by recently existing econometric methods and we are trying to make a contribution to the inflation persistence debate. In this study, we consider the method of Perron and Qu (2010) to investigate the possibility of confounding long memory with structural breaks in the inflation rate process of Mexico. According to the authors, a short memory process infected with structural breakpoints is able to distort and upward the value of the fractional long memory parameter and initiate autocorrelations to decline slowly, which may imply the spurious long memory. Thus, they propose a simple test to differentiate long from short memory processes alongside with structural breaks. Two issues discriminate this study from other empirical study. First, we will be able to discriminate clearly between long memory and structural breaks process. Second, we examine a longer period of time.

The aim of this study is to give a better comprehension of the dynamics of the Mexican inflation rate series by employing a discrimination procedure based on the work of Perron and Qu (2010). We follow a methodology that permit to determine the persistence of inflation series and allow detecting the structural breaks. The empirical results reveal the existence of a long memory process in the dynamics of inflation in Mexico. Our findings give evidence to support that inflation in Mexico is conducted by a long memory process. Our results demonstrate that even the formal adoption of the inflation-targeting framework in 2001 and the global crisis of 2008 did not influence the persistence of inflation.

The rest of the paper is structured as follows: Section 2 presents the methodology employed to investigate the inflation properties. In Sections 3, we describe the data and consider the empirical results, while Section 4 presents this study's conclusion.

2. Methodology

In order to examine the presence of the long memory process, we follow the work of Ben Maatoug et al. (2018) which can be explained as follows: First of all, we use the long memory tests, then the structural break test and finally the PQ test. To investigate the presence of a long memory for the series inflation, different techniques are used. Granger and Joyeux (1980) and Hosking (1981) was the first authors who developed the Autoregressive Fractionally Integrated Moving Average (ARFIMA) model in the literature. Further, a process $\{X_t\}_1^T$, with $t \in Z$follows an ARFIMA(p, d, q) process if:

$$\phi(L)(1-L)^d X_t = \theta(L)\varepsilon_t \tag{1}$$

where d presents the order of fractional integration and L designates the lag operator i.e. $LX_t = X_{t-1}$ t. $\phi(L)$ and $\theta(L)$ represent the autoregressive and the moving average polynomials of order p and q. While, ε_t is a white Gaussian noise. If $-\frac{1}{2} < d < 0$, the series is antipersistent and the autocorrelations decreases hyperbolically and incline to zero. If $d = 0$, the series is a short memory process and can be estimated by a standard ARMA model. If $0 < d < \frac{1}{2}$, the series is a stationary with long memory patter. The autocorrelations remain positive, decrease hyperbolically and become near to zero when the delay rises. The spectral density is intense around the low frequencies and inclines towards infinity when the frequencies incline near zero. The testing technique for the presence of a long memory process resides on examining the null hypothesis of a short memory pattern versus the alternative hypothesis of long memory pattern:

$$\begin{cases} H_0 : d = 0 \\ H_1 : d \neq 0 \end{cases}$$

We begin with the resized range statistic (*R/S*), initiated by Hurst (1951). This statistic allows the sorting of time series giving their class and memory by designating a coefficient H, called the Hurst exponent. Let $y_t, t = 1, \ldots, T$, a time series with an average $\overline{y}_t$, of T series; the R/S statistic, designated as Q_T, is written as:

$$Q_T = \frac{R}{S_T} = \frac{1}{\left[\frac{1}{T}\sum_{j=1}^{T}\left(y_j - \bar{y}_T\right)^2\right]^{\frac{1}{2}}} \times \left[\max_{1\le k\le T}\sum_{j=1}^{k}\left(y_j - \bar{y}_T\right) - \min_{1\le k\le T}\sum_{j=1}^{k}\left(y_j - \bar{y}_T\right)\right] \tag{2}$$

This statistic is equivalent to T^H, where $0 < H < 1$, and is specified by $H \sim \frac{log Q_T}{log T}$. It allows classifying the time series conforming to their dependency level. If $0 < H < \frac{1}{2}$, the antipersistence structure is present. If *H=0*, the process is white noise. When $\frac{1}{2} < H < 1$, the long memory structure is present. If $H \geq 1$, the process is considered as non-stationary and encloses infinite variance.

