Danut-Vasile JEMNA, PhD
Alexandru Ioan Cuza University of Iasi, Romania
E-mail: danut.jemna@uaic.ro
Professor Carmen PINTILESCU, PhD
Alexandru Ioan Cuza University of Iasi, Romania
E-mail: carmen.pintilescu@uaic.ro
Elena-Daniela VIORICĂ, PhD
Alexandru Ioan Cuza University of Iasi, Romania
E-mail: dana.viorica@gmail.com
Mircea ASANDULUI, PhD
Alexandru Ioan Cuza University of Iasi, Romania
E-mail: asmircea@yahoo.com

INFLATION AND INFLATION UNCERTAINTY IN ROMANIA

Abstract. *In this paper, we analyze the causality between inflation and inflation uncertainty in Romania. The monthly growth in Consumer Price Index (CPI) in the period from October 1990 to December 2012 has been used as an inflation measure. The inflation uncertainty is estimated by the conditional variances of inflation obtained by the GARCH models selected with Akaike and Schwarz information criteria. In order to ensure the robustness of the results, the Granger-causality tests are performed for four, eight and twelve lags, and they are then used to test two economic hypotheses. Our results showed that the inflation significantly Granger-causes inflation uncertainty, confirming the Friedman-Ball hypothesis, but no empirical evidence was found to support the Cukierman - Meltzer hypothesis, that inflation uncertainty Granger-causes inflation.*

Keywords: Inflation, inflation uncertainty, heteroscedastic model.

JEL Classification: C22, E31, E37

1. INTRODUCTION

The study of the relationship between inflation and inflation uncertainty has been a widely debated topic in the literature, especially after the publication of Milton Friedman's (1977) Nobel lecture. It is unanimously recognized that inflation is a phenomenon with negative influences on economy, while the economists argue that inflation has small costs if it is perfectly anticipated, but larger costs if it raises uncertainty. Thus, one of the most important costs of inflation is the uncertainty it creates about future inflation.

High inflation creates uncertainty about future monetary policy, because the policymakers will adopt disinflationary policies, but the timing and short-run impact of policy on inflation are uncertain. The monetary policy measures take time to produce their effect on inflation. When the inflationist phenomenon is accompanied by the economic recession, it is not obvious which goal should come first.

Uncertainty about future inflation can affect financial markets by raising long-term interest rates and can lead to uncertainty about other economic variables (wages, tax rates, investments). In the same way, inflation uncertainty determines businesses to spend resources avoiding the risk of future inflation, either for improving their forecast of inflation, or for their protection by using financial instruments, known as derivatives. The resources used for the protection against risk of future inflation are thus diverted from other productive business purposes.

The transition economies in the Central and Eastern European countries have experienced in the 90s great inflationist phenomena, as a consequence of the price liberalization measures and the economic reforms necessary to pass to a market economy. Of these countries, Romania has known one of the highest levels of inflation rate, of 256.1% in 1993. The delay and inconsistency of the reform measures of the economy, the gradual but overly extended liberalization of prices, have determined the inflation phenomenon to occur on a long period of time. The year 2005 has been the first year when inflation in Romania has reached a single figure (9%). Inflation is conceived in the Romanian economy as one of the main phenomena of instability of the economic environment. In August 2005, the National Bank of Romania has thus adopted a new monetary policy strategy - the direct inflation targeting.

In the present paper, we analyze and test the causality relation between inflation and inflation uncertainty for Romania. Inflation is measured by means of the Consumer Price Index (CPI), while the inflation uncertainty is provided by the GARCH models. The data series is compounded of the monthly data for the period October 1990 – December 2012 on the Consumer Price Index (CPI). At the time of the elaboration of this paper, no such extensive study was conducted for Romania.

The paper is structured as follows: Section 2 presents the literature review on this subject. Section 3 deals with aspects related to data series and applied methodology, mainly GARCH-type models used for the estimation of conditional residual variances as measures of uncertainties. Section 4 presents an economic overview regarding the situation of Romania, taking into account the most important macroeconomic indicators. In Section 5, we attempted to highlight our empirical results for the hypotheses tested. The last section comprises our main conclusions.

2. LITERATURE REVIEW

The relationship between inflation and inflation uncertainty was extensively researched in the last 30 years, and its debut lies with the pioneer preoccupations of Okun (1971), who found, for 17 OECD countries, a positive relationship between inflation rate and inflation variability. But Friedman's contribution (1977) on the real effects of inflation was the one that generated extensive debates in the literature. First, he states that an increase in inflation will lead to more uncertainty about inflation, and second, that an increase in inflation uncertainty leads to a decrease in output. In this paper we analyse the first part of Friedman's statement, which was later developed and confirmed by Ball (1992). Pourgerami and Maskus (1987) and then Ungar and Zilberfarb (1993) studied the relationship between inflation and inflation uncertainty and found evidence that inflation influences uncertainty about inflation, but, unlike Friedman and Ball, they brought evidence that high inflation actually reduces the uncertainty about inflation.

