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INTEREST RATES: THE CAUSE OR THE RESULT? A CHICKEN AND EGG PROBLEM REVISITED (THE RELATIONSHIP BETWEEN INTEREST RATES AND INFLATION IN TURKEY)

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Abstract

This paper investigates the validity of Fisher Hypothesis and Neo-Fisherian approach for Turkey by using Autoregressive Distributed Lag (ARDL) method developed by Pesaran et al. (2001) as well as the Granger causality test developed by Toda and Yamamoto (1995). The scope of the study focuses on flexible inflation targeting period in Turkey. Inflation uncertainty is estimated by employing the GARCH model for the period October 2010-May 2020. Empirical results gathered from ARDL indicate that there is a positive and significant relationship between compound interest rate for government domestic debt securities (nominal interest rate), expected inflation rate and inflation uncertainty in the long run. The results of Toda and Yamamoto causality test suggest that inflation uncertainty and expected inflation affect nominal interest rates. Also, inflation uncertainty and expected inflation rate are affected by nominal interest rates. The empirical results indicating two-way causality provides significant empirical evidence for the presence of the Neo-Fisherian effect in addition to the Fisher Hypothesis in Turkey.

Keywords: Inflation, Inflation Uncertainty, Unconventional Monetary Policy, Flexible Inflation Targeting, Toda-Yamamoto Causality Test

JEL Codes: E31, E43, E58.

1. Introduction

The nature of the relationship between interest rates, inflation and inflation uncertainty has been of utmost interest to economists and policymakers. Conventional wisdom suggests that decreasing interest rates invigorates business and vice versa. Hence, interest rates have historically provided the central banks

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with an effective tool to control inflation as an increase in nominal interest rates is expected to cool down the economy and help to decrease the inflation rate. Yet the aftermath of the global financial crises of 2007 and 2008 pointed to a rather unconventional relationship among interest rates and inflation rates. Following the global financial crises major central banks followed a low interest rate policy for an extended period. However, the persistence of low inflation rates along with low interest rates triggered motive for revisiting the classical Fisher effect.

The neo-classical Fisher hypothesis suggests that there is a positive relationship between interest rates and expected inflation where the direction is from expected inflation towards nominal interest rates. Williamson (2018) argues that conventional macroeconomic monetary models can exhibit Neo-Fisherian properties and under certain conditions Neo-Fisherianism may create an alternative to conventional inflationary controls. As stated in Bullard (2015) and Cochrane (2016), Neo-Fisherian view emphasizes the long-run relation between the nominal interest rates and inflation rate and argue that inflationary expectations affect the long-run inflation rate. The Neo- Fisherian effect based on the New Keynesian perspective argues that a permanent increase in nominal interest rates increase the inflation rate via the surge in expected inflation rate (Uribe, 2017). Therefore, the inflation rate is expected to increase as much as the raise in nominal interest rate in the long run. Conversely, low nominal interest rates are expected to decrease inflation rate by bringing expected inflation rate down in the long run. Despite the limited empirical work in the literature Iona (2017) detects Neo-Fisherian effect in Middle and Eastern European countries. Low interest rates pursued in response to the Global Financial Crises in these countries led to further decline in inflation rate. This empirical finding provides support for the Neo-Fisherian effect indicating causality from interest rates towards inflation. Mumtaz and Theoridis (2018) examine inflation targeting policies of the Federal Reserve (FED) during the pre-1980 period and conclude that the positive inflation target shocks acted as a driving force to the persistent decline observed in long-run interest rates.

Amano et al. (2016) argue that a simple New Keynesian model may under certain conditions lead to a Neo-Fisherian link from high nominal interest rates to high inflation. Bullard (2015) argues that major oil price shocks and anchored inflation expectations over an extended period of time may be effective as well hence the Neo-Fisherian mechanism should be observed closely in the future before resorting to alternative monetary policies. Lukmanova and Rabitsch (2018) investigate the transmission mechanisms in response to an inflation target shock and detect short-run positive co-movement of the inflation rate and the interest rates for the US economy over the period 1947- 2017. By this way, their study provides an empirical evidence for the existence of Neo-Fisherian effects.

