

# The Phillips Curve for the Romanian Economy, 1992-2017

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## Abstract

*The paper analyses the relationship between the unemployment rate and inflation, in Romania, during the 1992 – 1997 (March) period. For this purpose, we have estimated two econometric models, where the inflation trend has considered as a benchmark for inflation dynamics and the unemployment gap was built after applying the Hodrick-Prescott (HP) filter at unemployment rate. We have found that the unemployment gap had the greatest relevance in inflation model if we have taken a four months delay. The data support the hypothesis of a significant relationship between inflation and unemployment, with the shape described by the Phillips curve, namely the coefficients of unemployment gap were negative, econometrically significant and comparable as dimension in both models of inflation dynamics. We have calculated that the coefficient of unemployment gap is -0.344 in the Phillips curve model where the errors follow an ARMA(2, 2) process and -0.386 in the model which includes the inflation inertia.*

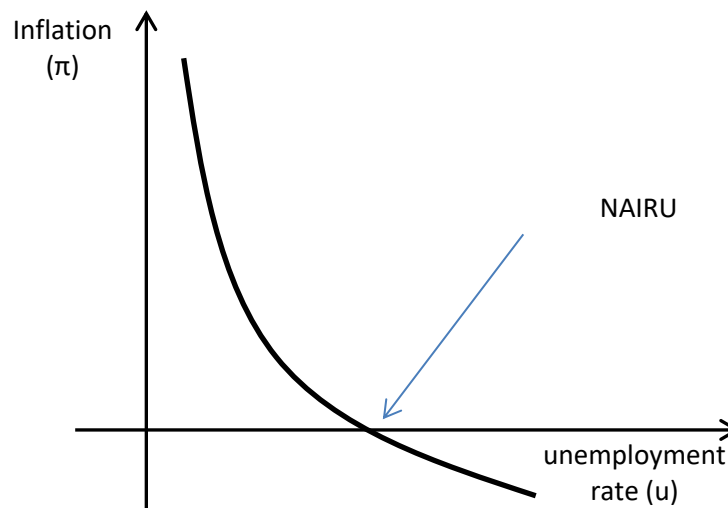
**Keywords:** *Phillips curve, inflation, unemployment, Romanian economy.*

*JEL Classification:* C22, E31, J63

## 1. Introduction

In the literature, is called "Phillips curve" the inverse relationship between inflation and unemployment rate, in the sense that an increase in unemployment is associated with a reduction in inflation and vice versa.

Figure 1. Phillips curve



Starting with the 1958 Phillips seminal work (Phillips, 1958), there is a vast literature that analyses the relationship between inflation and unemployment (in his pioneering paper, Phillips analysed the relation between unemployment and the rate of change of money wage rates). We do not propose a review of the literature. We will present only a few of the analysis regarding the Romanian economy, released over the past 10 years.

On this line, Ciurilă and Murarușu (2008) estimated a reduced form of New Keynesian Phillips Curve in order to identify the main factors which drive inflation in Romania. In addition to other factors (such as the output gap, the unit labour cost, the capacity utilization rate, the economic sentiment indicator), they found that the unemployment rate was a significant factor in the dynamics of inflation. They used as exogenous variables in Phillips curve equation the inflation inertia, forward-looking expectations for inflation, respectively unemployment rate (as a *proxy* for real marginal cost). The coefficients of inertia and of inflation expectation

were positive, while the unemployment coefficient was a negative one (- 0.731). As dimension, this value is comparable to the one obtained by Iordache, Militaru and Pandioniu (2016). By analysing a period who stretch on 36 months (2006 – 2008), Diaconescu (2009) detected a trade-off between inflation and unemployment no more than at the end of 2006 and the beginning of 2007 (p. 256). Balaban and Vîntu (2010) analysed quarterly data from 2000 to 2009 and developed a Phillips curve model (through a relationship between inflation and output gap) with backward-looking component (distributed lag on past inflation). They found a nonlinear Phillips curve in Romania (the influence of the output gap on inflation is in the quadratic form) and a strong inertial tendency of prices.

Săman and Păuna (2013) estimate the New Keynesian Phillips curve in the case of Romanian economy and found that "there are still rigidities present in the labour so that unemployment instantly reacts to the changes in output" and that "an increase in inflation is accompanied by a positive output gap" (p. 170). By mean of a simple linear regression model between consumer price index and unemployment rate, Ciupac-Ulici and Beju (2014) found for Romania that, over the period 1998-2013 (May), an increase in consumer price index was caused a decrease in unemployment rate (as well as in the Czech Republic, Poland and Slovakia). Simionescu (2014) tested a Phillips Curve for Romania (1990-2013) and found that there is a negative relation between inflation and unemployment rate in the short run and that Phillips curve is not valid for Romania on the long run (pp. 67, 72 ). The same, Herman (2010) was not identified a stable, statistically significant relationship between inflation and unemployment rate, in Romania, in the long run (1990-2009).

Tong (2014) was filtered the monthly series of the unemployment rate and inflation into business-cycles frequency (18 to 60 months) and then calculated the Pearson's correlations between these variables. He found significant negative correlations in most of the EU-member states. For Romania, the coefficient of correlation was -0.3388 (Jan. 1997 – Oct. 2013). Also, Tong calculated the Pearson's Correlations between inflation and unemployment gap (determined by the difference between the real unemployment rate and the NAIRU) and found for Romania -0.6631 (2000Q1 – 2014Q1). Iordache, Militaru and Pandioniu (2016) analysed a triangular model (in which inflation depends on its lags and both on demand-side and supply-side factors) by using quarterly data. The data covering the 2004-2014 (Q2) period revealed a relationship between inflation and unemployment (the unemployment coefficient in Phillips curve was at around -0.7), but the model used by the authors "shows that the intensity of the relationship between inflation and cyclical unemployment changes over time", with a "possible reduction in the slope of the Phillips curve starting 2007, with a more pronounced decrease occurring after 2010". (p.28-29). According to an International Monetary Fund paper (2016), "A one standard deviation change in unemployment gap leads to a 0.9 standard deviation change in headline inflation. It explains more than 10 percent of variations in headline inflation during the sample period" (p. 7). The unemployment gap coefficient in consumer price index equation is -5.05, if OLS was selected for estimating the regression and -7.18 for 2 stage OLS (the analysed period was 2003, December - 2015, September). The unemployment gap is derived using the HP filter.

