BANK OF FINLAND DISCUSSION PAPERS

20 • 2002

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Finlands Banks diskussionsunderlag

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The views expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

I am grateful to Juha Tarkka and Jouko Vilmunen for helpful comments and Päivi Nietosvaara and Heli Tikkunen for editorial assistance.

Suomen Pankin keskustelualoitteita
Finlands Banks diskussionsunderlag

http://www.bof.fi

ISBN 952-462-003-0
ISSN 0785-3572
(print)

ISBN 952-462-004-9
ISSN 1456-6184
(online)

Suomen Pankin monistuskeskus
Helsinki 2002

Inflation dynamics in the euro area and the role of expectations

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Abstract

This paper assesses empirically the two main alternative specifications of the output gap-based Phillips relation for the euro area: the older expectations-augmented Phillips curve and the new Keynesian Phillips curve. The main focus is on the role of expectations and comparison of the two theories. Instead of imposing rational expectations, an alternative and in principle less restrictive approach is applied to operationalising expectations. Direct measures of inflation expectations, ie OECD forecasts, are used as empirical proxies of economic agents' inflation expectations. The main interest is in the euro area as a whole, although potential heterogeneity of inflation dynamics is also examined across eleven EMU countries. According to the results, inflation expectations are central to the inflation process in all euro area countries. The paper finds evidence that the new Keynesian Phillips curve fits the euro area data slightly better than the expectations-augmented Phillips curve. Research on expectations formation would be an important complement to the present study.

Key words: Phillips curve, expectations, euro area

JEL classification numbers: E31, C52

Euroalueen inflaatiodynamiikka ja odotusten merkitys

Suomen Pankin keskustelualoitteita 20/2002

Maritta Paloviita
Tutkimusosasto

Tiivistelmä

Tämä euroaluetta koskeva empiirinen tutkimus tarkastelee kahta vaihtoehtoista, tuotantokuiluun perustuvaa Phillipsin käyrää: vanhempaa, odotuksin täydennettyä sekä uuskeynesiläistä Phillipsin käyrää. Tarkastelun päähuomio on inflaatio-odotuksissa ja kahden teorian vertailussa. Inflaatio-odotuksia ei oleteta rationaalisiksi, vaan niitä mitataan suoraan käyttämällä OECD:n ennusteita. Tutkimus keskittyy euroalueeseen, mutta se selvittää myös mahdollisia eroja euroalueen yksittäisten maiden inflaatiodynamiikassa. Tulosten mukaan inflaatio-odotukset ovat keskeisessä asemassa inflaation muodostumisessa kaikissa euromaissa. Empiirinen vertailu osoittaa, että uuskeynesiläinen Phillipsin käyrä soveltuu euroalueeseen hieman paremmin kuin odotuksin täydennetty Phillipsin käyrä. Lisätutkimus odotusten muodostumisesta täydentäisi hyvin tämän työn tuloksia.

Asiasanat: Phillipsin käyrä, odotukset, euroalue

JEL-luokittelu: E31, C52

Contents

1 Introduction

Inflation dynamics has continuously been one the most debated issues in macroeconomics. Among other things, the puzzling combination of low inflation and high real growth in many industrialised countries in the 1990's has stressed the importance of examining price changes. Moreover, the establishing of the European Central Bank with the explicit mission of price stability as well as different price developments in countries belonging to the European Monetary Union have emphasised the need to understand the determinants and dynamics of inflation. Recent methodological advances have increased the interest to study the nature of inflation process, which is crucial when designing optimal monetary policy.

Inflation seems to be costly to reduce. Over time many countries have witnessed disinflation together with output and employment losses, the causes of which appear to be associated with credibility and thus expectations formation. Since the late 1950's the research on inflation dynamics has been largely based on the Phillips curve, the economic modelling of which has changed considerably over the years. Originally Phillips (1958) and Samuelson and Solow (1960) hypothesized a stable negative relationship between unemployment and inflation without paying special attention to the role of expectations. About ten years later Phelps (1967) and Friedman (1968) developed the expectations-augmented Phillips curve with a central role of expectations in inflation process through wage bargaining and price setting. In the 1970's, when rational expectations was a major theme of macroeconomic research, Lucas (1976) presented the rational expectations hypothesis, which suggests that inflation expectations cannot systematically differ from actual inflation. In later empirical work on the expectations-augmented Phillips curve rational expectations are typically assumed and real economic activity is measured by actual output relative to potential, the output gap.