Inflation uncertainty which exacerbates the costs of inflation is also expected to have a significant positive relationship with inflation itself as the Friedman hypothesis (1977) suggests. The direction of causality among the interest rates and inflation rate as well as the effect of uncertainty of inflation is of crucial importance in understanding the dynamics of the relationship among monetary variables. Hence, the literature is remarkably rich in empirical studies dealing with the associations among interest rates, inflation rate, and its uncertainty.

Tayyar (2019) investigates the relationship between interest rates and inflation rate in Turkey for the period of 2002 – 2014 and concludes that both the Neo-Fisherian effect and the Fisher effect exist in Turkey for the short-run and the long-run, respectively. Sümer (2020) analyzed unconventional monetary policy that is implemented after the 2008 Global Financial Crisis in Turkey and provided evidence in favor of the Neo-Fisherian affect.

The Central Bank of the Republic of Turkey (CBRT) switched from implicit inflation targeting to full-fledged inflation targeting in 2006. The economic conjuncture due to the quantitative easing pursued by advanced economies in the aftermath of the 2008 Global Financial Crises has driven central banks of developing economies including the CBRT deviate away from conventional monetary policy (Varlık, 2014). As indicated in Başçı and Kara (2011) and Kara (2012) the CBRT adopted unconventional monetary policy in the last quarter of 2010. CBRT stated financial stability as a complementary objective in addition to its primary objective of price stability and hence enlarged its policy tool set to include macro prudential policy measures and hence adopted a flexible inflation targeting regime (see for the effects of multiple policy tool set on economy; Varlik and Berument, 2017; 2020). This paper investigates the period between October 2010-May 2020 which marks an unconventional monetary policy period departing from previous inflation targeting practice.

This paper is organized as three sections. Following the introduction, the data and the model is described, measurement regarding inflation uncertainty is explained and descriptive statistics are outlined in Section 2. Estimation results and concluding remarks are presented in Section 3.

2. Data, Model and Empirical Results

The variables included in the model are introduced, stationary test results for the series are presented and measurement of inflation uncertainty is explained in this section. The empirical relations among the variables in the short-run and the long-run are investigated by employing ARDL (Autoregressive Distributed Lag) co-integration and Toda-Yamamoto (TY) causality tests.

2.1. Data

This paper aims to investigate the short-run and long-run relationship between expected inflation rates (INF^{exp}), inflation uncertainty (INF^{unexp}) and compound interest rate for government domestic debt securities (*GDS)*. Monthly interest rates and inflation rates are used for the period 2010:M10-2020:M05. In order to measure inflation uncertainty, consumer price index (CPI) is obtained from the Electronic

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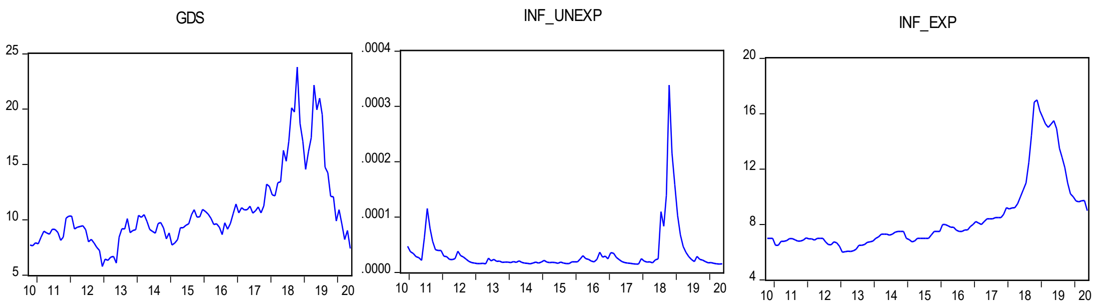
Data Delivery System (EDDS) of CBRT. CPI series is transformed into log difference and seasonally adjusted (dCPI). Inflation uncertainty is estimated by employing the GARCH model and identified as INF^{unexp}. The GDS is used for the interest rate variable because interest rate for government domestic debt securities are crucial in determination of market interest rates due to the major need of debt financing of Treasury in Turkey (Ceylan 2006)[3]. Hence the interest rates for government domestic debt securities are obtained from the statistical database of the Republic of Turkey Ministry of Treasury and Finance. The variable INF^{exp} indicates the median value of the expected CPI inflation rate for the next 12 months. The series for this variable are obtained from the EDDS.[4]

