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Empirical analysis of fisher hypothesis for the period following the inflation targeting strategy in Turkey

A. Oznur UMIT

Ondokuz Mayıs University, Faculty of Economics and Administrative Sciences,
Department of Economics, Samsun, Turkey

Abstract---In this study, the validity of the Fisher hypothesis in Turkey was investigated through the analytical method of time series with structural breaks for the period 2002:01 to 2016:08. A long-run relationship between short-term nominal interest rates and inflation rates has been achieved in the results of Maki (2012) co-integration test with the multiple structural breaks. The results of estimating the co-integration coefficients using the Dynamic Ordinary Least Squares (DOLS) method show that a unit increase in the inflation rates increases the nominal interest rates less than one. In the Vector Error Correction Model (VECM) results, a one-way causality relationship from short term inflation rates to nominal interest rates has been determined. The results of the analysis show that the weaker form of Fisher effect is valid in the review period in Turkey. In this context, the monetary policies applied following the inflation targeting period in Turkey may be said to be partially effective on real interest rates.

Keywords---Fisher Hypothesis, Inflation Rates, Nominal Interest Rates, Co-integration, Structural Break.

1. Introduction

The relationship between inflation and nominal interest rates is a subject of hot debate in the economic literature. The relationship between these two macroeconomic variables was examined for the first time by Fisher (1986, 1930); thus, the related literature was referred to as the "Fisher Hypothesis". According to the hypothesis, the sum of the real interest rates in any period and the expected inflation rates in the same period equals the nominal interest rates. The hypothesis states that in the long-run equilibrium of the economy (the full employment of the national income) the continuous increase in the money supply growth rate increases the inflation expectations, which then increases the nominal interest

rates. In other words, hypothesis states that there is a one-to-one relationship between the expected inflation and the nominal interest rates; therefore, the real interests are stable in the long run as they are not affected by the monetary policies, i.e. the real interest rates are determined by real factors (Payne & Ewing, 1997). The review of the validity of the Fisher hypothesis is of great importance in many respects for the economists and policy makers, especially for developing and less developed economies. Firstly, the validity of the Fisher hypothesis is important in terms of the rationality and efficiency of financial markets (Coppock & Poitras, 2000).

Second, in case the Fisher hypothesis is valid, changes in interest rates in the short term are reflected in expected inflation and are an indicator of future inflation forecasts. Finally, if the Fisher hypothesis is valid, the monetary policies imposed by the Central Bank will not affect the real economy. In other words, the stability of real interest rates in the long run is a result of the monetary policy; because of its impact on investment, savings and exchange rates, it does not affect trade and capital flows and economic growth (Gul & Acikalin, 2008; Hawtrey, 1997). There are not many studies empirically testing the validity of the Fisher hypothesis in the related literature for Turkey, which is a developing country. Besides, the inability to reach consensus in these studies increases the importance of re-examination of this issue in terms of Turkey. The aim of this study is to analyze the validity of the Fisher hypothesis after the 2001 crisis for Turkey, with monthly data for the period of 2002:01 to 2016:08. The analytical methods applied in this study are Carrion-i-Silvestre et al. (2009) unit root tests with multiple structural breaks, Maki (2012) co-integration test with multiple structural breaks, dynamic ordinary least squares method (DOLS) and vector error correction model (VECM). The first contribution made by the study to the relevant literature is that it takes the post-2001 crisis period as the period under investigation.

The reason for the focus on this period is the adoption of the floating exchange rate and inflation targeting strategy in the post-crisis period. In other words, it is to determine whether the monetary policies applied in the framework of the inflation targeting strategy have a long-term effect on the real sector and whether nominal interest rates are a good indicator for estimating future inflation rates. Secondly, analysis is made considering the structural changes caused by the internal/external crises of the review period. In the second section the empirical literature is presented; data and methodology is presented in the third section; the empirical findings and discussion is presented in the fourth section; and the last section is the concludes the study.

2. Empirical Literature

The validity of the Fisher hypothesis was analyzed by using different econometric methods for different periods for developed and developing countries. Among these studies, Gibson (1970) concluded with the US data that there is a positive relationship between the nominal interest rates and the expected rate of price change. Analyzing the Fisher hypothesis for the US with an efficient market hypothesis, Fama (1975) found that the bond market is efficient within the nominal interest rates of 1 to 6 month and that this market uses all the information to estimate the inflation rates of coming period. In addition, Fama (1975) found that

today's interest rate determines future price changes. Summers (1982) analyzed the relationship between the interest rates of commercial papers and the consumer price index with the US data by applying the OLS method and found no relationship between these two variables. Mishkin (1991) analyzed the validity of the Fisher hypothesis for the US by using the OLS and Engle-Granger co-integration method for monthly and twelve-month Treasury bill rate and inflation rate variables. According to the results of the analysis, it is found that there is a long-term co-integration relation between the two variables in the long run and that the Fisher hypothesis is not valid in the short run.

Phylaktis and Blake (1993) investigated the validity of the Fisher hypothesis for Argentina, Brazil and Mexico by using the Johansen co-integration test and the VECM. The results of the analysis show that there is a strong correlation between the long-term nominal interest rate and the inflation rate in all three countries. Evans and Lewis (1995) analyzed the relationship between the nominal interest rate and the inflation rate for the US by using the Johansen co-integration test and the Markov regime change model. According to the results of the analysis, they found a co-integration relationship between two variables in the long run. However, the authors found that the change in the nominal interest rate did not fully reflect to the expected rate of inflation. Peng (1995) investigated the relationship between nominal interest rates and inflation rates for France, the United Kingdom, the United States, Germany and Japan using the OLS and Johansen co-integration method. According to the co-integration tests, a relationship between these variables in the long run was found for France, the United Kingdom and the United States. In addition, the coefficients estimated by the OLS method show that the changes in the nominal interest rates in these three countries fully reflect to the inflation rate. Crowder and Hoffman (1996) analyzed the relationship between the inflation rate and the nominal interest rate after tax for Canada by using Johansen co-integration, DOLS and VECM methods (1996); and found that nominal interest rates could not be used to estimate the inflation rate.

