On the links between inflation, output growth and uncertainty: system-GARCH evidence from the Turkish economy

Korap, Levent

Istanbul University Institute of Social Sciences, Besim Ömer Paşa Cd. Kaptan-ı Derya Sk. 34452 Beyazıt /ISTANBUL

December 2009

ON THE LINKS BETWEEN INFLATION, OUTPUT GROWTH AND UNCERTAINTY: SYSTEM-GARCH EVIDENCE FROM THE TURKISH ECONOMY

ENFLASYON, ÇIKTI BUYUMESİ VE BELİRSİZLİK ARASINDAKİ İLİŞKİLER ÜZERİNE: TÜRKİYE EKONOMİSİNDEN SİSTEM-GARCH BULGULARI

Levent KORAP

İstanbul Üniversitesi Sosyal Bilimler Enstitüsü İktisat Ana Bilim Dalı, Besim Ömer Paşa Cd. Kaptan-ı Derya Sk. 34452 Beyazıt / İSTANBUL

E-mail: korap@e-kolay.net

ON THE LINKS BETWEEN INFLATION, OUTPUT GROWTH AND UNCERTAINTY: SYSTEM-GARCH EVIDENCE FROM THE TURKISH ECONOMY

Abstract. *In this study, the causal relationships between inflation, output growth and uncertainty have been re-examined for the Turkish economy. Based on the system-GARCH methodology, estimation results reveal that for the 1987M01 2008M09 investigation period with monthly data, the mutual Granger causality between inflation and inflation uncertainty cannot be rejected in a positive way. For the output growth and its uncertainty relationship, it is observed that the larger the output growth the lower the output growth uncertainty. Some evidence have also been obtained in favor of that an increase in inflation uncertainty lowers output growth and that an increase in the latter lowers the former. Furthermore, an increase in output growth uncertainty is likely to lead to more inflation. A sensitivity analysis implemented for the post-2001 period supports to a great extent these results. Consequently, it is inferred that policies aiming at reducing inflation would lead to a more efficient functioning of the price system, and this would contribute to the real output growth.*

Keywords: *Inflation, output growth, system-GARCH, Turkish economy.*

Jel Classification: *C32, C51, E31*

Ozet. Enflasyon, çıktı büyümesi ve belirsizlik arasındaki ilişkiler üzerine: Türkiye ekonomisinden sistem-GARCH bulguları

Bu çalışmada enflasyon, çıktı büyümesi ve belirsizlik arasındaki nedensel ilişkiler Türkiye ekonomisi için yeniden incelenmiştir. Sistem-GARCH yöntemine dayalı olarak tahmin sonuçları aylık veriler ile 1987M01 2008M09 inceleme dönemi için enflasyon ve enflasyon belirsizliği arasındaki karşılıklı Granger nedenselliğinin pozitif bir şekilde reddedilemeyeceğini ortaya koymaktadır. Çıktı büyümesi ve kendi belirsizliği ilişkisi için daha büyük çıktı büyümesinin çıktı büyümesi belirsizliğini azalttığı gözlenmektedir. Aynı zamanda enflasyon belirsizliğindeki bir artışın çıktı büyümesini azaltması ve çıktı büyümesindeki bir artışın da enflasyon belirsizliğini azaltması yönünde bulgular elde edilmiştir. Ayrıca, çıktı büyümesi belirsizliğindeki bir artış enflasyonda olası bir artışa yol açmaktadır. 2001-sonrası dönem için gerçekleştirilen bir duyarlılık analizi büyük ölçüde bu sonuçları desteklemektedir. Sonuç olarak, enflasyonu azaltmayı amaçlayan politikaların fiyat sisteminin daha etkin çalışmasına yol açarak reel çıktı büyümesine katkı sağlayacağı çıkarmasına ulaşılmıştır.

Anahtar Kelimeler: *Enflasyon, çıktı büyümesi, sistem-GARCH, Türkiye ekonomisi.*

Jel Sınıflaması: *C32, C51, E31*

I. INTRODUCTION

The relationships between inflation, real output growth and their volatility components have long been perceived in the economics literature as a special research area based mainly on empirical findings. Testing the causality between these aggregates enables us to attain the significant knowledge of whether or not inflation and its associated volatility tend to have some potential negative effects on the growth process of the economy. As was pronounced by Friedman (1977) in his Nobel Lecture, high inflation rate would not likely to be steady especially during the transition decades subject to new institutional arrangements to which firms in the economy try to adapt, and the higher the inflation rate the more variable it is likely to be, since it distorts relative prices and financial contracts which have been adjusted to a long-term "normal" price level. This in turn lowers investment and output growth as well as increases unemployment and political unrest leading the society to be polarized. Thus this issue is also directly related to the course of the real output in the economy, because in an inflationary period some real costs would be accrued due to the distorting price stability, changing expectations and uncertain policy behavior of monetary authorities.

The initial stage of this transmission mechanism, resulted from unexpected variations in the course of the inflation, relates itself to the extent of the information content of inflation uncertainty. Beginning by the earlier analysis of Okun (1971) which found a positive correlation between inflation and inflation uncertainty, many researchers have tried to reveal the direction of preceding relationships between inflation and its uncertainty, and some authors in this sense have yielded pioneering essays upon which the following papers in the economics literature were based. In this sense, Ball and Cecchetti (1990) find that inflation has really significant effects on its uncertainty at long horizons which cause substantial costs due to the increased risks for individuals who have nominal contracts between themselves, and these effects would be resulted in a variation in policy behavior reacting to inflation by also destabilizing output growth. Furthermore, Ball (1992) employing an asymmetric game perspective between monetary authorities and the decision making process of the economic agents formalizes the view of Friedman in the sense that low levels of inflation coincides with the policy behavior of monetary authorities to keep inflation at these levels that give rise to low inflation uncertainty, as well. However, the public tend to be more uncertain the higher the level and variability of inflation as to when policy makers decide to implement a stabilization policy to fight inflation. In this case, an information problem stemmed from activating policy would be the length of the time lags which delay policy makers in achieving purposes consistent with *a priori* expectations.

An alternative approach comes from Cukierman and Meltzer (1986) and Cukierman (1992) relating mainly inflation uncertainty to the course of inflation. Since governments have different objectives determined stochastically over time that lead to a trade-off between expanding output by making monetary surprises and keeping inflation at low levels, choices of policy makers in favor of creating monetary surprises to stimulate economic growth would likely to be resulted in higher money growth rates and inflation than the estimates of economic agents using some form of adaptive expectations. Given that the money supply process is assumed to be random due to the imprecise monetary control mechanism which causes that policy makers may not choose the most appropriate policy instrument as a monetary control variable, these assumptions explicitly imply that the larger the uncertainty about monetary policy and inflation due to the opportunistic central bank behavior, the larger the actual inflation experienced by the public (Nas and Perry, 2000).

When we consider the potential relationships between output growth, inflation and their volatility components, earlier beliefs in economics literature which were put forward, for instance, by Mundell (1963) and Tobin (1965) emphasize the process of capital accumulation resulted mainly from portfolio shifts away from real balances into capital as the rate of return on money falls. However, unlike these conventional proposals assuming a positive relationship between inflation and output growth, the recent literature generally support the view that real economic growth is likely to be affected by inflation and its uncertainty in a negative way. Following Briault (1995), briefly to say, uncertainties about future price levels and inflation tend to distort resource allocation through changing attractiveness between real and nominal assets. Such a case discourages people from entering into long-term monetary contracts which are able to provide some assurance in business plans. This process would even lead to an ever-increasing risk-premium resulted in higher real costs of funds for borrowers, with a misallocation of capital due to the different expectations of savers and investors as to what will in fact be the *ex-ante* real rate of interest in the future. Thus if we relate these to the Friedman (1977), expectations for higher inflation uncertainty will distort the effectiveness of price mechanism in allocating resources with a negative output effect.

