Comparing alternative Phillips curve specifications: European results with survey-based expectations

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(running title: alternative Phillips curve specifications)

Abstract

This paper examines inflation dynamics in Europe. Econometric specification tests with pooled European data are used to compare the empirical performance of the New Classical, New Keynesian and Hybrid specifications of the Phillips curve. Instead of imposing any specific form of expectations formation, direct measures, ie Consensus Economics survey data are used to proxy economic agents' inflation expectations. According to the results, the New Classical Phillips curve has satisfactory statistical properties. Moreover, the purely forward-looking New Keynesian Phillips curve is clearly outperformed by the New Classical and Hybrid Phillips curves. We interpret our results as indicating that the European inflation process is not purely forward-looking, and inflation cannot instantaneously adjust to changes in expectations. Consequently, even allowing for possible non-rationality in expectations, a lagged inflation term enters the New Keynesian Phillips curve for inflation dynamics in Europe.

Key words: Phillips curve, expectations, Europe

JEL classification numbers: E31, C52

– 1 –

1   Introduction

Expectations have a central role in the inflation process and monetary policy design, since the effects of monetary policy on employment and production depend on credibility and thus expectations formation. It is very generally accepted that changes in monetary policy regimes affect the formation of inflation expectations and inflation dynamics. However, many recent empirical studies find evidence that the inflation process is persistent, ie that inflation is strongly correlated with its own lagged values (see eg Gordon 1997). Persistence may be due to deep parameters or institutional constraints (such as indexation) in the economy or due to more transient factors such as expectations or policy regimes. According to Erceg and Levin (2003) inflation responds sluggishly to shocks because of private sector's gradual learning about monetary policy inflation target. On the other hand, inflation persistence is due to imperfect information in Ehrmann and Smets (2002), which argue that inflation expectations change slowly, as agents do not know whether a shock hitting the economy is temporary or permanent. Gaspar, Smets and Vestin (2005) suggest that the monetary policy regime and inflation persistence are related.

In empirical studies of inflation dynamics, it is often assumed that expectations are rational. After the emergence of the rational expectations theory in the 1970's, there has been until recently very little interest in modelling expectations, although it has been argued that rationality of expectations may be an overly restrictive assumption. If we choose to avoid imposing rational expectations, we can use models which model expectations formation through limited information channels (Woodford 2002, Adam 2004), sticky information (Mankiw and Reis 2001, 2002), or bounded rationality and learning (Sargent

1999, Sims 2003, Evans and Honkapohja 2001). Alternatively, we can use directly measured expectations, which are based on surveys or financial markets information.

Since the late 1950s research on inflation dynamics has been largely based on the Phillips curve. Originally Phillips (1958) and Samuelson and Solow (1960) hypothesised a stable negative relationship between unemployment and inflation. Phelps (1967) and Friedman (1968) augmented expectations in the Phillips curve via wage bargaining and price setting. In the 1970s, Lucas (1976) presented the rational expectations hypothesis, which holds that inflation expectations cannot systematically differ from actual inflation. In empirical work applying this type of Phillips relation, which is nowadays often called the New Classical Phillips curve, real economic activity is often measured by the output gap.

The New Keynesian Phillips curve in its original form is purely forward-looking and based explicitly on microfoundations. In this specification time-contingent price setting can be derived using Taylor's overlapping contracts model (Taylor 1980), Rotemberg's model of quadratic costs of price adjustment (Rotemberg 1982) or the Calvo (1983) model with random price adjustment. All these models relate current inflation to currently expected future inflation and the current driving variable. In the New Keynesian theory, excess demand enters through real marginal costs, which is empirically measured by the output gap or real unit labour cost (labour income share). The hybrid specification of the New Keynesian Phillips curve (Galí and Gertler 1999) includes elements of both forward-looking and backward-looking price setting, since it has the lagged inflation term as an additional explanatory variable. In the Hybrid model only

some price setters behave optimally when adjusting prices while the rest use rules of thumb or indexation, which is based on recent history of aggregate prices.

In this study we analyse the inflation process in eleven out of twelve countries presently constituting the euro area[1]. Inflation dynamics in these countries is examined by comparing the empirical performance of the New Classical, New Keynesian and Hybrid Phillips curves. In comparison, econometric specification tests are applied to pooled European data. Consensus Economics survey data are used to proxy inflation expectations and in estimations least squares and the generalised method of moments (GMM) are used. Special attention is paid to the role of expectations in inflation dynamics.