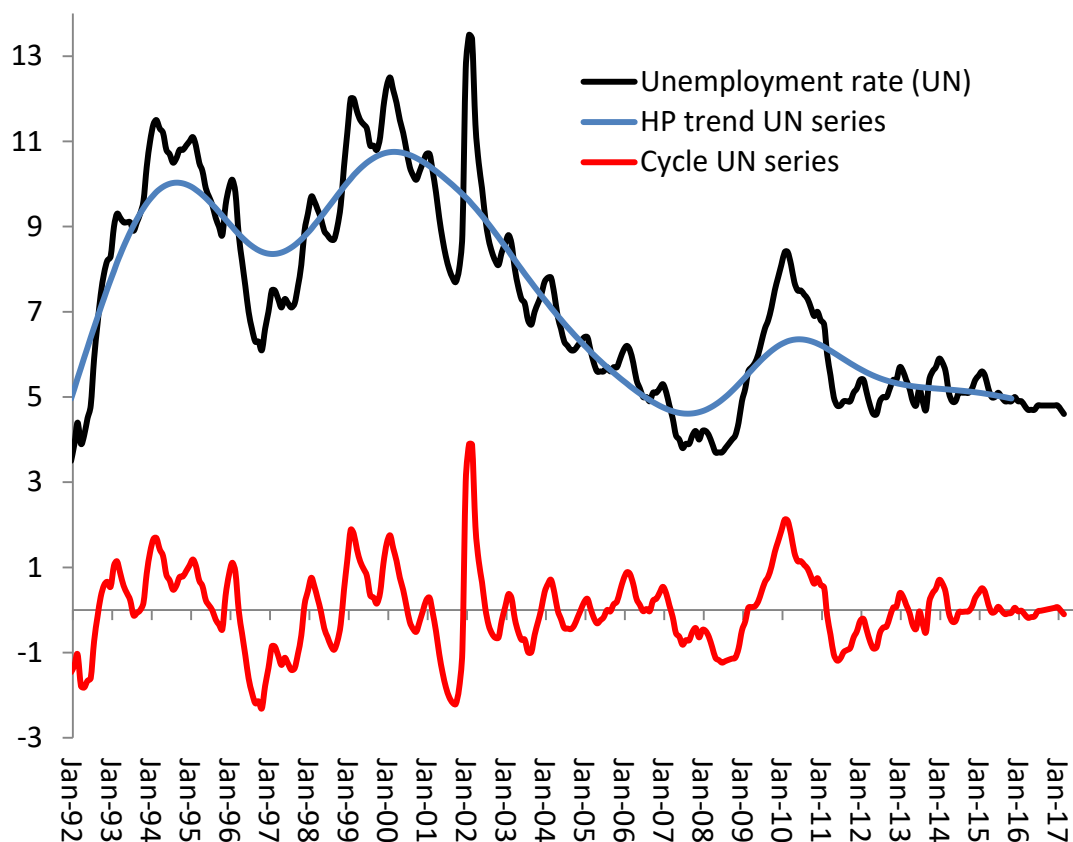
In this paper, we analyse the relationship between the unemployment rate and inflation, from Romania, during the period 1992-2017(March).

## 2. Data

### 2.1. The unemployment rate

The data on the unemployment rate are from the National Institute of Statistics, TEMPO-Online database (SOM103B - The unemployment rate registered at the end of the month, <http://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=SOM103B>. The analysed period is January 1992 – March 2017.

Figure 2. Unemployment rate, Hodrick-Prescott trend and cycle, 1992 – 2017 (March)



Source: For the *unemployment rate*: National Institute of Statistics, TEMPO-Online database, table SOM103B - Unemployment rate registered at the end of the month, <http://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=SOM103B>

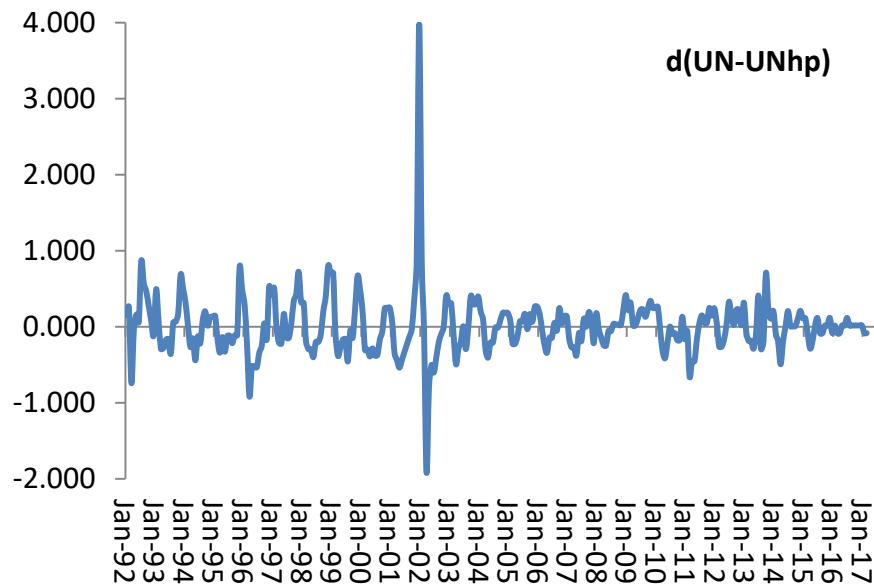
For *unemployment trend*: Hodrick-Prescott filter (own calculations). *Unemployment Cycle* = Unemployment rate – Unemployment trend (own calculations). Hodrick-Prescott filter are calculated for  $\lambda$  (smoothing parameter value) equal to 14400.

According to the unit root tests (Augmented Dickey-Fuller and Phillips-Perron), the unemployment rate, for the period from 1992 to 2017 (March), present stationary shocks around a deterministic trend (Annex 1).

