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Testing the Nonlinearity of the Phillips Curve. Implications for Monetary Policy

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Abstract. *This paper studies the nonlinearity of the Phillips Curve and its implications for monetary policy. To investigate the trade-off between output gap and inflation volatility we used a backward-looking model type. The data for our empirical analysis is obtained from the Area Wide Model (AWM) Database (from 1970 to 2008 for Euro area) and National Institute of Statistics (from 2000 to 2009 for Romania) and has quarterly frequency. The results of econometric tests indicate a significant estimated coefficient of the output gap for Romania, compared with the Eurozone; we find no significant evidence of nonlinearity of the Phillips curve in the European Monetary Union. This suggests that the optimal choice for European Central Bank should be a fixed inflation targeting, while the National Bank of Romania's monetary policy strategy should aim a flexible inflation targeting.*

Keywords: monetary policy; Phillips curve; output gap; inflation; nonlinearity.

JEL Codes: E52, E58, C22.
REL Codes: 8J, 8Z.

1. Introduction

It has been of great importance to macroeconomic policy makers identifying the Phillips curve, which posits a negative relationship between inflation and unemployment. As unemployment is countercyclical, the relationship between inflation and the output gap becomes positive. The Phillips curve helps the policymakers decide on policy with inflation and output. Hence, the estimation of the Phillips curve has been applied to economies like the US, Australia, the UK, Turkey, and China, in recent years. Rumler (2005) has estimated the new Keynesian Phillips curve (NKPC) for nine euro-area countries: Austria, Belgium, Finland, France, Germany, Greece, Italy, Spain, and the Netherlands.

Our purpose in this paper is to investigate the nonlinearity of the Phillips Curve in the Euro Area and Romania and its implications for monetary policy. Empirically, nonlinearity tests have a major implication for knowledge of monetary policy transmission mechanism. The trade-off between inflation and output is best explained by curvature of the Phillips curve. The effects of uncertainty on inflation or output become very important if the Phillips relation is non-linear. In this case, the shape of the Phillips curve is central to the conduct of monetary policy.

Lately, many recently study of the possible nonlinearity of the Phillips curve have been done. The short-run trede-off between unemployment and inflation is traditionaly assumed unchanged over time. Nevertheless, many theoretical models of price-setting behaviour suggest that economic activity has a nonlinear effect on inflation. Testing for nonlinearity is important on technical, empirical and economic policy grounds. The evidence from nonlinearity tests has crucial implications for knowledge about the monetary policy actions. The theoretical arguments in support of a nonlinear specification are, for example, capacity constraints, agents confused by a price shocks, menu costs, downward nominal wage rigidity or oligopolistic market. As each of these arguments implies a particular nonlinearity in the Phillips curve, from a policy perspective the choice of a source of nonlinearity is not neutral. Indeed, on the one hand, the output cost of fighting inflation will vary with the shape of the Phillips curve, and, on the other hand, given the monetary policy transmission lags, stronger or weaker incentives for preemptive policy tightening will exist to counter expected inflationary pressure (Baghli, Cahn, Fraisse, 2007). A convex Phillips curve implies that inflation may fail to decline in response to a shortfall of excess demand, but pick up significantly should demand exceed a certain threshold: the marginal reaction of inflation to a spending stimulus, for example coming from monetary policy, is therefore

path-dependent. An extreme form of convexity is an asymmetric curve, where inflation reacts to excess demand only if the latter is above a certain level. It is worth noting that, in fact, the relationship initially proposed by Phillips was, indeed, a curve.

Regarding the USA and other industrialised economies, Debelle and Laxton (1997), among others, suggest a convex Phillips curve is appropriate, while Gordon (1997) argues in favour of a linear curve and Stiglitz (1997) even of a concave one. In the Euro area, the evidence on the functional form of the Phillips curve is particularly scant and controversial, partly reflecting the challenges associated to gathering appropriately harmonised and long time series of data for this economy compared, for example, with the US.

Aguiar and Martins (2005) test the linearity of the Euro area Phillips curve using data from 1970 to 2002 and find that there is not enough statistical evidence for rejecting the null of linearity. However, Dolado et al. (2005) suggest that nonlinearities may be present, working on data from 1984 to 2001. In particular, in their specification the square value of the output gap enters significantly and with a positive coefficient in the equation, suggesting a convex Phillips curve.