The results of this study suggests that when using directly measured inflation expectations both the New Classical and New Keynesian Phillips curves are able to capture European inflation dynamics. However, a specification test by Davidson and MacKinnon (1993) indicate that the New Keynesian Phillips curve is outperformed by New Classical Phillips curve. More specifically, when comparing the relative weights of the expectations terms of alternative models, we get evidence in favour of the New Classical specification with lagged expectations. Thus, there seems to be sluggishness (or delay) in the effect of expectations on inflation contrary to the New Keynesian specification with current expectations. The empirical performance of the Hybrid Phillips curve is also reasonable. The Wald test of coefficient restrictions suggests that the empirical fit of this specification is clearly better than that of the purely forward-looking New Keynesian Phillips curve. Overall, this study provides evidence against the basic features of the New Keynesian Phillips curve. Thus, we get evidence that the

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[1] Luxembourg is not included in the analysis.

inflation process is not purely forward-looking, and the inflation rate does not adjust instantaneously to changes in expectations.

The rest of this study is structured as follows. In chapter 2 the three different Phillips curves and econometric specification tests are presented. Empirical evidence on European inflation dynamics is reported in chapter 3. Chapter 4 concludes.

2   Three Phillips curve relationships and specification tests

2.1   Standard specifications

The New Classical, the New Keynesian and the Hybrid Phillips curves involve very different assumptions about the role of expectations in the inflation process. In the New Classical Phillips curve (Phelps 1967, Friedman 1968, Woodford 2003) only a certain fraction of goods prices are fully flexible and the rest are set one period in advance. The New Classical specification relates the current inflation rate to the previously expected current inflation rate and to current excess demand

$$\pi_t = E_{t-1}\pi_t + \varphi\hat{y}_t \tag{2.1}$$

where π_t refers to the current inflation rate and E_{t-1} to period t-1 representative market expectations. The term $\hat{y}_t$ denotes to the output gap. As φ increases with a fraction of fully flexible prices, the New Classical Phillips curve is the steeper, the larger the portion of firms which are able to reset their prices without any restrictions.

The New Keynesian Phillips curve is also based on nominal rigidities, but since price setting is staggered, firms pay attention to relative prices. It can be derived following the Calvo model (Calvo 1983), which assumes that in every period a fraction $0 < \alpha < 1$ of the goods prices are unchanged and the remaining prices are readjusted. Each price has an equal probability of being revised in any given period and this probability is independent of the timing of the last price change. In the New Keynesian Phillips curve the current inflation rate is a function of the currently expected future inflation rate and current excess demand

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \hat{y}_t$$

where

$$\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha} > 0 \tag{2.2}$$

The term $0 < \beta < 1$ is a discount factor and κ is positive since, with excess demand, inflation tends to increase. In this analysis excess demand is measured only by the output gap, since when comparing alternative Phillips relations, the focus is on the expectations terms. Iterating equation (2.2) forward, we obtain

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k E_t(\hat{y}_{t+k}) \tag{2.3}$$

Since the current inflation rate is equal to the weighted, discounted stream of current and future output gaps, it is entirely forward-looking and there is no persistence in the inflation process.

It may not be reasonable to assume that in the Calvo model prices are unchanged between optimising periods. Instead, we can assume that firms can save costs if prices are changed between price adjustment periods according to a

mechanical rule. The Hybrid model (Galí and Gertler 1999) relates current inflation to both currently expected future inflation and the lagged inflation rate. Only some firms are assumed to be forward-looking and to set their prices optimally. The rest are assumed to be backward-looking in their pricing decisions. Thus, in the Hybrid modification of the New Keynesian Phillips curve, the lagged inflation term is needed as an additional explanatory variable

$$\pi_t = \omega_1 E_t \pi_{t+1} + \omega_2 \pi_{t-1} + \kappa \hat{y}_t \tag{2.4}$$

According to equation (2.4), the current inflation rate depends not only on the expected path of the driving variable (ie the output gap in this study), but also on the lagged inflation rate, π_{t-1}. Therefore, the Hybrid Phillips curve implies persistence in inflation. The inflation process is the more persistent, the larger the indexation parameter ω_2.

Alternative Phillips curve relationships are based on time-dependent optimal price setting with nominal rigidities. Since optimal pricing decisions are based on the present value of expected profits, expectations play a crucial role in pricing decisions in all specifications. The three specifications have clearly different policy implications. The New Classical Phillips curve implies that monetary policy will have only temporary effects on real economic activity. By contrast, longer-lasting real effects of monetary policy can be modelled using the New Keynesian Phillips curve. The Hybrid model is able to explain inflation persistence due to delayed effects of monetary policy on inflation.