To estimate the unemployment trend and the cycle, we use the Hodrick-Prescott (HP) filter (Figure 2). The cycle of the unemployment rate is stationary. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests do not support the null hypothesis (presence of a root unit) at a standard level of significance and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test does not reject the stationary hypothesis. The probability of the null hypothesis (cycle of the unemployment rate has a unit root) is 0.01% for Phillips-Perron test and is less than 0.01% for ADF test, while the probability of null hypothesis of stationarity for Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is less than 0.01%.

The data on unemployment rate shows outliers (with large differences in the trend) in early 2002, due to methodological changes in the calculation of unemployment. Differences between two successive values of the unemployment rate deviation from trend are shown in Figure 3. As we can see in the figure, the volatility of the series is higher in the first 10 years and a half (before June 2002) and lesser for the rest of time.

Figure 3. Differences between two successive values of the unemployment rate deviation from trend



Source: The same as the previous figure.

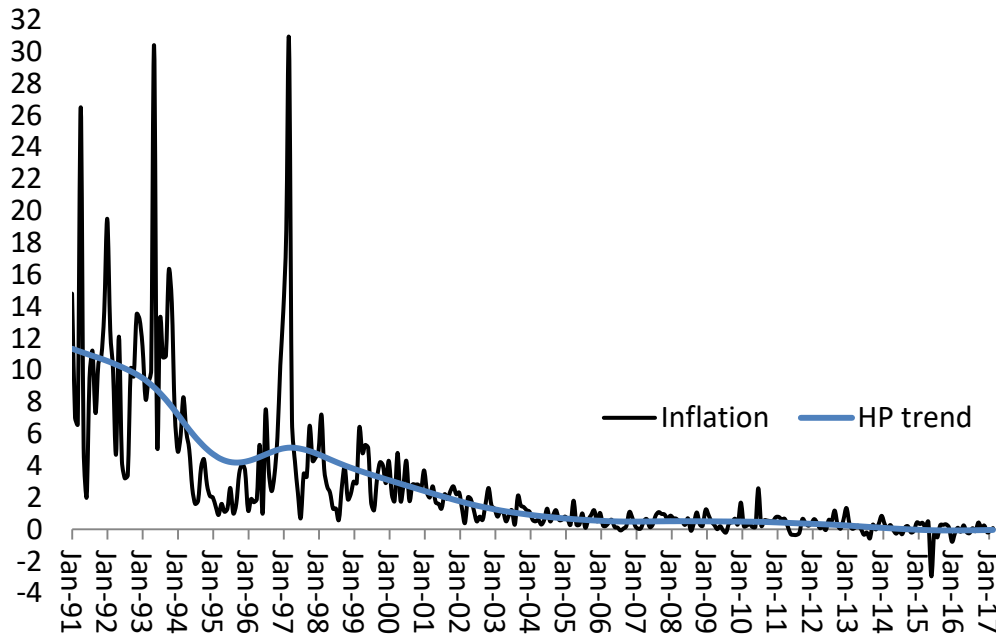
## 2.2. The inflation

The data on the *inflation* are from the National Institute of Statistics, TEMPO-Online database, table IPC102A – Consumer price indices - monthly evolution as against previous month (<http://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=IPC102A>). The analysed period is January 1991 – March 2017. Inflation was calculated as follows:

Inflation = Consumer Price Indices – 100.

Just as we did for the previous series, we used the Hodrick-Prescott (HP) filter to estimate the trend. The data are shown in figure 4.

Figure 4. Inflation and the Hodrick-Prescott trend, 1991 – 2017 (March)

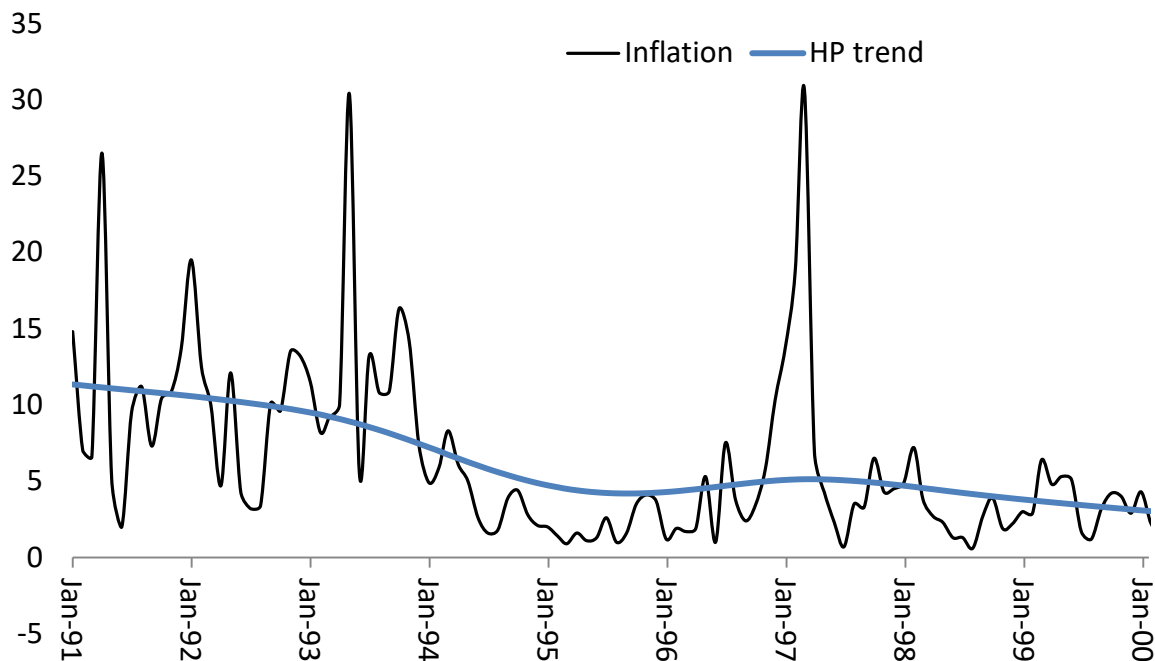


Source: For the *Inflation*: National Institute of Statistics, TEMPO-Online database, table IPC102A – Consumer price indices - monthly evolution as against previous month (<http://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=IPC102A>). Inflation was calculated as follows: Inflation = Consumer Price Indices – 100. For *Inflation trend*: Hodrick-Prescott filter (own calculations). Hodrick-Prescott filter was calculated for  $\lambda$  (smoothing parameter value) equal to 14400.