For the inflation effects of growth uncertainty, Devereux (1989) which examines the relationships between real and nominal shocks, optimal degree of inflation and the subsequent output and employment effects of creating inflation surprise predicts that increased growth uncertainty would tend to raise average inflation. Using a Barro and Gordon (1983) type model, the author indicates that the lower the uncertainty on real output the lower the optimal degree of private wage indexation, which enables policy makers to create a surprise inflation in raising real output level. Black (1987) also argues in a study upon business cycles that an increase in uncertainty for the output component can raise output growth, since attempts to undertake more risky investment and to use new technology can be resulted in output growth. This issue is of more importance especially for the case of developed countries which have specialized markets allowing firms to employ more risky and advanced technologies.

In this paper, the empirical validity of these competing approaches has been tested for the Turkish economy. To this end, system-based generalized autoregressive conditional heteroskedasticity (GARCH) modeling are used, and then some tests are carried out to reveal the causality issues between these aggregates. The next section reports some knowledge of the related literature. The third section introduces data and discusses methodology used in the paper. The fourth section presents estimates for the whole investigation period and the fifth section conducts some sensitivity analysis. The last section summarizes results.

II. LITERATURE REVIEW

There exists a large literature on the relationships between inflation, output growth and associated volatility relationships. Holland (1995) using the postwar US data estimates that an increase in the rate of inflation precedes, that is, Granger-causes an increase in inflation uncertainty. Such a finding would also mean that higher inflation uncertainty is part of the welfare cost of inflation since high rate of inflation would be resulted in an increasing uncertainty about future monetary policy and may lead to further uncertainty about future inflation. Grier and Perry (1998) approach the same relationship for the G7 countries between 1948 and 1993 and find that in all countries inflation significantly raises inflation uncertainty, however, increased inflation uncertainty lowers inflation in the US, UK and Germany and raises inflation in Japan and France. Fountas (2001) using the UK data over a century provides strong evidence in favor of the hypothesis that inflationary periods are associated with high inflation uncertainty. Likewise, Kontonikas (2004) using the UK data for the 1972 2002 period supports Friedman (1977) and estimates a positive relationship between past inflation and uncertainty about future inflation. When the indirect effects of lower average inflation are controlled, the author estimates that adoption of an explicit target eliminates inflation persistence and reduces uncertainty.

As to the inflation, growth and uncertainty relationship, some authors such as De Gregorio (1992) for the Latin America countries, Rudebusch and Wilcox (1994) and Sbordone and Kuttner (1994) for the US economy examine the relationships between inflation and growth or its productivity and give some support to the negative effects of inflationary framework on the growth. Al-Marhubi (1998) that examines cross-country evidence on the link between inflation volatility and growth shows that countries with higher inflation volatility tend to have a lower mean growth. Hayford (2000) finds that increasing inflation uncertainty leads to temporarily slower output growth. Likewise, Grier and Perry (2000) verify that an increase in the conditional variance of inflation significantly lowers average output as argued by Friedman (1977). Fountas et al. (2002) try to analyse bidirectional causal relationships between average inflation and real growth, on the one hand, and nominal and real uncertainty on the other hand for Japan. Their estimation results show that a higher rate of inflation and more inflation uncertainty lead to lower output growth so that a price stability objective should be followed by the authorities. Using data from the Japanese economy, Wilson (2006) finds that increased inflation uncertainty is associated with higher average inflation and lower average growth and that increased growth uncertainty is associated with higher average inflation but unrelated to average growth. Artan (2006) also yields a comprehensive empirical paper for the inflation and growth relationship employing data taken from 23 developed and 40 developing economies, and in the light of contemporaneous cross-sectional and panel data analysis, the author gives strong support to the inference that for both developed and developing countries inflation tends to influence growth in a negative way.

When papers from some recent literature upon the Turkish economy have been examined, findings in general support international evidence. Nas and Perry (2000) find that increased inflation significantly raises inflation uncertainty, but the effect of inflation uncertainty on average inflation is found mix and sensitive to the selection of sub-periods for investigation. Based on some causality tests, the authors infer that stabilizing policy behaviour seems to prevail in a long-run perspective while opportunistic behaviour for policy makers dominates in the short-run. Neyaptı and Kaya (2001) estimate that inflation and its uncertainty have a significant positive correlation, and provide further evidence in support of Friedman’s hypothesis that inflation leads to more uncertainty. Telatar and Telatar (2003) examine the relationship between inflation and different sources of inflation uncertainty, and find that there is a causative influence of inflation on its uncertainty. Telatar (2003) testing the causality relationship between inflation, inflation uncertainty and political uncertainty gives further evidence to the causative influence of inflation on its uncertainty. Akyazı and Artan (2004) give supportive results to the Friedman-Ball hypothesis and find a uni-directional causality running from inflation to inflation uncertainty. Likewise, Özer and Türkyılmaz (2005) find that inflation causes inflation uncertainty. In a recent paper, Özdemir and Fisunoğlu (2008) estimate that an increase in inflation raises its uncertainty, but there seems to be weak evidence for the effect of inflation uncertainty on the inflation. For the inflation-growth relationship, Karaca (2003) finds a uni-directional causality from inflation to growth and observes that inflation affects growth negatively. Berument et al. (2008) support such a finding and show that there is a negative relationship between inflation and growth in Turkey.

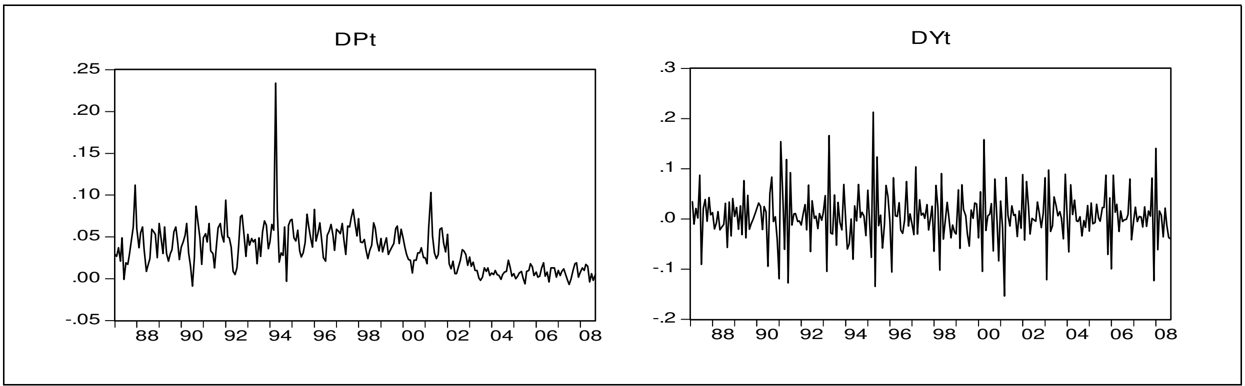
III. DATA AND METHODOLOGY

The data used consider 261 monthly frequency observations for the investigation period 1987M01 2008M09. The inflation data (DP_t) are calculated as $[(CPI_t - CPI_{t-1}) / CPI_{t-1}]$ using 2000: 100 based consumer price index (CPI), and real output growth (DY) are represented by the data from total industrial production (Y_t) again using the base 2000: 100, which is also calculated as $[(Y_t - Y_{t-1}) / Y_{t-1}]$. All the time series data have been obtained from the Organization for Economic Co-operation and Development (OECD) electronic statistics portal (http://stats.oecd.org).[1] Note that Grier and Perry (1998) implement a similar system-GARCH estimation procedure with monthly frequency US producer price inflation and industrial production series. The time series graphs are reported in Fig. 1 and the descriptive statistics of the variables are presented in Tab. 1 and Tab. 2.