2.2   Estimating formulas

The standard specifications for the New Classical, New Keynesian and Hybrid Phillips curves ie equations (2.1), (2.2) and (2.4) need to be modified slightly, when rational expectations are not imposed and inflation expectations are measured directly. In estimations we used the following modified formulas

$$\pi_t = \pi_t^* + \varphi \hat{y}_t \tag{2.5}$$

$$\pi_t = \beta_t \pi_{t+1}^* + \kappa \hat{y}_t \tag{2.6}$$

and

$$\pi_t = (1 - \omega)\pi_{t+1}^* + \omega \pi_{t-1} + \phi \hat{y}_t \tag{2.7}$$

where the terms $\pi_t^* = \overline{E}_{t-1}\{\pi_t\}$ and $\pi_{t+1}^* = \overline{E}_t\{\pi_{t+1}\}$ refer to period t–1 and period t representative market expectations, which are not necessarily rational. As Adam and Padula (2003) have shown, we can derive the New Keynesian Phillips curve with directly measured expectations. In applying equations (2.5)–(2.7) to the data, one need not assume any specific form of non-rationality in expectations. Since the task here is to compare the different models on their own terms, the theoretical restrictions are imposed in the estimated specifications of the New Keynesian models. Thus, in the New Keynesian Phillips curve, the imposed value of ß is 0.97 and, as seen in equation (2.7), the sum of forward- and backward-looking components is restricted to unity for the Hybrid Phillips curve.

When estimating alternative specifications separately, clear statistical preference cannot yet to be claimed for any of the Phillips curve relationships. In order to facilitate the comparison of models, we applied two statistical tests to the data. The New Classical and New Keynesian Phillips curves were compared using

a specification test proposed by Davidson and MacKinnon (1993). This test analyses, whether current or lagged expectations dominate the inflation process

$$\pi_t = \theta_1\left(\pi_t^*\right) + \theta_2\left(0.97 \cdot \pi_{t+1}^*\right) + \phi\hat{y}_t \tag{2.8}$$

Equation (2.8) includes both expectations variables and then encompasses both models under consideration as special cases. The sum of the estimated coefficients θ_1 and θ_2 was restricted to one in order to analyse the relative weights of alternative components in the inflation process, as the test typically puts strong weight on either of the variables compared. With the same driving variable in both specifications, we were able to focus clearly on the timing of the expectations term in the Phillips curve relationship.

The Wald test is based on parameter restrictions and it is weaker than the specification test. It was used to compare the three alternative Phillips curves against the following very general model, which incorporates all the specifications as special cases

$$\pi_t = a\pi_t^* + b\pi_{t+1}^* + c\pi_{t-1} + d\hat{y}_t \tag{2.9}$$

Previously expected current inflation, currently expected future inflation, lagged inflation rate, and current output gap are the explanatory variables in the general model. If the parameters b and c are equal to zero, the model reduces to the New Classical Phillips curve. Alternatively, if the coefficients a and c are equal to zero, we obtain the New Keynesian Phillips curve. Moreover, the general model reduces to the Hybrid model if the parameter a is equal to zero. Using the Wald

test of coefficient restrictions, we were able to determine whether restricted specifications are accepted by the data.

3 Empirical evidence

3.1 Data description

In order to construct the pooled European data until the year 2004, annual inflation rates and two alternative driving variables (HP filtered output gap and OECD output gap estimates) were constructed using the OECD Economic Outlook data set and OECD National Accounts. Inflation was measured by annual changes in consumer prices and corresponding inflation forecasts for each country were obtained from Consensus Economics monthly survey. Since we cannot pin down the exact timing of expectations term with annual data, we used both June and December estimates for the next calendar year. The HP filtered output gap[2] is defined as the difference between log real GDP and Hodrick-Prescott filtered log real GDP with smoothing parameter of 100. OECD output gap estimates are based on production function method. Empirical analysis is based on eleven out of twelve countries presently constituting the euro area. Since OECD output gap estimates and Consensus Economics inflation forecasts are not available for Luxembourg, it is not included in the data. Availability of data varies somewhat. For Greece, both survey forecasts are available since 1993. For the other ten countries, June forecasts are available since 1990 and December forecasts since 1989. Thus, in estimations the sample is from 1989–1991 till 2004.

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[2] When constructing HP filtered output gaps, we used long real GDP series since 1973. Moreover, we used OECD real GDP forecasts for the years 2005 and 2006 in order to reduce the impact of the end-point problem.

INSERT FIGURE 1 HERE

Figure 1 gives constructed series for Germany, France, Italy and Spain, which dominate the euro area, with a combined weight of over 80 per cent. Inflation histories have diverged across countries since the beginning of the 1990s. Only Greece and Portugal experienced two-digit inflation rates in the first years of the sample. In the whole sample, the average inflation rate was above 3 per cent in Greece, Ireland, Italy, Portugal and Spain, and below 3 per cent in rest of the economies. There has been remarkable heterogeneity in output gap developments across the countries. Finland, Ireland, and Portugal belong to the country group with more a divergent output gap history, while in other countries the output gap has been less volatile.

INSERT TABLE 1 HERE

The unbiasedness of Consensus Economics inflation forecasts was tested by estimating the equation $\pi_t = a + b\pi_t^*$, where π_t^* refers to period t inflation forecast, made in period t-1. As shown in table 1, with both cases we could not reject the joint hypothesis that the constant a is equal to zero and the coefficient of the expectations, b, is equal to one. Thus, we found evidence that since the beginning of the 1990s survey-based forecasts were unbiased, which means that inflation expectations seem to have not been far from rationality[3].

