Inflation and Inflation Uncertainty: Evidence from Turkey, 1923–2012

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Abstract

In this study, relationship between inflation and inflation uncertainty is analyzed using Granger causality tests with annual inflation series covering the time period 1923 to 2012 for Turkish Economy. Inflation uncertainty is measured by Exponential Generalized Autoregressive Conditional Heteroskedastic model. Econometric findings suggest that although in long run the Friedman's hypothesis that high inflation increases inflation uncertainty is strongly supported, in short run the Holland hypothesis proposing that the increase in the inflation uncertainty decreases inflation is also supported for Turkish Economy. We also make analysis for subsample periods selected due to the major policy changes in Turkish economic history. The causality between inflation and inflation uncertainty in these subsample periods is mixed and depends on time period analyzed.

Keywords: Inflation Uncertainty, Conditional Variance, Granger Causality, Exponential Generalized Autoregressive Conditional Heteroskedastic Model

JEL Classification: C22, E31

1. Introduction and Literature

Inflation uncertainty which is defined as the volatility seen in inflation series has begun to more attractive in the economic literature after the 1973 oil crisis started with the embargo of OAPEC (Organization of Arab Petroleum Exporting Countries-consisting Arab and, Egypt, Syria and Tunisia) members. Monetary policy makers have been obviously interested in the volatility of inflation ratio after this crisis because high volatility means greater uncertainty for the future inflation targeting.

A characteristic of inflation series is that in its level form it is random walk; that is, it is nonstationary but it is generally stationary in its first difference form. First difference of inflation series generally shows wide swings, suggesting that the variance of inflation series varies over the time. Such a varying variance can be modeled by autoregressive conditional heteroscedasticity (ARCH) model developed by Engle (1982). Nelson (1991) extended the asymmetric version of these ARCH models and proposed an exponentially generalized ARCH model (EGARCH). The EGARCH method has a capable of blocking the outlier shocks in the inflation uncertainty and thus allows us to decompose the negative and positive shocks of uncertainty in the inflation series separately (Berument, 2001: 1).

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There are many studies analyzing the relationship between inflation and inflation uncertainty for different country groups or individual countries.

The outline of the paper is as follows. Section two gives a brief literature review on inflation and inflation uncertainty, while section three introduces econometric methodology of the study. The estimation result of econometric models and inference of econometric findings are given in the section fourth. The final section concludes the study.

2. Econometric Model and Estimation Method

In applied econometric literature, ARCH class of models is used to model time varying conditional variance. In this study, inflation uncertainty is proxied as conditional variance. There are several formulations for conditional variance models forming ARCH family in the literature (e.g. GARCH, PARCH, TARCH). Generalized ARCH (GARCH) models allow us to estimate conditional variance of the model including its lagged value. However as Brunner and Hess (1993, p.7) and Fountas (2004, p.223) claim, the GARCH model assume a symmetric restriction on conditional variance. Nelson (1991) proposes an extended and asymmetric version of these ARCH models: EGARCH. Unlike ARCH and GARCH models, the EGARCH method blocks the effect of outlying shocks in the estimation of inflation uncertainty and thus allows us to decompose the negative and positive shocks of uncertaınty to inflation separately (Berument, 2001: 1).

Following Fountas et al. (2004), Berument (2001) and Brunner and Hess (1993), an EGARCH model is established to estimate variance equation, and extended with the inclusion of inflation rate and dummy variables as exogenous variables. Inflation, x_t, is modeled as a q lagged auto regressive (AR) process with time varying conditional variance: with one asymmetric order

$$x_t = \partial_0 + \partial_1 x_{t-1} + ... + \partial_q x_{t-q} + \varepsilon_t, \mathrm{E}(\varepsilon_t / \theta_{t-1}) = 0, Var(\varepsilon_t / \theta_{t-1}) = \sigma_t^2 \quad \textbf{(1)}$$

$$y_t = \delta_0 + \delta_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}^2} \right| + ... + \delta_p \left| \frac{\varepsilon_{t-p}}{\sigma_{t-p}^2} \right| + \alpha_1 y_{t-1} + ... + \alpha_m y_{t-m} + \ell \frac{\varepsilon_{t-1}}{\sigma_{t-1}^2} + \phi_1 x_{t-1} + \phi_2 D42 + \phi_3 D80 + \phi_3 D94 + v_t \quad \textbf{(2)}$$