Graph 1. Time Series Plots for Interest Rates, Inflation Uncertainty and Expected Inflation Rate



Source: Authors' calculations

First, Augmented Dickey-Fuller (ADF), Philips-Perron (PP), Kwaitowski, Phillips, Schmidt and Shin (KPSS) unit root tests are conducted to decide on causality tests. Table 1 indicates the unit root test results. The series GDS and INF^{exp} are non-stationary at level but INF^{unexp} is stationary at level.

Table 1. Unit Root Test Results

	ADF Test		KPSS Test		PP Test	
	Trend & intercept	**Intercept**	**Trend & intercept**	**Intercept**	**Trend & intercept**	**Intercept**
GDS	-1.8774	-1.9473	0.7063	0.1008	-2.0524	-1.9684
ΔGDS	-6.6911*	-6.6514*	0.0988*	0.1355*	-11.442*	-11.431*
INF^{exp}	-2.6105	-2.0530	0.1425	0.7775	-2.0639	-1.5521
ΔINF^{exp}	-4.3629**	-4.3841*	0.0863*	0.0834*	-4.3629*	-4.3841*
INF^{unexp}	-3.6450**	-3.6179*	0.0938*	0.1689**	-3.7435**	-3.7120*

[3] In addition to the CBRT policy interest rate, weighted average funding rate and late liquidity window are used as monetary policy interest rate during the flexible inflation targeting period. This practice has led the policy interest rate to lose its function. As the monetary policy of the CBRT has been recently market based this paper employs GDS interest rate (TCMB, 2021:3).

[4] Survey of Expectations are sent to 90 participants including 67 representing the financial sector, 10 representing the real sector and 13 professionals. Expectations indicate the calculated mean for each variable (TCMB, 2020).

*(1) * Significant at 1% level, ** Significant at 5% level (2) Schwarz Information Criteria (SIC) in ADF test is used to determine most appropriate lag length. (3) Newey-West and Barlett Kernel estimation methods are used in PP and KPSS tests.*

Source: Authors' calculations

Table 1 indicates that the variables to be used in the model are stationary at different levels[5]. Hence ARDL model is employed to detect cointegration among the series in the long run.[6] As some of the series have unit root short run causality is estimated by Toda-Yamamoto (1995) test. Toda-Yamamoto causality test is not sensitive to stationarity of the series. In case there exists a common stochastic tendency in the nominal interest rates, inflation uncertainty and expected inflation rate series used in the model, causality is expected to exist among these series.

2.2. Measurement of Inflation Uncertainty

As there are contrasting views on the effect of inflation uncertainty on interest rates the relation is rather investigated empirically. There are various methods for measuring inflation uncertainty. These methods can be categorized as survey-based measures, forecast based measures and model-based measures. The standard deviation of inflation forecasts is commonly used for measuring inflation uncertainty whereas Mankiw et al. (2003) argue that survey results cannot be used as an accurate measure of inflation uncertainty. The variance of the expected inflation rate and the absolute value of the errors of estimated inflation rate are also used to indicate inflation uncertainty (Grier and Perry, 1998; Johnson, 2002). Grier and Perry (1998) argue that measures of uncertainty based on surveys and these other methods demonstrate volatility over time and there is no test for examining if this volatility is statistically significant or not. Arguing that neither of these methods explain inflation uncertainty as Cukierman and Meltzer (1986) or Ball (1992), Grier and Perry (1998) investigate the relationship between inflation rate and inflation uncertainty by employing GARCH model to generate a time-varying conditional variance of unexpected inflation and use the derived conditional variance of the GARCH model as a measure of inflation uncertainty. The ARCH model of Engel (1982) and the GARCH model developed by Bollerslev (1986) enable testing the statistical significance of the movements observed in the conditional variance in time. Engle (1982) and Bollerslev (1986), estimated the US inflation by ARCH and GARCH method and then compared the estimated conditional variance series with the mean inflation. Caporale and McKiernan (1997) employ GARCH model and conclude that the level and variability of inflation in the US are positively related as suggested by Friedman (1977).