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[3] Qualitatively similar results with pooled euro area data can be found in Paloviita (2005a). When OECD inflation forecasts are used to proxy inflation expectations, we get evidence that in 1977–1990, when inflation was high and volatile in many European countries, inflation expectations

– 11 –

Further analysis of June and December forecasts (not reported here) showed that forecast errors are positively correlated and forecast errors seem not to be orthogonal to lagged information, as assumed under rational expectations. With both cases, regressing forecast error on lagged inflation rate and lagged output gap led to rejection of the null hypothesis that estimated coefficients are jointly equal to zero. These results indicate that deviations from full rationality may be important in empirical analysis of the Phillips curve relationship.

INSERT FIGURE 2 HERE

Figure 2 compares Consensus Economics December inflation forecasts with corresponding OECD estimates, also made in December. For Germany, France, Italy and Spain the correlation between these variables[4] varies between 0.942 and 0.985. Overall, both proxies seem to follow a similar pattern. We would conclude that in comparing alternative measures of inflation expectations, we obtained support for the reliability of Consensus Economics forecasts as a proxy for inflation expectations.

3.2   Empirical comparison of alternative Phillips curves

The three different Phillips curves were applied separately to pooled European data. Moreover, statistical preference of different specifications was examined using econometric specifications test presented in 2.2. When measuring inflation expectations directly, we can in principle use least squares in estimations, if we

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were biased. By contrast, the hypothesis of unbiasedness cannot be rejected in the euro area for the period 1991–2003.

assume that both inflation expectations and the output gap are measured correctly and they are not correlated with each other or with the error term. However, since least squares is not necessarily an appropriate estimation method for alternative Phillips relations, empirical results are mostly reported using only the generalised method of moments (GMM). In order to avoid too many instruments, ie possible small sample problems due to 'overinstrumenting', only two or three instruments were used in Phillips curve estimations.

First, the New Classical and New Keynesian Phillips curves ie equations (2.5) and (2.6) were estimated separately with least squares and the GMM. For both specifications two alternative expectations terms (June or December forecasts) and two alternative driving variables (the HP-filtered or OECD output gaps) were used. When using the GMM, the instrument sets included always two predetermined variables: the lagged output gap and the lagged inflation rate. J-statistic was used to test overidentifying restrictions of both specifications.

GMM results for the New Classical and New Keynesian Phillips relations are reported in Appendix 1. For both specifications we always obtained a positive coefficient for the output gap and only in one case for the New Keynesian specification, the estimated parameter was not statistically significant. When comparing alternative driving variable results of both models, we notice that the estimated coefficient was always higher with the HP filtered output gap. On the other hand, when using June forecasts instead of December forecasts, we got higher estimates. All in all, the New Classical Phillips curve results were quite reasonable, since the overidentifying results were never rejected at 5 per cent level. However, the empirical fit of the New Keynesian Phillips curve was poor,

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[4] For all countries in the sample, the correlation is 0.967.

since the overidentifying restrictions were always rejected at 5 per cent level

according to the Hansen test[5].

INSERT TABLE 2 HERE

In order to assess the statistical preference for the New Classical or New

Keynesian specification, the Davidson and MacKinnon (1993) specification test

was next applied to the data using GMM with lagged inflation rate and two lags of

the output gap as instruments. The test results are reported in table 2. They show

that in explaining inflation dynamics, in all cases lagged inflation expectations

had clearly bigger relative weights than current expectations. In three cases the

relative weight of the lagged expectations term was about 1 and in one case very

large, 1.4. The result of the dominant role of the lagged expectations term was

robust to choice of the output gap measure. Moreover, the test results were

qualitatively similar with June and December forecasts. Thus, the choice of exact

timing of current and lagged expectations (ie in the middle or in the end of the

period) seemed not to change the test results. Overall, when comparing the New

Classical and New Keynesian Phillips curves with the specification test, we got

evidence in favour of the New Classical Phillips curve.

Next, the Hybrid Phillips curve ie equation (2.7) was estimated using least

squares and the GMM (see Appendix 2). First, possible measurement errors or

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[5] Quite similar results were obtained, when using least squares (not reported here). For both
specifications, when comparing alternative driving variables, higher estimates were always got
with HP filtered output gaps. Moreover, June forecasts yielded in all cases higher coefficients than
December forecasts. However, for the New Keynesian specification, least squares results were
poor, since in one case we got a negative coefficient and only one of the estimated parameters was
statistically significant. The residual were strongly correlated in all cases.

simultaneity problems were not taken into account, which means that least squares estimation method was assumed to be sufficient. As shown in table A2.1, Hybrid Phillips curve results were quite reasonable: relative weights of backward-looking expectations were 0.38–0.41 and all estimated coefficients were statictically significant. Thus, we got evidence that forward-looking expectations dominate the inflation process in Europe.

