Brunel University London

Department of
Economics and Finance

Economics and Finance Working Paper Series

Working Paper No. 15-10

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# The Fisher Relationship in Nigeria

May 2015

http://www.brunel.ac.uk/economics

# THE FISHER RELATIONSHIP IN NIGERIA

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**April 2015**

## Abstract

This paper examines the Fisher relationship in the case of Nigeria by carrying out standard unit root tests and applying fractional integration techniques to 1-month, 3-month, 6-month and 12-month deposit rates and inflation. The evidence indicates that this relationship only holds in the short run, and therefore only over short intervals is the nominal interest rates a useful predictor of the inflation rate. The lack of a long-run Fisher effect also suggests that in Nigeria the nominal interest rate can be used as a monetary policy tool.

**Keywords:** Fisher effect; unit root tests; fractional integration

**JEL Classification:** C22, G12

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* Luis A. Gil-Alana gratefully acknowledges financial support from the Ministerio de Economía y Competitividad (ECO2014-55236).

## 1. Introduction

The Fisher Hypothesis is one of the tenets of neoclassical monetary theory. Under the assumptions of perfect capital markets and the same nominal interest rate for borrowers, Fisher (1930) derived the following relationship between the nominal interest rate ("i"), the real interest rate ("r") and the inflation rate ("π"):

$$r_t \approx i_t - \pi_t. \tag{1}$$

The price level in period "t+1" can be expressed as:

$$P_{t+1} = (1 + \pi_t)P_t, \tag{2}$$

and the nominal increase of the value of the assets can be written as: $(1+i_t))$ . Then the real increase is $(1+i_t)/(1+\pi_t)$, and the real interest rate can be seen as indicating the incremental consumption obtained in period "t+1" if one unit of consumption is given up in period t:

$$(1+r_t) = (1+i_t)/(1+\pi_t). \tag{3}$$

If this unit is invested in bonds, in period "t+1" the agent will have $P_t(1+i_t)$ available for consumption, deflated by the price level $P_{t+1}$.That is: $(1+i_t)/(1+\pi_t)$. Multiplying the expression (3) by $(1+\pi_t)$ and simplifying one obtains:

$$(1+r_t)(1+\pi_t) = (1+i_t), \tag{4}$$

which is the same as

$$1 + r_t + \pi_t + r_t\pi_t = 1 + i_t, \tag{5}$$

implying that

$$r_t + \pi_t + r_t\pi_t = i_t, \tag{6}$$

which can be approximated by:

$$r_t \approx i_t - \pi_t, \tag{7}$$

Therefore, according to the Fisher Hypothesis the real interest rate is approximately equal to the difference between the nominal interest rate and the expected inflation rate. If this relationship holds, the former cannot be used by the monetary authorities to stimulate the economy, but it is a useful predictor of the inflation rate.

This paper tests the Fisher relationship in the case of Nigeria by carrying out standard unit root tests and also applying fractional integration techniques to 1-month, 3- month, 6-month and 12-month deposit rates and inflation. The paper is structured as follows. Section 2 reviews the relevant literature. Section 3 describes the data and the empirical analysis, and Section 4 concludes.

## 2. Literature Review

The empirical literature on the Fisher Hypothesis is extensive. Early studies, such as Fama and Schwert (1975), overlooked possible non-stationarities in the data, and therefore they estimated possibly spurious regressions (see Granger and Newbold, 1974).

Rose (1988) was the first to carry unit root tests to investigate the Fisher Hypothesis in the United States, and concluded that the nominal interest rate contained a unit root whilst the inflation rate was stationary, and therefore the real interest rate was not stationary. MacDonald and Murphy (1989) took a cointegration approach and rejected the Fisher Hypothesis for Belgium and the UK, but not for Canada and the US during the period of fixed exchange rates. Mishkin (1992) also performed cointegration tests but did not find any evidence of a Fisher effect in the US in the long run. Numerous studies have been carried out since then adopting a similar framework, for both developed and developing economies, with mixed results (see, e.g., Evans and

Lewis, 1995; Lee et al., 1998; Rico, 1999; Koustas and Serletis, 1999; Lardic and Mignon, 2003; Ghazali and Ramlee, 2003; Kasman et al., 2006; Berument et al., 2007; Mitchell-Innes et al., 2007; etc.).