Crowder (1997) used the Johansen co-integration and VECM method for the Canadian economy. The author achieved results supporting the Fisher hypothesis in the long term. Hawtrey (1997) analyzed the validity of the Fisher hypothesis for the Austrian economy by using the Johansen co-integration test for the periods before financial liberalization (1969:Q3-1983:Q4) and after financial liberalization (1984:Q1-1994:Q4). According to the analysis results, the Fisher hypothesis is valid for the post-financial period. Moreover, they found that changes of interest rates after tax for the post-financial liberalization period are fully reflected to the inflation rate. Payne and Ewing (1997) investigated the validity of the Fisher hypothesis by using the Johansen co-integration test in nine less developed countries (Argentina, Fiji, India, Niger, Malaysia, Pakistan, Singapore, Sri Lanka and Thailand) and found the validity of full Fisher effect for Malaysia, Pakistan and Sri Lanka. Koustas and Serletis (1999) examined Fisher effect for 11 countries (Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Japan, the Netherlands, the United Kingdom and the United States) by Engle-Granger co-integration and long-term neutrality tests. Test results showed that the Fisher hypothesis is not valid in these countries. Malliaropoulos (2000) examined the relationship between nominal interest rates and inflation rates for the US by taking into account the structural breaks in the variables. In his work, he adjusted the structural break-free variables to the vector

autoregressive (VAR) model and found that the Fisher effect is valid in the medium and long term. Booth and Ciner (2001), who analyzed the relationship between the inflation rate of the nine European countries and the US and the short-term nominal interest rate of the Euro currency by using the co-integration test, found that the full Fisher effect was valid in most countries.

Using the bound test method based on the autoregressive distributed lag model (ARDL) for the US and Canada, Atkins and Coe (2002) found that the full Fisher effect is valid in both countries. Carneiro et al. (2002), who analyzed Fisher's effect by Johansen co-integration method for Argentina, Brazil and Mexico found that the full Fisher effect is valid only for Argentina and Brazil. Fahmy and Kandil (2002) investigated the validity of the Fisher hypothesis for the United States by Johansen co-integration test. The test results showed that the full Fisher effect is valid. Ghazali and Ramlee (2003), using the Autoregressive Fractionally Integrated Moving Average (ARFIMA) model and the fractional co-integration method, found that the Fisher hypothesis is not valid in the G7 countries. Lardic and Mignon (2003) showed in their study that there is a relationship between nominal interest rates and inflation rates in the majority of the G7 countries, according to the fractional co-integration test results.

Using the Zivot-Andrews (1992) and Lumsdaine-Papell (1997) structural break unit root test and bound test based on ARDL model, Atkins and Chan (2004) analyzed the relationship between nominal interest rates and inflation rates for Canada and the United States. According to the results of the analysis, it is found that there is a long-run relationship between the two variables in both countries. Granville and Mallick (2004) found that long-term nominal interest rate changes in the UK economy were reflected in the individual inflation rate in their work using Johansen co-integration method. Million (2004), by using the threshold autoregressive model (TAR), found that, in the existence of the stochastic trend of the nominal interest rate and the inflation rate in the US, there is a relationship among these variables are in the long-term. Kasman, Kasman and Turgutlu (2006) analyzed the Fisher effect using traditional co-integration and fractional co-integration methods for 12 developed and 21 developing countries. According to the traditional co-integration test results, with the exceptions of Korea, Chile, Mexico, Peru and Malaysia, there was no long-term relationship between the variables of nominal interest rate and the inflation rate. According to the result of fractional cointegration, they found a long run relationship between the variables of nominal interest rate and inflation rate in countries with the exceptions of Korea, Costa Rica, Czech Republic, Malaysia and the Philippines. Berument, Ceylan and Olgun (2007) investigated the validity of the Fisher hypothesis for the G7 countries and 45 developing countries by using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model.

Test results have shown that the Fisher hypothesis is valid in all G7 countries and in 23 developing countries. Christopoulos and León-Ledesma (2007) investigated the Fisher effect for the US using exponential smooth transition (ESTAR) and logistic smooth transition (LSTAR) methods based on the nonlinear time series technique. The results showed that Fisher effect is not valid for the US in the period under investigation. Hatemi-J and Irandous (2008), who used the Kalman filtering method, found that the full Fisher effect was not valid for Australia, Japan, Malaysia and Singapore. Ling, Liew Venus and Khalid Wafa (2008) analyzed the

validity of the Fisher hypothesis with the panel unit root test for 10 East Asian countries. The analytical results indicate that the Fisher hypothesis is valid in these countries. Investigating the validity of the Fisher hypothesis in the 20 OECD countries by the new panel co-integration test -Westerlund- Durbin-Hausman panel co-integration method, Westerlund (2008) find that the Fisher hypothesis is valid in these countries. Beyer, Haug and Dewald (2009) investigated the validity of the Fisher hypothesis for 15 developed countries with co-integration method based on linear time series and ESTAR and LSTAR models. In the co-integration test results based on the linear time series, they reached the conclusion that the Fisher hypothesis is valid in 15 countries.