We also estimated the Hybrid Phillips curve using GMM, since IV methods might be needed because of errors-in-variables and/or simultaneity problems. Also for the Hybrid model, predetermined variables were chosen for instruments: two lags of the output gap and second lag of inflation. As shown in table A2.2, The Hybrid Phillips curve results were slightly mixed: expectations were more forward-looking, when HP filtered output gap was used and by contrast, more backward-looking, when OECD output gap estimates were used. However, the relative weight of backward-looking expectations varied only between 0.46 and 0.53. All estimated coefficients for the driving variable were plausible and significant, and overidentifying restrictions were never rejected. All in all, the results in Appendix 2 indicates that the empirical fit of the New Keynesian Phillips curve can be improved by adding the lagged inflation term, ie by using the Hybrid model.

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

– 15 –

Finally, the three different Phillips curves were compared using the Wald test of coefficient restrictions (see tables 3 and 4). When the parameter restrictions of the New Keynesian Phillips curve were tested against the general model, the Wald test clearly rejected parameter restrictions implied by the New Keynesian Phillips curve specification. When the same test was used to evaluate the Hybrid model against the general model, the Hybrid model was clearly accepted in all cases. When comparing the New Classical Phillips curve to the general model, the test results were slightly mixed: in three cases the New Classical specification is accepted, but only at the 1 per cent level. Qualitatively, the Wald test results seemed to be robust with respect to exact choice of current or lagged expectations (ie choice of the month, June or December) and choice of the output gap measure.

To conclude, the test results suggested that both the New Classical and Hybrid Phillips curves provide a better description of the European inflation process than does the New Keynesian Phillips curve. Changing the timing of the expectations term in the New Keynesian Phillips curve, ie replacing current expectations by lagged expectations, we obtain the New Classical Phillips curve, which gives a better approximation of the inflation process than does the New Keynesian specification. In this case, we do not assume any backward-looking price setting. On the other hand, when the backward-looking expectations term is added to the purely forward-looking New Keynesian Phillips curve, the empirical fit is much improved.

Empirical evidence against the purely forward-looking New Keynesian Phillips curve can be found also in other studies with directly measured expectations. Paloviita (2005b) examines euro area inflation dynamics since the late 1970s and uses OECD inflation forecasts to proxy inflation expectations. Also

– 16 –

that study, which uses the same econometric specification tests in comparison of different Phillips relations, suggests that the New Keynesian Phillips curve is outperformed by the New Classical and Hybrid Phillips curves. The basic features of the New Keynesian Phillips curve are also rejected in Paloviita and Mayes (2005), who use real time information and directly measured inflation expectations (ie OECD forecasts) in different specifications of the Phillips curve. Gorter (2005) argues that with survey-based expectations, for France the New Keynesian Phillips curve is appropriate, but for Germany and Italy the Hybrid specification is needed. Adam and Padula (2003) find evidence that with survey-based expectations the Hybrid Phillips curve must be used to describe the US inflation process properly.

The New Keynesian Phillips curve has been widely studied also under the assumption of rational expectations, but the empirical evidence has been mixed. Galí and Gertler (1999) examines the US and Galí, Gertler and López-Salido (2001) the euro area inflation process. Both of these studies indicate that the New Keynesian Phillips curve provides a reasonably good approximation of inflation dynamics. Sbordone (2002), who uses a two-steps estimation procedure, also argues that US inflation dynamics can be captured fairly well with a purely forward-looking model. By contrast, McAdam and Willman (2003) find evidence that the New Keynesian Phillips curve fits euro area data poorly. Moreover, Jondeau and Le Bihan (2001) argue that both with US and euro area data the Hybrid specification fits better than the New Keynesian Phillips curve.

Benigno and López-Salido (2001) find that for Germany the New Keynesian Phillips curve is appropriate, but for France, Italy and the Netherlands the Hybrid models are needed (the results are mixed for Spain). According to Sondergaard

– 17 –

(2003) the Hybrid model is favoured for France and Italy, but the results are mixed for Spain. By contrast, Rudd and Whelan (2003) find little evidence for the rational forward-looking behaviour implied by the New Keynesian theory.

4   Conclusions

Expectations are crucial in the inflation process and for the effects of monetary policy. In empirical studies of inflation dynamics, different Phillips curve specifications have been used. These have different policy implications. If inflation is purely a forward-looking phenomenon, as the New Keynesian Phillips curve suggests, a fully credible disinflation is possible without output losses. On the other hand, if inflation process is persistent, there is a fundamental short-run tradeoff between inflation and output. In the latter case, we need alternative models with sluggish or backward-looking features to describe inflation dynamics accurately. The empirical application poses a challenge: when applying Phillips curve to the data, rational expectations have typically been assumed, but it may be an excessively restrictive assumption for economic behaviour.