Recent advances in the theoretical modelling of inflation dynamics have led to a specification called the new Keynesian Phillips curve, which is based on work by Taylor (1980) and Calvo (1983). This theory has been built explicitly from microfoundations. It suggests that prices are sticky and inflation depends entirely on current and expected future economic conditions. Currently expected future inflation determines inflation in this theory contrary to the expectations-augmented Phillips relation, where inflation is dependent on previously expected current inflation. In the new Keynesian theory excess demand enters through real marginal costs, the empirical measure of which in the literature is typically the output gap or real labour costs (labour income share).

This paper assesses empirically the two main alternative specifications of the output gap-based Phillips relation for the euro area: the older, expectations-

augmented Phillips curve and the new Keynesian Phillips curve. The main focus is on the role of expectations and comparison of the two theories. Instead of imposing rational expectations, an alternative and in principle less restrictive approach is applied to operationalising expectations. Direct measures of inflation expectations are used as empirical proxies of economic agents' inflation expectations. Similar studies with survey based expectations have been done by Roberts (1997, 1998) for the US economy. More specifically, inflation dynamics in the euro area are studied in this paper using the OECD inflation forecasts to represent prevailing inflation expectations in wage and price formation. They need not necessarily be rational although they may be. The expectations-augmented and the new Keynesian Phillips curves are fitted to the data with single equation estimations using generalised method of moments. Two statistical tests are used to assess the empirical superiority of one specification over the other. The main interest is in the euro area as a whole, although potential heterogeneity of inflation dynamics is also examined across eleven EMU countries.

As this paper shows, both versions of the Phillips relation do a reasonably good job in accounting for inflation dynamics in the euro area. However, the new Keynesian Phillips curve with the currently expected future inflation works slightly better compared with the expectations-augmented Phillips curve with the previously expected current inflation. Contrary to many other empirical studies, the output gap appears to be an adequate empirical measure of cyclical inflationary pressure in the Phillips relation. This study indicates that the OECD forecasts are likely to be useful estimates of expected inflation in the Phillips curve specification. Hence, this approach is worth exploring further.

This paper proceeds as follows. Section 2 describes the two Phillips relations and summarises earlier empirical studies of the new Keynesian specification. Section 3 presents empirical frameworks, testing strategy and the data. It also reports empirical results for the euro area and eleven EMU countries. Finally, section 4 concludes.

2 Two Phillips curve specifications

This section presents the two alternative Phillips curve specifications, which are applied in this study to the euro area for analysing the role of expectations in inflation dynamics. The expectations-augmented Phillips curve is described first, according to which current inflation depends on previously expected current inflation and excess aggregate demand. Second, the new Keynesian Phillips curve is presented. In this specification currently expected future inflation and real marginal costs determine current inflation. When describing the theories, special attention is paid to the role of expectations. The expectations-augmented and the

new Keynesian Phillips curve provide clearly different implications to monetary policy design, because of the crucial differences in the way expectations are linked to inflation dynamics.

2.1 The expectations-augmented Phillips curve

The expectations-augmentend Phillips curve can be usefully presented using Fischer's (1977) model with one-period wage contracts. In this model expected inflation plays a central role in wage bargaining, as nominal wages are predetermined in the beginning of every period. On the contrary, the output and the price level may adjust during each period as a reaction to random disturbances affecting the economy. As the constant real wage is assumed to be the goal of wage setting, the nominal wage contract for period t depends on the expected price level in the following way:

$$_{t-1}W_t = \gamma + {}_{t-1}p_t \tag{1}$$

where $_{t-1}W_t$ is the logarithm of period t nominal wage, the contract over which is made in the end of period t–1. The term $_{t-1}p_t$ is the expected price level for period t, as expectation is formed in the end of period t–1. For simplicity, the scale factor, γ, is henceforth assumed to be zero. In this framework the aggregate supply relation between the price level, the expected price level and excess demand can be rewritten in terms of inflation, expected inflation and excess demand. Hence, in Fischer's model with one-period wage contracts the expectations-augmented Phillips curve can be expressed by equation

$$\pi_t = {}_{t-1}\pi_t + \lambda \hat{y}_t \tag{2}$$

where π_t denotes the period t inflation rate, defined as the rate of change of prices from period t–1 to period t. The term $_{t-1}\pi_t$ refers to the corresponding expected rate of inflation ie the expected current inflation in period t. The term $\hat{y}_t$ denotes the period t excess demand. In the expectations-augmented Phillips relation inflation expectations pertain to the current inflation. In principle, the theory allows for different expectations formation mechanisms. Static, adaptive and rational expectations have been postulated in empirical studies. The standard formulation with rational expectations is

$$\pi_t = E_{t-1}\{\pi_t\} + \lambda \hat{y}_t \tag{3}$$

where E_{t-1} is the expectations operator conditional on information available in period t–1. The mean value of forecast errors is zero under rational expectations.