The other causal relationship, that inflation rate is determined by inflation uncertainty, was studied by Cukierman and Meltzer (1986) who found support that when the uncertainty about inflation increases, it causes high rates of inflation. The same causality, but with a negative relationship between variables, was found by Holland (1995).

In order to investigate the relationship between inflation and its uncertainty, considering all of the causal effects between the variables, we can study 4 possible causal relationships for the two variables considered. In Table 1 we presented the most significant contributions made for each type of causality.

Table 1. The investigated hypotheses

Hypothesis	*Sign of the causal relationship*
H1: Inflation Granger-causes inflation uncertainty	
Friedman (1977), Ball (1992)	(+)
Pourgerami and Maskus (1987), Ungar and Zilberfarb (1993)	(-)
H2: Inflation uncertainty Granger-causes inflation	
Cukierman and Meltzer (1986)	(+)
Holland (1995)	(-)

The first hypothesis is, as previously stated, the most investigated one, and has the strongest theoretical and empirical background, given the debates around Nobel-awarded contribution of Friedman.

Both Friedman's and Ball's research provide theoretical background in support for the first hypothesis, with evidence of a positive relationship between inflation and inflation uncertainty. They state that when the inflation rate increases, the monetary authority do not have a predictable and reliable response, and that generates uncertainty about the future rate of inflation for the public, because the money supply growth cannot be predicted. On the other side, Pougerami and Maskus, and Ungar and Zilberfarb found evidence that it is possible for high inflation to lead to a lower uncertainty about inflation, because in the case of an increased inflation, more resources would be invested to accurately predict the future inflation rate and that would lower the uncertainty level.

For the second hypothesis, Cukierman and Meltzer found support for a positive relationship between the two variables by stating that when inflation uncertainty increases, the policy authority has an opportunistic behaviour, meaning they generate surprise inflation for the economic agents, in order to obtain output gains. On the other hand, Holland found evidence of a negative relationship, suggesting that in the case of increased inflation uncertainty, the policymaker has a stabilizing behaviour, meaning that they reduce money supply growth to reduce the negative welfare effects. Related to this subject, Grier and Perry (1998) suggested that the opportunistic or stabilizing behaviour of the monetary authorities is related to the level of central bank independence. The higher the level of central bank independence, the lesser the rate of inflation.

The literature for empirical studies is very extensive, and some of it have significant contributions to both theoretical and empirical body of literature. Grier and Perry (1998) investigated the relationship for G7 countries, using GARCH models to estimate the inflation uncertainty. They found strong evidence to support Friedman-Ball hypothesis and weak evidence in support of the second hypothesis.

Kontonikas (2004) investigated the relationship between the two variables in UK and found a positive relationship between inflation and inflation uncertainty, confirming Friedman-Ball hypothesis. He analyzed the effect of inflation targeting policies on reducing inflation variability and found a negative impact of inflation targeting on long-run uncertainty.

Fountas, Ioannidis and Karanasos (2004) employed E-GARCH models to estimate inflation uncertainty and found strong evidence to support the Friedman-Ball hypothesis and mixed evidence for the second investigates hypothesis for a sample of six EU countries. They suggest that the European Central Bank can lower inflation uncertainty by targeting inflation.

Conrad and Karanasos (2005) used an ARFIMA-FIGARCH model to analyze the dual long-memory behaviour of inflation in relation to inflation uncertainty and found that inflation raises inflation uncertainty for all countries analysed, USA, Japan and UK. For the other hypothesis, that uncertainty raises inflation, mixed results were found.

Caporale, Onorante and Paesani (2010) analyzed the relationship between inflation and inflation uncertainty for the EURO zone, using an AR-GARCH model for inflation. The study showed that, after the introduction of EURO and with strong anti-inflation measures, empirical support was found for Friedman-Ball hypothesis, suggesting that by focusing on long-run price stability a lower inflation uncertainty can be achieved.

The two hypotheses were tested for Romania. There are several studies that found empirical evidence for Romania for the investigated hypothesis. From those studies, two are more extensive – Hasanov and Omay (2011), and Khan and Nenovsky (2012) – that investigated the causal relationships between the two variables for a sample of countries including Romania. For the first hypothesis, both papers found evidence to support Friedman-Ball hypothesis. For the second hypothesis, mixed results were obtained, given the fact that different econometric models and time periods were employed. Hasanov and Omay used a ccc-GARCH (1,1) model to estimate the uncertainty for a 2000-2007 data series, and found support for Holland hypothesis. Khan and Nenovsky used an E-GARCH (1,1) model for 2000-2011 data series and found no significant causal relationship to support the second hypothesis. Hence there are no evident patterns in the literature to support a certain type of causality for Romania for the second hypothesis.