[1] The consumer prices used for Turkey are mainly based on the 1994 consumer expenditure survey which has been subject to 5-year frequency updating. For combining prices to obtain lowest level indices as elementary aggregates, the average price of a sample of observations in the current period is compared to the average price of the sample period in the base period, and then these elementary aggregates are combined using some kind of index number formula and weights based on expenditure. In the case of the Turkish data, a standard Laspeyres type formulation is used to obtain such higher level aggregation price data. Note that OECD also calculates modified or chained Laspeyres indices for some other member countries. For the chain index that consists of a series of successive indices linked to its predecessor, the value of the successor index is multiplied by its predecessor in an overlap period, so that the index base period of the successor becomes the same as for the predecessor index, yielding a common reference year. For further detailed methodological information upon data weighting and index calculation of the price indices, see OECD (2002).

Fig. 1 shows the highly volatile characteristics of the monthly inflation and growth rates inside the investigation period. A short glance to the figure reveals that at some dates, inflation rates have been subject to one-time jump above the two digits levels. These dates coincide with 1987M12, 1994M04 and 2001M04 which have inflation rates 11.2%, 23.4% and 10.3%, respectively. For the output growth rates, we can observe that at some dates the

Fig. 1 Time Series Graphs



Tab. 1 Descriptive Statistics for Inflation

Series DP_t
Sample 1987M01 2008M09
Observation 261

Mean	0.0343	Skewness	1.8172
Median	0.0310	Kurtosis	13.652
Maximum	0.2340	Jarque-Bera	137.21
Minimum	-0.0090	$Q(1)$	92.542
Std. Dev.	0.0267	$Q(12)$	514.34

Tab. 2 Descriptive Statistics for Output Growth

Series DY_t
Sample 1987M01 2008M09
Observation 261

Mean	0.0047	Skewness	0.2332
Median	0.0041	Kurtosis	4.7996
Maximum	0.2125	Jarque-Bera	37.440
Minimum	-0.1538	$Q(1)$	76.548
Std. Dev.	0.0515	$Q(12)$	109.54

relevant statistics have also been subject to large jumps and falls carrying values with two digits. The mean and median of monthly inflation lie within the range of 3.4% and 3.1% and inflation data have a high standard deviation that reflects the high volatility in the time series, as well. However, in Tab. 2 we see that the standard deviation of output growth is nearly two-times larger than that of inflation, and this brings out how real output data have been volatile within the Turkish economy. From the descriptive statistics, we can observe that monthly inflation and growth data are biased to the right and have a right tail and that the distribution of both series are peaked relative to the normal. Supporting these findings, a significant departure from normality can be observed. These results mean that the large and significant autocorrelations of the 1st and 12th order and the significant departure from normality provide evidence in favor of the ARCH effects. Note also that for the inflation series the augmented Dickey-Fuller (1981) tests yield a test statistic -0.97 and -9.76 for only constant and constant&trend terms in the test equation, respectively. Thus the data seem to be trend-stationary. For the growth data, the relevant test statistics are -17.43 and -17.40, respectively.

Following the seminal paper of Engle (1982), autoregressive conditional heteroskedastic (ARCH) models and their extended version proposed by Bollerslev (1986) as generalized ARCH models have become highly popular to model the conditional volatility in high frequency financial and economic time series. The use of a GARCH-type model would enable us to estimate time-varying measures of inflation uncertainty, and this will be appropriate for an empirical attempt aiming at directly testing the implications of the hypotheses summarized in the former sections. Bolleslev (1990) extends univariate GARCH model to bivariate GARCH models and considers time-varying conditional variance and covariance with a constant conditional correlation, so that all the variations over time in the conditional variances are allowed to take place due only to changes in each of the conditional variances, leading the researcher to a reduction in the number of parameters to be optimized. Let us first consider a bivariate two-equation system:

$$DP_t = c_0 + \sum_{i=1}^{k} \alpha_i DP_{t-i} + \sum_{i=1}^{k} \beta_i DY_{t-i} + \varepsilon_{DP,t} \quad (1)$$

$$DY_t = d_0 + \sum_{i=1}^{k} \delta_i DP_{t-i} + \sum_{i=1}^{k} \phi_i DY_{t-i} + \varepsilon_{DY,t} \quad (2)$$

where c_0 and d_0 are the relevant constant terms estimated for the inflation and output growth equations, respectively. ε_t is the residual vector $\varepsilon_t = (\varepsilon_{DP,t}, \varepsilon_{DY,t})'$. ε_t is assumed to be subject to a process $(\varepsilon_t \mid \Omega_{t-1}) \sim N(0, H_t)$ with a zero mean vector and covariance matrix H_t. Ω_{t-1} is used for available information set up to the time t-1. Following Bollerslev (1990), conditional constant correlation is assumed on the conditional covariance matrix H_t:

$$h_{DP,t} = \sigma_{DP} + \gamma_{DP} h_{DP,t-1} + \eta_{DP} \varepsilon^2_{DP,t-1} \tag{3}$$

$$h_{DY,t} = \varphi_{DY} + \lambda_{DY} h_{DY,t-1} + \mu_{DY} \varepsilon^2_{DY,t-1} \tag{4}$$

$$h_{DPDY,t} = \rho \sqrt{h_{DP,t}} \sqrt{h_{DY,t}} \tag{5}$$

Thus it is the time-varying conditional variance of inflation and output which are of special interest for the uncertainty components. These are represented by $h_{DP,t}$ and $h_{DY,t}$ in Eq. 3 and Eq. 4, respectively. Eq. 5 shows conditional constant correlation ($h_{DPDY,t}$) between $\varepsilon_{DP,t}$ and $\varepsilon_{DY,t}$, for $-1 \leq \rho \leq 1$. The likelihood function of all unknown parameters ω is as follows:

$$l_t(\omega) = -\tfrac{1}{2} \log|H_t| - \tfrac{1}{2} (\varepsilon_{DP,t} \varepsilon_{DY,t}) H_t^{-1} (\varepsilon_{DP,t} \varepsilon_{DY,t})' \tag{6}$$

To calculate the maximum likelihood estimates of the parameters, the system of equations is solved by employing Berndt et al. (1974) numerical optimization (BHHH) algorithm so that the asymptotic covariance matrix of the coefficients will be consistent. Considering a large sample with 261 observations, the estimation results should be asymptotically accurate.

To the best of my knowledge, even though there exist many papers employing system-GARCH methodology upon this issue of interest in the contemporaneous international economics literature, e.g. Grier and Perry (2000), Fountas et al. (2002) and Wilson (2006) between many others, there is no paper using such a system-based autoregressive conditional heteroskedasticity approach with data taken from the Turkish economy. Hence, we try to simultaneously extract the knowledge of conditional means, variances and covariances of inflation and growth, and then implement bivariate causality tests using these estimates.

4.CONDITIONAL VOLATILITY ESTIMATES and CAUSALITY

Following the preliminary data issues and methodological discussions, system of equations examined above has been estimated through system-GARCH method. The autoregressive (AR) order of mean equations is determined by way of minimizing the Akaike model selection information criterion (AIC), so various models including different lag structures have been estimated. Beginning from the maximum lag selection 12, the true data generating process has been searched for and an AR(12) specification with the smallest estimated statistic has been determined as the chosen model. Thus, the results in this paper come from the bivariate AR(12) – conditional constant correlation (*ccc*) – GARCH(1,1) model using BHHH optimization algorithm. For the conditonal distribution of the error structure, multivariate normal (Gaussian) or multivariate student-*t* distributions can be used in empirical analyses. The normality assumption is adopted in this paper such as Wilson (2006). Standard errors are presented in parentheses.