Musso, Stracca and Dijk (2007) found no significant evidence of nonlinearity in the curve, in particular in relation to the output gap. They concluded that the Phillips "curve" is, at least in the Euro area, indeed a "line". The main policy implication of their study is that there is at least no convincing evidence of the existence of a "free lunch" for monetary policy, whereby the central bank is able to stimulate economic activity without creating inflationary pressure.

2. Model

We consider a standard Phillips curve with backward-looking component reprezented by a distributed lag on past inflation such as :

$$\Delta\pi_t = \sum_{k=1}^{k} \alpha_k \Delta\pi_{t-k} + \rho Z_t + \delta Z_t^2 + \varepsilon_t$$

Where Δ is the first difference operator;

π_t = inflation rate ,

$Z_t = \ln(Q_t) - \ln(Q_t^{pot})$ = output gap,

ε_t = disturbance term,

Q_t = real GDP,

Q_t^{pot} = potential real GDP

In this equation, the second output gap in the quadratic functional form describes nonlinearity of the Phillips curve. The quadratic functional form is a first approximation of the convex relationship. Higher values of δ imply greater convexity of the Phillips curve.

2.1. Data

The data for our empirical analysis is obtained from the Area Wide Model (AWM) database (for more details on the AWM database see Fagan et al., 2005) and National Institute of Statistics and has quarterly frequency. The sample periods are 1970:1–2008:4 for Eurozone and 2000:1–2009:4 for Romania. We used the main measures of inflation: GDP deflator for the Euro area (data are seasonally adjusted) and HICP for Romania. Regarding real GDP, data are also seasonally adjusted.

Phillips used an unemployment rate in his study but recently an output gap has been frequently used because of problems in measuring NAIRU and natural rate of unemployment. For these reasons the output gap is used in this study. There are many ways to measure potential output; in this study, to estimate potential output a Hodrick-Prescott filter is used. Real GDP and output gap are presented in the appendix (Chart 2, 3).

2.2. Empirical results

In equation we include three lags. Using correlogram table we find that the first three lags of inflation have significant coefficient, which indicates a strong inertial tendency of prices. Model results are given by:

Romania:

$$\pi_t = 0.239713 + 0.996373\pi_{t-1} + 0.251548\pi_{t-2} - 0.300762\pi_{t-3} + 0.25498Z_t + 0.186256Z_t^2 + \varepsilon_t$$

(0.086134) (0.149009) (0.234581) (0.124297) (0.013916) (0.091979)

$R^2 = 0.989553$

AIC = - 5.692063

SCH = - 5.430833

Euro Area:

$$\pi_t = 0.260704 + 0.4008064\pi_{t-1} + 0.377399\pi_{t-2} + 0.158136\pi_{t-3} + 0.0899572Z_t - 0.039293Z_t^2 + \varepsilon_t$$

(0.161467) (0.081719) (0.082732) (0.081737) (0.031198) (0.013541)

$R^2 = 0.838499$

AIC = - 8.316414

SCH = - 8.197050

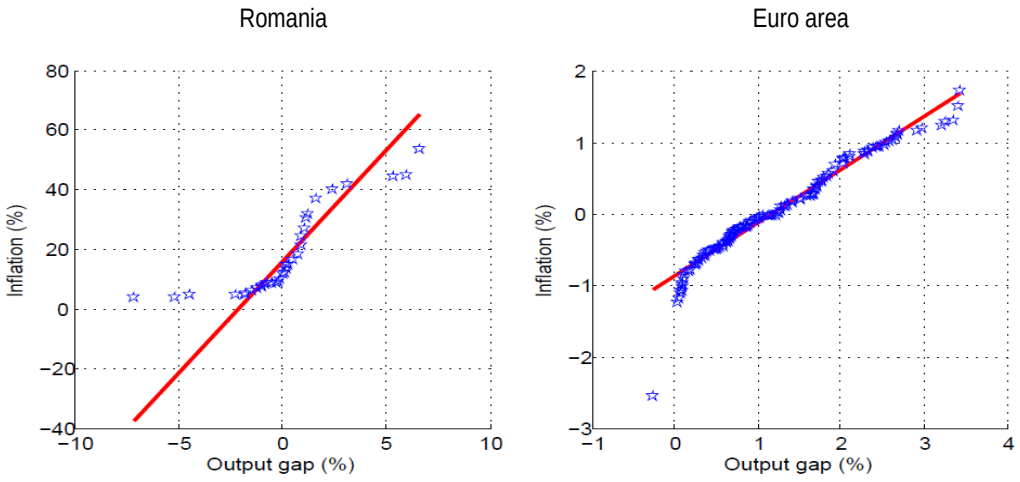
where heteroskedasticity-consistent standard errors are given in parentheses, below the estimated parameter, R^2 is R squared; *AIC*, *SCH* is Akaike, respectively Schwarz information criteria.