We use the semi-parametric estimator of log-periodogram advanced by Geweke and Porter-Hudak (1983) named the GPH is employed. Let y_t be the inflation rate, the long memory parameter, *d*,of the GPH estimator for y_t can be verified using the subsequent periodogram:

$$\log\left(I\left(w_j\right)\right) = \alpha + \beta log\left(4 sin^2\left(\frac{w_j}{2}\right)\right) + \varepsilon_j \tag{3}$$

where $j = 1,2, \dots, m,$ α is a constant, $w_j = \frac{2\pi j}{T}$, ε_j designates the residual term , T represents the sample size, w_j is the $m = \sqrt{T}$ Fourier frequencies (it is expected that *m* raises slowly with respect to the sample size). $I(w_j)$ indicates the sample periodogram defined as:

$$I(w_j) = \frac{1}{2\pi T} |\sum_{t=1}^{T} y_t \, e^{-w_j t}|^2, \tag{4}$$

where y_t is supposed to be a covariance stationary times series. Hence, the estimated *d* of long memory parameter $\hat{d}$ is ($-\hat{\beta}$) and it may be assesed by Ordinary Least Square, called OLS, an estimator distributed asymptotically for $0 < d < \frac{1}{2}$, yielding:

$$\sqrt{m}(\hat{d}_{GPH} - d) \rightarrow N(0, (\frac{\pi^2}{24})), \tag{5}$$

For a covariance stationary series, the estimator of the long memory parameter proposed by Robinson (1995), is consistent and asymptotically normal for $0 < d < \frac{1}{2}$, can be stated as follows:

$$\sqrt{\mathrm{m}}\left(\hat{\mathrm{d}}_{\mathrm{r}} - \mathrm{d}_0\right) \rightarrow \mathrm{N}\left(0, \frac{1}{4}\right), \tag{6}$$

with m is less than $[\frac{\mathrm{T}}{2}]$ in order to get out of aliasing effects; d_0 denotes the true value of d, with the only additional requirement that $m \rightarrow \infty$ slower than T, $\frac{1}{\mathrm{m}} + \frac{1}{\mathrm{m}} \rightarrow 0$ as $T \rightarrow 0$.

The Andrews and Guggenberger (2003) expansion of the GPH estimator called the AG test, is as follows:

$$\log\left(I(w_j)\right) = \sum_{r=0}^{R} \alpha w_j^{2r} + \beta d log(w_j) + \varepsilon_j, \tag{7}$$

To test the presence of structural breaks in the inflation rate, the test of multiple structural breaks advanced by (Bai and Perron, 1998, 2003) is used. The *m* _rupture (*m* + 1 break) model can be outlined as follows:

$$y_t = c_j + u_t, \tag{8}$$

where, $t = T_{j-1} + 1, T_{j-1} + 2, \dots, T_j and \;\; j = 1, 2, \dots, m + 1,$ y_t is the inflation rate and c_j is the average of the inflation rate. Structural breakpoints $(T_1, T_2, \dots, T_m)$ are handled as unknown. The error term u_t can be correlated, serially, and heteroscedastic. The test is directed with each j regime to observations among the dates $\hat{T}_{j-1}$+ 1 and $\hat{T}_j$ $(j = 1, 2, \dots, m + 1)$.