In Tab. 3, the conditional mean and variance equations for inflation and output growth are reported. The sum of the lagged output growth coefficients in the inflation mean equation is 0.087, while the lagged inflation coefficients in the mean growth equation sum to -0.056. Notice that the ARCH term ε_{t-1}^2 gives the news about volatility from the previous period measured as the lag of the squared residual from the mean equation, and the lagged GARCH term h_{t-1} refers to the last period's forecast variance. In the conditional variance equations for both inflation and output growth, the ARCH and GARCH parameters have statistical significance. The sum of the ARCH and GARCH terms is 0.987 and 0.736 for the inflation and growth equations, respectively. This means that the information content of the forecasts of the conditional variance has been of a more importance for the inflation equation. Furthermore, the conditional correlation coefficient has been found statistically not different from zero which means that residual covariance between inflation and output growth equations is not statistically significant. From Tab. 4 below, we see that the model satisfies the null hypothesis that there remains no autocorrelation problem at any order. The graphs of the conditional variances and the estimated covariance are also reported in Fig. 2. We can easily notice that the economic crisis period of 1994 witnesses a jump in the conditional variance of inflation. For the output growth rate, the stagnation period of 1991 and the 1994 and 2001 economic crisis periods have the highest variances. The course of the covariance graph supports such inferences, as well.

Tab. 3 Estimates of the Bivariate SYSTEM-GARCH Model

Panel A Inflation Mean Equation

$$DP = \underset{(0.002)}{0.001} + \underset{(0.057)}{0.503}DP_{-1} - \underset{(0.091)}{0.015}DP_{-2} + \underset{(0.091)}{0.084}DP_{-3} - \underset{(0.100)}{0.200}DP_{-4} + \underset{(0.080)}{0.234}DP_{-5} + \underset{(0.099)}{0.017}DP_{-6} +$$

$$\underset{(0.073)}{0.034}DP_{-7} - \underset{(0.055)}{0.112}DP_{-8} + \underset{(0.059)}{0.194}DP_{-9} - \underset{(0.055)}{0.164}DP_{-10} + \underset{(0.085)}{0.184}DP_{-11} + \underset{(0.077)}{0.170}DP_{-12} - \underset{(0.017)}{0.034}DY_{-1} -$$

$$\underset{(0.025)}{0.052}DY_{-2} - \underset{(0.021)}{0.010}DY_{-3} + \underset{(0.024)}{0.060}DY_{-4} - \underset{(0.023)}{0.080}DY_{-5} + \underset{(0.022)}{0.014}DY_{-6} + \underset{(0.024)}{0.006}DY_{-7} + \underset{(0.030)}{0.025}DY_{-8} +$$

$$\underset{(0.028)}{0.031}DY_{-9} - \underset{(0.036)}{0.002}DY_{-10} + \underset{(0.027)}{0.009}DY_{-11} + \underset{(0.026)}{0.016}DY_{-12} + \varepsilon_{DP,t}$$

Panel B Real Output Growth Mean Equation

$$DY = \underset{(0.006)}{0.012} - \underset{(0.132)}{0.329}DP_{-1} + \underset{(0.142)}{0.068}DP_{-2} - \underset{(0.129)}{0.266}DP_{-3} + \underset{(0.117)}{0.231}DP_{-4} + \underset{(0.116)}{0.034}DP_{-5} - \underset{(0.112)}{0.007}DP_{-6} +$$

$$\underset{(0.094)}{0.082}DP_{-7} - \underset{(0.088)}{0.076}DP_{-8} - \underset{(0.111)}{0.014}DP_{-9} - \underset{(0.127)}{0.007}DP_{-10} - \underset{(0.154)}{0.143}DP_{-11} + \underset{(0.145)}{0.371}DP_{-12} - \underset{(0.072)}{0.703}DY_{-1} -$$

$$\underset{(0.080)}{0.210}DY_{-2} - \underset{(0.087)}{0.118}DY_{-3} - \underset{(0.080)}{0.210}DY_{-4} - \underset{(0.055)}{0.105}DY_{-5} + \underset{(0.065)}{0.076}DY_{-6} + \underset{(0.065)}{0.018}DY_{-7} - \underset{(0.073)}{0.016}DY_{-8} +$$

$$\underset{(0.073)}{0.056}DY_{-9} - \underset{(0.073)}{0.094}DY_{-10} - \underset{(0.073)}{0.147}DY_{-11} + \underset{(0.062)}{0.072}DY_{-12} + \varepsilon_{DY,t}$$

Panel C Variance Equations

$$h_{DP,t} = -\underset{(0.001)}{0.001} + \underset{(0.157)}{0.303}\,\varepsilon^2_{DP,t-1} + \underset{(0.053)}{0.684}\,h_{DP,t-1}$$

$$h_{DY,t} = \underset{(0.001)}{0.001} + \underset{(0.082)}{0.209}\,\varepsilon^2_{DY,t-1} + \underset{(0.262)}{0.527}\,h_{DY,t-1}$$

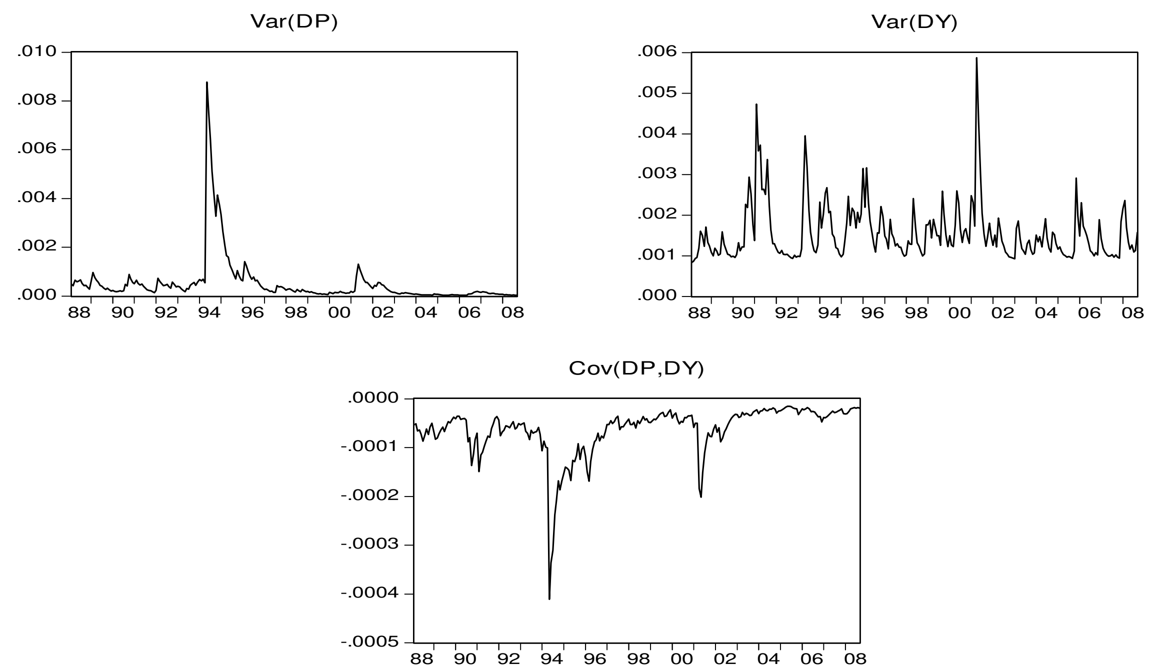
$$h_{DPDY,t} = \underset{(0.077)}{-0.085}\sqrt{h_{DP,t}}\sqrt{h_{DY,t}}$$

Tab. 4 GARCH System Residual Portmanteau Tests for Autocorrelations*

Lags	Q-Stat	Prob	Adj Q-stat	Prob	df
1	2.7058	0.6082	2.7177	0.6063	4
4	12.391	0.7167	12.515	0.7079	16
8	22.930	0.8808	23.317	0.8681	32
12	35.150	0.9164	36.085	0.8970	48

* Q-satistics and adjusted Q-statistics with a small sample correction refer to the computed Box-Pierce / Ljung-Box Q-statistic for residual serial correlation up to the specified order. df is degrees of freedom for (approximate) chi-square distribution.