Diagnostic tests reports for Romania show instability and nonlinearity for this model. For most tests, the p-values are below conventional significance levels. Estimation and test results are reported in Tables 1 and 2, which shows that the adjusted R^2 values are quite high for both models (0.98 and 0.83)

The coefficient of the output gap variable ρ deviate significantly from zero as measured with t-test when White's heteroscedasticity corrected standard errors are used. According to statistical tests, both model are concludent and can be further analised.

In the Euro area, the estimated parameter of the quadratic output gap term δ does not deviate significantly from zero. Moreover, the estimates of the second output gap in the quadratic form variables are not significant. In both economies the sum of the output gap coefficients is positive, which indicates a positive relationship between inflation and output gap. Our results confirm what other studies have shown, especially that achieved by Musso et al. (2007).

The results of the estimated equation through the ordinary least squares method are presented in tables 1,2 (see appendix).



Note: *The graphs show the quarterly output gap and inflation measures for the period 2000 – 2009 (Romania) and 1970 – 2008 (Euro area). The solid red line shows the least squares of the inflation-output gap trade-off.*

Figure 1. *Shape of the Phillips curve (Romania vs. Euro area)*

3. Implications for monetary policy

In recent decades, maintaining the price stability has become the primary objective of central banks in the world. A growing number of countries use a flexible inflation targeting strategy, in which inflation is stabilized around a small target in the medium term (rather than strict inflation targeting regime, which tries to stabilize inflation soon horizon as possible). Monetary policy can achieve average inflation equal to the target in an attempt of finding the best compromise between inflation variability and the output gap. It is well known that monetary policy can not completely stabilize either inflation or output gap. On the other hand, increased credibility by anchoring inflation expectations in the target will reduce inflation variability and the output.

Despite the fact that an analysis of the functional form of the Phillips curve is fraught with empirical difficulties, the policy implications of this question are extremely important. Most central banks use the Phillips curve to forecast inflation and set the interest rate. It is known that monetary policy operates and impacts on the economy quite differently under nonlinearity and, thus, the central bank policy should be conceived and conducted differently if enough evidence of asymmetry is found. If, for example, a policy-maker who is uncertain on whether the Phillips curve has a linear or alternatively a piecewise linear form, then, in the first case, the policy-maker is confronted with a trade-off between stimulating demand and creating inflation, while in the latter case there is the possibility of pushing demand at least up to a certain limit without causing a significant increase in inflation. Therefore, a careful empirical modelling of the functional form of the Phillips curve is of paramount importance.

A responsible central bank should have clearly defined the objectives of monetary policy. The general consensus among academics but also practitioners is that the primary objective of monetary policy should be price stability. In practice many central banks have this objective specified in their statutes. However, inflation is not the only concern of a central bank; simultaneously, the same central banks try to stabilize output too. Output's inclusion among the objectives of the central bank is beneficial. The problem is how important should be stabilization of GDP compared to stabilizing inflation in the objective function of the central bank. Svensson showed that by increasing output's share in the loss function, deviation of inflation from target will be more persistent. Consequently, if inflation is brought to target over a longer period means that the deviation of GDP is more important in the objective function of central bank.