Ito (2009) analyzed the Fisher hypothesis for Japan in three sub-periods (1987:01-1991:06, 1991:07-2000:07 and 2001:03-2006:06) monthly data by the Engle-Granger co-integration test and the DOLS method. The results of the analysis showed that the Fisher hypothesis is valid only in the 1987-1991 periods. Bajo-Rubio, Díaz-Roldán and Esteve (2010) have concluded that the Fisher effect is partially valid for the United Kingdom, as they found by using the Stock-Watson-Shin co-integration test and the multi-structural Bai-Perron co-integration test. Using the Time-Variant Coefficient (TVC) estimation method, Hall et al. (2010) reached to the conclusion that the full Fisher effect for the United States is valid. Badillo, Reverte and Rubio (2011) concluded that in the panel co- integration test results under horizontal section dependency, the partial Fisher effect is valid in 15 European Union countries. Toyoshima and Hamori (2011), who used the panel co-integration method, found that the exact Fisher effect was valid for the US, the UK and Japan. By using the Johansen co-integration and VECM methods, Fatima and Sahibzada (2012) found that the Fisher effect for Pakistan is valid in short and long terms. Ayub et al. (2014) showed that the Fisher hypothesis is valid during the review period in Pakistan by using the Engle-Granger and Johansen co-integration test. Everaert (2014) analyzed the Fisher effect for the 21 OECD countries by using the common correlated effects pooled (CCEP) method. The author, based on the analysis results, supported the Fisher effect.

Using panel unit root and panel co-integration tests, Ozcan and Ari (2015) showed that the partial Fisher effect is valid for G7 countries. Yaya (2015), using ARDL bound test for data from 10 African countries, finds that the exact Fisher effect is valid only in Kenya. Ito (2016) analyzed the validity of the Fisher hypothesis for Sweden with the co-integration and the DOLS method. The results showed that the Fisher hypothesis is valid for 2, 3, 4, 5 and 7 years. Panopoulou and Pantelidis (2016), who analyzed the Fisher effect for 19 OECD countries by using the time-varying data creation process and the effect of time changes on the co-integration coefficients, obtained results for the full Fisher effect in all countries with the exception of Switzerland. There are also studies in the empirical literature analyzing the Fisher hypothesis for different periods and in different econometric methods for Turkey. Among them; Turgutlu (2004) used Engle-Granger cointegration, piecewise stationarity and fractional co- integration test methods. The Engle-Granger co-integration test results showed that the Fisher hypothesis is not valid, but the piecewise co-integration test results showed that the Fisher hypothesis is valid. Şimşek and Kadılar (2006) found that the Fisher effect is valid when the ARDL bound test is applied. Yamak and Abdioğlu (2007) found that both strong and weak

forms of Fisher effect are found to be valid according to the HEGY (Hylleberg, Engle, Granger and Yoo) and Johansen co-integration tests.

Besides, empirical results have shown that the long-run relationship between the nominal interest rate and the inflation rate is also valid in the short-run. Gul and Acikalin (2008) found that the Fisher effect was very strong during the review period, although the Johansen co-integration test results failed to achieve a very powerful relationship between nominal interest rates and inflation rates. Zortuk (2008) concludes that there is a strong relationship between nominal interest rates and inflation rates in both the short and long run in the ARDL bound test results. Using the Engle-Granger co-integration test and the KSS (Kapetanios-Shin-Snell) test, which is a non-linear co-integration method, Yılcı (2009) finds that the Fisher effect is not valid in the period under investigation according to both of the applied methods.

Bayat (2011) applied a non-linear Seo co-integration test method for the period after the application of the floating- rate and inflation-targeting strategy (2002-2011) to analyze the relationship between 1, 3, 6, 9 and 12 months of weighted deposit interest rate and the consumer price index. In the analysis, he found that the Fisher effect was not valid during the examination period. Kose, Emirmahmutoglu and Aksoy (2012), who used the co-integration test with break in the trend, reached the conclusion that the weak form of Fisher effect is valid. İncekara, Demez and Ustaoglu (2012) analyzed the Fisher hypothesis with the Johansen co-integration test, VECM and VAR model. The results of the analysis show that the Fisher effect is valid for the long term and not for the short term. Using the Gregory-Hansen co-integration test, the Fully Modified Ordinary Least Squares (FMOLS) method, the Canonical Cointegrating Regression (CCR) and the Time Variable Parameters (TVP) approach, Arısoy (2013) concluded that the weak form of the Fisher effect is valid. Using the Engle-Granger co-integration and fractional co-integration test, Kıran (2013) found that the Fisher effect is valid for both tests. Mercan (2013) found that the partial Fisher effect was valid in the ARDL bound test results.

Atgür and Altay (2015) investigated the Fisher effect by using the Johansen, Lütkepohl-Saikkonen co-integration tests and the DOLS method. According to the results, they found a long-run relationship between the inflation and nominal interest rate. Using the Johansen co-integration and Granger causality tests, Kanca, Üzümcü and Deniz (2015) reached the conclusion that the Fisher hypothesis is valid. Köksel and Destek (2015) analyzed the Fisher hypothesis by using the multiple-structure fractured Maki co-integration test, the DOLS, the FMOLS and the VECM methods. They found that the Fisher effect is valid, but a unit increase in the inflation increases the nominal interest rate more than one. Besides, as they found with the VECM causality test, a unidirectional causality from the inflation rate to the nominal interest rates is valid in the short term.

3. Data and Methodology

3.1. Data and Empirical Model

In order to analyze the validity of the Fisher hypothesis for Turkey, the equation (3) was used and monthly data for the period 2002:01-2016:08 were used. The data starts with the year 2002, because the floating exchange rate and implicit inflation

targeting regime were implemented following the 2001 crisis. In the analysis, the inflation rates (π) data are obtained from the consumer price index (CPI) data, while the short term nominal interest rates (i) data is obtained from the weighted interest rates applied to the three-month term deposits. Inflation rate data are taken from the International Financial Statistics (IFS) published by the International Monetary Fund (IMF) and the weighted interest rates applied to the three-month time deposits are taken from the electronic data distribution system (EVDS) of the Central Bank of the Republic of Turkey (CBRT). Since the series did not show seasonal effects in the study, they were not adjusted for seasonal effects and the natural logarithms of the series were taken.

