The Phillips Curve in Italy

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ABSTRACT

The estimation of the Phillips curve in Italy, using the wage inflation rate as a dependent variable, based on annual data from the period 1961-2012, using the Johansen Method, allows us to conclude two things. Firstly, in the long term, there are two long-term relationships: the wage inflation rate relates positively to the inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index, as was expected; the inflation rate relates positively to the wage inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index, as was expected. Secondly, in the short term, the variation of the wage inflation rate relates positively and significantly to the error correction mechanism of the first long-term relationship; therefore, there is a significant response to the equilibrium error between the wage inflation rate and its determinants (inflation rate, unemployment rate, labour productivity growth index). Besides this adjustment, the variation of wage inflation rate responds significantly and negatively to the variation in unemployment rate and significantly and positively to the average labour productivity growth.

JEL Classification: C12, C32, E24, E31

Key Words: Wage Inflation, Phillips curve, Cointegration

1. Introduction

The original Phillips curve describes an empirical relationship between wage inflation and unemployment in accordance with Phillips (1958). Lipsey (1960) introduces the theoretical fundaments of that curve and Samuelson and Solow (1960) apply the more used modification: the relation between the inflation rate and the unemployment rate. This relationship was greatly used in the 1960s by policy-makers. The trade-off between inflation and unemployment was recommended to economic policy makers as an instrument that would allow them to formulate policy programmes with alternative combinations of unemployment and inflation rate.

The Oil Shock in the 1970s raised problems in relation to that theory, because there was unemployment together with increasing inflation. Friedman (1968) and Phelps (1967) introduced expectations in the original Phillips curve to take account of expected inflation. The first expectations introduced were adaptive expectations:

$$\dot{W} = f\left(U, \dot{P}^e\right) \tag{1}$$

where $\dot{W}$ is the money wage rate, U the unemployment rate, $\dot{P}^e$ the inflation expectations.

Friedman (1977) distinguished three stages of the Phillips curve: first, a stable trade-off between inflation and unemployment; second, the distinction between short and long run: in the long run, the Phillips curve was vertical; third, a positively sloped Phillips curve. Today, the most accepted is the second stage, but the new classical school (see Lucas (1973)) with the introduction of rational expectations and market clearing, admits that the Phillips curve is almost vertical, even in the short run. However, the new Keynesian school do not believe that markets clear all the time, so sticky wages and prices imply that the Phillips curve is not vertical in the short run.[1]

According to Roberts (1995), the New Keynesian Phillips curve is:

$$\Delta P_t - E_t \Delta P_{t+1} = c_0 + \gamma y_t + \varepsilon \qquad \gamma > 0_t \tag{2}$$

where P_t is the log of actual price at time t, E_t are the rational expectations at time t, y_t is the percent deviation of aggregate output from is trend, γ is a positive constant, and ε_t is is a residual error term.

This equation is similar to that of Friedman and Phelps, but the New Keynesian models "emphasize the role of explicit nominal rigidities in interpreting model" (Roberts, 1995, p. 980), this equation is also similar to that of Lucas (1973), except this equation "includes expectations do next period's inflation, whereas Lucas´s supply curve incorporates expectations of current inflation. The reason future inflation matters in the New Keynesian model is that prices are sticky." (Roberts, 1995, p. 980).

Remembering the Okun Law we can have the equation:

$$\Delta P_t - E_t \Delta P_{t+1} = c_0 - \eta \Delta U_t + \varepsilon_t \qquad \eta > 0 \tag{3}$$

where U is the unemployment rate.

According to Galí and Gertler (1999) we can have a hybrid version of the New Keynesinan Phillips curve:

$$\pi_t = \delta \left(y - y^*\right) + \left(1 - \phi\right) E_t \pi_{t+1} + \phi \pi_{t-1} \qquad 0 < \phi < 1 \tag{4}$$

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[1] See Ball, Mankiw and Romer (1988) and Roberts (1995).

where π_t is the inflation rate at time t, y-y* is the output gap. Therefore inflation depends on the output gap, expected future inflation and lagged inflation. But the difficult with using the output gap let the economists to use measures of real marginal cost, and the hybrid Phillips curve becomes:[2]

$$\pi_t = \lambda mc_t + \gamma_f \, E_t \pi_{t+1} + \gamma_b \, \pi_{t-1} + \varepsilon_t \qquad [5]$$

where *mc* is a measure of aggregate marginal cost.[3]

But remembering the Okun Law we can have the equation:

$$\pi_t = \alpha(U - U^*) + \gamma_f \, E_t \pi_{t+1} + \gamma_b \, \pi_{t-1} + \varepsilon_t \qquad [6]$$

where U is the unemployment rate. So the inflation rate depends on the unemployment rate, expected future inflation and lagged inflation.