Recently some forms of ARCH and GARCH type models are used to measure inflation uncertainty in Turkey. For instance, Artan (2008) employs

[5] GDS and INF^{exp} series are not stationary at level. However, these series are stationary at first difference.

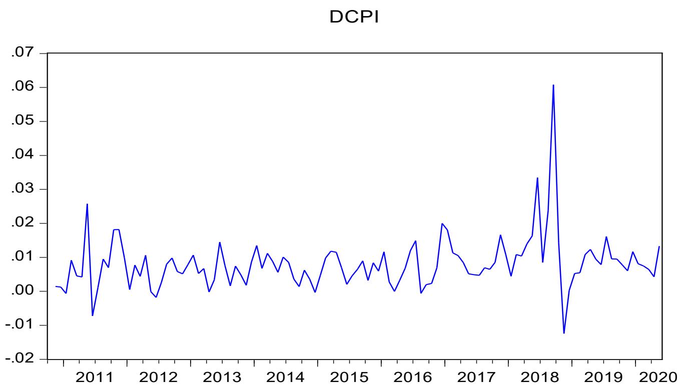
[6] The ARDL approach developed by Pesaran, Shin and Smith (2001) enable cointegration analysis among series irrespective of their level of stationarity.

GARCH model to investigate inflation uncertainty in Turkey for the period 1987:1-2003:3 and concludes that the uncertainty of inflation has a larger negative impact on growth compared to inflation itself. Berument et al. (2007) test the validity of the Fisher hypothesis and augmented Fisher relation including inflation uncertainty, by using GARCH model and conclude that the Fisher relation holds in all G7 countries but in only 23 developing economies out of 45 whereas augmented Fisher relation holds for six G7 countries and 18 developing economies. Berument et al. (2001) employ EGARCH model to analyze inflation uncertainty in Turkey. Neyaptı and Kaya (2000) employ ARCH model to measure inflation uncertainty and conclude that the relationship between the level and uncertainty of the inflation has a significant positive correlation.

This paper employs GARCH model to measure inflation uncertainty following the recent and common practice in the empirical literature (Berument and Dincer, 2005; Güler and Özlale, 2005; Oltulular and Terzi, 2006; Berument et al. 2007; Thornton, 2008; Jiranyakul and Opiela, 2010; Khan, 2010; Bhar ve Mallik, 2012; Buth et al., 2015; Bamanga, 2016, Raihan, 2017; Nyoni, 2018; Ftiti and Jawadi, 2019; Lawton and Gallagher, 2020; Munir and Riaz, 2020).

First the CPI series obtained from the EDDS is seasonally adjusted by using Tramo Seats and then transformed into the log difference and identified as dCPI. Graph 2 visualizes that the dCPI series used for estimation of inflation uncertainty displays volatility over time.

Graph 2. Time Series Plot for dCPI Series



Source: Authors' calculations

The series dCPI_sa is tested for unit roots and the series is found to be stationary.

Table 2 Unit Root Test Results for dCPI Series

	ADF Test		**PP Test**	
	Trend & intercept	**Intercept**	**Intercept**	**Trend & intercept**
DCPI	-5.284855*	-5.032463*	-7.740868*	-7.924398*
Critical Values at % 1 * Significant at %1	-4.042042	-3.489659	-3.488585	-4.040532

Source: Authors' calculations

Alternative ARMA structures are analyzed by Box-Jenkins methodology (1976). ARMA (1,1) structure is found to be the best fit for the dCPI series. Langrange Multiplier test is conducted to test for the presence of ARCH effect, and it is concluded that there exist ARCH effects in the model. Then the ARCH type models (Bollerslev, 1986) are estimated by maximum likelihood method. Employment of model selection criteria led to the choice of GARCH (1,1) model as the best fit. The GARCH (1,1) Model estimated for the DCPI series is denoted below in Equation (1).

