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Abstract

This paper investigates the stationarity of the Federal Funds Rate. It contributes to the existing empirical literature in two ways. First, it explores both the presence of unit root and structural changes in the federal funds rate monthly data, by allowing for interaction between these two assumptions as suggested by the recent work of Lee and Strazicich. The second contribution consists in testing formally for the number of breaks. Using monthly data from January 1960 to April 2008, we find strong evidence in favor of a stationary process with two breaks. The two breaks identified correspond respectively to the first oil shock and to the change in the Fed operating procedure in the early eighties.

Key Words: Federal Funds Rate; Unit root test; Structural change; Endogenous break dates.
JEL Classification: C12, C13, C22

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1. Introduction

The Federal Funds rate (hereafter FF) is probably the most important indicator of the U.S. monetary policy. Indeed, over the past two decades, its influence on the U.S. financial and monetary markets as well as its impact on the U.S. economy as a whole have been largely recognized. Consequently, a vast literature has developed, aiming at improving the understanding and forecasting of the FF behavior.

Numerous different models have been proposed to explain the FF dynamic process such as univariate, multivariate, linear and nonlinear models. However, conclusions regarding the stationarity of this series are far from being clear-cut. For instance, Campbell (1987), Hamilton (1996) or more recently Lanne (1999) reject the unit root hypothesis. On the contrary, many authors provide evidence for not rejecting the unit root hypothesis (see Stock and Watson (1999) and references therein). This is quite important since while a I(0) process is mean-reverting, this is not the case of a random-walk, or I(1) process.

This lack of consensus may stem from structural changes in the FF process, as e.g. the monetary policy change which occurred between October 1979 and October 1982, when Paul Volker switched the operating target from short-term interest rates to nonborrowed reserves. It is well know by now that standard unit root tests have quite low power when the data generating process is characterized by structural change. Hence, investigating the interaction between unit root and structural change assumptions is desirable.[1]

Unit root tests against a single-break stationary alternative were proposed by — amongst others — Banerjee et al. (1992) or Zivot and Andrews (1992). They were extended to a two-break stationary alternative by Lumsdaine and Papell (1997) and up to five-break stationary alternative, with an a priori unknown number of breaks, by Kapetianos (2005).

[1]This has been done recently by Lee (2002) — Federal funds target changes and interest rate volatility, Journal of Economics and Business, 54, 159-191 — who uses the unit root tests against the alternative of stationarity with a single (a priori unknown) breakpoint developed by Zivot and Andrews (1992) and the unit root test against a (a priori unknown) two-break stationarity alternative proposed by Lumsdaine and Papell (1997). According to his daily FF data between January 1, 1975 and December 31, 1999, the unit root null cannot be rejected even against single- or two-break stationary alternatives.

However, note that Lumsdaine and Papell (1997) as well as Kapetanios (2005) maintain the linearity assumption under the unit root null hypothesis. Yet, as pointed out by Nunes, Newbold and Kuan (1997), in the case of a single-break test and two breaks test, these tests present an important size distortion when the DGP is in fact I(1) with break. This size issue leads to over-reject the unit root null. This is the reason why Lee and Strazicich (2003) have developed a Lagrange Multiplier (LM) test statistics, which allows for breaks both under the null and the alternative hypothesis. Therefore, when this LM test concludes to the unit root null rejection, it provides quite strong evidence of stationarity.

Our contribution to the literature is twofold: *i)* To our knowledge, the question of FF stationarity has not been explored using the recent econometric tool by Lee and Strazicich (2003) and *ii)* we exploit the evidence of FF stationarity to formally check that the maintained assumption of at most two breaks in the LM test is not at odd with the data. To this end, we perform the sequential test developed by Bai and Perron (1998,2003) for stationary processes with multiple structural changes. This empirical study finally points to a stationary process with two trend breaks: the first one corresponds to the first oil shock while the second one captures the Fed monetary policy change in the early eighties.

2. Methodology

The LM unit root test proposed by Lee and Strazicich (2003, 2004) allows for breaks under both the null and the alternative hypothesis in a consistent manner. It is based on a DGP given by:

$$y_t = \delta' Z_t + e_t, \qquad e_t = \beta e_{t-1} + \varepsilon_t \tag{1}$$

where Z_t is a vector of exogenous variables and ε_t is an iid Gaussian error term. In the following, we will consider a model allowing for two changes in level and trend, i.e. $Z_t = [1, t, D_{1t}, DT_{1t}, D_{2t}, DT_{2t}]'$, where D_{jt} and DT_{jt} for $j = 1, 2$ are dummies with $D_{jt} = 1$ for $t \geq T_{Bj} + 1$ and 0 otherwise and $DT_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1$ and 0 otherwise. T_{Bj} denotes the j^{th} break date. The DGP given in equation (1) allows for breaks under the null ($\beta = 1$) and the alternative ($\beta < 1$). Lee and Strazicich (2003) use the following regression to obtain the LM unit root test statistic:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \tilde{S}_{t-j} + u_t, \tag{2}$$

with $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$ for $t = 2, ..., T$ the detrended series. $\tilde{\delta}$ are the coefficients from the regression of Δy_t on ΔZ_t, $\tilde{\psi}_x = y_1 - Z_1\tilde{\delta}$ where y_1 and Z_1 correspond to the first observations. The lagged terms $\Delta\tilde{S}_{t-j}$ are included to correct for serial correlation. From equation (2), the LM test statistics are given by the t-statistics testing the null hypothesis $\phi = 0$. The break dates are determined endogenously by a grid search over all possible dates, i.e. once 10% of the endpoints are eliminated, such that they minimize the test statistic. The critical values are tabulated in Lee and Strazicich (2003, 2004) for the single-break and two-break cases respectively.