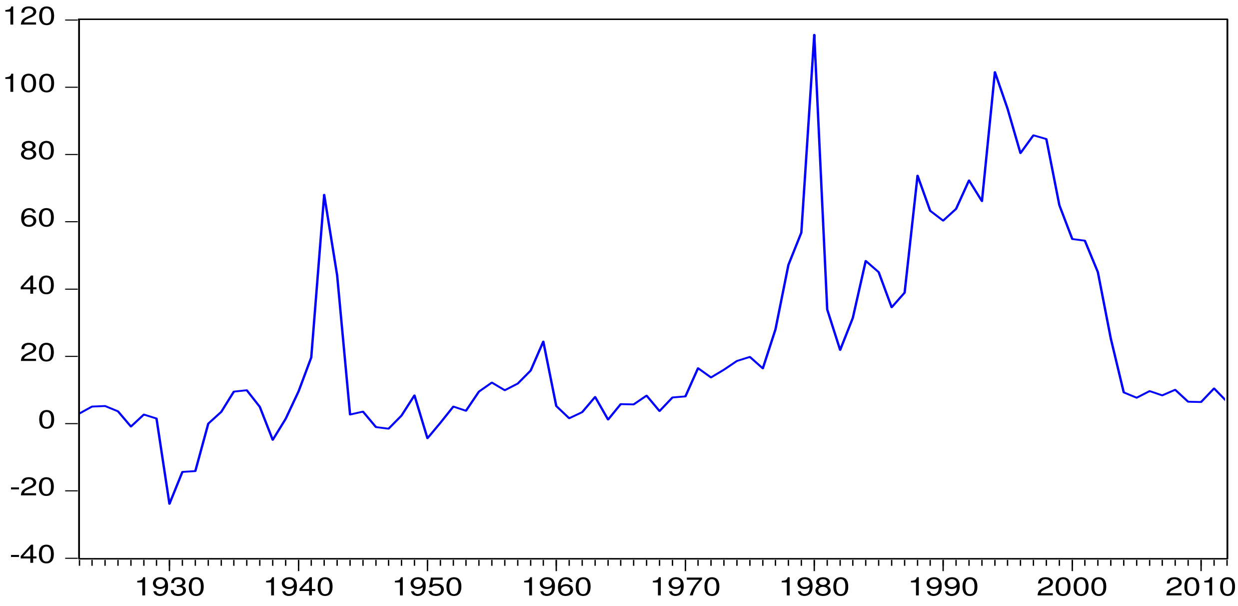
Where m, p and q are lags, and θ_{t-1}, y_t, x_{t-1}, D42, D80 and D94 stands for information set at time t-1, logarithm of conditional variance ($\log(\sigma_t^2)$) at time t, one lagged average inflation, and dummy variables at year 1942, 1980 and 1994, respectively. Lagged residuals standardized by conditional variance ($\frac{\varepsilon_{t-1}}{\sigma_{t-1}^{2}}$) shows the asymmetric part of the model and possibility of the leverage effect. If $\ell > 0$ an unpredicted increment shock in inflation, inflation uncertaınty increases more than when there is an unpredicted decrement shock in inflation (Berument, 2001: 5). Friedman hypothesis suggest that $\phi_1 > 0$.

3. Data

This section examines the relationship between inflation and inflation uncertainty for Turkish Economy using annual inflation rate covering the time period 1923-2012 and its subsamples periods selected based on major policy changes in Turkish economic history. In this section firstly some descriptive and stability properties of inflation series is analyzed, then econometric results are reported.

The data used in this study is annual CPI inflation from 1923 to 2012. Yenturk (2010), Turkish Statistical Institute main economic indicator and the Central Bank of the Republic of Turkey electronic data delivery system. Figure 1 shows the volatility of consumer price index during the period analyzed and table 1 presents descriptive statistics of annual inflation. It is seen from figure 1 that there is a prolonged low volatility from year 1946 to year 1978 and also there exist a prolonged period of high volatility from year 1980 to year 2002.