Mazumder (2012) finds "there is evidence to this day that the Phillips Curve remains highly robust between different monetary policy regimes, contrary to the claims of Lucas (1976)" in his study for the United States, so the traditional Phillips curve is alive.

We can say that the three main factors influencing wage negotiation and driving the rate of growth of nominal wages are core inflation, productivity growth and the state of demand in the labour market. The core or underlying rate of inflation has one backward-looking component and one forward-looking component, but in low-inflation periods there is little difference between core and actual inflation. In our model, we can refer to it as expectation of inflation. The productivity gains means that wages can rise without any increase in unit labour cost, so without impact on the inflation rate. In our model, we can expect a positive impact of productivity growth on wages. The state of demand in the labour market can be measured by the unemployment rate. When the unemployment rate is above the equilibrium rate of unemployment (NAIRU in economic terms), wages tend to slow down, and vice-versa. In our model, we can expect a negative relationship between the rate of growth of nominal wages and the unemployment rate, where $\dot{Q}$ is the average labour productivity growth:

$$\dot{W} = f\left(\overset{(-)}{U}, \overset{(+)}{\dot{P}^e}, \overset{(+)}{\dot{Q}} \right) \qquad [7]$$

2. Data

We use annual data whose justification in theoretical terms is given by Campbell and Perron (1991, p. 153), where either due stationarity analysis needs a long-term period, or because "seasonal adjustment procedures often create a bias toward nonrejection of a unit root hypothesis" (Campbell and Perron, 1991, p. 153). As stated previously, we formulated the model on the basis of rates of change, so we opted to transform the available annual data into rates of change. Thus we selected four annual variables for the period 1961-2012: $\dot{W}$, money wages rate; $\dot{P}$, inflation rate; *U*, unemployment rate ; $\dot{Q}$, average labour productivity growth.

The data source is *AMECO*.

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[2] See Andreas Hornstein (2008).

[3] See also Russel and Chowdhury (2013) about "modern" theories of the Phillips curve and Nason and Smith (2008) about the application of the New Keynesian Phillips curve to the USA.

3. Stationarity of the data

The Dickey-Pantula (1987) test allows us to reject the null hypothesis of I(2) against I(1) in all variables studied. With the ADF test, we can say the variables $\dot{W}$, U, $\dot{P}$ are I(1), and the variable $\dot{Q}$ is I(0). Using the Perron and Vogelsang (1992) test to inquire for a unit root in times series under structural change with endogenous choice of the break point (Tb), with the procedure of endogenous selection of k described by Perron (1997, p. 359), we can reach the same conclusion.

4. Estimation of the Phillips curve model

We use the Johansen method as being the one that allows the detection of the presence of more than one cointegrating vector among variables in the study.

There are stationary regressors in the VAR model, so we cannot use the critical values of Johansen (1996). Therefore, we follow the methodology of Rahbek and Mosconi(1999), which consists of adding to the VAR the cumulated explanatory I(0) variables as I(1) exogenous variables, and thus the critical values of the trace or eigenvalue tests of, among other authors, Pesaran, Shin and Smith(2000) can be used.[4] First, as we have exogenous variables, the cointegrated VAR model to use corresponds to the conditional model:[5]

$$\Delta Y_t = \mu_c + \delta_c\, t + \sum_{i=1}^{k-1} \Psi_i \Delta X_{t-i} + \Pi_y X_{t-1} + \omega \Delta Z_t + \varepsilon_{ct} \qquad [8]$$

where X_t is a N×1 vector of I(1) variables, which we can divide into N_y endogenous I(1) variables (Y_t) and N_z exogenous I(1) variables (Z_t), such that $N_y + N_z = N$. Π_y is the long-run multiplier matrix of order (N_y×N) given by $\Pi_y = \alpha_y \beta'$, where α_y is a (N_y×r) matrix and β a (N×r) matrix of r cointegranting vectors.

The null hypothesis of the cointegration rank (existence of r cointegrating vectors) is written:

Hr: R [Π_y] = r,   r = 0, ..., N_y; $\qquad$ [9]

where "R" is the rank of the matrix.

In the estimation of the conditional model (8), we can consider 5 cases (or models) consonant with the restrictions imposed on the deterministic terms, in accordance with PSS(2000).