Fig. 2 The Graphs of Conditional Variances and Covariance of Inflation and Output Growth



The bivariate system-GARCH model has also been estimated briefly with an alternative method of the conditional covariance matrix for comparion. For this purpose, the diagonal-vec (*dvec*) model of Bollerslev et al. (1988) has been used. In this model the conditional variance follows a GARCH(1,1) process:

$$h_{DPDY,t} = \Omega + a_{DPDY}\varepsilon_{DP,t-1}\varepsilon_{DY,t-1} + \beta_{DPDY}h_{DPDY,t-1} \tag{7}$$

According to the model selection Akaike information criterion (AIC), Schwarz criterion (SC) and the maximum likelihood value (ML) estimates in Tab. 5, we can observe that the *ccc*-GARCH (1,1) model is preferred to the *dvec*-GARCH (1,1) model. The more detailed outputs are available from the author upon request.

Tab. 5 Model Comparison

	AIC	SC	ML
ccc-GARCH (1,1)	-8.732	-7.924	1139.724
dvec-GARCH (1,1)	-8.599	-7.849	1119.345

For the bi-directional causal relationships between output growth, inflation and their associated volatility components represented by conditional variance series, some conventional Granger causality tests have been performed. Fountas et al. (2002) discuss briefly some advantages of employing such a methodology over the estimation of simultaneous-equation based approaches. In line with Nas and Perry (2000) and Daal et al. (2005), since Granger causality tests initially show the temporal ordering or precedence relationship between each variable but do not reveal the sign of this relationship, the sign of the sum of the coefficients taken from each Granger causality equation is also given in order to determine whether the Granger causality, if estimated, occurs in the positive or negative way. Following the related literature on this issue, various lag lengths for the dynamic structure of the model are considered to see whether the estimation results are sensitive to the *a priori* lag selection. By employing *F*-type Wald tests, the results of pairwise Granger causality analysis, which are applied on the joint significance of the sum of lags of each explanatory variable, are reported in Tab. 6. The asterisks ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 levels, respectively. The signs (+) and (–) are used for the process by which the sum of the coefficients of Granger equation yields a positive or negative sign. "$\not\rightarrow$" means null hypothesis of no Granger causality for the estimated equation. For instance, the phrase H_0: $DP_t \not\rightarrow DY_t$ states the null hypothesis that inflation does not Granger-cause output growth.

Tab. 6 Bivariate Granger Causality Tests for the 1987M01 2008M09 Period

Lags	H_0: $DP_t \rightarrow h_{DP,t}$	H_0: $DP_t \rightarrow DY_t$	H_0: $DP_t \rightarrow h_{DY,t}$
3	45.161*** (+)	0.4235 (–)	1.8999 (+)
6	23.983*** (+)	1.0884 (–)	1.1786 (+)
12	18.081*** (+)	1.5840 * (–)	0.9641 (+)
18	15.134*** (+)	1.4172 (–)	1.6353* (+)
24	13.489*** (+)	0.3181 (–)	1.2617 (+)
Lags	H_0: $h_{DP,t} \rightarrow DP_t$	H_0: $h_{DP,t} \rightarrow DY_t$	H_0: $h_{DP,t} \rightarrow h_{DY,t}$
3	2.5737* (+)	1.3499 (–)	0.1329 (+)
6	5.5157*** (+)	1.0389 (–)	0.1456 (+)
12	3.1217*** (+)	2.2729*** (–)	0.2379 (+)
18	2.7900*** (+)	1.7490** (–)	0.3976 (+)
24	2.2094*** (+)	1.8005** (–)	0.6123 (+)
Lags	H_0: $DY_t \rightarrow DP_t$	H_0: $DY_t \rightarrow h_{DP,t}$	H_0: $DY_t \rightarrow h_{DY,t}$
3	1.4780 (–)	2.5734* (–)	4.2444*** (–)
6	1.2269 (–)	2.0554* (–)	3.3588*** (–)
12	1.5126 (+)	1.2298 (–)	2.8292*** (–)
18	1.2070 (+)	1.4206 (–)	1.9298** (–)
24	0.8002 (+)	1.2318 (–)	2.1403*** (–)
Lags	H_0: $h_{DY,t} \rightarrow DP_t$	H_0: $h_{DY,t} \rightarrow h_{DP,t}$	H_0: $h_{DY} \rightarrow DY_t$
3	0.8402 (+)	1.1836 (+)	3.0650** (–)
6	0.6447 (+)	1.3271 (+)	1.9164* (–)
12	1.5560 (+)	2.0367** (+)	1.6153* (–)
18	1.4526 (+)	1.7707** (+)	1.2819 (–)
24	1.0355 (+)	1.4807* (+)	1.0732 (–)

The null hypothesis of Granger causality between inflation and inflation uncertainty cannot be rejected mutually in a strong way at the 0.01 level. Thus both Friedman-Ball and Cukierman-Meltzer hypotheses can be supported, that is to say briefly, inflation Granger-causes inflation uncertainty and also inflation uncertainty precedes the course of inflation in a positive way. For the output growth and associated uncertainty relationship, the results reveal that the larger the output growth the lower the output growth uncertainty in a statistically significant way. This also means that it is necessary to provide sustainable growth rates so as to decrease uncertainties related to the aggregate level of real economic activity. Such an inference is confirmed by the estimation result that the larger output growth uncertainty would lead to the lower output growth especially for small lag selections chosen for the temporal ordering of the causality analysis. However being estimated highly sensitive to the lag selections used, it is also found some weak form of evidence that an increase in inflation uncertainty lowers output growth and that an increase in the latter lowers the former. No statistically significant causal relationship has been observed between output growth uncertainty and inflation and between output growth and inflation. Finally, we can observe that an increase in output growth uncertainty is likely to lead to more inflation uncertainty the larger the autoregressive framework of the causality analysis.

5. ROBUSTNESS CHECK

Having examined the whole period characteristics of the data in an empirical way, some sensitivity analysis may be required since considerable policy changes such as variations in monetary policy strategies, exchange rate framework and operational characteristics of fiscal policy were implemented within our estimation period for the Turkish economy, and all these can lead us to obtain unhealthy results in the absence of a sub-sample analysis.[2] In the light of this consideration, we now check out whether our results obtained for the whole period of 1987M01 2008M09 are valid for the sub-period of the free-floating exchange rate system that the Turkish economy has recently been witnessed. Thus some sensitivity analyses have been conducted for the causal relationships examined in this paper. Of course, many other sub-periods can also be identified for the Turkish economy due to the unstable characteristics experienced with respect to the different aspects of the economy. On this point, we choose to further proceed by considering 2001M03 2008M09 period of the economy as a main diversification date for the sensitivity analysis.

For this purpose, the system-GARCH equations have been re-estimated for a sub-period analysis. The AR order of the mean equation is again determined by sequentially testing down the AIC statistics sequentially beginning form the maximum lag order 12 and an AR(11) process is determined as the relevant model specification of the data.

[2] The author would like to thank an anonymous referee for suggestions on this issue.