Figure1. Inflation, 1923-2012



According to table 1, the mean and standard deviation of inflation is approximately 27% and 29%, respectively. Maximum and minimum inflation rate during period analyzed is 115% and -4%, respectively. Skewness, Kurtosis and Jarque-Bera statistics indicate that inflation series is not distributed normally, and shows a distribution skewed to the right. Higher Jarque-Bera statistics also confirms that inflation series is not distributed normally. The significant Ljung- Box Q2 statistics which is equal to squared deviation of the inflation rates from its average mean shows that there is ARCH effect in the inflation series. Similarly, LM statistics statistically significant at the 1% level also confirms the impact of ARCH effects in the series. The Ljung-

Box Q^2 and ARCH LM statistics reveal that the inflation series can be modeled with one of the models from the class of ARCH.

Table1. Summary of Descriptive Statistics for Annual Consumer Price Inflation, 1923-2010

Descriptive Statistics	Value
Mean	27.929
Standard deviation	29.102
Maximum	115.600
Minimum	-4.400
Skewness	1.134
Kurtosis	3.304
Jarque-Bera Statistic	912.374(0.000)
Q_{12}^2	54.454(0.000)
LM(12)	61.685(0.008)

4. Empirical Results

We begin to the econometric analyses by examining the stationarity property of time series using formal unit root tests. For this purpose, Augmented Dickey- Fuller (ADF) test developed by Dickey and Fuller (1979), Philips- Perron (PP) test developed by Philips and Perron, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test and Dickey Fuller GLS test developed by Elliott-Rothenberg-Stock (1996) and Perron (1989) test, which is taking into account the structural break, are implemented to the data to determine whether the inflation series are stationary. The disadvantage of ADF, PP and GLS tests are their bias of nonrejection of the null hypothesis in the presence of a structural break due to the impact of liberalization measures, financial and economic cries on inflation (Thornton, 2007: 863). During the sample period we analyzed each of these particular problems or measures were experienced in Turkish Economy. The null hypothesis of ADF, DF-GLS and PP tests are based on presence of a unit root in series, while the null hypothesis of the KPSS test is that the series is stationary. Our last unit root test is Peron (1989) test considering structural break in the series. The null hypothesis of the Perron (1989) test is that the series has a unit root with no break. Although a substantial literature supports nonstationarity of the inflation series, the empirical evidence on the issue is mixed. The ADF, PP and KPSS tests indicate that inflation series is stationary. DF-GLS test reject the presence of null hypothesis only at level 10% but accept the stationarity of the inflation for 5 and 1% levels. In the case of Perron (1989), the alternative hypothesis indicating that the series is stationary with structural break is accepted as well, namely Perron (1989) test also suggest that inflation series has a unit root when we consider the case of structural break.

Table2. Inflation Unit Root Tests

Tests	t-statistics	Include in test equation	lags
ADF	-2.98	Trend and intercept	0
PP	-2.86	Trend and intercept	2
KPSS	0.103	Trend and intercept	6
DF-GLS	-3.05***	Intercept	0
Perron (1989) [a]	-2.71	Trend and intercept	1

Notes: Tests are for the level of inflation rate;
***, ** and * indicate statistical significance levels at 10, 5 and 1% levels.
[a]: Structural break unit root test . Critic values for 5% and 1% from Perron (1989), p.1376 table IV.B are -3.76 and -4.39, respectively, and $\lambda = T_b / T = 20/90 = 0.22$
Critical values for Dickey Fuller GLS are -3.62, -3.06 and -2.77 for 1, 5 and 10%, respectively. Critical values of the KPSS test for 1, 5 and 10%, which are obtained from Kwiatkowski-Phillips-Schmidt-Shin (1992) Table 1, are 0.7390, 0.4630 and 0.3470, respectively.
Lag lengths are automatically selected on the basis of the Akaike Info Criterion for the case of ADF and DF-GLS, and the Newey West criterion is used for cases of PP and KPSS.

4.1. EGARCH Model Estimation Result

Panel A and B Table 3 reports the estimation results of conditional variance (Model 2) and average inflation equation (Model 1) within the framework of the AR(s) and EGARCH (p, q) methods. The average inflation equation, estimated as an autoregressive process AR(3) by OLS method is presented in Panel A, and the conditional variance (proxied as inflation nunceratinty) estimated by maximum likelihood (ML) method as an EGARCH (1, 1) process is shown in Panel B. The model AR(s)-EGARCH(p, q) has been estimated for lag length 24 and narrowed on the basis of minimum Schwarz and Akaike Information Criterions. Only statistically significant parameters of the model having the smallest AIC and SIC values are reported. All of the parameters in the average inflation and conditional variance model have predicted signs and high level of significance. The coefficient of lagged inflation (x_{t-1}) is positive and statistically significant as expected but its impact on inflation uncertainty is less than 1%. This show that in Turkey there is a positive relationship between inflation and inflation uncertainty, even if it is weak. The coefficient of the standardized lagged residual in variance equation shown by $\varepsilon_{t-1} / \sigma^2_{t-1}$ is also positive and statistically significant at 1%. This coefficient indicates the possibility of the leverage effect which detects the presence of the asymmetric structure in the equation. This implies that when there is an unpredicted increment in inflation, inflation uncertainty increases more than when there is an unpredicted decrement in inflation (Berument, 2000: 5). Finally, all the dummy variables proxied by crises are statistically significant at 10% and have positive signs as anticipated.