3. ROMANIA'S ECONOMIC OVERVIEW

In order to assess the level of economic and social development in Romania, we registered the evolution of the most important macroeconomic indicators for the period 1990-2011, namely: *The growth rate of GDP (in %), Unemployment rate* (%), *Activity Rate (%), the Growth rate of the total income of main household categories* (lei, monthly per person), *Employment rate* (%) and *Inflation rate* (%).

After the processing of registered data, the following results were obtained:

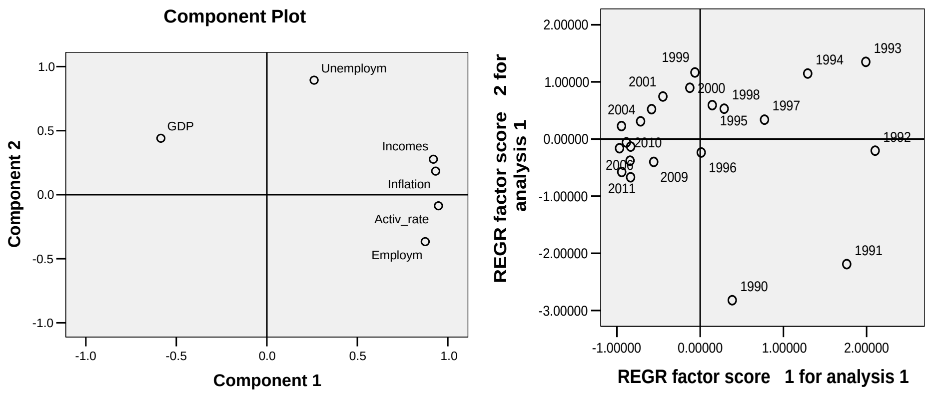

Figure 1. The main economic indicators registered in Romania during 1990-2011

As the figure above shows, the evolution of the main macroeconomic indicators presents two distinct periods: the period of the 90s, when the most significant reform measures of the economy were adopted and the period following the global economic and financial crisis, which started in 2008.

The measures adopted in the 90s in view of transforming the Romanian economy in a market economy have led to the significant decrease of the occupation rate and activity rate of population. The privatization of state companies in Romania and the lack of domestic capital which might ensure the development of the private sector have generated a drop in the occupation rate from 82%, in 1990, to 59.6%, in 2011. The activity rate has known the same decreasing trend.

The global economic and financial crisis in 2008 determined both the reduction of the GDP growth rate and the depreciation of the life standard. In 2009, Romania registered a decrease of 7.1% of the GDP, which followed an increase of 7.3% registered in 2008.

The inflationist phenomenon represented for Romania one of the main factors of instability of the economic environment. This phenomenon manifested since 1990, when the process of economic reform had started.

The evolution of the yearly inflation rate during 1990-2012 is represented in the figure below:

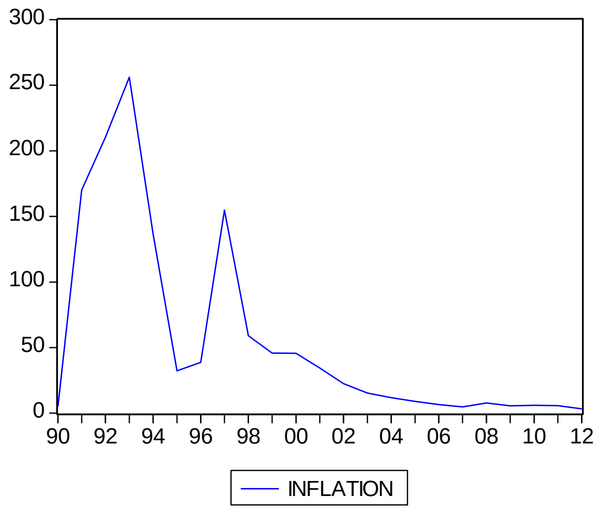

Figure 2. The dynamics of the yearly inflation rate in Romania during 1990-2012

The price liberalization, started in 1991, determined a significant increase in the consumption prices, the highest level being registered in 1993, when the consumption prices had a yearly average variation of 256.1%. A high value of inflation rate, of 154.8% was also registered in 1997, when the last stage of price liberalization took place. The inflation rate level has decreased after this year, reaching 3.33% in 2012.

Inflation is appreciated as a negative phenomenon, but the uncertainty generated by an inflationist environment is harmful as well for the insurance of the economic stability, through the effect of attracting foreign investments, essential for the Romanian economy in order to ensure the financing of the current account deficit. These evolutions caused that starting with 2005 the strategy of monetary policy of the National Bank of Romania should be represented by direct inflation targeting.

4. DATA AND METHODOLOGY

In our empirical analysis, for the inflation measuring, we consider the Consumer Price Index (CPI). The data source is represented by the International Financial Statistics (IFS), published by IMF, while the sample under consideration contains monthly data for the period October 1990 – December 2012 on the Consumer Price Index (CPI). For a precise and robust estimation of inflation (π), we measure it by the annualized monthly difference of the log CPI $[\pi_t = \ln(CPI_t/CPI_{t-1}) x1200]$.

