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An analysis of the ex post Fisher hypothesis at short and long term

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Abstract

This paper tests the Fisher effect. The analysis is applied to the U.S.A. It contributes to the existing empirical literature in three ways. First, it considers a panel of short term and long term real interest rates between 1960 and 2008. Second, it explores both the presence of unit root and structural changes in real interest rates, by allowing for interaction between these two assumptions as suggested by the recent work of Lee and Strazicich. The third contribution consists in testing formally for the number of breaks using Bai and Perron (1998, 2003) test.

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1. Introduction

The Fisher relation has an important implications for theoretical models in financial economics and macroeconomics. The Fisherian theory of interest rate states that a change in inflation implies a proportional change in nominal interest rate at long term. Thus, real interest rate is not affected by shocks to inflation in the long run. If the Fisher effect holds, nominal interest rate reflects changes in expected inflation rate and helps predict future movements in inflation. In international finance, due to the Fisher hypothesis the exchange rate between two currencies is equivalent to the difference between their nominal interest rates.

According to Fisher (1930), nominal interest rate (i_t) at date t can be represented as the sum of real interest rate (r_t) and expected inflation rate (π_t^e) at the same date t.[1]

$$i_t = r_t + \pi_t^e \tag{1}$$

This is the *ex post* version of the Fisher equation. If the long-run Fisher effect holds then an increase in π_t^e has no permanent effect on r_t. Any changes in expected inflation will be fully reflected in movements of i_t. Say it differently there is a one-to-one relation between expected inflation rate and nominal interest rate at long term. If the Fisher relation holds, then real interest rate is constant. Thus, r_t should be a mean reverting stationary process. However, conclusions regarding the stationarity of this series are far from being clear-cut.

The stationarity of the real interest rate has been questioned since the work of Rose (1988). The two approaches used to answer this question involve either testing for a unit root in the real interest rate or for cointegration in systems containing inflation and nominal interest rates. Among other papers that use the first method we cite Patel and Akella (1996), Coppock and Poitras (2000), Lanne (2001), Atkins and Coe (2002) and Rapach and Wohar (2004). According to these studies real interest rate has a unit root. Thus, they do not support the long-run Fisher effect. The second method finds that nominal interest rate and inflation rate are $I(1)$ and tests the presence of a cointegration relation, in univariate or multivariate models, between these two variables. This method consists in estimating the following equation:

$$i_t = \alpha + \beta\pi_t^e + \epsilon_t \tag{2}$$

and testing the presence of a cointegrating vector between i_t and π_t^e equal to $(1, -1)'$. This literature includes, among others, Engsted (1995), Koustas and

[1] The exact Fisher equation is represented by $i_t = r_t + \pi_t^e(1 + r_t)$. Since $\pi_t^e r_t$ is small, the Fisher relationship can be approximated by equation (1).

Serletis (1999), Atkins and Serletis (2003), Atkins and Serletis (2003), Rapach (2003) and Rapach and Weber (2004) who find no support for cointegration between inflation and nominal interest rates. Mishkin (1992) and Evans and Lewis (1995) find evidence in favor of cointegration. Farmer (2007) and Beyer *et al.* (2009) test for cointegration with break between nominal interest rate and inflation rate. Westerlund (2008) tests the Fisher effect in a cointegrated panel of 20 OECD countries. Costantini and Lupi (2007) uses a panel unit root test with breaks to investigate the order of integration of inflation and interest rates in a panel of 19 countries.

The lack of consensus concerning the stationarity of the real interest rate may stem from the presence of structural changes. It is well known by now that standard unit root tests have quite low power when the data generating process is characterized by structural change. Hence, if nominal interest rate and inflation rate are stationary with a break then no need to test for cointegration relation between them. From equation (1) we would expect r_t to be $I(0)$ probably with a change in the mean or the slope. Investigating the interaction between unit root and structural change assumptions has been done recently by Lai (2004). He finds that the real interest rate is stationary with one break in the mean. He neither allows for multiple number of breaks nor for breaks under the null hypothesis of unit root. Yet, as pointed out by Nunes *et al.* (1997), in the case of a single-break and two-break tests, unit root tests with break only under the alternative of stationarity 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, 2004) 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. Rapach (2005) test also for structural changes in the mean real interest rate for 13 industrialized countries using Bai and Perron (1998, 2003) test. The problem is that Bai and Perron procedure is valid only when the series under investigation is stationary. Rapach (2005) do not check the stationarity of the series. In this paper we try to fill this gap. We test the stationarity of the real interest rate in the presence of a break under the null and the alternative using Lee and Strazicich (2004) test. Then, only for the stationary series, we test the number of structural changes in the mean and the slope using Bai and Perron (1998, 2003) test.