The diagnostic tests of the model which shows goodness of the estimated model are presented in panel C below table 3. The Ljung- Box Q(k) and Q^2(k) statistics tests the autocorrelation in the residual of the estimated model, namely tests whether the residuals are distributed independently and identically. According to the Ljung-Box statistics estimated for lag length 4 and 12 (short run and long run) the alternative hypothesis suggesting that there is no autocorrelation in level values of residuals is not rejected at the error level of 5 %. On the other ARCH LM test statistics also indicate that the null hypothesis suggesting that there is no ARCH effect in residual for lag length 4 and 12 is not rejected.

Table3. AR (3)-EGARCH (1,1) Estimation Result

Variable	Coefficient	z-Statistics	P-value
Panel A: Mean equation, dependent variable: x_t			
Constant	2.456900	18.89020	0.0000
x_{t-1}	0.705529	17.82841	0.0000
x_{t-2}	0.217566	5.927600	0.0000
x_{t-3}	-0.082818	-9.471833	0.0000
Panel B: Variance equation, dependent variable: y_t			
Constant	1.295701	35.15316	0.0000
$\lvert \varepsilon_{t-1} / \sigma^2_{t-1} \rvert$	-0.638628	-524452.9	0.0000
y_{t-1}	0.370116	3.936493	0.0001
$\varepsilon_{t-1} / \sigma^2_{t-1}$	0.784083	129.0146	0.0000
x_{t-1}	0.005674	4.831918	0.0000
D42	3.318410	4.982262	0.0000
D80	4.039178	4.304468	0.0000
D94	1.682655	1.707245	0.0878
Panel C: Diagnostic Tests			
R^2-adj.	0.689952		
Log-L	-311.0945		
AIC	7.404472		
SC	7.716254		
ARCH LM(4)	0.40(0.80)		
ARCH LM(12)	0.43(0.94)		
Q(4)			
Q(12)			
Q^2(4)			
Q^2(12)			
Jarque-Bera	116.88(0.00)		

Notes: Q^2(k) is the Ljung-Box statistics. Probabilities are in parentheses

4.2.1. Granger- Causality Test

We examine the relationship between inflation and inflation uncertainty using Granger causality tests. In this part result of Granger-Causality tests is presented to provide some statistical evidence on direction of relationship between average inflation and inflation uncertainty. Following Granger (1969), bivariate vector auto regression model is established to test whether inflation (x_t) Granger causes inflation uncertainty and whether inflation uncertainty (y_t) Granger causes inflation:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} \beta_\pi \\ \beta_h \end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix} c_{1\pi,i} c_{1h,i} \\ c_{2\pi,i} c_{2h,i} \end{bmatrix} \begin{bmatrix} x_{t-i} \\ y_{t-i} \end{bmatrix} + \begin{bmatrix} \omega_{\pi t} \\ \omega_{ht} \end{bmatrix} \tag{3}$$