Tab. 7 Estimates of the Bivariate SYSTEM-GARCH Model

Panel A Inflation Mean Equation

$$DP = \underset{(0.002)}{0.003} + \underset{(0.161)}{0.366}DP_{-1} + \underset{(0.178)}{0.226}DP_{-2} - \underset{(0.186)}{0.169}DP_{-3} - \underset{(0.197)}{0.048}DP_{-4} - \underset{(0.201)}{0.051}DP_{-5} + \underset{(0.79)}{0.400}DP_{-6} -$$

$$\underset{(0.149)}{0.252}DP_{-7} - \underset{(0.122)}{0.038}DP_{-8} - \underset{(0.132)}{0.051}DP_{-9} + \underset{(0.119)}{0.036}DP_{-10} + \underset{(0.110)}{0.223}DP_{-11} + \underset{(0.031)}{0.002}DY_{-1} - \underset{(0.039)}{0.001}DY_{-2} +$$

$$\underset{(0.034)}{0.028}DY_{-3} - \underset{(0.044)}{0.010}DY_{-4} - \underset{(0.052)}{0.021}DY_{-5} + \underset{(0.051)}{0.017}DY_{-6} + \underset{(0.045)}{0.012}DY_{-7} - \underset{(0.034)}{0.018}DY_{-8} - \underset{(0.041)}{0.036}DY_{-9} -$$

$$\underset{(0.030)}{0.009}DY_{-10} - \underset{(0.030)}{0.008}DY_{-11} + \varepsilon_{DP,t}$$

Panel B Real Output Growth Mean Equation

$$DY = \underset{(0.017)}{0.017} - \underset{(0.747)}{0.842}DP_{-1} + \underset{(0.857)}{0.739}DP_{-2} - \underset{(0.752)}{0.412}DP_{-3} - \underset{(0.909)}{0.061}DP_{-4} + \underset{(0.745)}{0.086}DP_{-5} + \underset{(0.985)}{0.166}DP_{-6} -$$

$$\underset{(1.097)}{0.148}DP_{-7} - \underset{(0.850)}{0.322}DP_{-8} + \underset{(0.958)}{0.400}DP_{-9} - \underset{(0.979)}{0.291}DP_{-10} + \underset{(0.750)}{0.542}DP_{-11} - \underset{(0.180)}{0.675}DY_{-1} - \underset{(0.264)}{0.243}DY_{-2} -$$

$$\underset{(0.229)}{0.107}DY_{-3} - \underset{(0.267)}{0.118}DY_{-4} - \underset{(0.246)}{0.190}DY_{-5} - \underset{(0.267)}{0.099}DY_{-6} - \underset{(0.263)}{0.047}DY_{-7} - \underset{(0.304)}{0.003}DY_{-8} + \underset{(0.272)}{0.108}DY_{-9} -$$

$$\underset{(0.241)}{0.211}DY_{-10} - \underset{(0.197)}{0.297}DY_{-11} + \varepsilon_{DY,t}$$

Panel C Variance Equations

$$h_{DP,t} = \underset{(0.001)}{0.002} - \underset{(0.038)}{0.109}\,\varepsilon^2_{DP,t-1} + \underset{(0.056)}{0.976}\,h_{DP,t-1}$$

$$h_{DY,t} = \underset{(0.001)}{0.001} + \underset{(0.186)}{0.001}\,\varepsilon^2_{DY,t-1} + \underset{(0.525)}{0.558}\,h_{DY,t-1}$$

$$h_{DPDY,t} = \underset{(0.181)}{-0.056}\sqrt{h_{DP,t}}\sqrt{h_{DY,t}}$$

Following the whole period analysis, the normality assumption is also used for the conditional distribution of the error structure. Standard errors are given in parentheses. The results of the system-GARCH model and the relevant Granger-causality analyses are reported in Tab. 7 and Tab. 8.

In Tab. 7, the conditional mean and variance equations for inflation and output growth are reported. As a difference from the whole period analysis, we can observe that the knowledge from the variance equation have a statistical significance only for the inflation equation. The coefficient of conditional correlation coefficient implies that, as is in the whole period analysis, the residual covariance between inflation and output growth equation is statistically insignificant. As can be seen in Tab. 8 below, there remains no 12th order autocorrelation problem of the monthly frequency.

Tab. 8 GARCH System Residual Portmanteau Tests for Autocorrelations for the sub-Period*

Lags	*Q*-Stat	Prob	Adj *Q*-stat	Prob	df
1	11.725	0.0195	11.856	0.0185	4
4	19.772	0.2307	20.220	0.2105	16
8	26.725	0.7307	27.625	0.6878	32
12	55.416	0.2152	60.055	0.1137	48

* *Q*-satistics and adjusted *Q*-statistics with a small sample correction refer to the computed Box-Pierce / Ljung-Box *Q*-statistic for residual serial correlation up to the specified order. df is degrees of freedom for (approximate) chi-square distribution.

Since the main interest area in this paper is to examine the causality issues between inflation, output and their volatilities, some Granger-causality tests have also been implemented for the post-2001 period. Consider that the conditional variance series are taken from the post-2001 sample analysis. The results are reported in Tab. 9. The results verify the validity of the Friedman hypothesis in the sense that there seems to exist a positive causal relationship running from inflation to inflation uncertainty. However, when we examine the reverse causality recalling Cukierman and Meltzer hypothesis, we estimate a diversification in the economy. The results point out a negative precedence relationship from inflation uncertainty to inflation, which possibly reflects that the alteration in the trend course of the inflation leading to a greater volatility in inflation rates coincides with the lower inflation

Tab. 9 Bivariate Granger Causality Tests for the 2001M03 2008M09 Period

Lags	H_0: $DP_t \rightarrow h_{DP,t}$	H_0: $DP_t \rightarrow DY_t$	H_0: $DP_t \rightarrow h_{DY,t}$
3	4.3311*** (+)	0.2535 (–)	0.9841 (+)
6	5.8178*** (+)	0.2125 (–)	0.4695 (+)
12	1.5844 (+)	1.2891 (–)	1.0340 (+)
18	0.9371 (+)	0.6191 (–)	1.0211 (+)
24	2.4871** (+)	0.5169 (–)	0.8984 (+)

Lags	H_0: $h_{DP,t} \rightarrow DP_t$	H_0: $h_{DP,t} \rightarrow DY_t$	H_0: $h_{DP,t} \rightarrow h_{DY,t}$
3	8.2043*** (–)	0.0806 (–)	0.9145 (+)
6	3.4161*** (–)	0.4873 (–)	0.6948 (+)
12	2.4126*** (–)	1.2013 (–)	0.5563 (+)
18	1.1972 (–)	0.7953 (–)	0.4856 (+)
24	0.8332 (–)	0.5639 (–)	0.5508 (+)

Lags	H_0: $DY_t \rightarrow DP_t$	H_0: $DY_t \rightarrow h_{DP,t}$	H_0: $DY_t \rightarrow h_{DY,t}$
3	3.5538*** (–)	3.0498*** (–)	2.1160 (–)**
6	2.8248*** (–)	1.3230 (–)	3.8022 (–)***
12	1.9132** (–)	0.7402 (–)	2.4960 (–)***
18	1.2660 (–)	0.6154 (–)	2.5215 (–)***
24	1.2344 (–)	1.8596* (–)	1.9107 (–)**

Lags	H_0: $h_{DY,t} \rightarrow DP_t$	H_0: $h_{DY,t} \rightarrow h_{DP,t}$	H_0: $h_{DY} \rightarrow DY_t$
3	0.0771 (+)	6.8182*** (+)	0.1381 (–)
6	3.1018*** (+)	4.8531*** (+)	0.3041 (–)
12	1.9837** (+)	0.3635 (+)	1.9575** (–)
18	0.7470 (+)	0.5563 (+)	1.0350 (–)
24	0.7918 (+)	0.8849 (+)	0.9975 (–)

experienced within the 2001M03 2008M09 sub-period. Following Nas and Perry (2000) and Fountas et al. (2002), a possible explanation of this finding can be expressed such that in the light of the past experiments, if increasing uncertainty has been perceived by the policy makers so much detrimental that leads to real costs, this can direct policy makers to applying to a tight monetary policy stabilization attempts to lower average inflation, so that they are more likely to achieve their commitment to long-run price stability. Supporting the results of the whole period, it is found that the larger output growth would precede the lower output growth uncertainty with a negative causal relationship, and these results again verify the need of sustainable growth rates to decrease the uncertainties on real economic activity. We can also observe that the real output growth seems to be a Granger-cause to the inflation in a negative way, which means that the larger growth rates would lead to both lower inflation and inflation unceratinty for the period under investigation. Finally, a decrease in the output growth uncertainty coincides with the lower inflation and that the higher the growth uncertainty the higher the inflation uncertainty for the small lags chosen in a statistically significant way.