The trade-off between inflation variability and output-gap variability and the choice between strict and flexible inflation targeting have been discussed extensively in the monetary policy literature. The central banks aim to stabilize inflation around the inflation target but also, to some extent, stabilize output around potential output. Acknowledging that, because of the trade-off, unpredictable shocks, uncertainty and unavoidably imperfect control, there will always remain some variability in both inflation and the output gap.

Since the objectives of macroeconomic policies are different (economic growth, low unemployment, price stability, currency stability, balance of payments, etc.) and the number of actors involved is large (government, central bank, unions, employers, European institutions and/or supranational) central banks should clearly define their objectives for improving credibility. Practical experience shows that credibility has to be earned over time. In most new inflation-targeting regimes, especially when initial inflation is high and a period of disinflation is required, inflation expectations are high and credibility is low. An idea that makes a lot of sense is that in a new inflation-targeting regime, the central bank should initially put more weight on reducing and stabilizing inflation and be a less flexible inflation targeter in order to more quickly achieve credibility. The cost would be more output-gap variability in the beginning of the regime. The benefit would be an improved trade-off and lower variability of both inflation and the output gap later on, when credibility has improved and the central bank can afford to be a more flexible inflation targeter.

In terms of nominal and real criteria for accession to the European Monetary Union, disinflation process must be done considering that the real economy must grow in order to achieve a high rate criterion GDP/capita. In addition, any reaction too aggressive of monetary policy generates an increase in volatility's output gap, which results in slow economic growth process. An activist approach to monetary policy, short-term oriented, examines whether monetary policy measures can be taken to stimulate GDP and employment, some of them considering the control of inflation as given.

Since the adoption of inflation targeting regime, domestic macroeconomic environment has been encumbered by a multitude of structural changes and shocks from factors outside the scope of monetary policy influence. In this context, concern for the sustainability of disinflation has involved a focus of the NBR for complementary objectives, notably maintaining financial system stability and mitigate external imbalances arising along the way. Critical importance of these objectives has been highlighted by worsening financial crisis and global economic and propagation of its effects on the national economy since the fourth quarter 2008.

Inflation targeting in Romania was less orthodox, soft type, for several reasons: monetary duality of the economy – with large euroisation, high interest differential, premature liberalization of capital account and under conditions of imperfect markets (of a monetary transmission mechanism immature), NBR was unable to disregard the exchange rate dynamics. Interest rates were sometimes very low in the money market with the desire to discourage speculative capital, while the central goal was to get disinflation, so to not leave excess liquidity in the market. We have a relatively small economy at the scale of Europe and excessive currency fluctuations may not only cause financial instability. In terms of the dilemmas that may have a central bank, we had to reconcile disinflation with the need to discourage speculative high capital inputs, markets imperfections allowing a central bank practice ”less clean”. We practice inflation targeting in a hybrid formula that allows for flexibility.

Currently, many analysts believe that NBR should reduce the interest rate monetary policy more aggressively, their main argument being that the economy has dropped dramatically in the last year. Those who share this vision implicitly assumes that the central bank must intervene to stabilize production close to its potential. In practice, central banks, including NBR, set their short-term interest rate according to inflation and output gap. However, those who claim that BNR should aggressively reduce interest neglect uncertainties about expectations formation and inflation inertia, but also weakness of the Phillips curve partly due to uncertainties related to output gap. The current output gap in Romania (2009) is surprisingly high, maintaing firm proposals to reduce interest rates. But the output gap suffers from some major shortcomings that make it necessary to take it into account very cautiously (potential GDP can not be calculated with reasonable accuracy and econometric estimates capture contemporary late-year changes). Stabilizing inflation around the target would also stabilize the output gap at the relevant level for wellbeing.

National Bank of Romania should not have any problem in establishing the interest rate to levels that ensure achieving the inflation target agreed with Government. The law states that NBR has two objectives: price stability and financial stability, so no specific order to stabilize production. NBR should consider output gap with caution and correlated with other variables when tries to achieve the two objectives.

Conclusions

The results of the paper support the assumption of a nonlinear Phillips curve in Romania, while the Phillips curve in the Eurozone appear to be linear. Some analysts of the European Central Bank have reached the same conclusion in a recent study (Musso et al., 2007). They found no significant evidence of

nonlinearity in the curve, in particular in relation to the output gap. Their conclusion is that the Phillips curve is linear in the Euro area.