More recently, fractional integration and fractional cointegration techniques have been used, starting with Phillips (1998), who found stationarity but also a high degree of dependence in US interest rates. Tsay (2000) modelled interest rates as ARFIMA processes using the Conditional Sum of Squares (CSS) method, and concluded that the ex-post real interest rate can be well described as a fractionally integrated process.

Very few studies have considered African countries. One of the few exceptions is that by Etuk et al. (2014), who investigated the existence of a long-run Fisher effect in the case of Nigeria using monthly data on consumer prices and interest rates for the period from 1970 to 2003. They found fractional cointegration between inflation and nominal interest rates, since their Geweke and Porter-Hudak (GPH, 1983) test results indicate that the residuals are fractionally integrated.

## 3. Data and Empirical Results

The four interest rate series considered are the 1-month, 3- month, 6-month and 12-month deposit rates for the time period January 2006 – August 2013. The source is the Central Bank of Nigeria. The first three series are obtained by dividing the annual interest rate by 12, 4, and 2 respectively. The price series is monthly and taken from the CPI. We compute monthly, quarterly, 6-month and annual inflation using the formula:

$$INFLATION_t = (CPI_t - CPI_{t-1}) / CPI_{t-1} .$$

As a first step, we carry out a variety of unit root tests: ADF (Dickey and Fuller, 1979), Phillips and Perron (PP, 1988), Kwiatkowski et al. (KPSS, 1992), and Elliot et al. (ERS, 1996). Table 1 reports the results for the nominal interest rate (1-month, 3-month, 6-month and 12-month), for both levels and first-differenced data, which suggest that the former is I(1) and the latter I(0) in all cases.

**[INSERT TABLES 1 - 3 ABOUT HERE]**

Next we focus on the inflation rate (Table 2). Here the results are mixed. Monthly inflation is stationary, 6-month and annual inflation are stationary in first differences, whilst quarterly inflation exhibits non-stationarity even in first differences. As for the real interest rate, (Table 3) stationarity in levels is found only for monthly rates, the results are inconclusive for the 3-month rate, whilst stationarity is rejected for the 6-month and 12-month rate; overall the evidence suggests that the Fisher relationship only holds in the short run.

The possibility of structural breaks is also taken into account by performing multiple breakpoint tests. This type of tests was originally proposed by Chow (1960), who tested for regime change at a priori known dates using an F-statistic. Quandt (1960) modified the Chow (1960) framework to determine the breakpoint endogenously on the basis of the largest F-statistic. Andrews (1993) and Andrews and Ploberger (1994) derived the limiting distribution of the Quandt and related test statistics. Bai (1997) and Bai and Perron (1998, 2003) extended the Quandt-Andrews framework by allowing for multiple unknown breakpoints. Perron (2005) offers a useful survey of this literature. In this paper we follow the Bai and Perron (1998; 2003) two-step approach. Firstly, the number of breaks in the series is identified by using a sequential testing procedure with an efficient algorithm based on the principles of dynamic programming. Secondly, stationarity/nonstationarity is tested using some of the above mentioned methods (ADF, PP, KPSS, etc.).

**[INSERT TABLE 4 ABOUT HERE]**

In the case of the 1-month deposit rate, it appears that there are three breakpoints, corresponding to June 2008, March 2010 and October 2011. For the 3-month rate the breaks occur in April 2008, March 2010 and October 2011. For the 6-month rate the dates are May 2008, March 2010 and January 2012. Finally, for the 12-month rate they are January 2008, February 2010 and December 2011. This evidence of structural breaks suggests that the series may be fractionally integrated. Thus, next, we consider the possibility of fractional degrees of differentiation. The model is the following:

$$y_t = \alpha + \beta t + x_t; \quad (1 - L)^d x_t = u_t, \qquad (8)$$

where $y_t$ is the observed (univariate) time series; α and β are the coefficients on the intercept and a linear trend respectively, and $x_t$ is assumed to be an I(d) process. Therefore, $u_t$ is I(0), and, given the parametric nature of the method used here (a Whittle parametric approach in the frequency domain, Dahlhaus, 1989), its functional form must be specified: we assume in turn that it is a white noise process (Table 5), and an autocorrelated one, first imposing the non-parametric approximation of Bloomfield (1973) that produces autocorrelations decaying exponentially as in the AR case (Table 6), and, finally, given the monthly nature of the data, assuming a seasonal (monthly) AR(1) process (Table 7).