In this study three different Phillips curves were applied to the pooled European data since the beginning of the 1990s. As we did not use a priori assumption of expectations formation, inflation expectations were proxied by Consensus Economics survey-based inflation forecasts. Moreover, two different measures for the output gap were used. Alternative specifications were compared using the specification test by Davidson and MacKinnon and the Wald test of coefficient restrictions.

The results obtained suggest that with survey-based inflation expectations one could capture European inflation dynamics with the New Classical Phillips curve.

– 18 –

Also the New Keynesian Phillips curve fit the data, but poorly. According to econometric specification tests the New Classical and the Hybrid Phillips curves clearly outperformed the New Keynesian Phillips curve. Thus we found evidence against the basic features of the New Keynesian model. The evidence of this paper suggests that the inflation process is not purely forward-looking and that the inflation rate cannot adjust instantaneously to new information. The backward-looking or sluggish features are different in the New Classical and Hybrid models, but the results indicate that they are important in European data.

If a possible departure from rational expectations is allowed, directly measured expectations in principle provide a channel through which inflation persistence could be introduced to the New Keynesian Phillips curve with microfoundations for optimal price setting. However, although this channel seems to be important, this study suggests that it is not powerful enough to properly explain all of the persistence in the European inflation process. This is reasonable, since inflation expectations seem not to be very far from rationality. To conclude, since expectations have important autonomous effects on the monetary policy environment, expectations should be taken explicitly and independently into account in conducting monetary policy. Moreover, there seems to be evidence of inflation persistence which cannot be reduced to the persistence of expectations. This is important because it implies the presence of some sort of structural basis for the short-run correlation between inflation and output.

– 19 –

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Appendix 1

New Classical and New Keynesian Phillips curve results

Table A1.1   New Classical Phillips curve

$$NCPC \quad \pi_t = \pi_t^* + \varphi \hat{y}_t$$

June forecast	φ	J-statistic
HP filtered output gap	0.261	0.018
	(0.037)*	[0.099]
OECD output gap	0.207	0.021
	(0.037)*	[0.209]

December forecast	φ	J-statistic
HP filtered output gap	0.155	0.002
	(0.038)*	[0.869]
OECD output gap	0.114	0.005
	(0.028)*	[0.347]

Notes: GMM using Barlett kernel with fixed bandwidth. Instruments: lagged output gap and lagged inflation. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to Hansen test of overidentifying restrictions (below in brackets the associated p-values are reported).

Table A1.2   New Keynesian Phillips curve

$$NKPC \quad \pi_t = 0.97 \cdot \pi_{t+1}^* + \kappa \hat{y}_t$$

June forecast	κ	J-statistic
HP filtered output gap	0.250	0.038
	(0.040)*	[0.045]
OECD output gap	0.124	0.064
	(0.038)*	[0.005]

December forecast	κ	J-statistic
HP filtered output gap	0.184	0.048
	(0.044)*	[0.004]
OECD output gap	0.036	0.069
	(0.039)	[0.003]

Notes: See table A1.1.

Appendix 2

Hybrid Phillips curve results

Table A2.1   Hybrid Phillips curve results using least squares

$$HPC \quad \pi_t = (1-\omega)\pi_{t+1}^* + \omega\pi_{t-1} + \phi\hat{y}_t$$

June forecast	ω	ϕ	D-W	R^2
HP filtered output gap	0.379	0.126	2.002	0.916
	(0.048)*	(0.021)*		
OECD output gap	0.411	0.084	1.916	0.909
	(0.048)*	(0.020)*		

December forecast	ω	ϕ	D-W	R^2
HP filtered output gap	0.394	0.082	2.308	0.921
	(0.036)*	(0.025)*		
OECD output gap	0.402	0.050	2.199	0.917
	(0.040)*	(0.022)*		

Notes: Numbers in parentheses are Newey-West HAC standard errors, * indicates significance at 5 per cent level.

Table A2.2   Hybrid Phillips curve using GMM

$$HPC \quad \pi_t = (1-\omega)\pi_{t+1}^* + \omega\pi_{t-1} + \phi\hat{y}_t$$

June forecast	ω	ϕ	J-stat.
HP filtered output gap	0.462	0.136	0.021
	(0.055)*	(0.020)*	[0.189]
OECD output gap	0.522	0.118	0.014
	(0.066)*	(0.020)*	[0.316]

December forecast	ω	ϕ	J-stat.
HP filtered output gap	0.485	0.119	0.0002
	(0.038)*	(0.023)*	[0.985]
OECD output gap	0.530	0.097	0.010
	(0.049)*	(0.020)*	[0.436]

Notes: GMM using Barlett kernel with fixed bandwidth. Instruments: two lags of the output gap, second lag of inflation. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to Hansen test of overidentifying restrictions (below in brackets the associated p-values are reported).