In both economies we find a strong inertial tendency of prices. In Romania's case, compared with the Euro area, we found a considerable influence of the output gap, in the quadratic form, on inflation, which suggests that the central bank's monetary policy strategy should be a flexible inflation targeting, while the European Central Bank should aim a strict inflation targeting.

Regarding Romania's economy it is important for policy makers to adopt appropriate economic policy measures in order to stabilize the economy, in the context of current crisis. In this respect the Romanian National Bank has slightly reduced the benchmark interest rate, to not conflict with the objective of achieving the inflation target. Thus, it is necessary a coordination of the two macrostabilization policies for the central bank not be constrained to pursue several objectives.

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Appendix

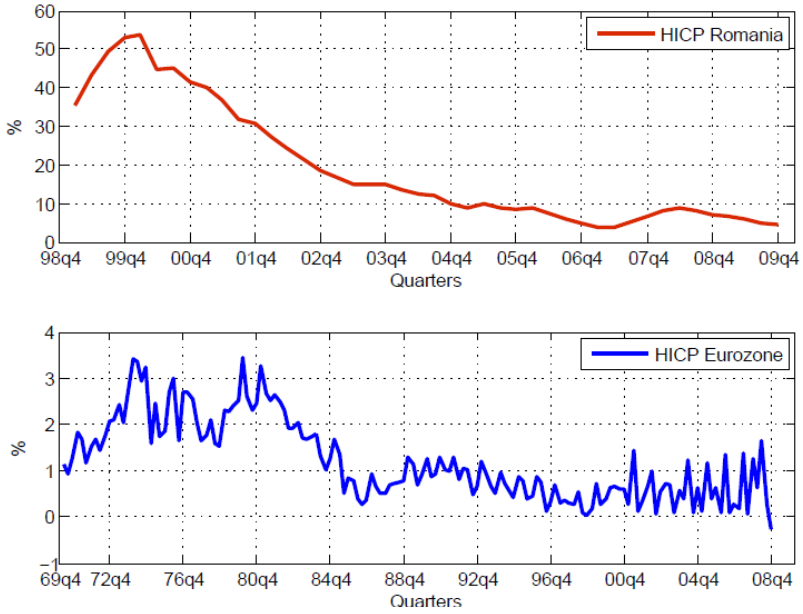

Chart 1. *HICP (Romania, Eurozone)*

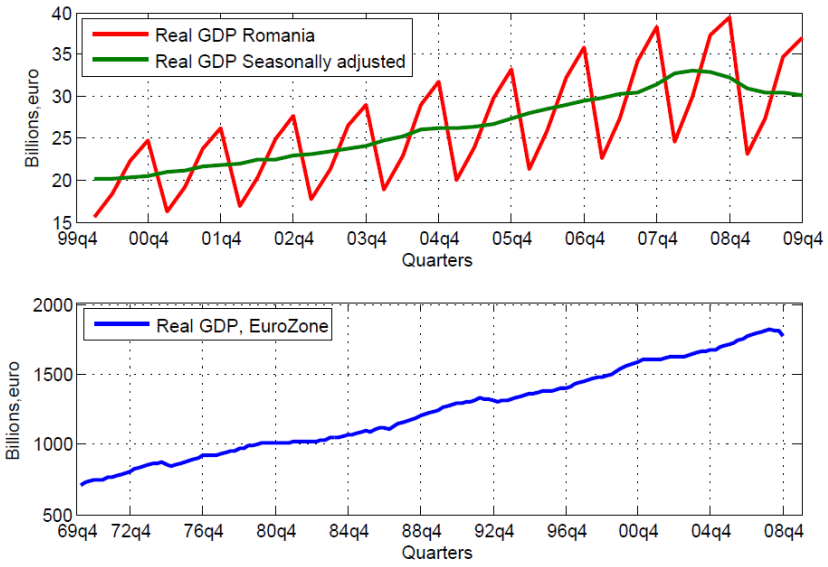

Chart 2. *Real GDP (Romania, Eurozone)*

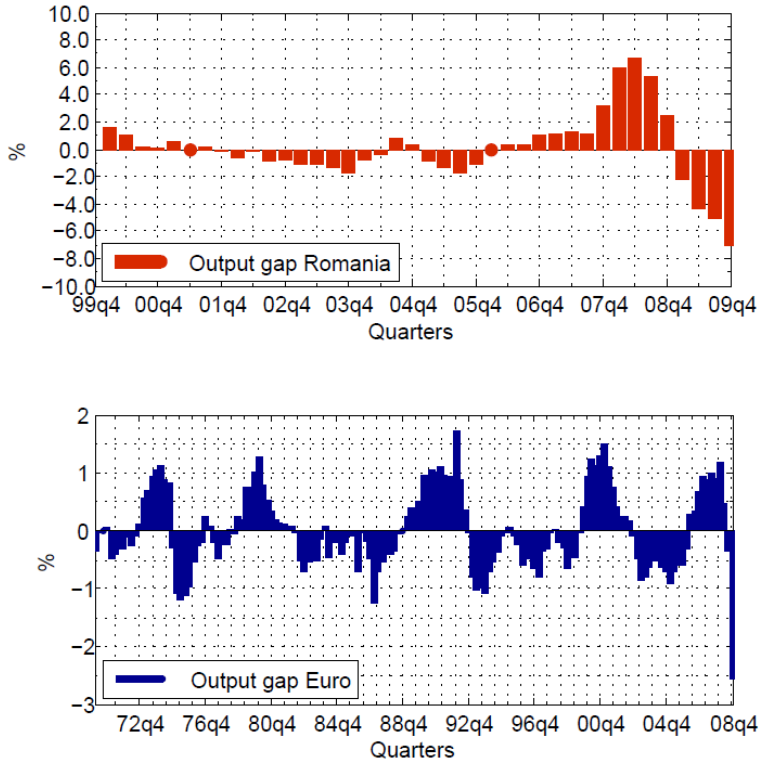

Chart 3. *Output gap (Romania, Eurozone)*

Table 1

OLS estimation results of the Phillips curve (Romania)

(*Dependent variable is DLHICP; D denotes difference & L denotes log)*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.239713	0.086134	2.783012	0.0091