In all cases, we present the results for the three standard cases examined in the literature, i.e. those of no deterministic terms (i.e, α = β = 0 a priori in the above equation); an intercept ($\alpha$ unknown and $\beta = 0$ a priori), and both an intercept and a linear time trend (both $\alpha$ and $\beta$ unknown). The results are fairly similar in all three cases.

Under the assumption of white noise disturbances, mean reversion takes place for the 1-month and 12-month but not for the 3- and 6-month real rates. In the case of the 1-month real rate mean reversion could reflect the fact that the inflation rate is stationary I(0). However, in the remaining cases (3, 6 and 12-month rates) the inflation rate (as well as the nominal rates) appears to be I(1).

**[INSERT TABLES 5 – 7ABOUT HERE]**

When allowing for autocorrelated disturbances as in Bloomfield (1973), mean reversion is found for the 1- and 3- month real rates, and I(0) stationarity in most cases for the inflation rates. For the 6-month rate, the confidence intervals are so wide that both the I(0) and the I(1) hypotheses cannot be rejected. Finally, when assuming a monthly seasonal AR(1) process for the error term, the only evidence of mean reversion is found for the 12-month real rate, with the nominal rate also appearing to be mean-reverting.

## 4. Conclusions

This paper has examined the Fisher relationship in the case of Nigeria by carrying out standard unit root tests and applying fractional integration techniques to 1-month, 3-month, 6-month and 12-month deposit rates and inflation. The evidence indicates that this relationship only holds in the short run, and therefore only over short intervals is the nominal interest rates a useful predictor of the inflation rate. The lack of a long-run Fisher effect also suggests that in Nigeria the nominal interest rate can be used as a monetary policy tool: there is “monetary illusion”, with changes in inflation not being completely reflected in the nominal interest rate in the long run, and therefore monetary policy can affect the real economy. The main advantage of using monetary instead of fiscal policy is that the former is easier to implement and changes can be made more quickly.

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**Table 1: Nominal interest rates**

| | | | | | |
|---|---|---|---|---|---|
| **1A) Original data** | | | | | |
| | | 1 month | 3 month | 6 month | 12 month |
| DF | Intercept | -1.400456 | -1.548782 | -1.515252 | -1.290033 |
| | Lin. Trend | -1.552312 | -1.840003 | -1.692221 | -1.634747 |
| ADF | Intercept | -1.417872 | -1.570439 | -1.500912 | -1.295944 |
| | Lin. Trend | -1.884865 | -1.945230 | -1.889976 | -1.755464 |
| PP | Intercept | -1.528226 | -1.468586 | -1.500912 | -1.798174 |
| | Lin. Trend | -2.012176 | -1.780756 | -1.889976 | -2.254018 |
| KPSS | Intercept | 0.476743** | 0.492598** | 0.456885* | 0.450037* |
| | Lin. Trend | 0.124609* | 0.121445* | 0.129140* | 0.137540* |
| ERS | Intercept | 6.423732 | 4.591461 | 5.362220 | 6.726230 |
| | Lin. Trend | 22.20964 | 12.36946 | 17.89419 | 18.15257 |
| **1B) First differences** | | | | | |
| | | 1 month | 3 month | 6 month | 12 month |
| DF | Intercept | -1.921915* | -4.804135*** | -9.198526*** | -15.02213*** |
| | Lin. Trend | -3.080502** | -4.957519*** | -9.747180*** | -15.29682*** |
| ADF | Intercept | -4.242152*** | -5.047629*** | -9.837571*** | -15.36341*** |
| | Lin. Trend | -4.212357** | -5.021445*** | -9.789802*** | -15.30983*** |
| PP | Intercept | -10.34852*** | -10.17971*** | -9.837767*** | -15.70536*** |
| | Lin. Trend | -10.29826*** | -10.13644*** | -9.789988*** | -15.65617*** |
| KPSS | Intercept | 0.128289 | 0.098114 | 0.116855 | 0.098057 |
| | Lin. Trend | 0.113339 | 0.096079 | 0.103365 | 0.072491 |
| ERS | Intercept | 3.743308* | 1.073904*** | 0.605233*** | 0.704486*** |
| | Lin. Trend | 7.295861 | 3.654448*** | 2.040001*** | 2.578446*** |