As regards the inflation uncertainty, an impressive part of the literature proves that uncertainty can be estimated with good results, by means of the conditioned variance estimated through a heteroscedastic model, such as those of the ARCH-GARCH type.

Of this family of models, certain authors use simpler, easy to control and manipulate models, such as the GARCH model. Other authors use for the estimation of uncertainty models of the EGARCH type or more complex models such as GARCH in Mean.

The first step in the proposed analysis is to test the stationarity of the series that we take into consideration. If the stationarity hypothesis is not confirmed for one of the series, then the series must be stationarized through one of the known traditional procedures, such as the creation of the series of differences of order 1. In order to test the stationarity we use the ADF (Augmented Dickey-Fuller), Phillips-Perron and KPSS (Kwiatkowski-Phillips-Schmidt-Shin) tests.

The Dickey-Fuller test is performed for first order autoregressive variables and is based on the following general equation:

$Y_t = \mu + \gamma \cdot t + \cdot \rho Y_{t-1} + \varepsilon_t$ or, in a simpler formula:

$\Delta Y_t = \mu + \gamma \cdot t + \theta \cdot Y_{t-1} + \varepsilon_t$, where $\theta = \rho - 1$, and $\Delta Y_t = Y_t - Y_{t-1}$.

With this test we can verify the presence of a unit root. Using the t-Student test we can verify the following hypotheses:

$$H_0 : \theta = 0$$

$$H_1 : \theta \neq 0$$

If the test results show that the residuals are autocorrelated, the following model is used, which correspondes to the Augmented Dickey-Fuller test:

$$\Delta Y_t = \mu + \gamma \cdot t + \theta \cdot Y_{t-1} + \beta_1 \cdot \Delta Y_{t-1} + ... + \beta_n \cdot \Delta Y_{t-n} + u_t .$$

The decision regarding the unit root hypothesis is made based on the statistic test presented below:

$$t_\theta = \frac{\hat{\theta}}{\hat{\sigma}_{\hat{\theta}}} .$$

The Phillips-Perron (PP) test is a non-parametric method for testing the presence of the unit root, under the conditions of residual autocorrelation. The PP method is based on the Dickey-Fuller test's equation:

$$\Delta Y_t = \mu + \gamma \cdot t + \theta \cdot Y_{t-1} + \varepsilon_t .$$

The Phillips-Peron test modifies the t-ratio statistic of the θ coefficient so that the serial correlation does not affect the asymptotic distribution of the test statistic. The PP statistic test is based on the equation:

$$PP = t_\theta \sqrt{\frac{\hat{\gamma}_0}{\hat{\phi}_o}} - \frac{T\left(\hat{\phi}_0 - \hat{\gamma}_0\right)\hat{\sigma}_{\hat{\theta}}}{2\sqrt{\hat{\phi}_0} \cdot \hat{\sigma}'},$$

where t_θ is the t-ratio of θ from ADF test, $\hat{\sigma}'$ is the standard error of the regression coefficient, $\hat{\gamma}_0$ is a consistent estimator of the error variance in the above equation, where $\hat{\gamma}_0 = \frac{(T-k)\hat{\sigma}'^2}{T}$, and $\hat{\phi}_0$ is an estimator of the residual spectrum at frequency zero.

The Kwiatkowski, Phillips, Schmidt şi Shin (KPSS) test analyses the properties of the residuals from the regression equation of Y_t depending on the previous values entered into the system.

For the estimation of uncertainty we firstly estimate the inflation by means of an autoregressive model. A *p* order autoregressive model (AR(p)) is defined by the formula:

$$\left(1 - \alpha_1 L - \alpha_2 L^2 - ... - \alpha_p L^p\right)Y_t = \varepsilon_t ,$$

where the lag *L* is defined by the function $LY_t = Y_{t-1}$.

The choice of the most appropriate AR model will be performed through successive estimation of autoregressive models until the order 12. The choice of the most appropriate model is performed by means of the information criteria Akaike and Schwartz.

Once the autoregressive model is chosen, the identification of the optimum heteroscedastic model for the uncertainty estimation follows. Several authors, such as Fountas and Karanasos (2007) or Berument et al. (2005) propose the estimation of this uncertainty by means of a GARCH (1,1) type model.

We consider four heteroscedastic models for estimating uncertainty, namely: ARCH, GARCH, EGARCH and PARCH. The choice of the model used for estimating the conditional variance, which measures the inflation uncertainty, will be performed by means of the information criteria Akaike and Schwartz, the lowest absolute values offering the most appropriate model.

The ARCH model, introduced in 1982 by Engle, represents the starting point for many subsequent developments that we shall present in what follows. Unlike the previous models, the ARCH model does not rely on the past standard deviation, but on the conditional variances, noted with h_t ($\sigma_t^2 = h_t$).

In the ARCH process of order q, the conditional variance is of the form:

$$h_t = \varpi + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2$$

where $\omega > 0$ and $\alpha_j \geq 0$ to ensure the conditions that h_t should always be positive.