Our contribution to the literature is threefold: *i)* To our knowledge, this study is the most extensive study that test the *ex post* Fisher hypothesis using a panel of short run and long run real interest rates. *ii)* The question of real interest rate stationarity has not been explored using the recent econometric tool of Lee and Strazicich (2004) and *iii)* we exploit the evidence of real interest rate stationarity to formally check that the maintained assumption of at most one break 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.

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. It is based on a DGP given by:

$$y_t = \delta' Z_t + e_t, \qquad e_t = \beta e_{t-1} + \varepsilon_t \tag{3}$$

where Z_t is a vector of exogenous variables and ε_t is an $i.i.d$ Gaussian error term. In the following, we allow for one and two breaks in level and trend, i.e. $Z_t = [1, t, D_1, DT_t]'$, where D_t and DT_t are dummies with $D_t = 1$ for $t \geq T_B + 1$ and 0 otherwise and $DT_t = t - T_B$ for $t \geq T_B + 1$ and 0 otherwise. T_B denotes the break date. The DGP given in equation (3) allows for breaks under the null ($\beta = 1$) and the alternative ($\beta < 1$). Lee and Strazicich use the following regression to obtain the LM unit root test statistic:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \tilde{S}_{t-i} + u_t, \tag{4}$$

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 $\Delta\tilde{S}_{t-i}$ are included to correct for serial correlation. Contrary to other papers, we do not compute the lags number before testing the presence of a break. We let the lags number change with every possible break date. From equation (4), 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. We allow a break in the constant and the slope .The critical values are tabulated in Lee and Strazicich (2004).

3. Empirical results

This LM unit root test with endogenous break is applied to the real interest rate monthly data. Nominal interest data is either treasury bill (i_{TB}) or treasury constant maturities (i_{TCM}) rates.[2] Expected inflation rate is the real inflation forecasts constructed from household survey data by the University of Michigan Surveys of Consumers. The data sample that is used is reported in Table (1). The results for the LM test with one a priori unknown break are also reported in Table (1).

Table 1: Lee and Strazicich LM unit root test

Series	m	Sample period	$\hat{T}_B$	k	t-stat
$i^m - \pi^e$	FFR	1978:01-2008:12	1981:10	1	-4.749**
$i^m_{TB} - \pi^e$	3-month	1978:01-2008:12	1981:03	0	-4.438***
$i^m_{TB} - \pi^e$	6-month	1978:01-2008:12	1981:02	0	-4.416***
$i^m_{TCM} - \pi^e$	1-year	1978:01-2008:12	1981:02	0	-4.427***
$i^m_{TCM} - \pi^e$	2-year	1978:01-2008:12	1981:03	0	-4.505***
$i^m_{TCM} - \pi^e$	3-year	1978:01-2008:12	1981:05	0	-4.685**
$i^m_{TCM} - \pi^e$	5-year	1978:01-2008:12	1981:06	0	-4.942**
$i^m_{TCM} - \pi^e$	7-year	1978:01-2008:12	1981:02	0	-4.494**
$i^m_{TCM} - \pi^e$	10-year	1978:01-2008:12	1981:02	0	-4.336***
$i^m_{TCM} - \pi^e$	20-year	1978:01-1986:12	1982:04	0	-3.271
$i^m_{TCM} - \pi^e$	20-year	1993:01-2008:12	1994:02	0	-4.563**
$i^m_{TCM} - \pi^e$	30-year	1978:01-2002:02	1981:07	1	-3.426

Note: superscript $\star$, $\star\star$ and $\star\star\star$ denote rejection of the null respectively at the 1% 5% and 10%-level. m is the U.S Treasury bonds' maturity. FFR is the Federal Funds rate.

This test provides strong evidence in favor of the stationarity of the real interest rate. According to these results, the unit root null is not rejected at the 5%-level only for the real treasury constant maturities rate for 20 years between 1978:01 and 1986:12 and for 30 years. The other measures for real interest rate are stationary with break. 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. Once appointed as chairman of the Fed, Paul Volcker initiated a strong disinflationary policy. He switches the focus of monetary policy to tighter control of the monetary base in order to bring

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

down the high inflation rate. Controlling the growth of the money supply made interest rate more volatile and allowed it to reach unprecedented high levels.

Table 2: Bai-Perron test for the number of breaks, *ex post* real interest rate.