Inflation in Romania has recorded a downward trend, with a higher volatility between 1990 and 1997. The dynamics of the consumer price index is shown in Figures 5 and 6, separately for the period 1990-1999 and 2000-2017 (March).

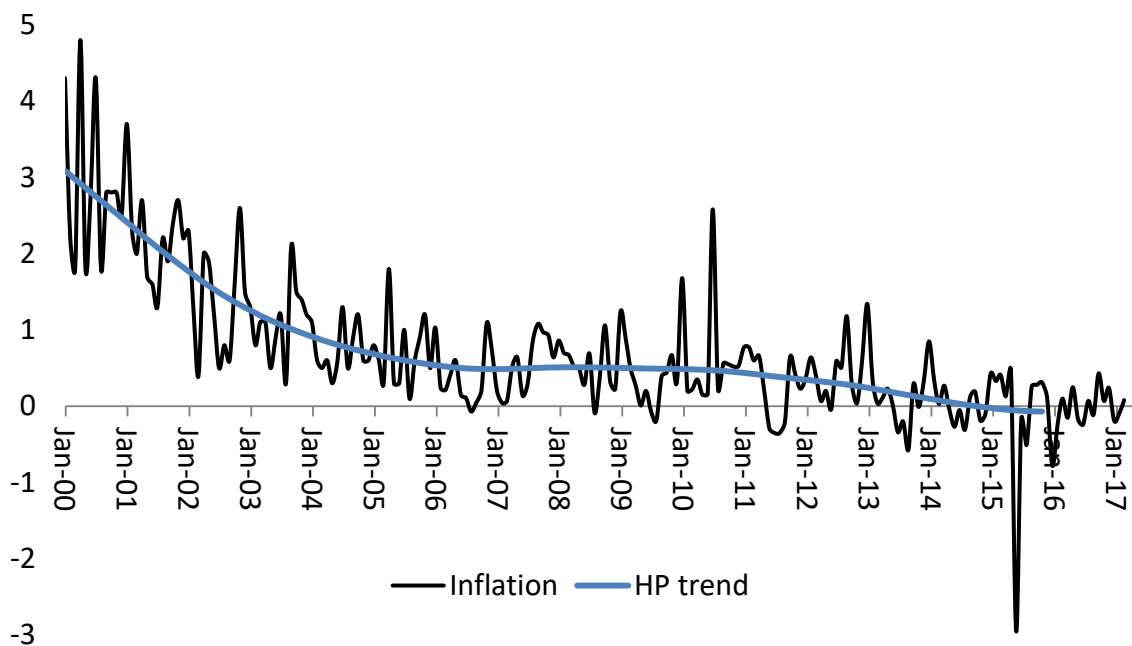
According to the unit root tests (Augmented Dickey-Fuller, Phillips-Perron, Elliott-Rothenberg-Stock Point Optimal, Elliott-Rothenberg-Stock DF-GLS, Ng-Perron, not and according to the KPSS test), the inflation, for the period from 1991 to 2017 (March), is stationary. Details are given in Annex 2.

Figure 5. Inflation, 1990 – 1999



Source: An extract from the dynamics presented in Figure 4 (1991-1999 period).

Figure 6. Inflation, 2000 – 2017 (March)

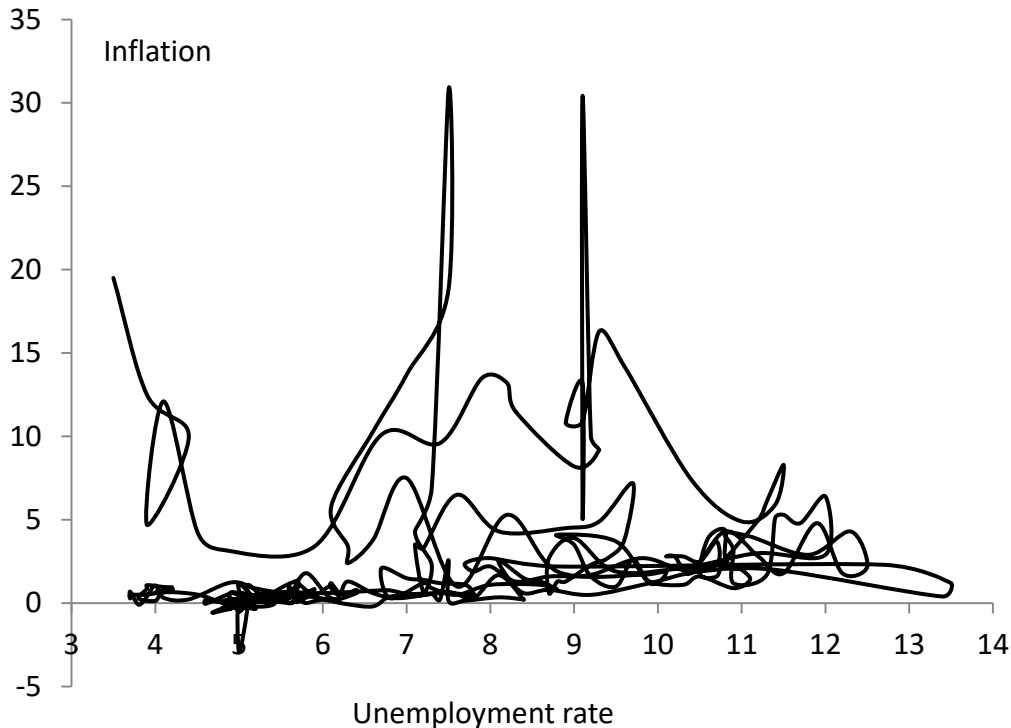


Source: An extract from the dynamics presented in Figure 4 (2000-2017 period)

### 3. The relationship between unemployment and inflation

The direct graphic representation of inflation in respect with the unemployment rate does not suggest an analytical form of the link between the two variables (Figure 7).