*Rejection al the 10%; **Rejection at the 5%; ***Rejection at the 1%

**Table 2: Monthly inflation rates**

| | | 1 month | 3 month | 6 month | 12 month |
|---|---|---|---|---|---|
| **2A) Original data** | | | | | |
| DF | Intercept | -6.242201*** | -0.191914 | -0.274282 | -1.886847* |
| | Lin. Trend | -6.932340*** | -0.899962 | -0.961149 | -1.914787 |
| ADF | Intercept | -7.210010*** | -1.964193 | -1.975746 | -1.878190 |
| | Lin. Trend | -7.170743*** | -1.636810 | -1.657708 | -1.900077 |
| PP | Intercept | -6.931999*** | -4.510435*** | -4.162855*** | -1.975430 |
| | Lin. Trend | -6.882158*** | -4.510435*** | -4.434340*** | -2.016440 |
| KPSS | Intercept | 0.061636 | 0.107544 | 0.287690 | 0.378340* |
| | Lin. Trend | 0.062508 | 0.083298 | 0.143419* | 0.195908* |
| ERS | Intercept | 0.757391*** | 73.57344 | 77.12600 | 3.633553* |
| | Lin. Trend | 2.374370*** | 113.4567 | 91.17673 | 12.76390 |
| **2B) First differences** | | | | | |
| | | 1 month | 3 month | 6 month | 12 month |
| DF | Intercept | -0.710813 | -0.287145 | -2.990845*** | -8.783315*** |
| | Lin. Trend | -10.66841*** | -1.891980 | -11.66011*** | -8.806033*** |
| ADF | Intercept | -7.837900*** | -9.629857*** | -12.54700*** | -8.757884*** |
| | Lin. Trend | -8.059872*** | -9.649679*** | -12.59556*** | -8.715499*** |
| PP | Intercept | 32.46073*** | -10.59600*** | -6.280437*** | -8.728941*** |
| | Lin. Trend | -32.25883*** | -10.60819*** | -6.372094*** | -8.682966*** |
| KPSS | Intercept | 0.191877 | 0.350931* | 0.104588 | 0.090785 |
| | Lin. Trend | 0.145965* | 0.164142** | 0.029740 | 0.075494 |
| ERS | Intercept | 5508.631 | 689.4112 | 11.66436 | 0.549293*** |
| | Lin. Trend | 13176.20 | 996.4707 | 42.67612 | 1.997339*** |

**Table3: Real interestrates**

| 3A) Original data | | | | | |
|---|---|---|---|---|---|
| | | 1 month | 3 month | 6 month | 12 month |
| DF | Intercept | -6.235239*** | -0.069907 | -0.230805 | -1.804201* |
| | Lin. Trend | -6.907975*** | -0.973420 | -1.214018 | -2.169969 |
| ADF | Intercept | -6.952634*** | -1.721827 | -1.651360 | -1.795475 |
| | Lin. Trend | -6.953007*** | -1.319645 | -1.498061 | -2.504975 |
| PP | Intercept | -6.800741*** | -4.458562*** | -3.892904*** | -2.300347 |
| | Lin. Trend | -6.696350*** | -4.315148*** | -3.862489** | -2.855742 |
| KPSS | Intercept | 0.178576 | 0.313128 | 0.581763** | 0.717626** |
| | Lin. Trend | 0.070758 | 0.079205 | 0.110668 | 0.151642** |
| ERS | Intercept | 0.725935*** | 102.8298 | 77.26534 | 3.741646* |
| | Lin. Trend | 2.286736*** | 116.3202 | 65.36509 | 10.62269 |
| **3B) First differences** | | | | | |
| | | 1 month | 3 month | 6 month | 12 month |
| DF | Intercept | -0.778935 | -0.299742 | -0.930235 | -11.88836*** |
| | Lin. Trend | -10.84670*** | -1.873576 | -10.32546*** | -12.08344*** |
| ADF | Intercept | -8.241193*** | -9.275520*** | -11.51948*** | -12.08686*** |
| | Lin. Trend | -8.259480*** | -9.276416*** | -11.51448*** | -12.01909*** |
| PP | Intercept | 31.05832*** | -10.48174*** | -6.138150*** | -12.32136*** |
| | Lin. Trend | -30.79569*** | -10.44552*** | -6.205703*** | -12.25000*** |
| KPSS | Intercept | 0.180180 | 0.325965 | 0.090252 | 0.085204 |
| | Lin. Trend | 0.146912** | 0.156734** | 0.027312 | 0.085861 |
| ERS | Intercept | 2081.303 | 639.3644 | 10.31611 | 0.582543*** |
| | Lin. Trend | 4880.802 | 911.9009 | 35.37762 | 2.136545*** |

