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The Relationship between Inflation and Inflation Uncertainty: Empirical Evidence from Turkey

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Abstract

In our paper, we research the relationship between inflation and inflation uncertainty of Turkish economy for the period of (2005:01-2020:05) using ARMA-GARCH model. There are several theoretical and methodological studies conducted in this topic. Although some of the empirical studies support the Friedman-Ball hypothesis of positive effect of inflation-on-inflation volatility, some of them support Cukierman & Meltzer hypothesis that inflation uncertainty contributes to higher inflation, and finally rest of their findings corroborate Holland hypothesis indicating that uncertainty trigger to decrease potential inflation. In our study inflation causes, an increase in uncertainty in all four five conditions of lag selection, which supports the Friedman-Ball hypothesis. Inflation uncertainty does not cause an increase in inflation, which does not support the Cukierman & Meltzer hypothesis and Holland hypothesis. Therefore, it is concluded that The Central Bank of the Republic of Turkey should respond to stabilize the inflation uncertainty by implementing the inflation targeting policy successfully.

Keywords: Turkey, Inflation, Uncertainty, ARCH, GARCH,

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1. Introduction

Inflation is a definition of the continual increase in market prices. This means that the purchasing power of national economy declines day by day in an unbalanced and distrustful economy and in a market that is affected by inflation. Defined as one of the fundamental economic problems, inflation has several severe impacts on the households and all the other players in the economy. The process of the price instability known as inflation uncertainty has tended to reduce economic activity and contribute the high unemployment by affecting the function of the price mechanism.

The decision of household and business can be affected by inflation uncertainty, which has negative impact on the macro level of economy (Golob, 1994: 27). The academic studies on inflation have been received much attention since Okun and later continued by Friedman studies (Erdem and Yamak, 2014: 246).

The studies of M. Friedman have two points to emphasize. Firstly, they pointed to the positive relations between the degree of the inflation and the uncertainty. Secondly, they emphasized that higher inflation causes to distort the price information quality that is important in the resource allocation. Later, the relationship between inflation and inflation uncertainty has been tested by many scholars empirically and obtained mixed results due to model specifications and the proxies for inflation uncertainty (Caglayan, Ozge and Kostas, 2011: 45).

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In this study we are going to investigate the relationship between inflation and inflation uncertainty to know whether inflation caused of uncertianties or not. For the mentioned purpose we used the Consumer Price Index (C.P.I.) as a monthly percentage change obtained from The Central Bank of Republic of Turkey (TCMB) , and for inflation uncertainty we will use the conditional variance of inflation through GARCH model.

Our study is divided into four sections. Section one is specified for introduction in the section two we have literature review, data and methodology belong to section three and in the last section we have conclusion and policy implication.

2. Literature

Empirically we can review all studies in the literature into three categories : (1) supporting Friedman-Ball hypothesis (inflation causes of uncertainty)[a], (2) Cukierman & Meltzer Hypothesis (1986)[b], (Uncertianty Causes Positively Inflation), (3) Holland Hypothesis (1995), (uncertainty lower the average inflation)[c].

Below, we review 13 studies we found that analyzed the relation between inflation and inflation uncertainty. Each of them has different results on the validity of Friedman-Ball, Cukierman & Meltzer and Holland hyopthesis. We summarize all the methods and results each of studies in Table 1.

Table 1. Summary of Econometric Studies on the Relationship Between Inflation and Inflation Uncertainty

Authors	Method	Period	Result
Elton, Atsuyuki and Benito (2005)	APGARCH	1957-2004	Support Friedman-Ball, Cukierman and Meltzer, and Holland
Erkam (2008)	ARCH, GARCH and PARCH	1982–2008	Support the Friedman-Ball
Fisunoğlu and Özdemir (2008)	GARCH	1987-2003	Support the Friedman-Ball and Cukierman and Meltzer
Fountas(2001)	GARCH	1885-1998	Support the Friedman-Ball
Kim(1993)	ARCH	1958–1990	Support the Friedman-Ball hypothesis
Kontonikas (2004)	GARCH-M models	1972-2002	Support the Friedman-Ball hypothesis
Orhan and Keske (2010)	GARCH-M	1984-2005	Support the Friedman-Ball hypothesis, and Holland hypothesis
Telatar and Telatar(2003)	Granger	1995–2000	Support the Friedman-Ball
Thornton (2007)	GARCH model	Period varies from country to country	Support Friedman-Ball, Cukierman and Meltzer, and Holland

[a] Friedman concluded that an increase in expected inflation causes confusion about how to fight future monetary policy, leading to large fluctuations in real and projected inflation, leading to economic inefficiency and lower production growth.