In the simplest terms, the equation for the Fisher hypothesis that the nominal interest rate is equal to the sum of the real interest rate and the expected inflation rate is given below.

$$i_t = r_t + \pi_t^e \quad (1)$$

Where, i_t ; t denotes the nominal interest rate during the period t ; r denotes the real interest rate in period t ; π_t^e ; denotes the expected inflation rate during the period t . Fama (1975) stated that in an efficient market, in other words, the assumption that the economic units are rational, the realized inflation rate is defined as follows.

$$\pi_t = \pi_t^e + u_t \quad (2)$$

In Equation (2), u_t denotes the prediction error of inflation and has a white noise process irrelevant of π_t^e . Under the assumption that the real interest rates in period t follow the u_0 average white noise process, the Fisher effect is tested by the following equation.

$$i_t = \alpha_0 + \alpha_1 \pi_t + \varepsilon_t \quad (3)$$

Under the assumption of rational expectations in equation (3); u_0 denotes the average real interest rates, α_1 denotes the coefficient of inflation in the period t , and the ε_t denotes the combined error term (Granville and Mallick, 2004: 88; Panopoulou and Pantelidis, 2016: 497). The full Fisher effect is valid when ε_t is stationary and $[I(0)]$ and $\alpha_1 = 1$ is equal, obtained by the estimation of equation (3) with the ordinary least squares (OLS) method. In other words, the changes in the inflation rate are fully reflected in the nominal interest rate. However, both the inflation rate and the nominal interest rate must be stationary in order to estimate Equation (3) with the OLS method. If both variables are stationary in the first order $[I(1)]$, the long-run relationship between two variables is generally investigated with the co-integration analysis in the relevant empirical literature. The full Fisher effect is valid if the analysis shows that there is a co-integration relationship between the two variables and if the predicted coefficient of co-integration is found to be $\alpha_1=1$. On the other hand, there is a Fisher effect in the weaker form if a co-integration relation is found between two variables but the predicted coefficient of co-integration is found to be $\alpha_1 < 1$ (Panopoulou and Pantelidis, 2016: 497).

3.2. Empirical Methodology

The validity of the Fisher hypothesis for Turkey is analyzed by the Carrion-i-Silvestre et al. (2009) (CS) unit root test with multiple structural breaks, Maki (2012) co-integration test with multiple structural breaks, DOLS and VECM methods. Gauss-10 is applied in the CS unit root and Maki co-integration tests while the Eviews 8 program was used in the DOLS and VECM methods.

3.2.1. Unit Root Test

Granger and Newbold (1974) have shown in their analysis made by the non-stationary time series that spurious regressions may occur although R^2 value is high and t statistic value is significant. For this reason, it is necessary to test the stationarity of the series in order to avoid the problem of false regression when applying the time series. In the related literature, generally, Dickey-Fuller (ADF) (1981), Phillips-Perron (PP) (1988), Dickey-Fuller Generalized Least Squares [DF-GLS (ERS)] (1996) and Ng-Perron (2001) (NP) unit root tests are used in testing the stationarity of the series. However, the reliability of the results of these tests is reduced in the presence of structural breaks in the series. For this reason, the stationarity of the series must be tested with structural fracture unit root tests. In the presence of more than two breaks in the series, Carrion-i-Silvestre et al. (2009) (CS) developed a unit root test with multiple structural breaks test where the time of the break is defined internally and which allows five structural fractures in the series. In the CS unit root test, the Bai and Perron (2003) algorithm is applied; and the time of the break is defined by the quasi-GLS (Generalized Least Squares) method, a dynamic programming approach and the minimization of the sum of squared errors method. In order to test the stationarity of the series, Carrion-i-Silvestre et al. (2009) developed five test statistics for the multiple structural breaks. These test statistics are: P_t denotes to possible optimal point test statistic developed by Perron and Rodriguez (2003); MP_t denotes to modified optimal point test statistic developed by tracing the Ng and Perron (2001) and M-class test statistics; and the test statistics developed by the Ng and Perron (2001) and Perron and Rodriguez (2003), which allow multiple structural breaks.

In the CS unit root test, when the calculated test statistics are smaller than the critical values, the basic hypothesis (H_0), which expresses the existence of unit root with structural breaks, is rejected. In other words, the alternative hypothesis (H_1) that there is no unit root with structural breaks is accepted. Thus, the series studied is assumed to be stationary under structural breaks.

3.2.2. Maki Co-integration Test

In the studies made with time series, the long-run relationship between the series is analyzed by co-integration tests if the series are not stationary at the level and if they are stationary when the differences are taken at the same order. Besides, the results of co-integration tests that take structural breaks into account in the presence of structural breaks in the series are more reliable than those obtained in traditional co-integration tests. Maki (2012), in the presence of more than two structural breaks in the series, has developed a co-integration test with multiple structural breaks, which allows for up to five structural breaks in the series and

where the structural break time is determined internally (Maki, 2012, 2011). The Maki co-integration test is based on the following four different models.