We consider sup$F_T(l)$, perceiving that the *F* statistic for the hypothesis of absence of structural breakpoints is versus the alternative enclosing an random number of structural breakpoints, and we specify $M = 5$ as the maximum agreed number of breakpoints. Besides, the double maximum statistic is defined as, $UD_{max} = max_{1 \le l \le M} supF_T(l)$, and the weighted double maximum statistic is expressed as $\mathrm{WD_{max}} = \mathrm{max_{1 \le l \le M} w_l supF_T(l)}$, where weights $\mathrm{w_l}$ are as the marginal p-values are equivalent within values of l.

$$F_T\left(l + \frac{1}{l}\right) = \frac{\left\{Q_T(\widehat{T_1}, \dots, \widehat{T_l}) - \min_{1 \le i \le l+1}, inf_{\lambda \epsilon \Delta_{i,n}} Q_T(\hat{T}_1, \dots \hat{T}_{i-1}, \lambda, \hat{T}_i, \dots, \hat{T}_l\right\}}{\hat{\sigma}^2} \tag{9}$$

where $\Delta_{i,n} = \left\{\lambda; \hat{T}_{i-1} + (\hat{T}_i - \hat{T}_{i-1})\eta \le \lambda \le \hat{T}_i - (\hat{T}_i - \hat{T}_{i-1})\eta\right\}$.

The PQ test, suggested by Perron and Qu (2010), is founded on the estimation of the log-periodogram and allows to discern the long and short memory with structural breaks. Under the null hypothesis, the inflation rate is described as a long memory process versus the alternative hypothesis of a short memory process affected with structural breaks or spurious long memory process. If $0 < a < b < 1$ and $b < \frac{4}{5}$, the test statistic is represented as follow:

$$t_d(a,b) = \sqrt{\frac{24[T^a]}{\pi^2}}\left(\hat{d}_a - \hat{d}_b\right) \xrightarrow{d} N(0,1) \quad (10)$$

For the frequencies, $m_a = T^a$ and $m_b = T^b$, $\hat{d}_a$ and $\hat{d}_b$, respectively designate the log-periodogram estimate of the long memory parameter. We follow Qu and Perron (2007). Then, we execute the test with $a = \frac{1}{2}$ and $b = \frac{4}{5}$.

2. Data

This analysis is based on monthly data of the Consumer Price Index (CPI) inflation rate of Mexico, calculated in 2010 based on 100. The data range from 1969:01 to 2018:03 for 592 monthly observations and is reported by Federal Reserve Bank of St. Louis. The inflation rate is calculated by the monthly difference of the log CPI, i.e., $y_t = 100 * log\ (CPI_t/CPI_{t-1})$, where CPI_t designates the Consumer Price Index at month t. We apply on the series a logarithmic transformation to eliminate the negative effect generated by non-stationarity in variance, the transformed series is designated by LCPI. The empirical analysis is provided utilizing the statistical software RATS.

Table 1 shows descriptive statistics for the CPI and LCPI series. For the two series, the Skewness coefficients are positive and also different from zero, implying a distribution which is right-skewed. In the case of CPI series, the excess kurtosis show a platycurtic distribution that is less peaked and has less frequent extreme values than normal distribution. The excess kurtosis reveals a leptokurtic distribution with values concerted around the mean and fat tails for the LCPI series. Jarque–Bera statistics indicate the non-acceptance of the normality hypothesis for the two series, demonstrating non-linear behavior.

Table 1: Descriptive statistics

Variables	Mean	Standard errors	Skewness	Excess Kurtosis	Min	Max	Jarque-Bera
CPI	41.687	44.688	0.576	-1.216	0.015	135.536	69.135
LCPI	1.566	2.047	2.676	9.492	-0.737	15.462	2919.444

Figure 1 describes the evolution of the Mexican monthly inflation rates denoted by the LCPI series. We observe periods of high inflation followed by periods of low inflation. We note an important spike of inflation between 1981 and 1982 due to the Mexican debt crisis and the devaluation of the Peso (the Mexican debt crisis). The inflation remained high with an important acceleration between in the late of 1987 due to the real exchange-rate depreciation, which increased the country's debt-to-gross domestic product (GDP).