4.1 Estimation of the Long-Term Model

At the beginning we have a model with three endogenous I(1) variables ($\dot{W}$, U, $\dot{P}$), and one exogenous I(0) variable ($\dot{Q}$).

In terms of k order of the VAR, we selected VAR(3), using either multivaried statistics, or univaried statistics, so that the estimated residuals have no serial correlation (LM test), no

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[4] Referred to as PSS(2000), afterwards.
[5] We assume that the Z_t variables are weakly exogenous and they are not cointegrated between them, which implies that we can efficiently determine and test the parameters of long term (α and β), but with resource to the conditional model [see PSS(2000)].

autoregressive conditional heteroscedasticity (ARCH test) and they do not deviate too much from normality (BJ test), as Johansen (1996, p. 20) recommends.

With k=3, whatever the model of the Johansen method is in relation to the deterministic terms, we cannot reject the existence of two cointegranting vectors by the Trace test .

We cannot reject the weak exogeneity of the unemployment rate (U) in the models II to IV,[6] on a significance level of 5% (Table 1).

Table 1 - Weak exogeneity test [7] of unemployment rate (U)

Model	Model II	Model III	Model IV
LR test	$\chi^2(2)= 0.26$ [0.88]	$\chi^2(2)= 0.66$ [0.72]	$\chi^2(2) = 0.11$ [0.95]

Note: The null hypothesis is H0: $\alpha_U = 0$.
Source: Calculations were performed by the author.

We estimated the model with two endogenous I(1) variables ($\dot{W}$ and $\dot{P}$), one I(1) exogenous variable (U), one I(0) variable ($\dot{Q}$). in accordance with the Rahbek and Mosconi(1999) methodology:

$$\dot{W} \quad \dot{P} ; U \operatorname{csum}\dot{Q} \ \& \ \Delta U \ \dot{Q}$$

We confirm the k order of the VAR with exogenous *U*, as a VAR(3) and the methodology of PSS(2000) leads us to choose model IV. Given VAR(3) and model IV, one can confirm that the existence of two cointegranting vectors cannot be rejected, either by the trace test, or by the maximum eigenvalue test (Table 2).

Table 2 – Cointegration tests

Eigenvalue λ	Trace test			Maximum eigenvalue test		
	H0	Ha	Trace	H0	Ha	λmax
0.47811	r = 0	r ≥ 1	51.3219[a]	r = 0	r = 1	31.8642[a]
0.32773	r ≤ 1	r = 2	19.4577[a]	r ≤ 1	r = 2	19.4577[a]

[a] = the null hypothesis (H0) is rejected against the alternative hypothesis (Ha).
Source: Calculations were performed by the author.

The AIC, SBC and HQC criterions also select the model with r=2. The vector 1 normalized in relation to $\dot{W}$ without restrictions with X't = [$\dot{W}$ $\dot{P}$ U csum$\dot{Q}$ Trend] is given by:

$$\beta_1' = \begin{bmatrix} 1 & -0.707 & 1.058 & -0.143 & 0.373 \end{bmatrix}$$

The vector 2 normalized in relation to $\dot{P}$ without restrictions with X't = [$\dot{P}$ $\dot{W}$ U csum$\dot{Q}$ Trend] is given by:

$$\beta_2' = \begin{bmatrix} 1 & -0.962 & 0.396 & -0.158 & 0.058 \end{bmatrix}$$

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[6] PSS(2000) models.

[7] Elaborated on CATS in RATS by the restriction B'*alpha=0 with B'=[0 1 0] selecting r=2 in the model $\dot{W}$ U $\dot{P}$; csum$\dot{Q}$ & $\dot{Q}$, lag 3.

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so, we have the ecm1 and the ecm2:

ECM1 = $\dot{W}$ - 0.707 $\dot{P}$ + 1.058 U − 0.143 csum $\dot{Q}$ + 0.373 Trend

ECM2 = $\dot{P}$ - 0.962 $\dot{W}$ + 0.396 U − 0.158 csum $\dot{Q}$ + 0.058 Trend

and therefore, the long-term relationships are:

$\dot{W}$ = 0.707 $\dot{P}$ - 1.058 U + 0.143 csum $\dot{Q}$ - 0.373 Trend

$\dot{P}$ = 0.962 $\dot{W}$ - 0.396 U + 0.158 csum $\dot{Q}$ - 0.058 Trend

that is, firstly, the wage inflation rate relates positively to the inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index The Trend means there are others factores the have some influence on wage inflation. Secondly, the inflation rate relates positively to the wage inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index. The Trend means there are others factores the have some influence on inflation rate.