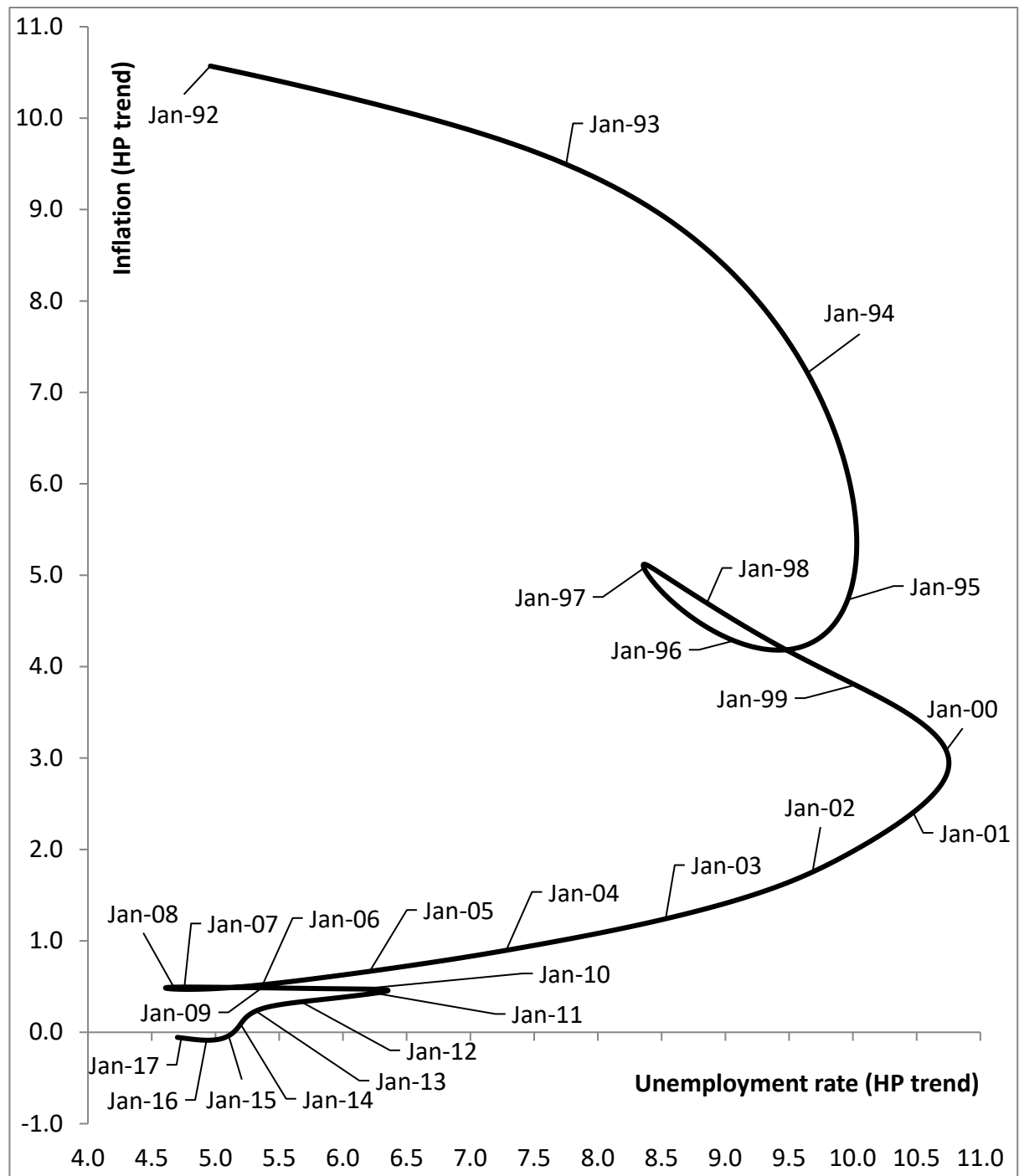
Figure 7. The relationship between unemployment and inflation