$$\text{Model 0: } y_t = \alpha + \sum_{i=1}^k \alpha_i D_{i,t} + \beta x_t + e_t \quad (4)$$

$$\text{Model 1: } y_t = \alpha + \sum_{i=1}^k \alpha_i D_{i,t} + \beta x_t + \sum_{i=1}^k \beta_i x_t D_{i,t} + e_t \quad (5)$$

$$\text{Model 2: } y_t = \alpha + \sum_{i=1}^k \alpha_i D_{i,t} + \gamma t + \beta x_t + \sum_{i=1}^k \beta_i x_t D_{i,t} + e_t \quad (6)$$

$$\text{Model 3: } y_t = \alpha + \sum_{i=1}^k \alpha_i D_{i,t} + \gamma t + \sum_{i=1}^k \gamma_i t D_{i,t} + \beta x_t + \sum_{i=1}^k \beta_i x_t D_{i,t} + e_t \quad (7)$$

Model 0 is the non-trending model with a break in the constant term; Model 1 is the non-trending model with break in the constant term and the slope; Model 2 is the trend model with break in the constant term, Model 3 is the trend model in which the constant term and the slope are broken. Here; $D_{i,t}$, ($i = 1, \dots, k$) denotes the dummy variable and takes the value of 1 when $t > T_{Bi}$ and 0 in other cases. T_{Bi} , denotes the time of the structural break. The hypothesis of the thesis is as follows:

H_0 = There is no co-integration relationship under structural breaks between the series

H_1 = There is a co-integration relationship between the series under structural breaks

In the presence of structural breaks, the critical values required when testing the co-integration relationship between the series are derived from Monte Carlo simulations (see Maki, 2012, 2013). Accordingly, if the Maki co-integration test statistic is smaller than the critical values, the H_0 hypothesis is rejected. In this study, the long-run relationship between variables was analyzed by Maki (2012) co-integration test with multiple structural breaks.

3.2.3. Dynamic Ordinary Least Squares Method

The co-integration coefficients in the presence of co-integration relationship between time series can be estimated by Dynamic Ordinary Least Squares (DOLS) method developed by Stock and Watson (1993). This method can also be used in small samples. In this method, Stock and Watson (1993) included the lags and leads of level values of the independent variables and the differences of the independent variables in the method to solve the problem of endogeneity and autocorrelation between the independent variables (Esteve and Requane, 2006: 118). Besides, Stock and Watson noted that in case the independent variables are co-integrated in various levels [I(0), I(1) and I(2)] χ^2 distributed DOLS and the dynamic generalized least squares estimator can be applied (Stock and Watson,

2003, 800-801). The two variant regression results for estimation with the DOLS method are given below.

$$Y_t = B'X_t + \sum_{i=-m}^m \delta_i \Delta X_{t-i} + \sum_{i=-n}^n \phi \Delta Trend_{t-i} + \varepsilon_t \quad (8)$$

In Equation (8), $B' = (c, \alpha, \beta)$ denotes the coefficient matrix; $X_t = (1, X, Trend)$ denotes the explanatory variable matrix; (-m and -n) denotes the lags; and (m and n) denotes the length of the predecessors.

3.2.4. Vector Error Correction Model

In the presence of the co-integration relation between variables, the short and long-term causality relationship between variables is analyzed by the VECM method developed by Engle and Granger (1987). In addition, this method uses the short- and long-term records of the data without allowing spurious relationships among the variables. Thus, this method distinguishes between long-term and short-term dynamics between variables.

4. Findings and Discussion

In this study, the stability of the series has been tested with the CS unit root test because many internal/external crises have been experienced during the review period in Turkey. CS test results are given in Table 1.

Table 1: CS Unit Root Test Results

Variables	PT	MPT	MZ α	MSB	MZT	Break Dates
lni	28.492 (9.449)	26.602 (9.449)	-17.018 (-47.012)	0.171 (0.104)	-2.905 (-4.814)	2003:06, 2004:12, 2006:06, 2008:12, 2013:05
ln π	21.164 (9.376)	20.456 (9.376)	-22.142 (-47.641)	0.150 (0.102)	-3.326 (-4.863)	2004:05, 2006:07, 2008:01, 2011:04, 2013:05
Δ lni	6.366* (8.447)	5.833* (8.447)	-66.872* (-45.215)	0.087* (0.105)	-5.782* (-4.762)	-
Δ ln π	5.448* (8.919)	4.946* (8.919)	-85.025* (-46.554)	0.077* (0.103)	-6.5183* (-4.811)	-

Instructions: Δ symbol states first difference operator, * symbol states that the series are stationary at 5% significance level. Critical values shown in the parentheses and with the help of bootstrap with 1000 iterations made. Structure break dates were determined by the test method.

CS unit root test results show that the test statistics calculated in the level values of the series are larger than the critical values. These results indicate that the series are not stationary with the structural breaks. In Table 1, it is seen that the test statistics calculated when the first difference of the series are taken, are smaller than the critical values. These results show that they are stationary in the first differences of the series [I (1)], in other words they are integrated in the first order.

Table 2: Maki Co-Integration Test Results

Model	t-Statistic	1% Critical Value	5% Critical Value	10% Critical Value	Break Dates
Model 0	-5.450**	-5.959	-5.426	-5.131	2004:01, 2004:12, 2008:12, 2009:12, 2014:11
Model 1	-6.021**	-6.193	-5.699	-5.449	2004:12, 2006:08, 2007:06, 2008:12, 2014:11
Model 2	-6.151***	-6.915	-6.357	-6.057	2004:12, 2008:12, 2010:07, 2013:04, 2014:11
Model 3	-7.479**	-8.004	-7.414	-7.110	2004:12, 2006:07, 2008:12, 2011:02, 2013:05

Instructions: While the number of dependent variables is 1 (RV=1) and the number of maximum break is five (m=5) the critical values of 1%, 5% and 10% at a significance level is excerpted from Maki (2012, 2013). *, ** and *** denotes the co-integration relationship respectively in 1%, 5% and 10% significance level.