To sum up, these results mainly verify the suggestions of Friedman (1977) and Ball (1992) and indicate that stabilization policies aiming at reducing inflation would decrease both inflation and its conditional volatility, and in turn, the lower uncertainty for inflation that enables relatively more efficient functioning of the price system would signal more accurate foresights for economic agents as to the future course of the real economic activity. Such a causal transmission mechanism would also be resulted in a decrease in the uncertainty component of real output. Therefore we can infer that inside the period examined, had there not been chronic and high inflation rates witnessed by the Turkish economy, other things being equal, the larger growth rates could have been achieved by the policy makers.

6.CONCLUDING REMARKS

In this paper, the causal relationships between inflation, output growth and related uncertainty components have been re-examined by using data from the Turkish economy. For this purpose, some main approaches that explain possible transmission links between these aggregates have initially been documented. Then, empirical validity of these approaches have been tested in the light of some contemporaneous estimation techniques. Based on the system generalized autoregressive conditional heteroskedasticity (GARCH) methodology by which relevant conditional variance series for inflation and output growth uncertainty have been extracted, estimation results reveal that for the 1987M01 2008M09 investigation period with monthly frequency data, the mutual Granger causality between inflation and inflation uncertainty cannot be rejected. Supporting the suggestions of Friedman-Ball and Cukierman-Meltzer hypotheses, the results verify that inflation is a Granger-cause to the inflation uncertainty and that inflation uncertainty precedes the course of inflation, as well. Both causalities tend to occur in a positive way. For the output growth and associated uncertainty relationship, the results show that the larger the output growth the lower the output growth uncertainty in a statistically significant way, which explicitly means that it is necessary to provide sustainable growth rates so as to decrease uncertainties related to the aggregate level of real economic activity. Some evidence have also been found in favor of that an increase in inflation uncertainty lowers output growth and that an increase in the latter lowers the former. Finally, we observe that an increase in output growth uncertainty is likely to lead to more inflation uncertainty. Some sensitivity analyses have also been implemented for the recent 2001M01 2008M09 free-floating exchange rate period of the Turkish economy. The results verify, to a great extent, the inferences extracted for the whole period. As a difference, it is found a negative causal relationship from inflation uncertainty to inflation and this is attributed to the alteration in the trend course of the inflation leading to a greater volatility in inflation rates which coincides with the lower inflation experienced within the 2001M03 2008M09 sub-period. This might also reflect monetary stabilization attemts due to the fear of inflation in the light of past experiences. Besides, a positive causality running from output growth uncertainty to both inflation and inflation uncertainty is estimated.

All in all, the paper concludes that inside the investigation period considered, stabilization policies aiming at reducing inflation would decrease both inflation and its conditional volatility, and in turn, the lower uncertainty for inflation that enables relatively more efficient functioning of the price system would signal more accurate foresights for economic agents as to the future course of the real economic activity. The course of the real output growth rates mutually contributes to the disinflation period of the economy. In this sense, under the increased autonomy of the monetary authority with central bank operational independence through the amendment of the CBRT Law on April 22 2001, the policy choices supporting the lower inflation – higher economic growth process witnessed by the post-2001 Turkish economy will serve to decrease uncertainties on the real and monetary aggregates in the economy. This, of course, needs to eliminate opportunistic policy implementations leading to inflationary pressures and negative impacts on the growth process. On this point, future researchs that try to examine to what extent the demand and supply based stabilization attempts are effective against each other on the business-cycle realizations of the Turkish economy will be complementary to such a proposal. Further, enlarging the time span when additional data are available to the researchers will be helpful to appreciate the robustness of the results obtained in this paper.

ACKNOWLEDGEMENTS

The author would like to thank an anonymous referee for suggestions upon the final version of the paper. The author is also grateful to Dündar M. Demiröz of the İstanbul University Department of Economics for his invaluable criticisms upon an earlier version of this paper. The usual disclaimer applies.

REFERENCES

Akyazı, H. & Artan, S. (2004). Türkiye'de Enflasyon-Enflasyon Belirsizliği İlişkisi ve Enflasyon Hedeflemesinin Enflasyon Belirsizliğini Azaltmadaki Rolü. *Türkiye Bankalar Birliği Bankacılar Dergisi*, 48, 3-17.

Al-Marhubi, F. (1998). Cross-country Evidence on the Link between Inflation Volatility and Growth. *Applied Economics*, 30, 1317-326.

Artan, S. (2006). Gelişmiş ve Gelişmekte Olan Ülkelerde Enflasyon ve Büyüme: Yatay-kesit ve Panel Veri Analizi. *İktisat, İşletme ve Finans*, 21(239), 109-24.

Ball, L. & Cecchetti, S.G. (1990). Inflation and Uncertainty at Short and Long Horizons. *Brookings Papers on Economic Activity*, 1, 215-54.

Ball, L. (1992). Why Does Higher Inflation Raise Inflation Uncertainty?. *Journal of Monetary Economics*, 29, 371-78.

Barro, R.J. & Gordon, D.B. (1983). A Positive Theory of Monetary Policy in a Natural Rate Model. *Journal of Political Economy*, 91, 589-610.

Berndt, E., Hall, B., Hall, R. & Hausman, J. (1974). Estimation and Inference in Nonlinear Structural Models. *Annals of Economic and Social Measurement*, 3, 653-65.

Berument, H., Inamlık, A. & Olgun, H. (2008). Inflation and Growth. *Journal of Applied Sciences*, 8(2), 192-204.

Black, F. (1987). *Business Cycles and Equilibrium*. New York: Basil Blackwell.

Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, 31, 307-27.

Bollerslev, T. (1990). Modeling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Model. *Review of Economics and Statistics*, 72, 498-505.

Bollerslev, T., Engle, R.F. & Wooldridge, J.M. (1988). A Capital-Asset Pricing Model with Time-varying Covariances. *Journal of Political Economy,* 96(1), 116–31.

Briault, C. (1995). The Costs of Inflation. *Quarterly Bulletin*, Bank of England, February, 33- 45.

Cukierman, A. (1992). *Central Bank Strategy, Credibility, and Independence*. Cambridge: MIT Press.

Cukierman, A. & Meltzer, A. (1986). A Theory of Ambiguity, Credibility, and Inflation under Discretion and Asymmetric Information. *Econometrica*, September, 54, 1099-128.

Daal, E., Naka, A. & Sanchez, B. (2005). Re-examining Inflation and Inflation Uncertainty in Developed and Emerging Countries. *Economics Letters*, 89, 180-86.

De Gregorio, J. (1992). The Effects of Inflation on Economic Growth – Lessons from Latin America. *European Economic Review*, 36, 417-25.

Devereux, M. (1989). A Positive Theory of Inflation and Inflation Variance. *Economic Inquiry*, 27, January, 105-16.