Figure 1.   **Inflation history, December inflation forecasts for the next year and the output gaps**
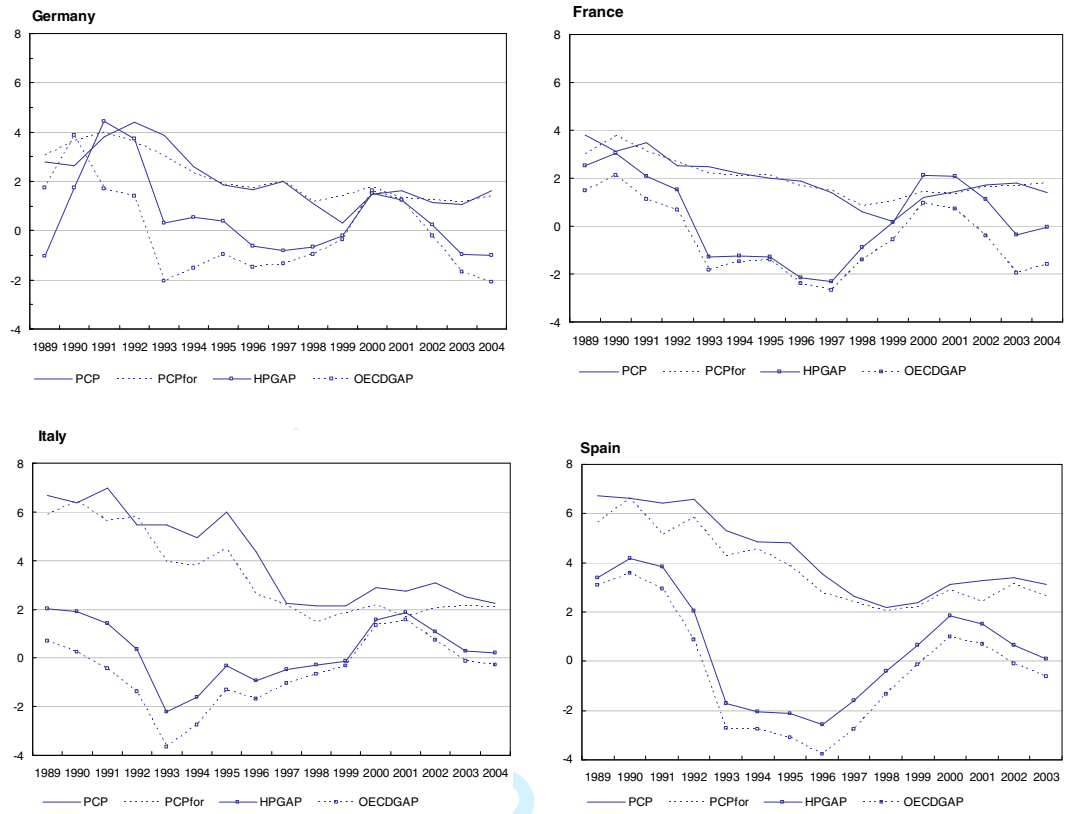
Figure 2.   **Consensus Economics and OECD inflation forecasts for the next year**

Germany

France

Italy

Spain

Table 1. **Unbiasedness of Consensus Economics inflation forecasts**

$$\pi_t = a + b\pi_t^*$$

	Joint Hypothesis	June forecast		December forecast	
Pooled European data	(a,b) = (0,1)	F=0.582	(0.560)	F=0.273	(0.762)

Notes: Newey-West HAC Standard errors, p-values in parenthesis.