The GARCH model, introduced by Bollerslev in 1986, defines the conditional variance by the relation:

$$h_t = \alpha_0 + \sum_{i=1}^{p} \beta_i h_{t-i} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2$$

with the restriction that $\alpha_0 > 0$. We suppose that the coefficients α_i and β_i are all positive so that the conditional variance should always be positive.

The empirical studies have shown that in most cases, a simple model such as GARCH(1,1), which uses only three parameters in the equation of the conditional variance, is sufficient to model the data series (Hansen and Lunde, 2001). For more complex, high order models, the constraints are tougher and the modelling more complex; in this respect, a very thorough analysis was conducted by Nelson and Cao (1992).

The exponential GARCH model (EGARCH) was introduced in 1991 by Nelson. The *EGARCH* model presents the conditional variance under a logarithmic form, this implying a constraint for obtaining a positive variance:

$$\ln h_t = \alpha_0 + \sum_{j=1}^{q} \beta_j \ln h_{t-j} + \sum_{k=1}^{p} \left[\theta_k \xi_{t-k} + \gamma_k \left|\xi_{t-k}\right|\right], \text{ where } \xi_t = \frac{\varepsilon_t}{\sqrt{h_t}}.$$

In this model, h_t depends both on the value and the sign of ε_t. This approach allows the capture in the model of the fact that a negative shock determines a higher value of the conditional variance in the period following the shock, than in the case of a positive shock. The process is stationary covariant if and only if $\sum_{j=1}^{q} \beta_j < 1$.

Another development of the GARCH models has been done by Taylor (1986) and Schwert (1989), who introduced the standard deviation GARCH model, where the standard deviation is modelled rather than the variance. This model, along with several other models, was generalized by Ding in 1993 with the Power ARCH specification. In the Power ARCH model, the power parameter δ of the standard deviation can be estimated rather than imposed, and the optional γ parameters are added to capture asymmetry of up to order *r*:

$$\sigma_t^{\delta} = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^{\delta} + \sum_{i=1}^{p} \alpha \cdot \left(|\varepsilon_{t-1}| - \gamma_i \cdot \varepsilon_{t-i} \right)^{\delta}$$

The Bollerslev model sets $\delta = 2$, $\gamma = 0$, and the Taylor (1986) model sets $\delta = 1$ and $\gamma = 0$. Empirical estimates indicate the power term is sample dependent and values of near 1 are common in the case of stock data, while for foreign exchange data the power term varies between 1 and 2.

The measuring of the inflation uncertainty will be performed on the basis of this variable which results from the estimation of the best fitted heteroscedastic model for the variable CPI. To this end we use indicators built on information theory, namely Akaike Information Criterion (AIC), Schwartz Criterion (SC) şi Hannan-Quinn Criterion (HQC). These indicators operate on the principle of minimizing the number of model parameters and the variance of the model's errors. It is considered to be the best model, the model for which the values of the listed indicators are the lowest.

The information indicators are defined by the following relations:

$$AIC = T \log \sigma_{\varepsilon}^{2} + 2k \ ;$$

$$SC = T \log \sigma_{\varepsilon}^{2} + k \log T \ ;$$

$$HQC = T \log \sigma_{\varepsilon}^{2} + 2k \log(\log T),$$

where σ_{ε}^{2} is the variance of the model's errors;

T – the number of the observed values of the time series;

K –the number of parameters of the stochastic process model;

There are many cases when the three values don't indicate the same stochastic process model, in which case we privilege the Schwartz criterion.

Once the uncertainty is measured, a Granger causality test is undertaken. For that we considered two variables h_t and π_t, for which we can build variables with a certain lag (h_{t-1}, π_{t-1} etc.), where π_t determines h_t in Granger sense if and only if:

$$M(h_t / h_{t-1}, \pi_{t-1}) \neq M(h_t / h_{t-1}),$$

meaning that the past values of π_t are necessary for the prediction of h_t.

The result of the tests will highlight the type of correlation between the variables.

With the help of the VAR methodology the sign of the correlation is established, which is given by the sum of the coefficients for the variable inflation in the first hypothesis, and for the inflation uncertainty, for the second hypothesis. In this case, the VAR model is of the form:

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + ... + \alpha_m h_{t-m} + \beta_1 \pi_{t-1} + ... + \beta_m \pi_{t-m} + u_t$$
$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + ... + \gamma_m \pi_{t-m} + \lambda_1 h_{t-1} + ... + \lambda_m h_{t-m} + v_t ,$$

where m takes alternatively the values 4, 8 and 12.

5. EMPIRICAL RESULTS

The empirical study performed in the paper concerns the causality between inflation and inflation uncertainty in Romania. Before the presentation of results, in the first sub-section we will undertake a brief description of the variable under consideration, namely the Consumer Price Index (*CPI*).