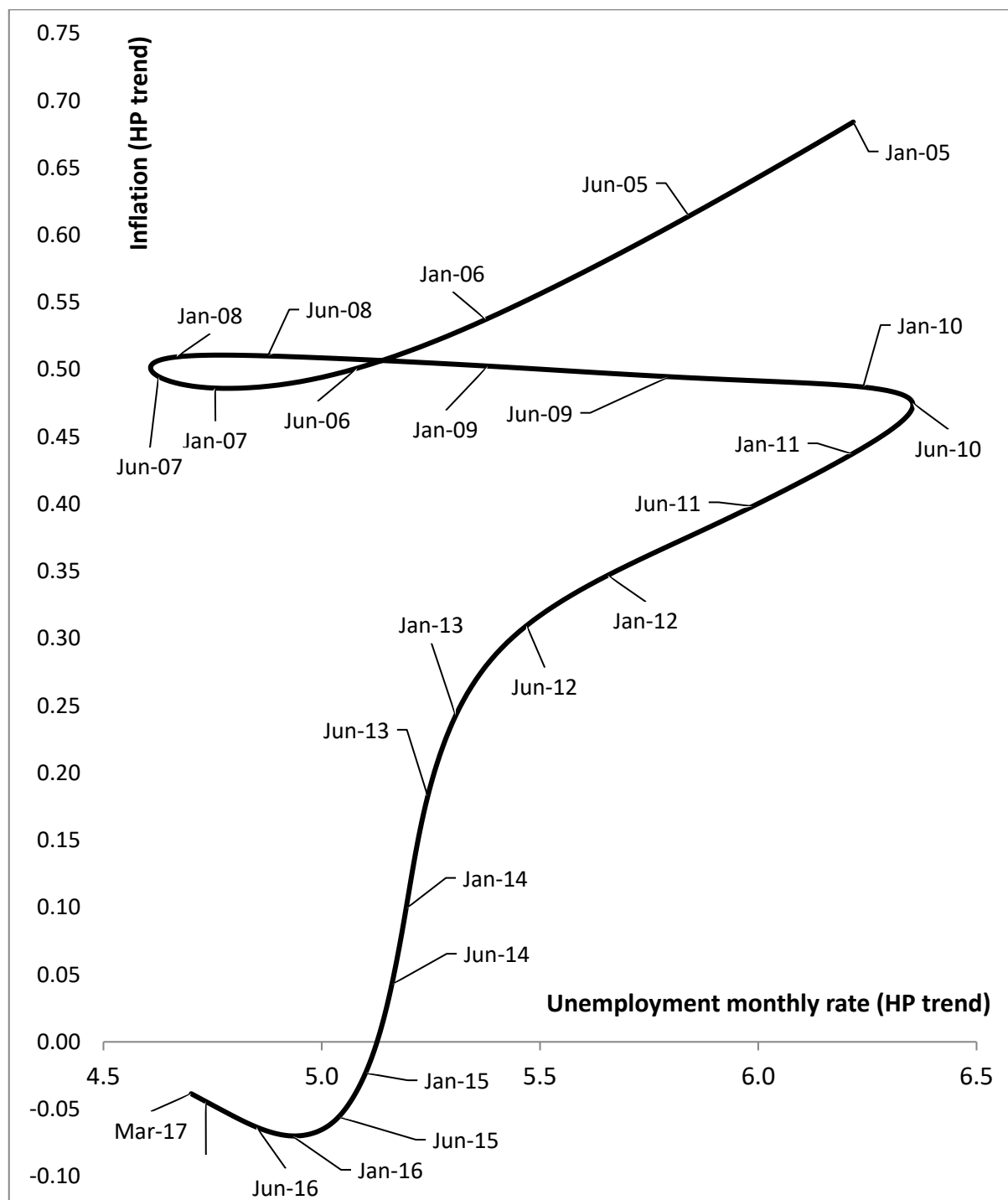
Source: National Institute of Statistics, TEMPO-Online database, tables IPC102A (Consumer price indices - monthly evolution as against previous month) and SOM103B (The unemployment rate registered at the end of the month).

Instead, there is a bifurcation relationship between the trends of the two variables, trends calculated using the Hodrick - Prescott filter. This relationship is shown in Figure 8 and a detailed graphic, for 2005-2017 (March), is shown in Figure 9.

In their neo-classical form, the Phillips curve analyses the relationship between deviations from the normal level of the two variables (inflation and unemployment rate). Figure 10 shows the relationship between the deviation of the inflation from the anticipated (Hodrick-Prescott) level and the deviation of the unemployment rate from the trend (likewise, calculated through the HP filter). There is a negative relationship between the two variables, as predicted by Phillips's theory.

Figure 8. HP-trend of the *Inflation* in relation to the HP-trend of the *Unemployment rate* (monthly data, 1992-2017, March)

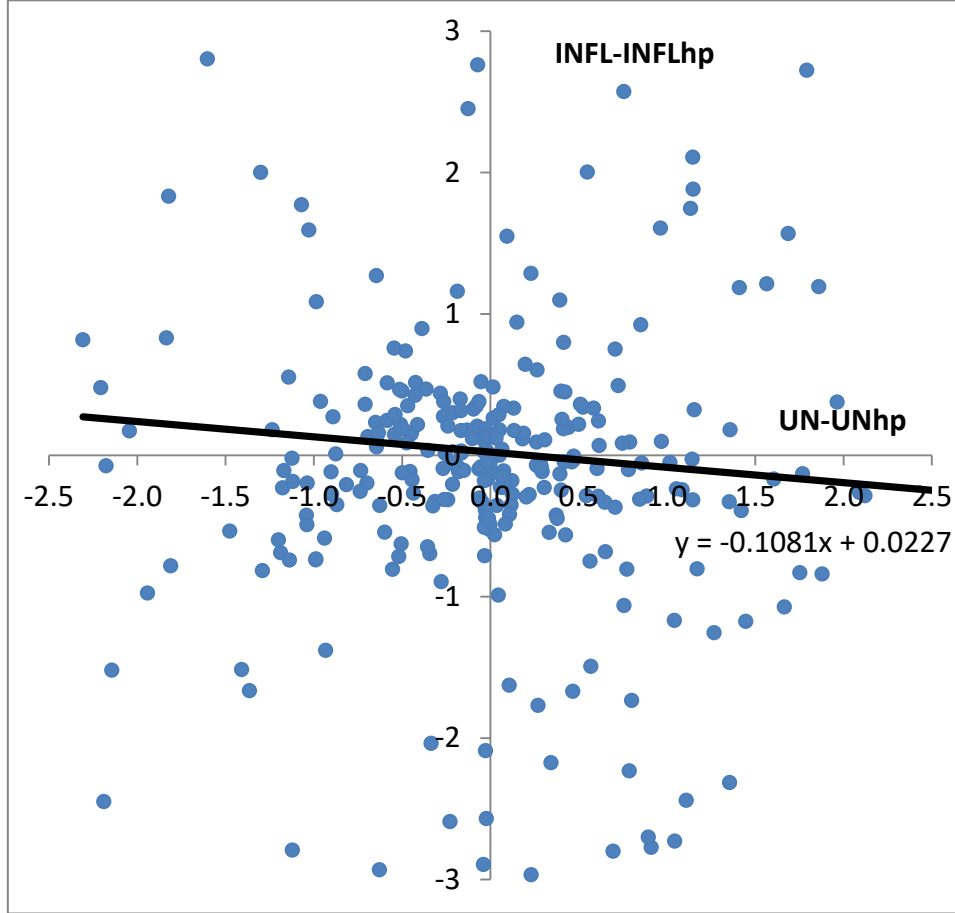
Source: Own calculations by using *TEMPO-Online Time series* database from National Institute of Statistics, table IPC102A (Consumer price indices - monthly evolution as against previous month) and SOM103B (Unemployment rate by gender, macroregions, development regions and counties, at the end of the month). Hodrick-Prescott filter was calculated for  $\lambda$  (smoothing parameter value) equal to 14400.