DLHICP(-1)	0.996373	0.149009	6.686685	0.0000
DLHICP(-2)	0.251548	0.234581	1.072332	0.2918
DLHICP(-3)	-0.300762	0.124297	-2.419698	0.0216
Z_t	0.025498	0.013916	1.832193	0.0765
Z_t^2	0.186256	0.091979	2.024976	0.0516
R-squared	0.989553	Mean dependent var	4.769390	
Adjusted R-squared	0.987868	S.D. dependent var	0.118517	
S.E. of regression	0.013054	Akaike info criterion	-5.692063	
Sum squared resid	0.005283	Schwarz criterion	-5.430833	
Log likelihood	111.3032	F-statistic	587.2913	
Durbin-Watson stat	2.341282	Prob(F-statistic)	0.000000	

Table 2

OLS estimation results of the Phillips curve (Euro area)

(*Dependent variable is* DLGDP_Deflator*; D denotes difference & L denotes log)*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.260704	0.161467	1.614591	0.1086
DLGDP_Deflator(-1)	0.408064	0.081719	4.993490	0.0000
DLGDP_Deflator (-2)	0.377339	0.082732	4.561007	0.0000
DLGDP_Deflator (-3)	0.158136	0.081737	1.934688	0.0550
Z_t	0.089572	0.031198	2.871022	0.0047
Z_t^2	-0.039293	0.013541	-2.901730	0.0043
R-squared	0.838499	Mean dependent var	4.618456	
Adjusted R-squared	0.832968	S.D. dependent var	0.009080	
S.E. of regression	0.003711	Akaike info criterion	-8.316414	
Sum squared resid	0.002011	Schwarz criterion	-8.197050	
Log likelihood	638.0474	F-statistic	151.6036	
Durbin-Watson stat	1.926668	Prob(F-statistic)	0.000000	