In compliance with the strategy of monetary policy of the National Bank of Romania, represented by the direct inflation targeting and taking into account that for the period taken, the inflation evolution indicates for the first part of the period very high values (Figure 3), we believe that an appropriate approach would be the split of the initial data set in two sub-samples.

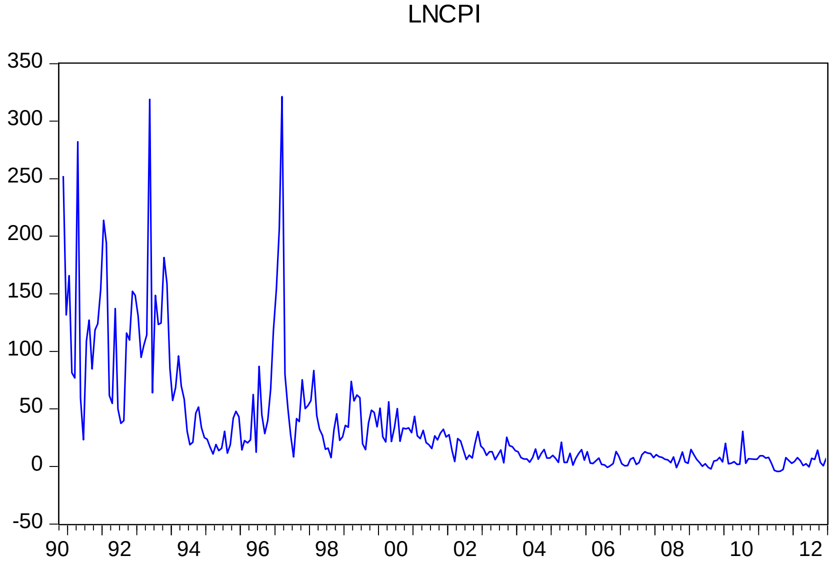

Figure 3. Dynamics of monthly inflation in Romania during 1990-2012

When choosing the point where the data series needs to be split in two parts, we took into consideration one of the priorities of monetary policy strategy of Romania. We proposed to determine the first month of the total period for which the inflation average for the last 12 months should be lower than 10. The first month when this condition was fulfilled was November 2004. The breaking point highlighted a level of steady-state inflation uncertainty which reflects the uncertainty when inflation is at its steady-state level and there are no shocks to the system (Caporale *et al*, 2010).

Taking into account this aspect, the analysis will focus on two data sub-samples. These are comprised by the period October 1990 – October 2004 and the period November 2004 – December 2012.

a. Testing for stationarity

As we presented in the previous section, in the first stage of the study we tested the stationarity of data series using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, for which the null hypothesis is the non-stationarity hypothesis and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, for which the null hypothesis is the stationarity one. The results of the statistical testing are presented in Table 2.

Table 2. Unit root tests

Sub-sample 1 October 1990 - October 2004			**Sub-sample 2 November 2004 – December 2012**		
ADF	PP	KPSS	ADF	PP	KPSS
-4.652	-6.775	1.123	-8.568	-8.604	0.213

Note: A constant and 12 lagged difference terms are used for the Augmented Dickey-Fuller test. The MacKinnon critical value for the rejection of the unit root null hypothesis at the 1% significance level is -3.45. The KPSS critical values for the rejection of the unit root null hypothesis at the 1%, 5% and 10% significance levels are 0.739, 0.463 and 0.347, respectively.

The applied tests highlight that the analyzed variable is stationary for the 2 sub-samples.

b. Modelling inflation

The next stage of the empirical study is the determination of the adequate autoregressive model for each period. The values of the Akaike and Schwarz informational criteria for each model are presented in table 3. On their basis we believe that for modelling the inflation rate for the period October 1990 – October 2004 the best fitted is the autoregressive model of order 10. In this model we considered only the variables with significant coefficients, meaning those of order 1, 2 and 10. The estimated equation of this model is presented below. The t-ratio values for coefficients are given in brackets.

$$\pi_t = \underset{(2.34)}{41.53} + \underset{(6.38)}{0.49}\,\pi_{t-1} + \underset{(2.26)}{0.17}\,\pi_{t-2} + \underset{(2.60)}{0.14}\,\pi_{t-10}\,.$$

Table 3. The values of Akaike (AIC) and Schwarz (SIC) information criteria for the tested autoregressive models

lag	October 1990 – October 2004		November 2004 – December 2012	
	AIC	SIC	AIC	SIC
1	10.44	10.47	6.21*	6.27*
2	10.40	10.45	6.23	6.31
3	10.38	10.46	6.24	6.35
4	10.38	10.48	6.26	6.39
5	10.38	10.50	6.26	6.42
6	10.27	10.40	6.22	6.40
7	10.23	10.38*	6.23	6.44
8	10.22	10.40	6.25	6.49
9	10.22	10.43	6.26	6.52
10	10.21*	10.43	6.28	6.57
11	10.22	10.45	6.30	6.61
12	10.23	10.48	6.32	6.66

This model meets the validation hypotheses and based on the estimated equation we shall determine the adequate heteroscedastic model for the estimation of the inflation uncertainty.