Dickey, D.A. & Fuller, W.A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with Unit Roots. *Econometrica*, 49, 1057-072.

Engle, R.F. (1982). Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation. *Econometrica*, 50, 987-1008.

Fountas, S. (2001). The Relationship between Inflation and Inflation Uncertainty in the UK: 1885-1998. *Economics Letters*, 74, 77-83.

Fountas, S., Karanasos, M. & Kim, J. (2002). Inflation and Output Growth Uncertainty and their Relationship with Inflation and Output Growth. *Economics Letters*, 75, 293-301.

Friedman, M. (1977). Nobel Lecture: Inflation and Unemployment. *Journal of Political Economy*, 85(3): 451-72.

Grier, K.B. & Perry, M.J. (1998). On Inflation and Inflation Uncertainty in the G7 Countries. *Journal of International Money and Finance*, 17(4): 671-89.

Grier, K.B. & Perry, M.J. (2000). The Effects of Real and Nominal Uncertainty on Inflation and Output Growth: Some Garch-M Evidence. *Journal of Applied Econometrics*, 15(1), 45-58.

Hayford, M.D. (2000). Inflation Uncertainty, Unemployment Uncertainty and Economic Activity. *Journal of Macroeconomics*, Spring, 22(2), 315-29.

Holland, A.S. (1995). Inflation and Uncertainty: Tests for Temporal Ordering. *Journal of Money, Credit, and Banking*, 27(3), 827-37.

Karaca, O. (2003). Türkiye'de Enflasyon – Büyüme İlişkisi: Zaman Serisi Analizi. *Doğuş Üniversitesi Dergisi*, 4(2), 247-55.

Kontonikas, A. (2004). Inflation and Inflation Uncertainty in the United Kingdom, Evidence from GARCH Modelling. *Economic Modelling*, 21, 525-43.

Mundell, R. (1963). Inflation and the Real Interest. *Journal of Political Economy*, 71, 280-83.

Nas, T.F. & Perry, M.J. (2000). Inflation, Inflation Uncertainty, and Monetary Policy in Turkey: 1960-1998. *Contemporary Economic Policy*, 18(2), 170-80.

Neyaptı, B. & Kaya, N. (2001). Inflation and Inflation Uncertainty in Turkey: Evidence from the Past Two Decades. *Yapı Kredi Economic Review*, 12(2), 21-5.

OECD (2002). *Main Economic Indicators - Comparative Methodological Analysis: Consumer and Producer Price Indices*, Vol. 2002, Supplement 2.

Okun, A. (1971). The Mirage of Steady Inflation. *Brookings Papers on Economic Activity*, 2, 485-98.

Özdemir, Z.A. & Fisunoğlu, M. (2008). On the Inflation - Uncertainty Hypothesis in Jordan, Philippines and Turkey: A Long Memory Approach. *International Review of Economics & Finance*, 17(1), 1-12.

Özer, M. & Türkyılmaz, S. (2005). Türkiye'de Enflasyon ile Enflasyon Belirsizliği Arasındaki İlişkinin Zaman Serisi Analizi. *İktisat İşletme ve Finans*, Nisan, 93-104.

Rudebusch, G. & Wilcox, D. (1994). Producticity and Inflation: Evidence and Interpretations. Federal Reserve Board, Washington D.C., *mimeo*, May.

Sbordone, A. & Kuttner, K. (1994). Does Inflation Reduce Productivity?. *Economic Perspectives*, Federal Reserve Bank of Chicago, 2-14.

Telatar, F. (2003). Türkiye'de Enflasyon, Enflasyon Belirsizliği ve Siyasi Belirsizlik Arasındaki Nedensellik İlişkileri. *İktisat, İşletme ve Finans*, 18(203), 42-51.

Telatar, F. & Telatar, E. (2003). The Relationship between Inflation and Different Sources of Inflation Uncertainty in Turkey. *Applied Economics Letters*, 10(7), 431-35.

Tobin, J. (1965). Money and Economic Growth. *Econometrica*, 33, 671-84.

Wilson, B.K. (2006). The Links between Inflation, Inflation Uncertainty and Output Growth: New Time Series Evidence from Japan. *Journal of Macroeconomics*, 28, 609-20.

Extensive Summary

ON THE LINKS BETWEEN INFLATION, OUTPUT GROWTH AND UNCERTAINTY: SYSTEM-GARCH EVIDENCE FROM THE TURKISH ECONOMY

Levent Korap*

Istanbul University Institute of Social Sciences

INTRODUCTION

The relationships between inflation, real output growth and their volatility components have long been perceived in the economics literature as a special research area based mainly on empirical findings. Testing the causality between these aggregates enables us to attain the significant knowledge of whether or not inflation and its associated volatility tend to have potential negative effects on the growth process of the economy. Based on a contemporaneous literature, in this paper, some main approaches dealing with the transmission of the effects of inflation, output growth and their uncertainties upon each other have been documented, and then, the empirical validity of these competing approaches has been tested for the Turkish economy.

METHOD

To test the causal relationships between inflation, output growth and uncertainty, system-based generalized autoregressive conditional heteroskedasticity (GARCH) modeling are used, and then some tests are carried out to reveal the causality issues between these

* Address for Correspondence: Levent Korap, İstanbul Üniversitesi Sosyal Bilimler Enstitüsü İktisat Ana Bilim Dalı, Besim Ömer Paşa Cd. Kaptan-ı Derya Sk. 34452 Beyazıt / ISTANBUL. E-posta: korap@e-kolay.net.

aggregates. The use of a GARCH-type model enables us to estimate time-varying measures of inflation uncertainty, and this will be appropriate for an empirical attempt aiming at directly testing the implications of the hypotheses examined in this paper. For this purpose, we follow Bolleslev (1990) to estimate a system of equations using GARCH methodology, and consider time-varying conditional variance and covariance with a constant conditional correlation so that all the variations over time in the conditional variances are allowed to take place due only to changes in each of the conditional variances.

RESULTS

Estimation results reveal that for the 1987M01 2008M09 investigation period with monthly frequency data, the mutual Granger causality between inflation and inflation uncertainty cannot be rejected. Supporting the suggestions of Friedman-Ball and Cukierman-Meltzer hypotheses, the results verify that inflation is a Granger-cause to the inflation uncertainty and that inflation uncertainty precedes the course of inflation, as well. Both causalities tend to occur in a positive way. For the output growth and associated uncertainty relationship, the results show that the larger the output growth the lower the output growth uncertainty in a statistically significant way, which explicitly means that it is necessary to provide sustainable growth rates so as to decrease uncertainties related to the aggregate level of real economic activity. Some evidence have also been found in favor of that an increase in inflation uncertainty lowers output growth and that an increase in the latter lowers the former. Finally, we observe that an increase in output growth uncertainty is likely to lead to more inflation uncertainty.

Some sensitivity analyses have also been implemented for the recent 2001M01 2008M09 free-floating exchange rate period of the Turkish economy. The results verify to a great extent the inferences extracted for the whole period. As a difference, it is found a negative causal relationship from inflation uncertainty to inflation and this is attributed to the alteration in the trend course of the inflation leading to a greater volatility in inflation rates which coincides with the lower inflation rates experienced within the 2001M03 2008M09 sub-period.

CONCLUSION

The paper concludes that stabilization policies aiming at reducing inflation decrease both inflation and its conditional volatility, and in turn, the lower uncertainty for inflation that enables relatively more efficient functioning of the price system tend to signal more accurate foresights for economic agents as to the future course of the real economic activity. The course of the real output growth rates mutually contributes to the disinflation period of the economy. Thus it is inferred that inside the period examined, had there not been chronic and high inflation rates witnessed by the Turkish economy, other things being equal, the larger growth rates could have been achieved by the policy makers.