$$\underset{}{dCPI_t} = \underset{(0.000)}{0.007399} + \underset{(0.0145)}{0.331503} + \varepsilon_t + \underset{(0.000)}{0.764369}\,\varepsilon_{t-1} \tag{1}$$

$$h_t = a_0 + a_1\varepsilon_{t-1}{}^2 + \beta_1 h_{t-1}$$

$$h_t = \underset{(0.0291)}{0.00000557} + \underset{(0.000)}{0.149965}\,\varepsilon_{t-1}{}^2 + \underset{(0.000)}{0.599965}\,h_{t-1}$$

Following the estimation of the GARCH (1,1) model in Equation (1) LM test is conducted to investigate if there are any remaining ARCH effects and it is found that there is no further ARCH effect left. Hence the GARCH model capturing the ARCH effect indicates that the conditional variance series obtained from this GARCH model can be used as an indicator of inflation uncertainty. Also, the sum of a_1 and β_1 is equal to 0.74993 which is less than 1 but close to 1 signaling rather high persistency in the conditional variance. This finding indicates the existence of inflation inertia in the economy during the relevant period. Both the values of a_1 and β_1 are between 0 and 1 which also satisfies stability conditions.

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2.3. ARDL Model and Empirical Results

As a first step in investigating the relationship among nominal interest rates, inflation uncertainty and expected inflation rate, the stationarity of the time series is tested. As Table 1 displays that the series are integrated of different order the cointegration relation among the variables in the long-run is tested by employing ARDL methodology.

The model to employ the ARDL test developed by Pesaran et al. (2001) is displayed in Equation (2).

$$\Delta GDS_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta GDS_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta INF_{t-i}^{UNEXP} + \sum_{i=1}^{p} \alpha_{3i} \Delta INF_{t-i}^{EXP} + \beta_1 GDS_{t-1} + \beta_2 INF_{t-1}^{UNEXP} + \beta_3 INF_{t-1}^{EXP} + \varepsilon_t \quad (2)$$

where p denotes the lag length and ε_t denotes the error term. α_1, α_2 *and* α_3 indicate the short-run dynamics and β_1, β_2 *and* β_3 indicate the long-run dynamics of the model.

The existence of a long-run relationship among the variables is tested by the Bound Test.

H_0: β_1=β_2=β_3 =0 (no cointegration)

H_1: β_1≠β_2≠β_3 ≠0 (cointegration)

The ARDL bound testing approach of cointegration is conducted.

Table 3. Bound F-test for Cointegration

Dependent Variable						**F-statistic**
GDS						6.53***
Asymptotic Critical Values						
Pesaran et al. (2001), p. 301, Table CI(ii) Case II	1%		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	4.13	5.0	3.1	3.87	2.63	3.35

Note: *** denotes statistical significance at 1% level

Source: Authors' calculations

Table 3 displays that the *F* statistic for the GDS series is higher than the upper bound. Hence there exists a cointegration relation among nominal interest rates, inflation uncertainty and expected inflation rate during the flexible inflation targeting period in Turkey at % 1 significance level. This empirical finding with the nominal interest rate as the dependent variable validates the Fisher hypothesis. .

The optimal lag length for the estimation of the ARDL model is determined by employing Akaike Information Criterion and ARDL (2,1,1) model is selected as the best fit. The long-run estimation results of the associated model are displayed in Table 4 Panel A and the short-run results are displayed in Table 4 Panel B.