Table 2 shows that the test statistics are lower than the critical values in all models. These results show that the H_0 hypothesis is rejected and that there is a long-run relationship between variables of nominal interest rates and the inflation rate. On the other hand, the structural break dates obtained in the model 2 can be evaluated as follows (see Table 2). The CBRT resumed the currency purchase auctions in December 2004. Turkey is affected by the 2008 financial crisis and CBRT used the interest rate corridor as a monetary policy in order to ensure financial stability in 2010. In 2013, the CBRT made the highest amount of foreign exchange selling auctions; and in 2014 the CBRT continued to implement strict monetary policy. Co-integration coefficients are estimated by the DOLS method in this study. In addition, the structural break dates obtained from the model 2 in the Maki co-integration test are included as dummy variables.

Table 1: The Estimation Results of Co-integration Coefficients

Dependent Variable: ln<i>i</i>			
Variables	Coefficient	t-Statistic (p-Value)	Standard Error
ln π	0.579	8.497 (0.0000) *	0.068216
C	0.739	7.869 (0.0000) *	0.093877
D1	-0.061	-1.741 (0.0837) ***	0.035053
D2	-0.149	-5.387 (0.0000) *	0.027598
D3	-0.079	-2.863 (0.0048) *	0.027943
D4	-0.023	-0.81 (0.4191)	0.02832
D5	0.085	2.742 (0.0068) *	0.031019

Instructions: R² and adjusted R² values are respectively 0.951 and 0.948. The values in parentheses denote the probability (p) values. * and *** states that the significances of the coefficients at *, 1%, ***; 10% significance level. Newey-Best bandwidth is used in long-term covariance estimation. Lead and lag lengths are accepted maximum 6 according to Schwarz information criterion. It is found that lead and lag lengths are respectively 1 and 4. The problems of autocorrelation and heteroscedastic are solved with Newey-Best method. Dummy variables are taken as, D1; 2004:12, D2; 2008:12, D3; 2010:07, D4; 2013:04, d5; 2014:11.

According to the results in Table 3, it is seen that the coefficient of variable of the inflation rate is significant and smaller than one. This result shows that a unit increase in the inflation rate leads to an increase in the nominal interest rates smaller than one, and therefore the weaker form of Fisher effect is valid for the review period in Turkey. When the dummy variables are examined, we see that all variables but D4 are statistically significant; and the D1, D2 and D3 make a negative impact on the interest rate variable, while the impact of D5 is positive.

The VEC model adapted to the study is given below.

$$\Delta \ln i_t = \alpha_0 + \alpha_1 \Delta \ln \pi_t + \alpha_2 ECT_{t-1} + \varepsilon_t \quad (9)$$

In the equation (9) Δ denotes the first difference operator; ECT_{t-1} denotes the error correction term; α_1 denotes the coefficient of the first difference of the inflation rate variable; and α_2 denotes the coefficient of the error correction term. The significance of the t-statistic of the α_1 coefficient indicates unidirectional causality from the short-term inflation rate to the nominal interest rate. α_2 shows the speed of achieving the long-run equilibrium from the short-run equilibrium among series. This coefficient should be statistically significant and negative. On the other hand, the significance of the t statistic value of this coefficient indicates that there is a long-run causality among the variables. The results of equation (9), estimated by the OLS method, are given in Table 4.

Table 4. VECM Results

Variables	Coefficients	t-Statistic (p-Value)
$\Delta \ln \square$	0.139	3.655 (0.0003)*
ECT_{t-1}	-0.041	-2.629 (0.0093)*
C	-0.003	-1.944 (0.0536)***
Instructions: The values in parentheses denote the probability (p) values. * and *** states that the significances of the coefficients at *, 1%, ***, 10% significance level.		

In this model, autocorrelation and the presence of changing variance are examined by Breusch-Godfrey (B-G) and White test, respectively. In the B-G test results, the probability value (p) of the χ^2 test statistic was found to be 0.02, and therefore the basic hypothesis (H_0) was accepted which indicates that there is no autocorrelation at the 1% significance level. In the White test results, the probability value (p) of the χ^2 test statistic was found to be 0.31, and therefore the basic hypothesis (H_0) was accepted, indicating that there is no changing variance at the 1% significance level. In other words, in the B-G and White test results, autocorrelation and changing variance were not found in the model.

When the results in Table 4 are examined, the coefficient of the inflation rate variable is found to be significant at the 1% significance level. This result shows the existence of a one-way causality relationship from inflation rates to nominal interest rates in the short term during the review period in Turkey. On the other hand, the coefficient of error correction term is found to be statistically significant and negative. This indicates that there is a unidirectional causality relationship from inflation rates to nominal interest rates in the long run. In addition, this result shows that short-term imbalances of the series moving together in the long-run disappears; and the series become closer to equilibrium values in the long run.

5. Conclusion

The Fisher hypothesis states that there is a long-run positive relationship between short-term nominal interest rates and inflation rates. The existence and direction of the relationship between nominal interest rates and inflation rates is particularly important in terms of the effectiveness of the applied monetary policies on the real economy. In this study, the validity of Fisher hypothesis in Turkey is analyzed with the monthly data of the 2002:01 to 2016:08 periods. In the study, the analytical methods of CS unit root test with multiple structural breaks, Maki (2012) co-integration test with multiple structural breaks, DOLS and VECM methods. The main contribution made by the study to the relevant literature is that it focuses on the period when the floating exchange rate and inflation targeting strategy is applied in Turkey. Secondly, analysis is made considering the structural changes caused by the internal/external crises that took place during the review period. In the Maki co-integration test results, long term co-integration relationship was found between variables. According to the results of the DOLS method, it was seen that inflation rates affected the short-term interest rates in statistically significant way and positively in accordance with the expectations of the Fisher hypothesis.