*Rejection al the 10%; **Rejection at the 5%; ***Rejection at the 1%

**Table4: Multiple break points**

| | | 0 vs 1 | 1 vs 2 | 2 vs 3 | 3 vs 4 |
|---|---|---|---|---|---|
| 1 monthdepositrate | Value | 101.9762 | 30.27416 | 46.35129 | 6.869821 |
| | Data | 2010M03 | 2011M10 | 2008M06 | - |
| 3 monthsdepositrate | Value | 108.6479 | 29.62747 | 67.86344 | 1.625633 |
| | Data | 2010M03 | 2011M10 | 2008M04 | - |
| 6 monthsdepositrate | Value | 104.7380 | 24.98437 | 50.23119 | 1.503904 |
| | Data | 2010M03 | 2008M05 | 2012M01 | - |
| 12 monthsdepositrate | Value | 132.6467 | 19.57415 | 23.68303 | 0.000000 |
| | Data | 2010M02 | 2008M01 | 2011M12 | - |
| Criticalvalues | | 11,47 | 12,95 | 14,03 | 14,85 |

**Table 5: Fractional integration results for the case of white noise disturbances**

| | | | |
|---|---|---|---|
| 1 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 1.02 , 0.91, 1.17) | 0.97 , 0.87, 1.10) | 0.97 , 0.87, 1.10) |
| Inflation rate | 0.13 , -0.06, 0.45) | 0.13 , -0.08, 0.43) | 0.13 , -0.06, 0.45) |
| Real interest rate | **0.18 , 0.02, 0.46)** | **0.19 , 0.02, 0.46)** | **0.17 , -0.03, 0.46)** |
| 3 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.82 , 0.47, 1.29) | 1.06 , 0.49, 1.54) | 1.06 , 0.55, 1.54) |
| Inflation rate | 0.91 , 0.44, 1.40) | 1.07 , 0.49, 1.56) | 1.07 , 0.55, 1.56) |
| Real interest rate | 0.82 , 0.47, 1.29) | 1.06 , 0.49, 1.54) | 1.06 , 0.56, 1.54) |
| 6 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.99 , 0.87, 1.15) | 0.96 , 0.85, 1.12) | 0.96 , 0.85, 1.12) |
| Inflation rate | 1.26 , 1.01, 1.56) | 1.28 , 1.06, 1.54) | 1.27 , 1.06, 1.53) |
| Real interest rate | 1.21 , 0.93, 1.56) | 1.33 , 1.10, 1.61) | 1.32 , 1.10, 1.61) |
| 12 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.76 , 0.67, 0.87) | 0.69 , 0.61, 0.79) | 0.69 , 0.60, 0.79) |
| Inflation rate | 0.94 , 0.76, 1.17) | 1.00 , 0.86, 1.21) | 1.00 , 0.86, 1.21) |
| Real interest rate | **0.73 , 0.62, 0.89)** | **0.74 , 0.64, 0.89)** | **0.74 , 0.62, 0.89)** |

In bold, evidence of mean reversion in the real interest rates.