[b] A theoretical one is given by Cukierman and Meltzer (1986). Model that describes a causal effect like this. More inflation in the case of Uncertainty, the potential for less cautious central bankers to surprise Hoping for production gains, the public and generate unanticipated inflation.

[c] Holland discovered that inflation in the United States increases inflation volatility and that higher inflation uncertainty contributes to lower average inflation, the so-called "stabilizing Fed assumption"

Wilson (2006)	bivariate EGARCH-M model	1957 – 2002	Support the Cukierman and Meltzer
Riaz and Munir (2020)	ARMA-GARCH	1998-2018	Support Friedman-Ball and Cukierman – Meltzer
Farzinvash , Elaahi , Kiaalhosseini & Haashemi Dizaj (2016)	MS – VAR	1990-2015	Support the Friedman-Ball
Jiranyakul(2020)	EGARCH	1979 – 2019	Support Friedman-Ball hypothesis and Cukierman – Meltzer

3. Data and Methodology

In this study, we investigated the relationship between inflation and inflation uncertainty for Turkey over the period of 2005:M1-2020M5 for the inflation, we used the Consumer Price Index (C.P.I.) as a monthly percentage change obtained from The Central Bank of Republic of Turkey (TCMB). In order to attain the index of inflation uncertainty we will use the conditional variance of inflation through GARCH model, the method that we apply for our analysis is ARMA –EGARCH model, and then we investigate causality between two variables with Granger-causilty test.

3. 1. The Empirical Results

Table 2 summarizes the descriptive statistics of the inflation variable, CPI, from Turkey over the period of 2005-2020.

Table 2. Summary Statistics for CPI

Mean	0.762270	Skewness	1.423253
Median	0.650000	Kurtosis	10.12803
Maximum	6.300000	Jarque-Bera	454.109
Minimum	-1.44	Sum	141.0200
Std. Dev.	0.892523	Sum Sq. Dev.	146.5738

The Table.2 shows the mean, median, standard deviation (std), minimum value (min), and maximum value (max) are 0.76, 0.65, 6.3, -1.44, 0.89 respectively, for the variable.

Prior to fitting the ARIMA ARCH model, series should be stationary, otherwise it should be converted into stationary series.

Table 3. Unit Root Test Results for CPI

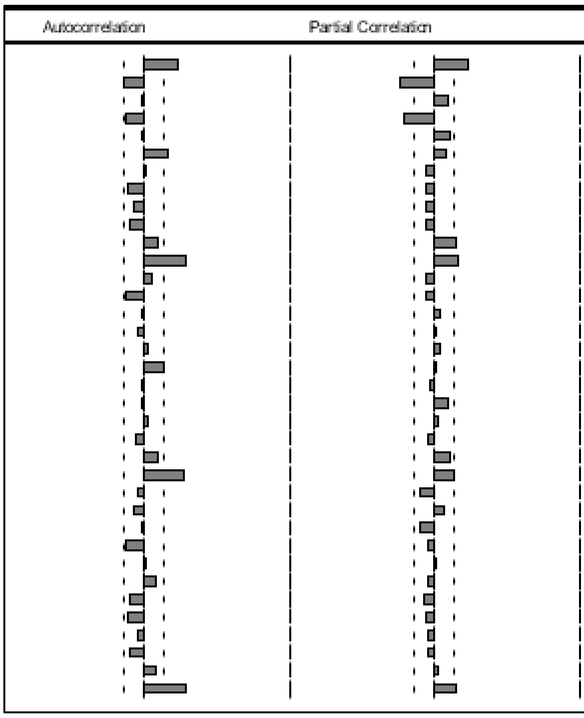
ADF	ADF test statistic	Mac Kinnon Test critical values			Prob
	5.302232	1%	5%	10%	0.0000
		-3.467	-2.877	-2.575	

The stationary properties of the CPI variable is investigated by ADF test. According to test results, the absolute value of test statistics is greater than critical value at 1%, 5% and 10%, and the probablity value is also significant, which indicates that a series is I(0) which means stationary at level.

After all, the data are certainly stationary at further level (which means not necessary first difference) in determining the best model of ARMA (ARIMA will be used if the data is experiencing first difference when the unit root test.

In order to estimate ARMA model for our data, firstly we need to examine the correlogram of consumer price index monthly changes, which is provided in the following table.