Where k is the number of lags specified, $\omega_{\pi t}$ and ω_{ht} are white noise residual of the VAR model. To test whether x_t (y_t) strictly Granger causes y_t (x_t) is a simple F-test of joint significance of all the $c_{1\pi,i}$ ve $c_{2\pi,i}$ (i=1, 2, 3…, k) are equal to zero. Results of the Granger causality tests are reported in Table 4. The null hypothesis suggesting that inflation does not Granger cause inflation uncertainty is rejected only for lag 4, and accepted for lags 8 and 12 for the full sample period. The sum of the coefficients is positive for all the lags. Moreover only in short run Friedman's (1977) and Ball's (1992) hypotheses suggesting that high inflation rate is associated with more volatile inflation rate (uncertainty in inflation) is supported at the 10% significance level for Turkish Economy. The null hypothesis indicating that inflation uncertainty does not Granger cause inflation is rejected for lags all lags, namely 4, 8 and 12 lags. The sum of the coefficients of the lagged value of the inflation uncertainty is negative, meaning that an increase in inflation uncertainty leads to lower future inflation for the full period from 1923 to 2012. We conclude that Holland (1995) hypothesis suggesting that the increase in the inflation uncertainty reduces future inflation is strongly supported for Turkish Economy. Holland propose that when inflation uncertainty depending on high inflation increases, a *stabilizing central bank* gives a tightening monetary policy reactions to reduce inflation uncertainty and inflation, and as a result of these reactions inflation uncertainty leads to a more reduced inflation rates in economy. Granger tests reveal that in short run, for lag 4, a bidirectional causality relationship between inflation and inflation uncertainty is valid; however in long run causality is only from high inflation uncertainty to lower inflation rate.

We also examined the relationship between inflation and inflation uncertainty for three subsample periods selected according to the major economic policy changes happened in Turkish Economic history between 1923 and 2012: (B) The economic development period dominated by statehood: 1923-1949, (C) the economic development period dominated by import- substitution strategy: 1950-1979 and (D) the period of economic stabilization and trade liberalization (Nas an Perry, 2000: 175) with export-led development: 1980-2012. After 1986, CBRT (Central Bank of Republic of Turkey) is allowed to make open market operations more freely. Law and goal independence of CBRT has been improved gradually from 1991 to 2001 in when CBRT takes its autonomy on its monetary policy goals and choosing monetary policy instruments. The conditional variance (inflation uncertainty) of each subsample period is estimated by best fitted AR(q)- EGARCH (1,1) model jointly based on Schwarz Byesian Criterion (SC). We do not report here these results to save space.

Granger causality test of these subsample periods are presented in Table 4 in panel B, C, and D. From table it is clearly seen that for all periods and all lag lengths, except period 1923-1950, the effect of inflation on inflation uncertainty is strongly significant and positive. The unidirectional Granger causality test result from inflation to inflation uncertainty is mixed for these three subsample periods. The null hypothesis indicating that inflation does not Granger cause inflation uncertainty is strongly rejected for only two subsamples, namely 1950-1980 and 1980-2012. In these subsample periods the higher inflation is associated with more volatile and higher inflation uncertainty. The same causal relationship from inflation to inflation uncertainty is not significant during the time period 1923-1950. This is more interesting because foundation of CBRT goes to 1930. Therefore, Granger causality test indicates an increment in inflation associated with higher inflation uncertainty for only short run of full sample period but for short and long run (for all lags) of subsample periods of 1950-1979 and 1980-2012 the higher inflation is associated with higher inflation uncertainty.

On the other hand, the unidirectional Granger causality relationship from inflation uncertainty to inflation is also mixed for subsample periods. For 1923-1949 period we find a very limited and weak evidence that inflation uncertainty Granger cause inflation and lowers inflation. We have less evidence in favor of the hypothesis of Holland based on stabilizing behavior of the central bank. In this period inflation uncertainty lowers inflation only for medium term (lag length 8). At lags 4 and 12 there is not a statistically significant causality relationship between inflation uncertainty and inflation. During the economic development period dominated by import- substitution strategy (1950-1979), in the short and long run the effect of inflation uncertainty on inflation is positive and strongly significant. In this period the behavior of the central bank is explained in the framework of the opportunistic central bank approach proposed by Cukierman and Meltzer (1986). Cukierman and Meltzer suggest that following opportunistic and surprise inflation policies leads to inflation uncertainty which causes the increment of the future inflation rate.

The unidirectional causality relationship from inflation uncertainty to inflation rate for the subsample period 1980-2012 is similar to full sample period. Inflation uncertainty causes the increment of inflation, namely display a stabilizing behavior in both the short and the long run (for all lags): In the short and long run the effect of inflation uncertainty on inflation is negative and strongly significant. The results obtained for the last period is consistent with the policies adopted by the CBRT after 1986. During this time period CBRT adopted four different monetary policy regimes to have a low and stable inflation rate: Monetary targeting regime (1990-2005), exchange rate anchor policy (2000-2001), implicit and explicit and inflation targeting regimes (2002-2005 and 2006-now). Econometric results of this study are in line with findings of these studies on the Economy of Turkey: Nas and Perry (2000), Berument et al (2001), Serkan (2008), Karahan (2012).