3. Empirical results

This LM unit root test with endogenous break(s) is applied to the effective federal funds rate monthly data from January 1960 to March 2008.[2] The results for the LM test with one and two a priori unknown breaks are reported in Table 1. The lags number k included in equation (2) is chosen so as to eliminate residuals autocorrelation. According

Table 1: Lee and Strazicich LM unit root test

	LM test with one break			LM test with two breaks		
Series	$\hat{T}_B$	k	t-stat	$\hat{T}_B$	k	t-stat
FF	1981:11	9	-5.674*	{1974:10; 1980:04}	9	-5.647*

Note: superscript $\star$ denotes rejection of the null at the 5%-level.

to these results, the unit root null is always rejected at the 5%-level, whether allowing for one or two breaks. The break dates which minimize the LM statistics are quite meaningful since they correspond to the new operating procedures for the monetary policy used in the early eighties by Paul Volker and/or to the first oil price shock. Hence, this test provides strong evidence in favor of the stationarity of the FF process.

One limit of this test is that it assumes that the number of breaks is known a priori and is strictly lesser than 3. Yet, other break dates are possible for the federal funds rate: for instance the second oil price shock, the arrival of Paul Volker at the head of the Fed

[2]The data come from the FRED® Federal Reserve Bank of Saint-Louis database.

or the end of the use of the nonborrowed reserve as the primary tool of the monetary policy. The stationarity result found above allows us to perform the sequential F-test, $SeqF(\ell+1|\ell)$, proposed by Bai and Perron (1998,2003) to test the null of ℓ breaks against the alternative of $\ell+1$ for $\ell = 1, \cdots, M-1$. We retain $M = 3$, the trimming parameter is set to 10%, and again we allow for changes in level and trend. The value obtained for

Table 2: Bai-Perron test for the number of breaks

	$SeqF(\ell+1\|\ell)$		
	$SeqF(2/1)$	$SeqF(3/2)$	$SeqF(4/3)$
Statistics	16.845*	3.435	2.964
5% critical value	14.500	15.420	16.160
	Estimated break dates		
	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$
Dates	1974:11	1981:05	—
95% confidence interval	[1974:10-1974:12]	[1981:04-1981:06]	—

Note: See Table 1.

$SeqF(2/1)$ indicates a rejection of the null of one break against the two-break alternative at the 5%-level. On the contrary, the test of the null of two breaks against a three-break alternative clearly fails to reject the null with $SeqF(3/2) = 3.43$. Again, the estimated break dates correspond to the first oil price shock and to the middle of the period when the nonborrowed reserves were the operating target of the Fed. The FF series and its broken trend are plotted in Figure .

4. Conclusion

This study reconsiders the question of the stationarity of the main indicator of the U.S. monetary policy, namely the effective federal funds rate, using the unit root tests by Lee and Strazicich (2003, 2004) which allow for up to two changes in level and trend under the unit root null as well as the stationary alternative hypothesis. It leads to the conclusion that the monthly federal funds rate behavior is well described by a stationary process with two breaks.

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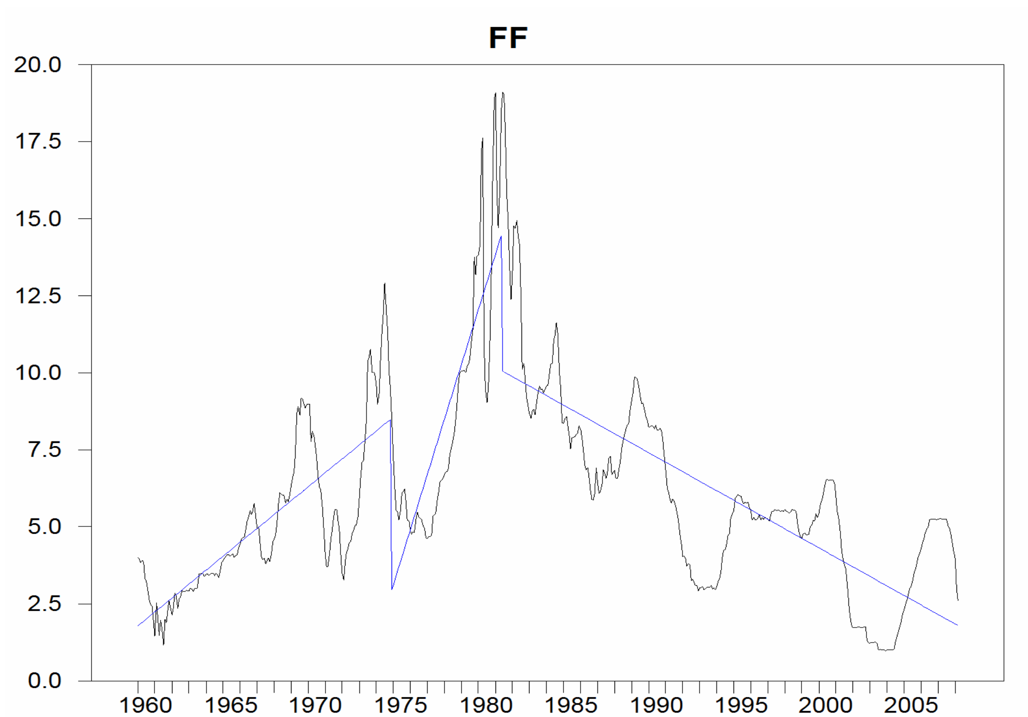

Note: The broken straight line is a fitted trend obtained by regressing the series on a constant, a trend, two intercept shifts and two slope shifts.

Figure 1: The FFR series with two trend breaks