		$SeqF(\ell+1\|\ell)$			Estimated break dates	
Series	m	$SeqF(1/0)$	$SeqF(2/1)$	$SeqF(3/2)$	$\hat{T}_1$	$\hat{T}_2$
$i^m - \pi^e$	FFR	17.438*	8.738		1981:03	—
95% confidence interval					[1981:02-1981:04]	—
$i^m_{TB} - \pi$	3-month	20.864*	9.231		1981:07	—
95% confidence interval					[1981:06-1981:08]	—
$i^m_{TB} - \pi$	6-month	20.599*	8.710		1981:07	—
95% confidence interval					[1981:06-1981:08]	—
$i^m_{TB} - \pi$	1-year	13.624*	6.018		1981:03	—
95% confidence interval					[1981:02-1981:04]]	—
$i^m_{TCM} - \pi^e$	2-year	23.411*	6.879		1982:04	—
95% confidence interval					[1982:03-1982:05]	—
$i^m_{TCM} - \pi^e$	3-year	27.096*	7.652		1982:04	—
95% confidence interval					[1982:03-1982:05]	—
$i^m_{TCM} - \pi^e$	5-year	26.668*	8.749		1982:03	—
95% confidence interval					[1982:02-1982:04]	—
$i^m_{TCM} - \pi^e$	7-year	36.509*	16.353*	5.760	1982:04	1985:08
95% confidence interval					[1982:03-1982:05]	[1985:06-1985:10]
$i^m_{TCM} - \pi^e$	10-year	30.736*	17.775*	8.757	1982:03	1985:07
95% confidence interval					[1982:02-1982:04]	[1985:05-1985:08]
$i^m_{TCM} - \pi^e$	20-year	4.497			—	—
95% confidence interval					—	—

Note: See Table 1. For $l = \{0, 1, 2\}$ critical values at 5% are respectively 12.250, 14.500 and 15.420. FFR is the Federal Funds rate. m is the U.S Treasury bonds' maturity.

One limit of this test is that it assumes that the number of breaks is known a priori. Yet, other break dates are possible for the real interest rate: for instance the second oil price shock, the arrival of Paul Volker at the head of the Fed 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 $\ell + 1$. We apply the test $SeqF(\ell + 1|\ell)$ sequentially, for $\ell = \{0, 1, \cdots, M-1\}$ to the stationary series until it fails to reject the null hypothesis of no additional structural break. The trimming parameter is set to 10%, and again we allow for changes in level and trend. The results of the structural test are given in Table (2).

The value obtained for $SeqF(2/1)$ indicates a rejection of the null of one break against the two-break alternative at the 5%-level only for real treasury constant maturities rate for 7 and 10 years. On the contrary, the test of the null of two breaks against a three-break alternative clearly fails to reject the null. Thus, there is two structural changes in real treasury constant maturities rate for 7 and 10 years. The estimated break dates correspond again to the middle of the period when the nonborrowed reserves were the operating target of the Fed and to the Plaza agreement ratification. The results of Volcker's economic policy was a decrease in U.S. exportation. Thus, international demand for american goods turned down and balance trade becomes negative. These changes contributed to the significant recession the U.S. economy experienced in early 1980s, which included the highest unemployment levels ever encountered. In order to reduce the U.S. current account deficit, and to help the U.S. economy to emerge from the recession, the governments of France, West Germany, Japan, the United States, and the United Kingdom, signed the Plaza Agreement in September 1985. The objective was to depreciate the U.S. dollar in relation to the Japanese yen and German Deutsche Mark by intervening in currency markets. The dollar devaluation made U.S. exports cheaper and more competitive. This boosted demand for american goods and services. The $SeqF(1/0)$ test do not reject the null of no break for the real treasury constant maturities rate for 20 years. This result contradicts the one obtained from Lee and Strazicich unit root test. Thus, we have doubts about the stationarity and the structural change results concerning this measure of short term real interest rate. For the rest of the series we find only one break and this break comes very close to the one found using Lee and Strazicich unit root test. It seems that real interest rate underwent a break in the early of the eighties.

4. Conclusion

This study reconsiders the question of the stationarity of the real interest rate. We use the unit root Lee and Strazicich (2004) test which allows for one change in level and trend under unit root null as well as the stationary alternative hypothesis. We also formally test the number of breaks in real interest rate. This paper leads to the conclusion that the monthly treasury bills real interest rates and the monthly treasury constant maturities interest rates for a maturity less then 10 years is well described by a stationary process with one or two breaks . Thus, we conclude that Fisher hypothesis is verified at short and long term provided that we take into consideration the presence of a break in the biginning of the eighties. Thus, the studies that rely on standard unit root or cointegration analysis are less informative.

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