Figure 9. HP-trend of the *Inflation* in relation to the HP-trend of the *Unemployment rate* – detailed graphic (monthly data, 2005-2017, March)

Source: An extract from the dynamics presented in Figure 1 (1995-2017 period)



Figure 10. The relationship between the deviations of Inflation and Unemployment rate from their trends



#### 4. Econometric model

The previous figure suggests a weak relationship between inflation and unemployment, a relationship which is, as sign, in line with the theoretical expectation. To analyse the link between inflation and the unemployment rate we used, as a first approach, the standard model described by the neo-classical version of the Phillips curve:

$$\pi_t = \pi_t^e - \beta(u_t - u_t^e) + v_t.$$

where  $\pi_t$  is the inflation at the month  $t$ ,  $u_t$  is the unemployment rate at the month  $t$ ,  $\pi_t^e$  symbolises the expected inflation,  $u_t^e$  represents the expected rate of unemployment (natural rate of unemployment - NAIRU) and  $v$  estimates the random innovations in supply. Concretely, we have estimated the inflation by the relationship  $INFL_t = CPI_t - 100$ , where  $CPI$  is consumer price index.

The trend of inflation ( $INFL_{hp}$ ) was calculated by applying the HP filter on  $INFL$  variable and, the same, for expected unemployment we have HP-filtered the unemployment rate. So, the econometric model is:

$$INFL_t - INFL_{hp,t} = a_0 + a_1 \cdot (UN_{t-4} - UN_{hp,t-4}) + v_t,$$

where the innovations  $v_t$  was defined as an ARMA process. Also, we included in the model two DUMMY variables (for May, 1993<sup>1</sup>, symbolised by  $D_{93M05}$  and March, 1997<sup>2</sup>, symbolised by  $D_{97M03}$ ). The unemployment

<sup>1</sup> Government Decision No. 206 of May 7, 1993 on measures to further liberalization of prices and tariffs.

<sup>2</sup> Inflation induced by the strong rise in the leu / dollar exchange rate

gap has the greatest relevance in inflation model if we take a four months delay. In these circumstances, the model is:

$$\text{INFL}_t = a_0 + a_1 \cdot (\text{UN}_{t-4} - \text{UNhp}_{t-4}) + a_2 \cdot \text{INFLhp}_t + a_3 \cdot D_{1993M05} + a_4 \cdot D_{1997M03} + e_t$$

where  $e_t$  is ARMA(2,2)

If a Phillips relationship exists, between the unemployment and inflation, then the coefficient  $a_1$  is significant and negative. We have dropped the constant term from the model because this coefficient is not econometrically significant. The results of the model are the following:

$$\begin{aligned} \text{INFL}_t - \text{INFLhp}_t = & -0.344 \cdot (\text{UN}_{t-4} - \text{UNhp}_{t-4}) + 21.983 \cdot D_{93M05} + 18.072 \cdot D_{97M03} + e_t, \\ (1 + 1.102 \cdot L - 0.567 \cdot L^5) \cdot e_t = & (1 - 0.494 \cdot L + 0.382 \cdot L^2) \cdot \varepsilon_t \end{aligned}$$

All the coefficients are significant at standard level (2.3% for  $a_1$  and less than 1% for everyone else), the ARMA process is stationary and invertible. The results are detailed in Annex 3. The coefficient of unemployment gap ( $\hat{a}_1 = -0.344$ ) is significant and with the expected sign if we consider this gap with a 4-lag. Under the shown circumstances, the results do not reject the hypothesis of a relationship between inflation and unemployment, with the shape described by the Phillips curve. But, the main problem of this specification of Phillips curve is that the ARMA terms control only for serial correlation, while the errors remain heteroskedastic. In the presence of heteroskedasticity, the estimators are still unbiased and consistent, but the estimators lose the efficiency so that the t-statistics are misleading (Jula & Jula, 2017, pp. 202-236).

In a second approach, we have included in the model the inflation inertia, which derives from "assumptions of adaptive expectations and price rigidities in general" (Iordache, Militaru, & Pandioniu, 2016, p. 15). We have kept, as a benchmark, the expected inflation (INFLhp). As in the previous model, we have dropped the constant term, because this coefficient is not econometrically significant. And, likewise, the unemployment gap has the greatest relevance if we take a four months delay. Therefore, the model is:

$$\text{INFL}_t = a_1 \cdot \text{INFL}_{t-1} + a_2 \cdot (\text{UN}_{t-4} - \text{UNhp}_{t-4}) + a_3 \cdot \text{INFLhp}_t + e_t.$$

We used White version of least squares method, in order to control for heteroskedasticity. The results are the following:

$$\text{INFL}_t = 0.393 \cdot \text{INFL}_{t-1} - 0.386 \cdot (\text{UN}_{t-4} - \text{UNhp}_{t-4}) + 0.626 \cdot \text{INFLhp}_t + v_t,$$

where  $v_t$  is the residual variable. All the coefficients are significant at standard level: 3.9% is in the right-hand tail area for (negative)  $a_2$  coefficient under the null hypothesis, 2.8% is in the left-hand tail area for (positive)  $a_1$  coefficient, and less than 1% for (positive)  $a_3$  coefficient). The errors are not serial correlated, at least until the lag 12 (Breusch-Godfrey Serial Correlation LM Test) and the White method allows to obtain heteroskedasticity-consistent estimates of the error variances and the corresponding robust t-statistics. The results are detailed in Annex 4.

The coefficient of unemployment gap ( $\hat{a}_2 = -0.386$ ) is significant and with the expected sign if we included this variable with a delay of four months. As in the first model, the results do not reject the hypothesis of a relationship between inflation and unemployment, with the shape described by the Phillips curve. The unemployment gap coefficient is comparable with the one detected in the first model.

## Conclusion

The purpose of our study was the analysis of the relationship between the unemployment rate and the inflation so that we have looking firstly on the significance of the coefficient that evaluates the linkage between the two variables. We found that the econometric analysis of unemployment rate and inflation, in Romania, during the period between 1992 and 1997 (March) do not reject the assumption that the relationships between these variables show a shape like the one described by the Phillips curve theory.