For the period November 2004 – December 2012, the information criteria designate the AR(1) model as being the best for the estimation of inflation rate. The equation used for modelling the inflation rate and the t-ratio values for coefficients, given in brackets, are:

$$\pi_t = \underset{(9.05)}{5.73} + \underset{(1.47)}{0.14}\,\pi_{t-1}$$

In what follows for each of the two equations, corresponding to the two periods, we will estimate heteroscedastic models in order to estimate the inflation uncertainty and to test the causality between inflation and its uncertainty.

c. Estimating the inflation uncertainty and the causality analysis

In this stage of the empirical study, we have built the four heteroscedastic models in order to estimate the conditional variances as measures for inflation uncertainty.

The results of the modelling for the first sub-sample are presented in table 4. The Akaike Informational Criteria and Schwarz Informational Criteria suggest that the most robust model for estimating inflation uncertainty is given by an EGARCH (1,1,1). The estimated equation and the t-ratio values are:

$$\ln h_t = \underset{(2.30)}{0.46} + \underset{(28.3)}{0.91}\ln h_{t-1} + \underset{(0.16)}{0.008}\left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \underset{(5.94)}{0.49}\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\,.$$

Table 4. Tested heteroscedastic models for the sub-sample October 1990 – October 2004

	ARCH(1)	GARCH(1,1)	EGARCH (1,1,1)	PGARCH (1,1,1)
Constant	197.94 (0.69)	9.41 (0.00)	24.34 (0.00)	1484.95 (0.99)
Lag 1	0.44 (0.00)	0.47 (0.00)	0.54 (0.00)	0.69 (0.00)
Lag 2	0.25 (0.00)	0.15 (0.54)	0.15 (0.10)	0.27 (0.00)
Lag 10	0.29 (0.00)	0.05 (0.00)	0.07 (0.00)	0.028 (0.47)
AIC	9.53	9.15	9.05*	9.21
SIC	9.65	9.28	9.21*	9.39
ARCH LM (1)	0.0064 (0.93)	0.1580 (0.69)	0.0094 (0.92)	1.98 (0.16)
ARCH LM (4)	0.29 (0.88)	0.39 (0.81)	0.20 (0.88)	0.83 (0.5)
R^2	0.48	0.44	0.50	0.44
Durbin Watson	1.78	1.71	2.02	2.16
Jarque-Bera	182.81 (0.00)	140.16 (0.00)	90.67 (0.00)	110.83 (0.00)

Note: The numbers in parentheses represent significance levels.
** denote the best fitted model.*

By means of the Granger test, we analyzed the endogeneity position of the variables inflation and inflation uncertainty. The result from table 5 allows us to ascertain that we do not have reasons to accept the hypothesis according to which inflation does not Granger cause inflation uncertainty. In other words, the endogenous variable is inflation uncertainty.

Table 5. Pairwise Granger Causality Tests

Null Hypothesis	**F-Statistic**	**Prob.**
Inflation does not Granger Cause Inflation Uncertainty	124.451	0.00
Inflation Uncertainty does not Granger Cause Inflation	0.709	0.49

For the period November 2004 – December 2012, the results of the estimation of the 4 types of heteroscedastic models are presented in the table below:

Table 6. Tested heteroscedastic models for the sub-sample November 2004 – December 2012

	ARCH(1)	GARCH(1,1)	EGARCH (1,1,1)	PGARCH (1,1,1)
Constant	5.79 (0.00)	5.17 (0.00)	6.61 (0.00)	5.64 (0.00)
Lag 1	0.16 (0.13)	0.12 (0.03)	-0.04 (0.71)	-0.08 (0.16)
AIC	6.25	6.07*	6.16	6.27
SIC	6.36	6.20*	6.32	6.45
ARCH LM (1)	0.00 (0.98)	0.50 (0.48)	0.19 (0.67)	0.03 (0.87)
ARCH LM (4)	0.35 (0.84)	0.74 (0.57)	0.84 (0.50)	0.35 (0.84)
R^2	0.02	0.01	0.04	0.03
DW	2.04	1.94	1.59	1.55
Jarque-Bera	129.99 (0.00)	3.27 (0.194)	20.04 (0.00)	50.63 (0.00)

Note: The numbers in parentheses represent significance levels.
** denote the best fitted model.*

Taking into consideration the condition that the results of the indicators of information criteria (Schwartz, Akaike) should have the lowest absolute values, we consider the GARCH (1,1) model as the most appropriate in the estimation of inflation uncertainty and it is validly estimated.

Following this estimation, we obtain the equation of the conditional variance that will measure the uncertainty for this period. The estimated equation and the t-ratio values are:

$$h_{\pi t} = \underset{(0.52)}{0.46} - \underset{(-4.32)}{0.08}\, \varepsilon^2_{\pi,t-1} + \underset{(20.95)}{1.09}\, h_{\pi,t-1}.$$

The result in table 7 allows ascertaining that for the period November 2004 – December 2012 the position of endogenous variable is occupied by inflation uncertainty.