Table4. Granger Causality Tests between Inflation and Inflation Uncertainty for Turkish Economy Covering Subsample Periods

Lags	$\mathbf{H_0}: x_t \rightarrow y_t$	$\mathbf{H_0}: y_t \rightarrow x_t$
Panel A: The full sample period: 1923-2012		
4	7.524(0.100)***(+)	7.772(0.000)*(-)
8	7.119(0.523)(+)	45.251(0.000)*(-)
12	8.311(0.760)(+)	45.623(0.000)*(-)
Panel B: The economic development period dominated by statehood: 1923-1949		
4	4.126(0.389)(+)	3.375(0.497)(-)
8	5.135(0.527)(+)	10.871(0.092)* (-)
12	4.546(0.715)(+)	6.586(0.473)(-)
Panel C: The period of industrialization effort driven by import- substitution strategy:		
4	37.583(0.000)*(+)	14.565(0.005)*(+)
8	38.615(0.000)*(+)	21.214(0.006)*(+)
12	35.721 (0.000)*(+)	24.404(0.017)**(+)
Panel D: The period of economic stabilization and trade liberalization (Export-led development): 1980-2012		
4	9.809(0.043)**(+)	21.379(0.000)*(-)
8	13.147(0.100)***(+)	44.959(0.000)*(-)
12	19.150(0.085)***(+)	34.677(0.000)*(-)

Notes: a/***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.
b/(+) and (-) shows the sign of the sum of the coefficients in causality model .
c/$x_t \rightarrow y_t$ indicates inflation does not Granger- cause inflation uncertainty
d/$y_t \rightarrow x_t$ indicates inflation uncertainty does not Granger- cause inflation.
e/ chi-square are statistics and probabilities are shown in parenthesis.
*** Shows the rejection of the null hypothesis at the level 10%
** Shows the rejection of the null hypothesis at the level 5%
* Shows the rejection of the null hypothesis at the level 1%

CONCLUSION

In this study the relationship between inflation uncertainty measured by exponential generalized autoregressive conditional heteroskedastic model and inflation is analyzed using Granger causality test approach in the framework of a bivariate vector autoregressive model for annual inflation rate covering the time period 1923-2012 and its subsamples periods selected based on major policy changes in Turkish economic history.

In short run the econometric result of the study is consistent with the hypothesis suggesting that a higher inflation rate is associated with a higher inflation uncertainty proposed by Friedman (1977) and Ball (1992) in Turkey between 1923 and 2012. However, in medium term and long run there is no evidence that inflation rate increases inflation uncertainty. On the other hand the Holland hypothesis (1995), indicating that a higher inflation uncertainty decreases inflation rate is strongly supported for all lag lengths. Hence, bidirectional Granger causality relationship is valid for only lag length 4. In the medium and the long run (lags 8 and 12) the causality relationship is unidirectional, and this unidirectional relationship is from inflation uncertainty to inflation rate.

For subsample periods the causality relationship between average inflation rate and inflation uncertainty is mixed and depends on time period analyzed. During the time period of industrialization effort driven by import- substitution strategy (1950-1979) and the time period of economic stabilization and trade liberalization (1980-2012), the higher inflation rate raises inflation uncertainty for both short and long run. In these two subsample periods, the effect of uncertainty on inflation rate is increasing and decreasing, respectively. For 1950-1979 period and 1980-2012 period opportunistic and stabilizing behavior of the central bank is reflected, respectively. The Turkish central bank (CBRT) adopted four different stabilization programs, including monetary targeting regime, exchange rate regime and explicit and implicit inflation targeting regime, between 1980 and 2012 to lower inflation rate. Our econometric findings is in line with goal of CBRT.

The third subsample period covering 1923 to 1949, we found no evidence for causality relationship from inflation to inflation uncertainty for any lags, however only for medium term a weak relationship is valid from inflation uncertainty to inflation rate.

As a result, we conclude that the political environment of Turkish economy is consistent with our econometric findings during the time period analyzed. The monetary policies of CBRT and fiscal policies of the governments ruling the country are generally prepared with a disinflationary perspective. These disinflationary efforts have been worked especially during 1980 and 2012. But also in short run because of the political instability in the early 1990s, the higher inflation results in higher inflation uncertainty too, reflecting opportunistic policy behavior.

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