Furthermore, in the DOLS method, it is found that the inflation rates affect the nominal interest rates less than one.

As to the VECM results, there found a unidirectional causality relationship from nominal interest rates to inflation rates in the short term. Besides, in the results of the VECM method, it is seen that the error correction mechanism of the model is working. In other words, the short-run imbalances of the series moving together in the long term disappears and they become close to each other in the long term. The results of the study show that the weaker form of Fisher effect is valid in Turkey in the review period. In addition, the results of the study support the results obtained by studies conducted by Kose, Emirmahmutoglu and Aksoy (2012) and Mercan (2013). The empirical results of the study achieved for the review period show that the changes in inflation rates in Turkey are related to the nominal interest rates. However, the conclusion that weaker form of the Fisher effect is valid indicates that monetary policy practices are partially effective on real interest rates in the CBRT's review period. Moreover, according to the results achieved, it can be said that the nominal interest rates are not indicators providing a full estimation the future inflation rate.

References

- Arisoy, İ. (2013). Testing for the Fisher hypothesis under regime shifts in Turkey: New evidence from time-varying parameters. *International Journal of Economics and Financial Issues*, 3(2), 496–502.
- Atgür, M., & Altay, N. O. (2015). Enflasyon ve nominal faiz oranı ilişkisi: Türkiye örneği (2004-2013). *Yönetim ve Ekonomi*, 22(2), 521–533.
- Atkins, F. J., & Chan, M. (2004). Trend breaks and the Fisher hypothesis in Canada and the United States. *Applied Economics*, 36(17), 1907–1913.
- Atkins, F. J., & Coe, P. J. (2002). An ARDL bounds test of the long-run Fisher effect in the United States and Canada. *Journal of Macroeconomics*, 24(2), 255–266.
- Ayub, G., Rehman, N. U., Iqbal, M., Zaman, Q., & Atif, M. (2014). Relationship between inflation and interest rate: Evidence from Pakistan. *Research Journal of Recent Sciences*, 3(4), 51–55.
- Badillo, R., Reverte, C., & Rubio, E. (2011). The Fisher effect in the EU revisited: New evidence using panel cointegration estimation with global stochastic trends. *Applied Economics Letters*, 18(13), 1247–125.
- Bajo-Rubio, O., Díaz-Roldán, C., & Esteve, V. (2010). Testing the Fisher effect in the presence of structural change: A case study of the UK, 1966–2007. *Economic Issues*, 15(2), 1–15.
- Bayat, T. (2011). Türkiye’de Fisher etkisinin geçerliliği: Doğrusal olmayan eşbütünleşme yaklaşımı. *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 38, 47–60.
- Berument, H., Ceylan, N. B., & Olgun, H. (2007). Inflation uncertainty and interest rates: Is the Fisher relation universal? *Applied Economics*, 39(1), 53–68.
- Beyer, A., Haug, A. A., & Dewald, W. (2009). Structural breaks, cointegration and the Fisher effect. *European Central Bank Working Paper Series*, No. 1013, 1–33.
- Booth, G. G., & Ciner, C. (2001). The relationship between nominal interest rates and inflation: International evidence. *Journal of Multinational Financial Management*, 11(3), 269–280.

- Carneiro, F. G., Ângelo, J., Divino, I. V. C. A., & Rocha, C. H. (2002). Revisiting the Fisher hypothesis for the cases of Argentina, Brazil and Mexico. *Applied Economics Letters*, 9(2), 95–98.
- Carrion-i-Silvestre, J. L., Kim, D., & Perron, P. (2009). GLS-based unit root tests with multiple structural breaks under both the null and the alternative hypotheses. *Econometric Theory*, 25, 1754–1792.
- Christopoulos, D. K., & León-Ledesma, M. A. (2007). A long-run non-linear approach to the Fisher effect. *Journal of Money, Credit and Banking*, 39(2/3), 543–559.
- Coppock, L., & Poitras, M. (2000). Evaluating the Fisher effect in long-term cross-country averages. *International Review of Economics & Finance*, 9(2), 181–192.
- Crowder, W. J., & Hoffman, D. L. (1996). The long-run relationship between nominal interest rates and inflation: The Fisher equation revisited. *Journal of Money, Credit and Banking*, 28(1), 102–118.
- Crowder, W. J. (1997). The long-run Fisher relation in Canada. *The Canadian Journal of Economics*, 30(4b), 1124–1142.
- Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, 49(4), 1057–1072.
- Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, 64(4), 813–836.
- Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error-correction: Representation, estimation and testing. *Econometrica*, 55(2), 251–276.
- Esteve, V., & Requena, F. (2006). A cointegration analysis of car advertising and sales data in the presence of structural change. *International Journal of the Economics of Business*, 13(1), 111–128.
- Evans, M. D. D., & Lewis, K. K. (1995). Do expected shifts in inflation affect estimates of the long-run Fisher relation? *The Journal of Finance*, 50(1), 225–253.
- Everaert, G. (2014). A panel analysis of the Fisher effect with an unobserved I(1) world real interest rate. *Economic Modelling*, 41, 198–210.
- Fahmy, Y. A. F., & Kandil, M. (2002). The Fisher effect: New evidence and implications. *International Review of Economics and Finance*, 12(4), 451–464.
- Fama, E. F. (1975). Short-term interest rates as predictors of inflation. *American Economic Review*, 65(3), 269–282.
- Fatima, N., & Sahibzada, S. A. (2012). Empirical evidence of Fisher effect in Pakistan. *World Applied Sciences Journal*, 18(6), 770–773.
- Fisher, I. (1896). Appreciation and interest. *Publications of the American Economic Association*, 11(4), 331–442.
- Fisher, I. (1930). *The theory of interest: As determined by impatience to spend income and opportunity to invest it*. Kelley Publishing.
- Ghazali, N. A., & Ramlee, S. (2003). A long memory test of the long-run Fisher effect in the G7 countries. *Applied Financial Economics*, 13(10), 763–769.
- Goodfriend, M. (1993). Interest rate policy and the inflation scare problem: 1979–1992. *Federal Reserve Bank of Richmond Economic Quarterly*, 79(1), 1–24.
- Gül, E., & Ekinci, A. (2006). Türkiye'de enflasyon ve faiz oranı ilişkisi: Fisher hipotezi. *Sosyal Bilimler Dergisi*, 6(1), 47–56.
- Hasanov, F., Omay, T., & Uçar, N. (2011). Testing for the Fisher hypothesis under regime shifts: New evidence from the USA and Canada. *Economic Modelling*, 28(3), 1321–1325.