Table 4. Results of ARDL Model

Panel A: Long-run Coefficients - Dependent variable is GDS

Regressor	Coefficient	Standard Error	t-ratio	Prob.
INF^{unexp}	0.034**	0.011	2.476	0.014
INF^{exp}	1.385*	0.152	9.073	0.000
C	-0.13	1.112	-0.120	0.904

Panel B: Short-run Coefficients - Dependent variable is ΔGDS; Δ=first difference operator

Regressor	Coefficient	Standard Error	t-ratio	Prob.
ΔINF^{unexp}	0.029	0.452	0.066	0.947
ΔINF^{exp}	2.173*	0.328	6.617	0.000
ECM(-1)	-0.315*	0.060	-5.186	0.000

R-squared	0.923	Resd. sum of sq.	108.21
Adjusted R-squared	0.919	F-statistic prob.	0.000
S.E. of regression	1.010	DW statistic	1.993
Akaike info criterion	2.918		

Note. * and ** respectively denotes stationarity at 1% and 5% significance levels. The results show that both statistic and diagnostic tests are satisfactory.

Source: Authors' calculations

Table 4 Panel A indicates that inflation uncertainty has a positive coefficient with a significance level of 5%. Similarly, the long run coefficients of the expected inflation series are positive and statistically significant at %1. Hence Table 5 Panel A displays that both inflation uncertainty and the expected inflation rate increase the nominal interest rates in the long run.

The Panel B of the Table 4 displays the short run dynamics of the established Model. The coefficient of the inflation uncertainty in the short run is positive but

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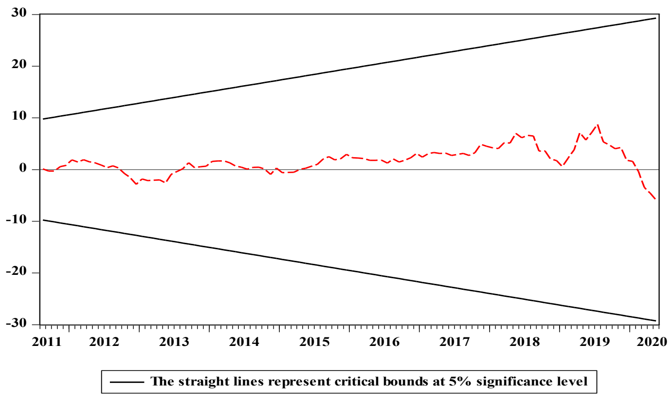
not statistically significant. Hence the empirical results suggest that an increase in inflation uncertainty does not affect nominal interest rates in the short run. Yet an increase in expected inflation rate increases nominal interest rates both in the short run and the long run. The ECM (-1) coefficient is found to be negative and statistically significant as expected (t-ratio= -5.186) which indicates that the error correction mechanism works properly. The GDS series has an automatic adjustment mechanism and short run deviations observed in the nominal interest rates converge to the long run equilibrium with a certain adjusment speed (-0.31). Accordingly, the error correction mechanism will approach the deviations from short-run equilibrium to the long-run equilibrium value with an adjustment speed of 31%.

The stability of the parameters is tested following Pesaran et al. (2001). The cumulative sum (CUSUM) of the long-run coefficients estimated in the model is significant at 5% confidence level as displayed in Graph 3.

Graph 3. Plot of cumulative sum of recursive residuals



Source: Authors' calculations

2.4. The Toda and Yamamoto (1995) Approach to Granger Causality

Following the detection of a cointegration relationship among nominal interest rates, inflation uncertainty and expected inflation, the validity of the Fisher hypothesis in Turkey during the flexible inflation targeting period is investigated. In order to explore the direction of causality between the inflation rate and the nominal interest rate, augmented vector autoregression (augmented VAR) model by Toda and Yamamoto (1995) is employed and linear and non-linear dynamics of nominal interest rate and inflation rate are investigated. Conventional Granger causality tests within the framework of unrestricted VAR assume that all series are either stationary or integrated of same order. However, TY model enables causality tests irrespective of the stationarity of the variables. Since the model established in this paper include time series that are not stationary, existence of cointegration is investigated and vector error correction model is used instead of unrestricted VAR. According to Ghosh and Kanjilal (2014), it is not possible to test the long run relationship if the series are not I (1) or integrated of same order. To cope with this problem, TY (1995) developed a method based on the estimation of augmented VAR model (k+d_{max}) [k is the optimal time lag on the first VAR model, d_{max} is the maximum integrated order on system's variables].