Figure 1: Plot of the Mexican inflation rate

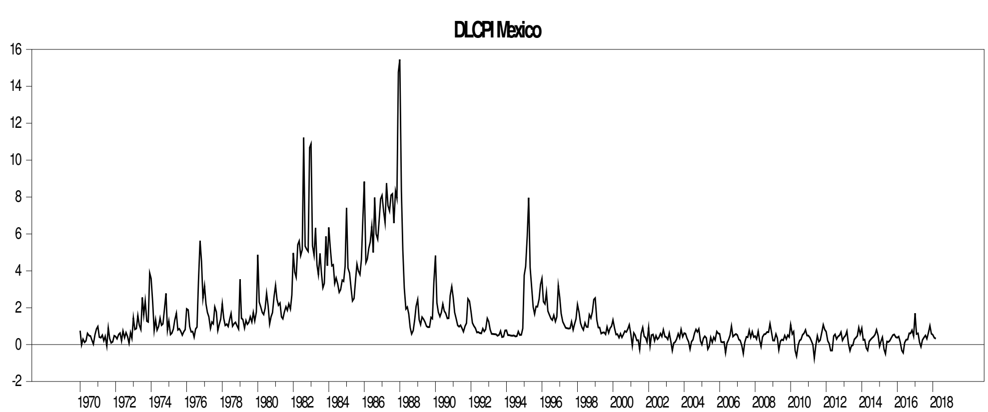
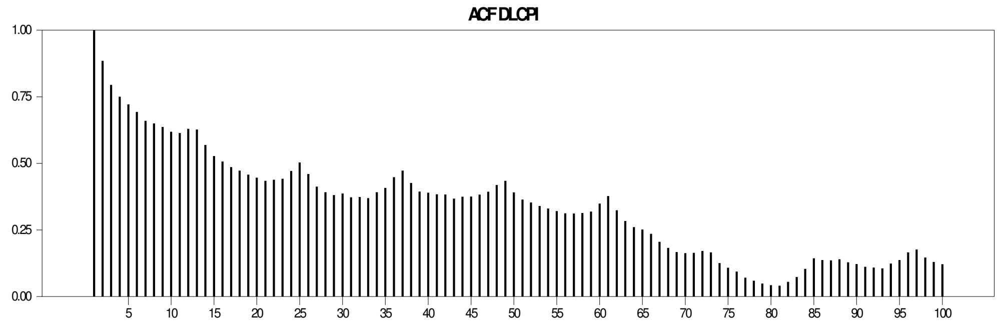


Figure 2: Autocorrelation for the Mexican inflation rate



The acceleration of inflation since 1994, can be explained by the twin balance-of-payments and financial crisis in Mexico caused by the complete evaporation of Mexico's international reserves which made the exchange-rate policy of Mexico no longer available (Federal Reserve Bank of Dallas). Since 1996, the inflation in Mexico seems to be remained stable (the Mexican economy had begun to improve, as capital inflows risen and the majority of productive sectors indicated positive growth rates). It is notable that the inflation in Mexico seems to be not affected by the subprime crisis. Figure 2 exposes the autocorrelation functions of the LCPI series. We notice a hyperbolic slow decay. This may imply the presence of long memory.

The different stationarity tests are reported in Table 2. For the ADF (Dickey and Fuller, 1981) and PP tests, meanwhile, confirm the stationarity of returns. Also, Results of the KPSS test show the presence of a stationary process.

Table 2: Stationarity tests

Variables	ADF	PP	KPSS
LCPI	-4.495	-5.312	0.306
Critical-value	-2.870	.-2.863	0.463

4. Dynamics of Inflation Rate
a. Long Memory Test

The estimation results of long memory parameter d for the LCPI series are reported in Table 3. Based on the previous works of Shimotsu (2006), also Aloy et al. (2011) and recently Charfeddine and Guégan (2012), we choose m frequency for the GPH and AG tests, $m = T^{0.5}, T^{0.6}, T^{0.7}, T^{0.8}$. The values of the parameter d ranges in value from 0.334 to 0.373. Based on the Log periodogram method, we observe decay over the estimation of the long memory parameter. This decline implies the presence of long memory in the Mexican inflation rate indicating a strong positive dependence between distant observations. Hence, an occurring shock will influence the progression of the series during a long period in the future but it dissipates since the series is mean reverting. Nevertheless, according to Davidson and Sibbertsen (2009), we can assume that the presence of short-run dynamic components is biasing the GPH estimator, and is falsely indicating the presence of long memory.