- Haug, A. A., MacKinnon, J. G., & Michelis, L. (2000). European monetary union: A cointegration analysis. *Journal of International Money and Finance*, 19(3), 419–432.
- Hassapis, C., & Kalyvitis, S. (2002). Investigating the Fisher effect in the presence of structural changes: A robust approach. *Applied Financial Economics*, 12(11), 785–797.
- Hendry, D. F., & Mizon, G. E. (1993). Evaluating dynamic econometric models by encompassing the VAR. In P. C. B. Phillips (Ed.), *Models, methods, and applications of econometrics* (pp. 272–300). Blackwell.
- Hülagü, T., & Yalçın, C. (2016). Enflasyon hedeflemesi öncesi ve sonrası Fisher etkisi: Türkiye için bir karşılaştırma. *TCMB Çalışma Tebliği Serisi*, No. 16/19, 1–24.
- Ihsan, I., & Anjum, S. (2013). Relationship between inflation and interest rate: Evidence from Pakistan. *Asian Journal of Social Sciences & Humanities*, 2(1), 83–91.
- İpek, E., & Dinçer, M. (2016). Türkiye’de Fisher etkisinin ampirik analizi: VAR modeli uygulaması. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 17, 15–26.
- Jaffe, J., & Mandelker, G. (1976). The “Fisher effect” for risky assets: An empirical investigation. *The Journal of Finance*, 31(2), 447–458.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2–3), 231–254.
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration: With applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52(2), 169–210.
- King, R. G., & Watson, M. W. (1997). Testing long-run neutrality. *Federal Reserve Bank of Richmond Economic Quarterly*, 83(3), 69–101.
- Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, 54(1–3), 159–178.
- Lee, J., & Strazicich, M. C. (2003). Minimum Lagrange multiplier unit root test with two structural breaks. *Review of Economics and Statistics*, 85(4), 1082–1089.
- Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. Springer Science & Business Media.
- Maddala, G. S., & Kim, I. M. (1998). *Unit roots, cointegration, and structural change*. Cambridge University Press.
- Mark, N. C. (2001). *International macroeconomics and finance: Theory and econometric methods*. Blackwell Publishers.
- Mishkin, F. S. (1992). Is the Fisher effect for real? A reexamination of the relationship between inflation and interest rates. *Journal of Monetary Economics*, 30(2), 195–215.
- Mishkin, F. S. (1993). Perspectives on inflation targeting. *National Bureau of Economic Research Working Paper*, No. 8974.
- Mundell, R. A. (1963). Inflation and real interest. *Journal of Political Economy*, 71(3), 280–283.
- Narayan, P. K., & Narayan, S. (2004). The Fisher hypothesis: Evidence from an autoregressive distributed lag model. *Applied Economics*, 36(19), 2227–2236.
- Nelson, C. R., & Plosser, C. I. (1982). Trends and random walks in macroeconomic time series: Some evidence and implications. *Journal of Monetary Economics*, 10(2), 139–162.

- Newbold, P., & Granger, C. W. J. (1974). Experience with forecasting univariate time series and the combination of forecasts. *Journal of the Royal Statistical Society. Series A (General)*, 137(2), 131–165.
- Ng, S., & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69(6), 1519–1554.
- Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57(6), 1361–1401.
- Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics*, 80(2), 355–385.
- Phillips, P. C. B., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies*, 57(1), 99–125.
- Phillips, P. C. B., & Moon, H. R. (1999). Linear regression limit theory for nonstationary panel data. *Econometrica*, 67(5), 1057–1111.
- Rapach, D. E., & Weber, C. E. (2004). Are real interest rates really nonstationary? New evidence from tests with good size and power. *Journal of Macroeconomics*, 26(3), 409–430.
- Rose, A. K. (1988). Is the real interest rate stable? *The Journal of Finance*, 43(5), 1095–1112.
- Schwert, G. W. (1987). Effects of model specification on tests for unit roots in macroeconomic data. *Journal of Monetary Economics*, 20(1), 73–103.
- Shiller, R. J., & Perron, P. (1985). Testing the random walk hypothesis: Power versus frequency of observation. *Economics Letters*, 18(4), 381–386.
- Stock, J. H., & Watson, M. W. (1988). Testing for common trends. *Journal of the American Statistical Association*, 83(404), 1097–1107.
- Summers, L. H. (1983). The non-adjustment of nominal interest rates: A study of the Fisher effect. In J. Tobin (Ed.), *Macroeconomics, prices, and quantities: Essays in memory of Arthur M. Okun* (pp. 201–246). Brookings Institution Press.
- Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.
- Thornton, D. L. (1983). Inflation and nominal interest rates: The Fisher equation revisited. *Federal Reserve Bank of St. Louis Review*, 65(9), 17–30.
- Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, 66(1–2), 225–250.
- Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press.
- Zivot, E., & Andrews, D. W. K. (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, 10(3), 251–270.