Graph 1. Correlogram of CPI Monthly Changes



	AC	PAC	Q-Stat	Prob
1	0.247	0.247	11.467	0.001
2	-0.156	-0.231	16.048	0.000
3	-0.012	0.104	16.074	0.001
4	-0.128	-0.217	19.227	0.001
5	-0.018	0.124	19.293	0.002
6	0.182	0.093	25.698	0.000
7	0.008	-0.062	25.712	0.001
8	-0.114	-0.063	28.260	0.000
9	-0.068	-0.050	29.159	0.001
10	-0.089	-0.050	30.737	0.001
11	0.102	0.157	32.823	0.001
12	0.300	0.180	50.859	0.000
13	0.047	-0.061	51.311	0.000
14	-0.130	-0.051	54.711	0.000
15	-0.010	0.054	54.732	0.000
16	-0.032	-0.007	54.943	0.000
17	0.038	0.054	55.241	0.000
18	0.147	0.013	59.689	0.000
19	-0.009	-0.023	59.706	0.000
20	-0.019	0.101	59.785	0.000
21	0.039	0.030	60.107	0.000
22	-0.065	-0.048	61.016	0.000
23	0.113	0.130	63.731	0.000
24	0.288	0.145	81.534	0.000
25	-0.032	-0.091	81.759	0.000
26	-0.078	0.073	83.093	0.000
27	-0.023	-0.091	83.210	0.000
28	-0.123	-0.025	86.519	0.000
29	0.005	0.002	86.524	0.000
30	0.088	-0.032	88.259	0.000
31	-0.084	-0.074	89.850	0.000
32	-0.105	-0.063	92.330	0.000
33	-0.037	-0.033	92.642	0.000
34	-0.086	-0.044	94.356	0.000
35	0.086	0.040	96.051	0.000
36	0.306	0.161	117.83	0.000

The Graph.1 explains the autocorrelation and partial correlation of inflation and error terms respectively. The ***correlogram*** indicates the autocorrelation and partial correlation in the first lag. Furthermore the autocorrelation seen in the 12th lag and 24th lag, and partial correlation seems in the 2nd and third lag of the table.

As per the results of the Graph 1 we are going to test the following tentative ARMA models. ARMA(1,1), ARMA(1,2), ARMA(1,4), ARMA(12,1), ARMA(12,2), ARMA(12,4), ARMA(24, 1), ARMA(24, 2), ARMA(24, 4) , ARMA(12-24, 1-2-4).

The best model will be selected based on the Akaike info criterion, R-squared, significance number of coefficients.

Based on the lowest Akaike info criteria, we select the ARMA- GARCH using the following criteria: the lowest Akaike info criteria, appropriate R2 coefficient, and the *significance* of model.

Table 4. EGARCH Model Results for CPI

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.813259	0.110569	7.355183	0.0000
AR(12)	0.192308	0.065437	2.938809	0.0033
AR(24)	0.323660	0.060992	5.306596	0.0000
MA(1)	0.292425	0.095984	3.046606	0.0023
MA(2)	-0.179979	0.073334	-2.454234	0.0141
MA(4)	-0.211985	0.062763	-3.377546	0.0007
	Variance Equation			
C(7)	-0.651527	0.188032	-3.464980	0.0005
C(8)	0.255642	0.157488	1.623252	0.1045
C(9)	0.430537	0.109539	3.930432	0.0001
C(10)	0.462085	0.138851	3.327933	0.0009
R-squared	0.299819	Mean dependent var		0.771801
Adjusted R-squared	0.277232	S.D. dependent var		0.925224
S.E. of regression	0.786586	Akaike info criterion		2.103272
Sum squared resid	95.90128	Schwarz criterion		2.294663
Log likelihood	-159.3134	Hannan-Quinn criter.		2.180985
Durbin-Watson stat	1.753473			

The results of the test for the monthly inflation rates in Turkey can be seen in the Table.4 above. In the model AR (12,14) and moving average (1,2,4) satisfy the stationary conditions.