Table 3

Correlogram of HICP (Romania)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |******* |	. |******* |	1	0.945	0.945	38.454	0.000
. |******* |	** | . |	2	0.867	-0.244	71.649	0.000
. |****** |	** | . |	3	0.762	-0.258	98.011	0.000
. |***** |	.* | . |	4	0.642	-0.144	117.22	0.000
. |**** |	. | . |	5	0.523	0.022	130.35	0.000
. |*** |	. |* . |	6	0.416	0.077	138.88	0.000
. |** |	.* | . |	7	0.308	-0.132	143.72	0.000
. |** |	.* | . |	8	0.205	-0.105	145.92	0.000
. |* . |	. | . |	9	0.111	-0.011	146.58	0.000
. | . |	. | . |	10	0.029	0.056	146.63	0.000
. | . |	. | . |	11	-0.039	0.017	146.71	0.000
.* | . |	.* | . |	12	-0.099	-0.119	147.30	0.000
.* | . |	. | . |	13	-0.142	0.038	148.56	0.000
.* | . |	. |* . |	14	-0.164	0.139	150.29	0.000
.* | . |	. |* . |	15	-0.166	0.086	152.14	0.000
.* | . |	. |* . |	16	-0.145	0.074	153.61	0.000
.* | . |	.* | . |	17	-0.112	-0.073	154.53	0.000
.* | . |	. | . |	18	-0.071	0.030	154.91	0.000
. | . |	. | . |	19	-0.025	0.050	154.96	0.000
. | . |	** | . |	20	0.000	-0.226	154.96	0.000

Table 4

Correlogram of HICP (Euro Area)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|******* |	.|******* |	1	0.876	0.876	121.26	0.000
.|******* |	.|*** |	2	0.860	0.396	238.77	0.000
.|****** |	.|* |	3	0.818	0.083	345.86	0.000
.|****** |	.|** |	4	0.827	0.236	456.13	0.000
.|****** |	*|. |	5	0.775	-0.089	553.65	0.000
.|****** |	.|. |	6	0.769	0.055	650.20	0.000
.|****** |	.|* |	7	0.757	0.111	744.40	0.000
.|****** |	.|. |	8	0.745	-0.003	836.39	0.000
.|****** |	.|. |	9	0.717	-0.019	922.02	0.000
.|***** |	*|. |	10	0.670	-0.180	997.45	0.000
.|***** |	.|. |	11	0.664	0.046	1071.9	0.000
.|***** |	.|. |	12	0.638	0.003	1141.2	0.000
.|***** |	.|* |	13	0.639	0.088	1211.1	0.000
.|**** |	*|. |	14	0.583	-0.147	1269.8	0.000
.|**** |	.|. |	15	0.573	-0.047	1326.9	0.000
.|**** |	.|. |	16	0.538	-0.026	1377.7	0.000
.|**** |	.|. |	17	0.526	-0.001	1426.5	0.000
.|**** |	*|. |	18	0.472	-0.079	1466.1	0.000
.|*** |	.|. |	19	0.452	-0.054	1502.7	0.000
.|*** |	.|. |	20	0.440	0.062	1537.5	0.000
.|*** |	.|* |	21	0.438	0.106	1572.4	0.000
.|*** |	*|. |	22	0.395	-0.083	1601.0	0.000
.|*** |	.|. |	23	0.367	-0.042	1625.8	0.000
.|*** |	.|. |	24	0.356	0.016	1649.4	0.000
.|** |	.|. |	25	0.325	-0.056	1669.2	0.000
.|** |	.|. |	26	0.304	0.033	1686.6	0.000
.|** |	.|. |	27	0.279	0.023	1701.5	0.000
.|** |	*|. |	28	0.267	-0.067	1715.1	0.000
.|** |	.|. |	29	0.248	0.021	1726.9	0.000
.|** |	*|. |	30	0.217	-0.079	1736.1	0.000
.|* |	.|. |	31	0.194	0.047	1743.5	0.000
.|* |	.|. |	32	0.176	-0.014	1749.6	0.000
.|* |	.|. |	33	0.166	0.010	1755.2	0.000
.|* |	*|. |	34	0.135	-0.077	1758.8	0.000
.|* |	.|* |	35	0.136	0.116	1762.6	0.000
.|* |	.|. |	36	0.111	-0.035	1765.1	0.000