Table 7. Pairwise Granger Causality Tests

Null Hypothesis	**F-Statistic**	**Prob.**
Inflation does not Granger Cause Inflation Uncertainty	45.92	0.00
Inflation Uncertainty does not Granger Cause Inflation	0.10	0.90

During the last stage of the empirical study we analyzed the direction of the relationship between the two variables by means of a VAR model. The results for the sign of the relationship between inflation and inflation uncertainty for 4, 8 and 12 lags are presented in table 8.

Table 8. The sign of the lagged coefficients of the causing variable

Sub-sample 1 Oct.1990 – Oct. 2004		**Sub-sample 2 Nov. 2004 – Dec. 2012**	
Lag	Sign	Lag	Sign
4	(+)	4	(-)
8	(+)	8	(-)
12	(+)	12	(-)

For both sub-samples of data we have consistent results for all lags. For the first sub-sample, which is defined by high inflation and high inflation uncertainty, the Friedman-Ball hypothesis is confirmed, i.e. increasing inflation generates more uncertainty about inflation. For the second sub-sample, defined by a steady-state inflation and inflation uncertainty, we found support for the Pourgerami and Maskus hypothesis, that the relationship between inflation and inflation uncertainty is negative. This result is consistent with the steady-state uncertainty which is specific for the second sub-sample.

6. CONCLUSIONS

Inflation is a phenomenon that affected the economies of the Central and Eastern European countries in the 90s. Of these countries, Romania has registered very high inflation rates that accentuated the uncertainty about future inflation.

In the present paper, we tested two hypotheses, first that *Inflation causes inflation uncertainty*, proposed by Friedman (1977), Ball (1992), Pourgerami and Maskus (1987) and Ungar and Zilberfarb (1993) and second that *Inflation uncertainty causes inflation,* proposed by Cukierman and Meltzer (1986) and Holland (1995). The *Consumer Price Index* registered in Romania during October 1990 – December 2012 was considered for measuring inflation. Given the established goals of the governmental authorities from the pre-adherence program to the European Union to reach an inflation level of below 10%, in the data processing we split the data series in two sub-samples. The first sub-sample comprises the values registered until October 2004, while the second sub-sample comprises the values registered for the period November 2004 – December 2012.

The empirical study conducted in the paper confirmed for the first data sub-series the Friedman's hypothesis, according to which inflation positively influences inflation uncertainty. For the second data sub-series, the empirical results confirmed the Pourgerami and Maskus' hypothesis (1987), according to which inflation negatively influences inflation uncertainty. The other tested causal relationships were not confirmed by the results obtained.

The results of the research highlight that in Romania the measures of economic reform adopted in the 90s and especially the price liberalization, have generated very high levels of inflation. On the other hand, the delay and inconsistency of the economic reform measures determined the extension of the inflation phenomenon on a long period of time as well as the increase in uncertainty about future inflation. This uncertainty was accentuated due to the recession period following the privatization measures of state companies and reform measures of the economic system until the end of the year 2004. The policymakers should have taken both measures to reduce inflation and measures to stimulate the economic growth. Given the spread of changes that needed implementation, it is not obvious which goal should take immediate priority. Moreover, the adopted measures and the efforts of economy stabilization bring forth their effects after a long span of time. The complexity of predicting how much and how quickly prices will respond to the adopted measures creates uncertainty about future inflation, even if the final aim was certain.

The negative influence of inflation upon inflation uncertainty was obtained for the data series after the year 2004, when certain price stability was reached. The decision of the National Bank of Romania to apply a new strategy of monetary policy – direct targeting of inflation, implemented in August 2005, has led to the reduction of uncertainty about future inflation. Nevertheless, this decision was mentioned for the first time as a major option of the Central Bank in 2001, in the Economic Programme of Pre-adherence to the European Union, but it was not put into practice sooner since the inflation rate had not reached a single-figure level. At the same time, the adherence criteria to the Euro zone, assimilated by the governmental authorities, imposed a sustainable disinflation in order to ensure a real EU convergence. The stability of the economic environment and the preoccupation of the Central Bank to reach an inflation rate level compatible with the one imposed by the Maastricht Treaty reduced the uncertainty about future inflation.

Our results are consistent with those of Kontonikas (2004), Fountas, Ioannidis and Karanasos (2004) and Caporale, Onorante and Paesani (2010), stating that an inflation-targeting monetary policy leads to a lower inflation uncertainty due to the long-lasting price stability.

No such extensive study was conducted for Romania, at this time, excepting this paper. As future research, we will attempt to study the causal relationships between inflation and its uncertainty on some other variables that can influence the economic policy decisions, such as the interest rate or the exchange rate. The monetary policy of a country with an emerging economy, such as that of Romania, may be affected by the decisions that must be adopted in order to ensure a real and nominal convergence with the European Union.

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