In a first model, we started from the hypotheses that the trend of inflation can be obtained through applying the HP filter on that variable and, the same, for unemployment trend (as estimating benchmark unemployment)

we had filtered (HP) the unemployment rate. The unemployment gap was calculated as a difference between the registered unemployment rate and their trend. In the second model, we adopt the assumption of an inflation inertia (the assumption of adaptive expectations) and keep the inflation trend as a benchmark for inflation dynamics. In both models, the unemployment gap has the greatest relevance in inflation model if we take a four months delay. The data support the hypothesis of a relationship between inflation and unemployment, with the shape described by the Phillips curve, and the coefficients of the unemployment gap are both negatives and econometrically significant. They are comparable (as a dimension) between the two specifications of the Phillips curve model: the coefficient of unemployment gap is -0.344 in the model where the errors follow an ARMA(2, 2) process and -0.386 in the model which includes the inflation inertia.

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## Annexes

### Annex 1. Unit Root Tests on Unemployment Rate

<i>Unit Root Test</i>	<i>Null Hypothesis</i>	<i>Test statistic</i>	<i>Critical value (5% level)</i>	<i>Decision</i>
Augmented Dickey-Fuller	unit root	-4.315	-3.989	I(0)
Phillips-Perron	unit root	-3.821	-3.425	I(0)
Kwiatkowski-Phillips-Schmidt-Shin	stationarity	0.138	0.146	I(0)

Note: The unit root tests were applied through test equations which include the constant and the trend (linear), as exogenous.

The t-statistic test values are below the 5% standard level for both tests (for the ADF, it is lower than the significance threshold of 1%, namely 0.34% and for PP test, it is 1.67%). This means that we do not accept the unit root hypothesis for the analysed series. For robustness, we also calculated the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for stationarity. The result confirms the above conclusion: we do not reject the

hypothesis of stationarity for unemployment series, if we include both the constant and the linear trend in the test equation.

## Annex 2. Unit Root Tests on Inflation

Unit Root Test		Null Hypothesis	Test statistic	Critical value (1% level)	Decision
Augmented Dickey-Fuller		unit root	-7.337	-3.988	I(0)
Phillips-Perron		unit root	-11.478	-3.988	I(0)
Kwiatkowski-Phillips-Schmidt-Shin		stationarity	0.287	0.216	I(1)
Elliott-Rothenberg-Stock DF-GLS		unit root	-4.736	-3.471	I(0)
Elliott-Rothenberg-Stock Point Optimal		unit root	2.446	3.998	I(0)
Ng-Perron	MZa	unit root	-38.801	-23.800	I(0)
	MZt	unit root	-4.380	-3.420	I(0)
	MSB	unit root	0.113	0.143	I(0)
	MPT	unit root	2.485	4.030	I(0)

Note: The unit root tests were applied through test equations which include the constant and the trend (linear), as exogenous.

Except for the KPSS test, all other tests reject the unit root hypothesis (the t-statistic test values are below the 1% standard level for these tests). This means that we do not accept the unit root hypothesis for the analysed series. The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test does not confirm the above conclusion, namely, if we reject the hypothesis of stationarity for inflation series, then the error is less than 1%. As consequently, we have also turned to other unit root tests: the value calculated for Elliott-Rothenberg-Stock Point Optimal (ERS) test statistic was 2.446 (in the model with linear trend), below the critical value for 1% level (3.998). Accordingly, we reject the unit root. The same, for Elliott-Rothenberg-Stock DF-GLS test statistic, the calculated value was -4.736, below the critical one (-3.471 for 1% level). Moreover, all the Ng-Perron test statistics were below the critical values, at 1% level of significance. Therefore, we reject the hypothesis of unit root for the inflation series, between 1991 and 2007 (March).

## Annex 3: Phillips curve for Romanian unemployment gap and inflation, ARMA model

Dependent Variable: INFL-INFL\_HP

Method: ARMA Maximum Likelihood (OPG - BHHH)

Sample: 1992M05 2017M03

Included observations: 299

Convergence achieved after 101 iterations

Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UN(-4)-UNhp(-4)	-0.344375	0.150543	-2.287557	0.0229
@ISPERIOD("1993m5")	21.98274	0.877071	25.06381	0.0000
@ISPERIOD("1997m3")	18.07199	1.187510	15.21839	0.0000
AR(1)	1.102433	0.117267	9.401058	0.0000
AR(2)	-0.567298	0.077053	-7.362399	0.0000
MA(1)	-0.494377	0.115156	-4.293097	0.0000
MA(2)	0.381584	0.074070	5.151688	0.0000
SIGMASQ	2.015087	0.085874	23.46556	0.0000
R-squared	0.714718	Mean dependent var		0.006703
Adjusted R-squared	0.707856	S.D. dependent var		2.662181

S.E. of regression	1.438918	Akaike info criterion	3.594485
Sum squared resid	602.5110	Schwarz criterion	3.693493
Log likelihood	-529.3754	Hannan-Quinn criter.	3.634112
Durbin-Watson stat	1.951427		
Inverted AR Roots	.55-.51i	.55+.51i	
Inverted MA Roots	.25+.57i	.25-.57i	

#### Annex 4. Phillips curve model with inflation inertia

Dependent Variable: INFL

Method: Least Squares

Sample (adjusted): 1992M05 2017M03

Included observations: 299 after adjustments

White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFL(-1)	0.392785	0.204721	1.918633	0.0560
UN(-4)-UNhp(-4)	-0.386079	0.217937	-1.771517	0.0775
INFL_HP	0.625992	0.185253	3.379120	0.0008
R-squared	0.609954	Mean dependent var	2.218763	
Adjusted R-squared	0.607319	S.D. dependent var	3.840121	
S.E. of regression	2.406384	Akaike info criterion	4.604110	
Sum squared resid	1714.042	Schwarz criterion	4.641238	
Log likelihood	-685.3144	Hannan-Quinn criter.	4.618970	
Durbin-Watson stat	2.086681			

Breusch-Godfrey Serial Correlation LM Test:  $20.717 < 21.026 = \chi^2(0.05; 12)$