Table 5. Heteroskedasticity Test: ARCH

F-statistic	0.019274	Prob.F(1,158)	0.8898
Obs*R-squared	0.019515	Prob. Chi-Square (1)	0.8889
F-statistic	1.131880	Prob. F(1,158)	0.8898
Obs*R-squared	4.541186	Prob. Chi-Square (1)	0.8889
F-statistic	1.153394	Prob. F(8,144)	0.3316
Obs*R-squared	9.213470	Prob. Chi-Square (8)	0.3246
F-statistic	1.960502	Prob. F(12,136)	0.0325
Obs*R-squared	21.97371	Prob. Chi-Square (12)	0.0378
F-statistic	1.771715	Prob. F(24,112)	0.0246
Obs*R-squared	37.69969	Prob. Chi-Square (24)	0.0372

According to the Heteroskedasticity test, estimated P value is less than 5 and 10 percent in the 12th and 24th lags so we can reject the null hypothesis which means that there is ARCH effect. And then we decided to use the GARCH type model in order to generate the conditional variance for the inflation uncertainty as proxy.

There are lagged forms of the square error term in GARCH (p, q) and q Terms of variable variances lagged. It is assumed that the coefficients αi and βi are positive to ensure that the conditional variance is still positive. Thus, in a GARCH model, the conditional variance is defined as a function of the previous square error terms and the conditional variance of past periods. If the αi and βi sums are close to one, the variance is strongly constant and has a reversing mean property.

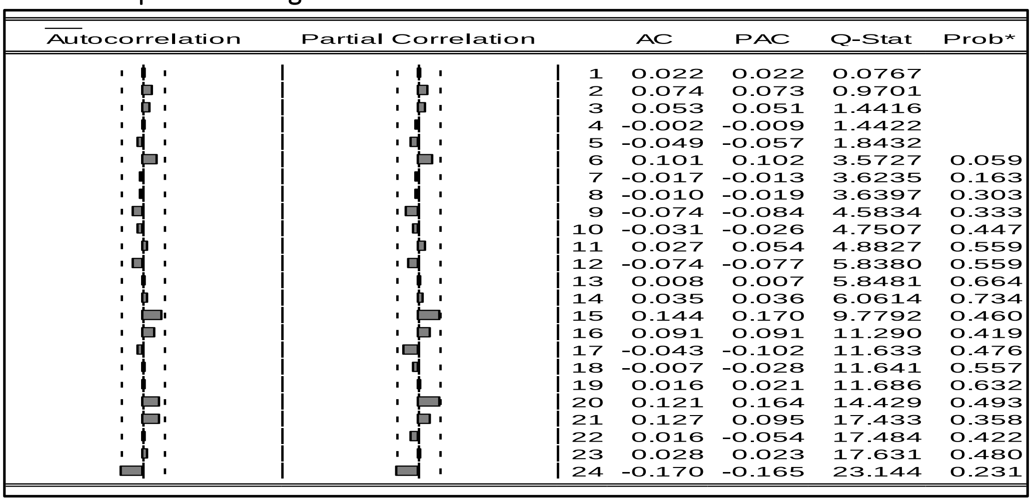
Table 6. GARCH ARMA Results

GARCH = C (7) + C(8)*RESID(-1)^2 + C(9)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.759337	0.130408	5.822800	0.0000
AR(12)	0.163811	0.070668	2.318018	0.0204
AR(24)	0.461818	0.079721	5.792919	0.0000
MA(1)	0.270886	0.103386	2.620146	0.0088
MA(2)	-0.177009	0.102787	-1.722101	0.0851
MA(4)	-0.191764	0.071015	-2.700317	0.0069
	Variance Equation			
C	0.174577	0.089622	1.947925	0.0514
RESID(-1)^2	0.335285	0.119144	2.814116	0.0049
GARCH(-1)	0.332668	0.230306	1.444464	0.1486
R-squared	0.291245	Mean dependent var		0.771801
Adjusted R-squared	0.268382	S.D. dependent var		0.925224
S.E. of regression	0.791387	Akaike info criterion		2.138928
Sum squared resid	97.07559	Schwarz criterion		2.311181
Log likelihood	-163.1837	Hannan-Quinn criter.		2.208870
Durbin-Watson stat	1.708566			

The results show that volatility persistence to inflationary shocks. As the sum of ARCH and GARCH term are much lower than one, and at the same time the P-value of the GARCH term is nearly insignificant, these mean that there is a low degree of volatility persistence in response to inflationary shocks.

We compared different models, and based on the the Akaike Information Criterion (AIC), R squared, number of significance coefficient, so we choose the GARCH ARMA model as the most appropriate model, where we have the lowest Akaike Info Criterion, almost all of the coefficient are significant and fair R squared besides these Durbin-Watson stat is also acceptable. All coefficients are significant in the mean equation, and in the variance equation just one is non-significant coefficient that we found.