Table 2.   **Comparison of New Classical and New Keynesian Phillips curves**

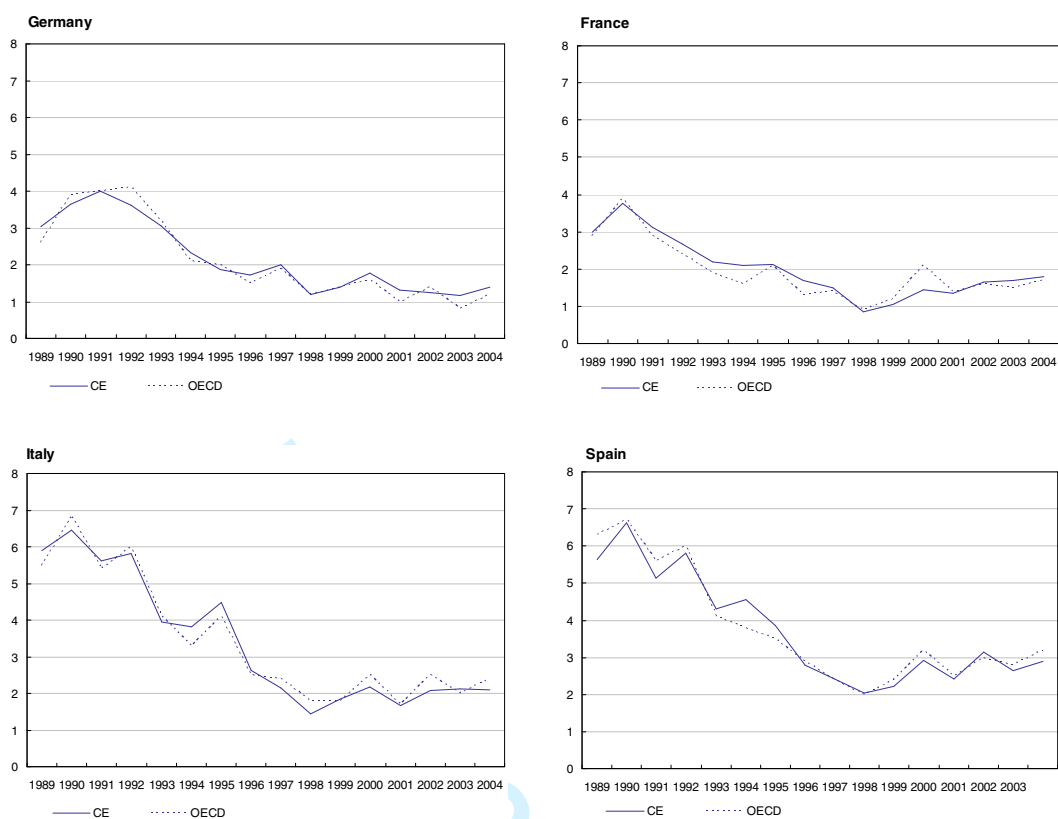$$\pi_t = \theta\left(\pi_t^*\right) + (1-\theta)\left(0.97 \cdot \pi_{t+1}^*\right) + \phi_t \hat{y}_t$$

	Driving variable			
	HP filtered output gap		OECD output gap	
	S.E. of the NCPC	S.E. of the NKPC	S.E. of the NCPC	S.E. of the NKPC
June forecast	0.782	0.870	0.840	0.890
	Encompassing test			Encompassing test		
	θ	φ	J-statistic	θ	φ	J-statistic
June forecast	1.041 (0.179)*	0.237 (0.036)*	0.037 [0.060]	1.411 (0.290)*	0.249 (0.049)*	0.023 [0.175]

	Driving variable			
	HP filtered output gap		OECD output gap	
	S.E. of the NCPC	S.E. of the NKPC	S.E. of the NCPC	S.E. of the NKPC
December forecast	0.716	0.905	0.739	0.872
	Encompassing test			Encompassing test		
	θ	φ	J-statistic	θ	φ	J-statistic
December forecast	1.038 (0.141)*	0.113 (0.031)*	0.017 [0.246]	1.171 (0.183)*	0.099 (0.029)*	0.014 [0.333]

Notes: GMM using Barlett kernel with fixed bandwidth. Instruments: lagged inflation rate, π_{t-1}, and two lags of output gap, $\hat{y}_{t-1}$ and $\hat{y}_{t-2}$. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to Hansen test of overidentifying restrictions (below in brackets the associated p-values are reported).

Table 3.   **Wald test results with HP filtered output gap**

$$\pi_t = a\pi_t^* + b\pi_{t+1}^* + c\pi_{t-1} + d\hat{y}_t$$

	Joint Hypothesis	June forecast		December forecast	
NKPC vs general model	$(a,b,c) = (0,0.97,0)$	F=28.122	(0.000)	F=49.514	(0.000)
HPC vs general model	$(a,b+c) = (0,1)$	F=0.616	(0.541)	F=0.381	(0.684)
NCPC vs general model	$(a,b,c) = (1,0,0)$	F=4.904	(0.003)	F=3.154	(0.027)

Notes: GMM using Bartlett kernel with fixed bandwidth.

Instruments: $\hat{y}_{t-1}, \hat{y}_{t-2}, \hat{y}_{t-3}, \pi_{t-2}, \pi_{t-3}$.

$$\pi_t = a\pi_t^* + b\pi_{t+1}^* + c\pi_{t-1} + d\hat{y}_t$$

Table 4. **Wald test results with OECD output gap**

$$\pi_t = a\pi_t^* + b\pi_{t+1}^* + c\pi_{t-1} + d\hat{y}_t$$

	Joint Hypothesis	June forecast		December forecast	
NKPC vs general model	(a,b,c) = (0,0.97,0)	F=22.762	(0.000)	F=41.138	(0.000)
HPC vs general model	(a,b+c) = (0,1)	F=0.261	(0.771)	F=0.538	(0.585)
NCPC vs general model	(a,b,c) = (1,0,0)	F=3.613	(0.015)	F=3.418	(0.019)

Notes: See table 3.

$$\pi_t = a\pi_t^* + b\pi_{t+1}^* + c\pi_{t-1} + d\hat{y}_t$$