According Koustas and Serletis (2003) "the evidence is consistent with a vertical long-run Phillips curve for most countries in the sample, with the exception of Italy", so is in accordance of our long-run relationship for Italy. Schreiber and Wolters (2007) finds also "a cointegration relationship between inflation and unemployment " in Germany.

4.2 Estimation of the Short-Term Model

The estimation of the multivariate model with only variables introduced initially in VAR(3) allows us to get the results in Table 3.

Table 3 – Multivariate model estimation

Equation/ Regressor	$\Delta\dot{W}$	$\Delta\dot{P}$
No. Observations	**T=49** [64-12]	**T=49** [64-12]
Intercept	-2.5461[.558]	-14.0490[.001]
$\Delta\dot{W}$ **(-1)**	-.36032[.233]	-.54006[.061]
$\Delta\dot{P}$ **(-1)**	.46902[.060]	.48843[.038]
$\Delta U(-1)$	1.3617[.087]	.78117[.289]
$\dot{Q}$ **(-1)**	.20231[.342]	.56179[.007]
$\Delta\dot{W}$ **(-2)**	-.22868[.290]	-.26921[.186]
$\Delta\dot{P}$ **(-2)**	.32515[.127]	.24820[.212]
$\Delta U(-2)$	.98682[.160]	-.0059655[.993]
$\dot{Q}$ **(-2)**	.09977[.679]	-.12000[.596]
ECM1(-1)	8.4370[.000]	.52461[.791]
ECM2(-1)	-6.2350[.005]	-8.2123[.000]

ΔU	-1.4917[.012]	-.73138[.177]
$\dot{Q}$	.21961[.365]	.26881[.239]
$\overline{\mathrm{R}}^2$	.48428	.35138
SEE	2.0913	1.9625
DW	2.1302	2.0467
LM(1, 35)	1.3634[.251]	1.2138[.278]
RESET(1, 35)	1.8292[.185]	3.3723[.075]
BJ(2)	.21542[.898]	6.1678[.046]
HET(1, 47)	.3021E-3[.986]	3.4911[.068]
ARCH(3, 33)	1.3933[.262]	1.0991[.363]

Note: see annex about diagnostic tests description and other notes.

Source: Calculations were performed by the author.

The **variation of the wage inflation rate** relates positively and significantly at 1% level to the error correction mechanism (ECM1) with an adjustment coefficient of about (8.0) and relates negatively and significantly at 1% level to the error correction mechanism (ECM2) with an adjustment coefficient of about (-6.0); therefore, there is a significant response to the long-term disequilibria. Besides this adjustment, the wage inflation rate responds positively and significantly to a lagged inflation rate and negatively and significantly to the unemployment rate.

The **variation of the inflation rate** relates positively and significantly at 1% to the error correction mechanism (ECM2), with an adjustment coefficient of about (-8.0). It relates positively and significantly at 5% to lagged variation of inflation rate and to the lagged average labour productivity growth. It presents a negative and but not significant relation to the variation of the unemployment rate.

The diagnostic tests indicate that, in both equations, the residuals are not autocorrelated, are homoescedastics, and the autoregressive conditional heteroescedasticity is also absent until the third order. We cannot reject correct specification of the model.

In both equations, CUSUM and CUSUMSQ tests do not cross any of the significant bars at 5% level.

With the aim of obtaining a **parsimonious Phillips curve model**, we tried to remove from the equation of $\Delta\dot{W}$ all the variables not significant at 5% level, using the Wald test on the joint nullity of its coefficients. We reject the exclusion of these variables from the model with the $\chi^2(9) = 26.8059[.002]$, so we leave the average labour productivity and we cannot reject the exclusion of eight variables from the model with the $\chi^2(8)= 12.8718[.116]$, so the parsimonious model is $\Delta\dot{W}$ = f(inpt, , $\Delta\dot{P}_{t-1}$, , ECM1$_{t-1}$, ECM2$_{t-1}$, ΔU, $\dot{Q}$). The estimation of the $\Delta\dot{W}$ equation with these regressors (W1 equation − Table I − Annex) presents all the coefficients significant at 5%, except the intercept and the ECM2(-1), and the diagnostic tests are very good. $\Delta\dot{W}$ is a function of the lagged variation of the inflation rate and of the ECM1 (long-term relationship between $\dot{W}$ and the other variables), and is also function of the variation in unemployment rate and of the average labour productivity growth.