Graph 2. Correlogram of Standardized Residual



	AC	PAC	Q-Stat	Prob*
1	0.022	0.022	0.0767	
2	0.074	0.073	0.9701	
3	0.053	0.051	1.4416	
4	-0.002	-0.009	1.4422	
5	-0.049	-0.057	1.8432	
6	0.101	0.102	3.5727	0.059
7	-0.017	-0.013	3.6235	0.163
8	-0.010	-0.019	3.6397	0.303
9	-0.074	-0.084	4.5834	0.333
10	-0.031	-0.026	4.7507	0.447
11	0.027	0.054	4.8827	0.559
12	-0.074	-0.077	5.8380	0.559
13	0.008	0.007	5.8481	0.664
14	0.035	0.036	6.0614	0.734
15	0.144	0.170	9.7792	0.460
16	0.091	0.091	11.290	0.419
17	-0.043	-0.102	11.633	0.476
18	-0.007	-0.028	11.641	0.557
19	0.016	0.021	11.686	0.632
20	0.121	0.164	14.429	0.493
21	0.127	0.095	17.433	0.358
22	0.016	-0.054	17.484	0.422
23	0.028	0.023	17.631	0.480
24	-0.170	-0.165	23.144	0.231

As indicated in Graph 2, all P values more than 5% indicate there is no serial correlations between the variables, which represents good performance for our model.

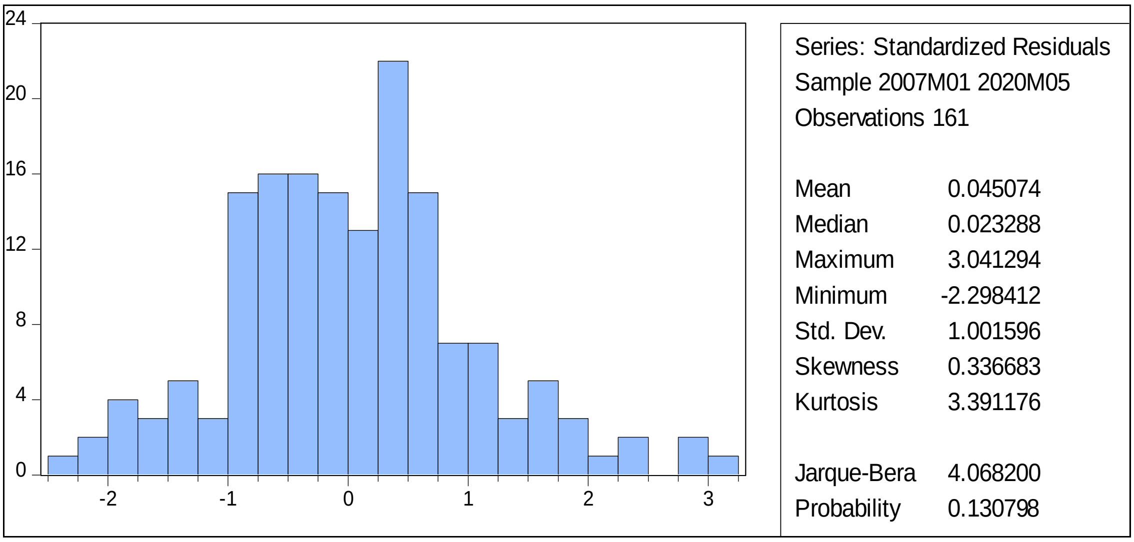
Graph 3. Correlogram of Standardized Residual Squared

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.008	0.008	0.0099	0.921
		2	0.125	0.125	2.5947	0.273
		3	0.024	0.023	2.6903	0.442
		4	0.055	0.039	3.1881	0.527
		5	-0.034	-0.041	3.3799	0.642
		6	0.057	0.047	3.9384	0.685
		7	-0.077	-0.072	4.9468	0.666
		8	-0.105	-0.120	6.8428	0.554
		9	-0.075	-0.058	7.8229	0.552
		10	0.117	0.148	10.190	0.424
		11	0.038	0.075	10.444	0.491
		12	-0.105	-0.141	12.383	0.415
		13	0.000	-0.018	12.383	0.497
		14	-0.113	-0.097	14.680	0.400
		15	0.007	0.014	14.689	0.474
		16	-0.138	-0.149	18.144	0.316
		17	-0.048	-0.059	18.569	0.354
		18	-0.003	0.105	18.571	0.419
		19	0.023	0.066	18.667	0.478
		20	0.030	0.004	18.839	0.532
		21	0.065	-0.011	19.638	0.544
		22	-0.047	-0.043	20.061	0.579
		23	-0.078	-0.116	21.213	0.568
		24	-0.004	-0.036	21.216	0.626

*Probabilities may not be valid for this equation specification.