Based on augmented VAR modelling, TY (1995) recommends a Wald test statistic that asymptotically has a chi-square distribution irrespective of the order of integration or cointegration properties of the variables in the model (Hacker and Hatemi, 2006). It uses a modified Wald (MWALD) test to test for restrictions on the parameters of the VAR model.

The model comprises some steps. First the series are tested for unit root. If the series are integrated of different order the maximum integration level for the series is detected (d_{max}). As displayed in Table 1 INF^{exp} and *GDS* series are I(1) while INF^{unexp} series is I(0). Then the unrestricted VAR model is established irrespective of the integration levels of the series and optimal lag length is determined. The optimal lag length is determined to be 3 by using the Schwarz information criterion (SIC). As the maximum integration level is 1, VAR (k+1) (adjusted VAR model) is formed. Hence only one extra lag (d_{max}=1) is added in this case for the implementation of the Toda-Yamamato causality test. Next, the TY causality test is applied by using pairwise equations. This is modified MWALD test for the significance of the parameters on examined equations on number of time lags (k+d_{max}). As a final step, cointegration is analyzed in the adjusted VAR model established.

The three-variable TY causality test is as follows (Yamada, 1998):

$$\begin{aligned} GDS_t = \mu_0 &+ \sum_{i=1}^{k} \theta_i \, GDS_{t-i} + \sum_{i=k+1}^{k+d_{max}} \theta_i \, GDS_{t-i} + \sum_{i=1}^{k} \delta_i \, INF_{t-i}^{unexp} \\ &+ \sum_{i=k+1}^{k+d_{max}} \delta_i INF_{t-i}^{unexp} + \sum_{i=1}^{k} \Psi_i \, INF_{t-i}^{exp} \\ &+ \sum_{i=k+1}^{k+d_{max}} \Psi_i INF_{t-i}^{exp} + \varepsilon_{1t} \qquad (3) \end{aligned}$$

$$INF_t^{unexp} = \alpha_0 + \sum_{i=1}^{k} \Phi_i \, INF_{t-i}^{unexp} + \sum_{i=k+1}^{k+d_{max}} \Phi_i \, INF_{t-i}^{unexp} + \sum_{i=1}^{k} \Upsilon_i \, GDS_{t-i} + \sum_{i=k+1}^{k+d_{max}} \Upsilon_i GDS_{t-i} + \sum_{i=1}^{k} \text{ɣ}_i \, INF_{t-i}^{exp} + \sum_{i=k+1}^{k+d_{max}} \text{ɣ}_i \, INF_{t-i}^{exp} + \varepsilon_{2t} \quad (4)$$

$$INF_t^{exp} = \beta_0 + \sum_{i=1}^{k} \varpi_i \, INF_{t-i}^{exp} + \sum_{i=k+1}^{k+d_{max}} \varpi_i \, INF_{t-i}^{exp} + \sum_{i=1}^{k} \text{⋔}_i \, INF_{t-i}^{unexp} + \sum_{i=k+1}^{k+d_{max}} \text{⋔}_i \, INF_{t-i}^{unexp} + \sum_{i=1}^{k} \yen_i \, GDS_{t-i} + \sum_{i=k+1}^{k+d_{max}} \yen_i GDS_{t-i} + \varepsilon_{3t} \quad (5)$$

where $\theta, \delta, \Psi, \Phi, \Upsilon$, ɣ, ϖ, ⋔ and ¥ are parameters of the model, d_{max} is the maximum order of integration.

The empirical findings of the Granger causality test based on TY (1995) methodology and estimated by MWALD test are presented in Table 5.