Table 3: Long memory test results

Variable	Robinson	*m*	GPH	AG
LCPI	0.372	0.5	0.373	0.419
		0.6	0.322	0.378
		0.7	0.285	0.342
		0.8	0.237	0.312

b. Structural Breaks Test

The test suggested by Bai and Perron (1998, 2003) is used to test the presence of structural breaks in the inflation rate of Mexico. The test results in Table 4 expose structural breaks appearing to expose the experience of the Mexican economy. The breakpoints correspond to historical events related to the Mexican market. The first breakpoint in July 1981 is the consequence of the period of depreciation of Peso. The second breakpoint is associated with the economic crisis of 1994 in Mexico. During this crisis, the inflation rates of Mexico were extremely volatile.

Table 4: Structural breaks test results

Variables	T1	T2	T3
LCPI	07:1981	12:1994	01:1999

The last breakpoint is related to the economic reforms and the political transition in the country. In 1999, the Central Bank of Mexico pronounced a series of inflation targets, with the definite objective of decreasing inflation in Mexico. The breakpoints considered coincide with major historical economic incidents in Mexico. Therefore, long memory and structural breaks can be considered as two relevant characteristics of the data related to inflation rates of Mexico.

c. Long Memory Versus Structural Break Test

According to the previous results, long memory and structural breaks can be easily confounded. We conduct the test of Perron and Qu (2010) to discriminate long memory from short memory infected by structural breaks. Hence, the null hypothesis of the evidence of long memory versus the alternative hypothesis of short memory with structural breaks is tested.

Table 5: Perron and Qu test results

Variables	LCPI
PQ statistics	-0.343
Critical-value 95%	±1.96

With referring to the results in Table 5, we conserve the null hypothesis of long memory for the inflation rate series. We assume that the inflation rate in Mexico follow a long-range dependency, even with the persistence of shocks and the occurrence of great spikes. We can advance that the intervention of central bank and the changes in the monetary policy in Mexico have no significant impact on the inflation rate.

Conclusion

The economic situation in Mexico was a significant trigger for a series of high inflation levels. Central bank and financial institutions needs to understand the nature of the process conducting the inflation rate series in order to design an optimal monetary policy. It is usually agreed that a long memory process conducts inflation rate series. This suggests that inflationary shocks due to economic and political events will persist, but will dissipate eventually. In this regard, we opt for a new test in order to distinguish between long memory and structural breaks in the Mexican inflation rate series.

Based on our modeling approach, the long memory tests demonstrate the presence of this property in the dynamics of inflation rate in Mexico. However, the Bai and Perron (1998, 2003) tests provides structural breakpoints that correspond to major historical events in the Mexican economy. The finding of Perron and Qu (2010) provides strong evidence in favor of long memory.

As a conclusion, we believe that this discrimination could be helpful in modeling and forecasting the dynamics of inflation rate series in Mexico. Besides, a long-range dependent process may include information, making forecasting more meaningful. Thus, policymakers can exploit the properties of long memory process in order to make long-term forecast. Granger (1980) states that persistence in the inflation rate series can appear from the aggregation of constituent process. Barkoulas et al. (1998), Altissimo et al. (2009) and Mayoral (2012) show that monetary aggregates present the long memory property and given the linkage of long-run inflation to the growth rate of money, the long memory will be transmitted to inflation.

Further analysis of the models that takes into account the long memory pattern of the inflation rate in Mexico may be one focal point of our forthcoming research.

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