**Table 6: Fractional integration results for the case of Bloomfield disturbances**

| 1 – month | | | |
|---|---|---|---|
| | No regressors | An intercept | A linear time trend |
| Nominal interest | 1.04 , 0.84, 1.34) | 1.15 , 0.90, 1.46) | 1.15 , 0.90, 1.46) |
| Inflation rate | -0.16 , -0.24, -0.03) | -0.38 , -0.57, -0.04) | -0.41 , -0.72, -0.04) |
| Real interest rate | **-0.12 , -0.26, 0.11)** | **-0.14 , -0.30, 0.12)** | **-0.37 , -0.68, 0.04)** |
| 3 - month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 1.08 , 0.86, 1.42) | 1.39 , 1.09, 1.84) | 1.39 , 1.09, 1.84) |
| Inflation rate | -0.11 , -0.20, 0.10) | -0.21 , -0.41, 0.13) | -0.24 , -0.45, 0.13) |
| Real interest rate | **-0.06 , -0.21, 0.22)** | **-0.07 , -0.24, 0.22)** | **-0.23 , -0.49, 0.16)** |
| 6 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.96 , 0.78, 1.24) | 0.98 , 0.78, 1.25) | 0.98 , 0.78, 1.25) |
| Inflation rate | 0.26 , -0.01, 1.09) | 0.25 , -0.01, 1.43) | 0.38 , -0.01, 1.47) |
| Real interest rate | **0.26 , 0.02, 0.72)** | 0.25 , 0.03, 1.24) | 0.25 , -0.09, 1.24) |
| 12 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 1.06 , 0.86, 1.36) | 1.14 , 0.94, 1.41) | 1.14 , 0.93, 1.41) |
| Inflation rate | 0.66 , 0.32, 1.16) | 0.85 , 0.61, 1.16) | 0.85 , 0.60, 1.16) |
| Real interest rate | 0.75 , 0.55, 1.09) | 0.82 , 0.59, 1.11) | 0.81 , 0.56, 1.11) |

In bold, evidence of mean reversion in the real interest rates.

**Table 7: Fractional integration results for the case of monthly AR(1) disturbances**

| 1 – month | | | |
|---|---|---|---|
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 1.02 , 0.91, 1.17) | 0.97 , 0.87, 1.09) | 0.97 , 0.87, 1.09) |
| Inflation rate | 0.06 , -0.09, 0.32) | 0.06 , -0.11, 0.29) | 0.06 , -0.11, 0.29) |
| Real interest rate | **0.12 , -0.02, 0.33)** | **0.12 , -0.02, 0.33)** | **0.11 , -0.04, 0.33)** |
| 3 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 1.00 , 0.89, 1.16) | 1.04 , 0.94, 1.17) | 1.04 , 0.94, 1.17) |
| Inflation rate | 0.67 , 0.41, 1.09) | 0.81 , 0.31, 1.29) | 0.83 , 0.34, 1.29) |
| Real interest rate | **0.53 , 0.31, 0.96)** | 0.76 , 0.31, 1.25) | 0.80 , 0.37, 1.25) |
| 6 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.99 , 0.87, 1.15) | 0.96 , 0.85, 1.13) | 0.96 , 0.85, 1.13) |
| Inflation rate | 1.10 , 0.88, 1.40) | 1.14 , 0.97, 1.36) | 1.14 , 0.97, 1.35) |
| Real interest rate | 0.99 , 0.74, 1.38) | 1.20 , 1.03, 1.43) | 1.19 , 1.03, 1.42) |
| 12 – month | | | |
| | No regressors | An intercept | A linear time trend |
| Nominal interest rate | 0.76 , 0.67, 0.88) | 0.69 , 0.61, 0.80) | 0.69 , 0.61, 0.80) |
| Inflation rate | 0.93 , 0.76, 1.17) | 1.01 , 0.86, 1.22) | 1.01 , 0.86, 1.22) |
| Real interest rate | **0.73 , 0.62, 0.89)** | **0.74 , 0.64, 0.89)** | **0.74 , 0.62, 0.89)** |

In bold, evidence of mean reversion in the real interest rates.