Table 5. Toda-Yamamoto Causality (modified WALD) Test Results

Excluded	Lag (k)	Lag ($k+d_{max}$)	Chi-sq	P-values	Direction of Causality
Dependent Variable: GDS INF^{unexp}	3	3+1	16.249	0.001*	$INF^{unexp} \rightarrow GDS$
Dependent Variable: INF^{unexp} GDS	3	3+1	7.663	0.053***	$GDS \rightarrow INF^{unexp}$
					$GDS \leftrightarrow INF^{unexp}$
Dependent Variable: GDS INF^{exp}	3	3+1	16.628	0.008*	$INF^{exp} \rightarrow GDS$
Dependent Variable: INF^{exp} GDS	3	3+1	21.690	0.001*	$GDS \rightarrow INF^{exp}$
					$GDS \leftrightarrow INF^{exp}$
Dependent Variable: INF^{unexp} INF^{exp}	3	3+1	38.553	0.000*	$INF^{exp} \rightarrow INF^{unexp}$

Dependent INF^{exp} INF^{unexp}	Variable:	3	3+1	22.988	0.000*	$INF^{unexp} \rightarrow INF^{exp}$

Note. a) The lag length selection was based on Schwarz information criterion (SIC). b) Significance of the modified Wald chi-square statistics to test whether the *k* lags are equal to zero (Kurozimi and Yamamato, 2000). c) The ($k+d_{max}$) denotes VAR order. c) * and *** denotes 1% and 10% significance level, respectively. d) → Denotes one-way causality and ↔ denotes two-way causality. EViews 10.0 was used for all computations.

Source: Authors' calculations

According to the TY test results, the significance of the p-values for the modified Wald (MWALD) statistic reveals that two-way Granger causality is predominant. Yet the causality from INF^{unexp}→GDS is more dominant compared to the causality from GDS→INF^{unexp} when the uni-directional causality from nominal interest rates to inflation uncertainty is investigated. Hence causality from inflation uncertainty towards interest rates is stronger than the causality otherwise.

3. Conclusion

This paper investigates the validity of Fisher's hypothesis and Neo-Fisherian approach for Turkey using cointegration test developed by Pesaran et al. (2001) as well as the Granger non-causality test developed by Toda and Yamamoto (1995).

The study covers the flexible inflation targeting period in Turkey. Nominal interest rates, inflation uncertainty and expected inflation rate are used in model estimation. Inflation uncertainty is estimated by using GARCH model.

The empirical results of the paper indicate that there exists a cointegration relationship among the variables. According to the findings of the ARDL model, nominal interest rates and the expected inflation rate are detected to move in synchronization in Turkey during the flexible inflation targeting period in the long run. The empirical findings indicate that a 1% rise in inflation uncertainty and expected inflation rate will increase the nominal interest rate by 0.03% and by 1.38% respectively in the long run. This finding confirms the validity of Fisher hypothesis in the long run. In addition, the dynamic short run estimation of the vector error correction model demonstrates that the GDS series has an automatic adjustment mechanism. According to this, the short run deviations observed in the nominal interest rate converge to the long-run equilibrium by 0.31% adjustment speed.

The direction of the causality between the nominal interest rates and inflation rate and the effect of inflation uncertainty is of crucial importance in understanding the dynamics of the relationship among monetary variables. The Fisher hypothesis, which marks one of the cornerstones of the neoclassical monetary theory, states that there is a positive association between the nominal interest rates and inflation in the long run and nominal interest rates increase with expected inflation rate. Neo-Fisherian view on the other hand stresses that the inflationary expectations affect the inflation rate and hence an increase in nominal interest rates increases inflation rate via escalation of inflationary expectations. Therefore, within the Neo-Fisherian framework, the causality of the relationship is from interest rate towards to inflation rates.

The results of Toda and Yamamoto causality suggest that nominal interest rates are affected by inflation uncertainty and expected inflation rate in the short run. And the expected inflation rate and inflation uncertainty are affected by the nominal interest rate. In other words, a two-way causality relationship has been determined between the variables during the flexible inflation targeting period in Turkey in the short run. This result emphasizes that the changes observed in the short run nominal interest rates are compelling with respect to the monetary policy followed by the Central Bank during the flexible inflation targeting period. Comparatively low interest rates do in fact have the power to diminish inflationary expectations and hence the realized expectation via the Neo-Fisherian mechanism. Therefore, the magnitude of a Neo-Fisherian effect under certain circumstances is determinative in initiation of alternative monetary policies. However, according to the results obtained from Toda Yamamato test, considering the two-way causality relationship, it shows that the egg and chicken problem continues during the flexible inflation targeting period in Turkey.

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