We cannot reject either the predictive capacity after 2005 or the structural stability before and after 2005 (W2 equation).

In all the estimated equations, we can verify the coefficient stability as the Chow(1960) tests suggest. The coefficient of ECM1$_{t-1}$ is more stable, about 7.0. The coefficient of $\Delta \dot{P}_{t-1}$ varies between 0.3 and 0.37, the   coefficient of ΔU varies between -1.3 and -2.7 and the coefficient of $\dot{Q}$ varies between 0.56 and 0,71.

In all equations of the parsimonious model, CUSUM and CUSUMSQ tests do not cross any of the significant bars at 5% level. However, not all the residuals are inside the line bands of double-standard deviation. In the period 1964-2012, as we verify that the plot of residuals crosses two standard error bands in 1979.

5. Conclusion

In the long term, there are two long-term relationships: the wage inflation rate relates positively to the inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index, as was expected; the inflation rate relates positively to the wage inflation rate, negatively to the unemployment rate and positively to the average labour productivity growth index, as was expected.

In the short term, the variation of the wage inflation rate relates positively and significantly to the error correction mechanism with wage inflation as dependent variable and negatively to the error correction mechanism with inflation rate as dependent variable, therefore, there is a significant response to the long-term disequilibria. Besides this adjustment, the wage inflation rate responds positively and significantly to a lagged inflation rate and negatively and significantly to the unemployment rate. It relates positively to the average labour productivity and is significant in the parsimonious model. We can have a parsimonious model as a relationship between the wage inflation rate, the lagged inflation rate, the two errors correction mechanisms, the unemployment rate and the average labour productivity growth.

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ANNEX

Table I: Parsimonious Equations of $\Delta\dot{W}$

Equation/ Regressor	W1	W2
	T=49 [64-12]	T_1=43,T_2=7 [64-05]
Intercept	3.6034[.157]	3.0251[.218]
$\Delta\dot{P}$ (-1)	.36895[014]	.30929[032]
ECM1(-1)	6.8753[.000]	7.3182[.000]
ECM2(-1)	-2.1568[.172]	-2.6352[.099]
ΔU	-1.2757[.024]	-2.7176[.000]
$\dot{Q}$	.55588[.004]	.70769[.001]
$\overline{\mathbf{R}}^2$	.39361	.53150
SEE	2.3609	2.2164
DW	1.9813	1.9468
LM$_{(1, \text{T-k-1})}$	1.0019[.322]	.014913[.903]
RESET$_{(1, \text{T-k-1})}$	.41720[.522]	.10152[.752]
BJ(2)	1.0458[.593]	.38770[.824]
Het(1, T-2)	3.3943[.072]	.16355[.688]
ARCH$_{(3, \text{T-k-3})}$	.892701[.453]	2.4166[.083]
Chow$_{(T_2,T_1-k)}$	-	1.8464[.107]
Cov$_{(k, T_1+T_2-2k)}$	-	2.1293[.072]

Notes: Dependent Variable: $\Delta\dot{W}$; Estimation Method: OLS; ECM1 = $\dot{W}$ - 0.707 $\dot{P}$ + 1.058 $U - 0.143$ csum $\dot{Q}$ + 0.373 Trend e ECM2 = $\dot{P}$ - 0.962 $\dot{W}$ + 0.396 $U - 0.158$ csum $\dot{Q}$ + 0.058 Trend estimated on the model: $\dot{W}$ $\dot{P}$; U csum $\dot{Q}$ & ΔU $\dot{Q}$.

Between square brackets: p-value or sample period (on the top). On the estimated coefficients, the null hypothesis is H0: β=0, and the Student t test is used.

T=number of observations used in regression; **k**=number of estimated coefficients; **T₁**=sub-sample used in estimation; **T₂**=Period post-sample (forecasting test) or second sub-sample (stability test, only possible when $T_1>k$ and $T_2>k$).

Source: Calculations were performed by the author.

Diagnostic tests description:

LM – statistic of Lagrange Multiplier test for serially correlated residuals ;
RESET – statistic of Ramsey)'s RESET test of functional form misspecification;
BJ – statistic of Jarque-Bera's test of normality of regression residuals;
HET – statistic of Heteroscedasticity test ;
ARCH – statistic of Autoregressive Conditional Heteroscedasticity test;
Chow-statistic of Predictive failure test (2nd test of Chow(1960));
Cov – statistic of Chow's test of stability of regression coefficients (1st test of Chow(1960)).