Graph 3 shows the correlogram of standardized residual squared and as it can be seen, the error term exhibits no autocorrelation.

Graph 2. Histogram Normality Test



In the graph of the histogram and normality test (Graph 4), it looks like a normal distribution model since the probability value is more than 10%, and skewness is between 0.5 and -0.5.

Table 7. Heteroskedasticity Test: ARCH

F-statistic	0.009578	Prob. F(1,158)	0.9222
Obs*R-squared	0.009699	Prob. Chi-Square(1)	0.9215
F-statistic	0.669148	Prob. F(4,152)	0.6144
Obs*R-squared	2.716795	Prob. Chi-Square(4)	0.6063
F-statistic	0.753087	Prob. F(8,144)	0.6446
Obs*R-squared	6.144179	Prob. Chi-Square(8)	0.6311
F-statistic	1.128183	Prob. F(12,136)	0.3425
Obs*R-squared	13.48947	Prob. Chi-Square(12)	0.3345
F-statistic	1.152676	Prob. F(24,112)	0.3015
Obs*R-squared	27.13651	Prob. Chi-Square(24)	0.2981

The Table 7 shows the results of autoregressive conditional heteroskedasticity in term of by using lagrange multiplier (LM), as it is seen that in all orders of lag the P value is greater than 5%.

The next step is Granger Causality Test. In order to perform the Granger Causality test through VAR model between inflation and inflation uncertainty firstly, we need to have data. For inflation, we have data, and inflation uncertainty we gain conditional variance as inflation uncertainty through GARCH model.

Table 8. Granger Causality Test

		F-Statistic	Prob.
Lag: 2	CVAR does not Granger Cause CPI	0.41353	0.6620
	CPI does not Granger Cause CVAR	17.8628	1.E-07
Lag: 4	CVAR does not Granger Cause CPI	0.68073	0.6064
	CPI does not Granger Cause CVAR	9.92395	4.E-07
Lag: 8	CVAR does not Granger Cause CPI	0.82109	0.5853
	CPI does not Granger Cause CVAR	6.43961	4.E-07
Lag: 12	CVAR does not Granger Cause CPI	0.78993	0.6600
	CPI does not Granger Cause CVAR	4.65925	3.E-06
Lag: 24	CVAR does not Granger Cause CPI	0.85557	0.6580
	CPI does not Granger Cause CVAR	2.64515	0.0005

Table 8 reports for all the lags that inflation causes of inflation uncertainty, strong support for the Friedman-Ball hypothesis. The null hypothesis that inflation uncertainty does not Granger Cause of inflation is not rejected across all signs and lags. The result did not validiate the Cukierman-Meltzer hypothesis.

Given the dedication to inflation targeting Turkey's central bank firmly exits its causality relationship between inflation volatility during the period of 2005M01- 2020M05. However, in our model the volatility persistence in response to inflationary shocks is limited.

4. Conclusion and Policy Implication

Inflation is a definition of the continual increase in market prices. Inflation has several severe impacts on households and all the other players in the economy. It has tended to reduce economic activity. In this study, we modeled the relationship between inflation and inflation uncertainty of the Turkish economy over the period of 2005M01- 2020M05. There are many theoretical and empirical studies performed in this topic. While some of the empirical studies support the Friedman-Ball hypothesis of positive impact of inflation-on-inflation uncertainty, some of them support Cukierman & Meltzer hypothesis that iflation uncertainty leads to higher inflation, and finally rest of their results corroborate Holland hypothesis suggesting that uncertainty cause to decrease future inflation.

In this study, inflation uncertainty is firstly proxied by the GARCH model, and then the *conditional variance* based on this estimation is *used* to as *proxy* for the *inflation*. Later, we proceeded to *Granger Causality test between two variables*. As per the findings, there is a limited degree of persistence of volatility in response to inflationary shocks. Moreover, the Granger causality test conducted indicated that high inflation Granger causes inflation uncertainty, which strongly agrees with the Friedman (1977)and Ball (1992) postulations as cited in (Ran, Zheng-Zheng, Xiao-Lin, and SU, 2018: 41). There was no sufficient evidence in support of the Cukierman-Meltzer hypothesis, as revealed by the causality test results.

Our findings suggest that central bank in Turkey should aim at achieving and sustaining low average inflation rate consistent with targeted economic growth, in order to eliminate the negative effects of inflation uncertainty on macro economic activity.

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