The output gap, which is here defined as the difference between logarithms of actual and potential output, is often used to indicate the excess demand in the economy. Other measures have also been used, like the capacity utilisation rate and the unemployment gap, which denotes the difference between the actual rate of unemployment and the non-accelerating inflation rate of unemployment, the NAIRU. Alternative specifications may include additional lags of excess demand.

The expectations-augmented Phillips curve approach has support in many empirical studies, see for example King and Watson (1994) and Lown and Rich (1997). In applied work, oil price and other additional variables have often been incorporated to the model in order to capture the supply shocks of the 1990's.

2.2 The new Keynesian Phillips curve

The new Keynesian approach has incorporated recent methodological advances in dynamic general equilibrium theory. In this approach, inflation is wholly explained by the current and expected future economic conditions, and non-neutral effects of monetary policy are based on temporary nominal price rigidities. Furthermore, the theory uses explicitly microfoundations assuming firms are monopolistically competitive and nominal price setting is staggered. Price-setting decisions of individual firms are derived from an explicit optimisation problem, as every firm maximises profits subject to constraints on the frequency of price adjustments or alternatively subject to menu costs related to changing prices (Rotemberg 1982).

Generally, aggregating the decision rules of firms is rather complicated when nominal price setting is staggered, but it can be simplified following the approach in Calvo (1983), where each firm has a fixed probability (1–θ) of changing its price in any period. Correspondingly, θ is a probability of keeping the price fixed. The probability of adjusting the price is independent of the length of time since the last price change. The expression 1/(1–θ) describes the average time a price is fixed. Thus, nominal rigidity increases, as θ rises.

Aggregating across the price setting decisions of the individual firms yields the following linearised relationship between current inflation, expected future inflation and real marginal costs:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda mc_t \tag{4}$$

where π_t denotes the inflation rate in period t and mc_t is the period t log deviation of the firms' real marginal costs from the steady state value. The term E_t refers to

the expectations operator conditional on information available in period t. Thus, in this specification, inflation is dependent on currently expected future inflation. The parameter β is the subjective discount factor and the coefficient on real marginal costs, the term λ, is a function of two structural parameters of the model in the following way: $\lambda = (1-\theta)(1-\beta\theta)/\theta$, where θ is the degree of price rigidity. Because λ is decreasing in θ, the longer prices are fixed on average, the less sensitive inflation is to current variation in real marginal costs. In this framework forward-looking firms have to set prices for possible multiple periods and base their pricing decisions on the expected future developments of marginal costs. Iterating equation (4) forward yields:

$$\pi_t = \lambda \sum_{k=0}^{\infty} \beta^k E_t \{mc_{t+k}\} \tag{5}$$

As inflation is equal to the discounted stream of future marginal costs, it is entirely forward looking with no persistence in it. The credibility issues of monetary policy are relevant in this framework. With credible monetary policy inflation can be reduced without output losses via expectations of future monetary policy.

In empirical studies, the output gap is a commonly used proxy for the real marginal costs, but also labour costs have been used. These variables are assumed to capture changes in real marginal costs associated with variation in excess demand in the economy. When using the output gap to measure cyclical variation, it must be linked to real marginal costs. With certain assumptions on technology, preferences and the structure of labour markets the following relation holds within a local neighbourhood of the steady state of log real marginal costs:

$$mc_t = \delta \hat{y}_t \tag{6}$$

Substituting the above relation into equation (4), we obtain the following typical specification for the new Keynesian Phillips relation:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \hat{y}_t, \tag{7}$$

where $\kappa = \lambda\delta$.

2.3 Earlier empirical studies

The output gap based new Keynesian Phillips curve under rational expectations has often been used in monetary policy analysis, but the empirical validity of the model has not been firmly established. When using the new Keynesian specification for studying price changes, inflation seems to be poorly captured and output gap enters often insignificantly or with a wrong, negative sign. To cope better with the data, the model has been typically modified using lagged inflation rate and alternative measures of real economic activity.

Real marginal costs, which are implied by the new Keynesian theory, are difficult to measure empirically. It has lead to a debate, whether the output gap or labour costs is the appropriate measure of cyclical inflationary pressure in applied work. The output gap has been criticised for having problems with measurement errors and it may not move proportionally with real marginal costs due to the failure to account for labour market frictions. On the other hand, the relation between unobservable firm-level marginal costs and observable aggregate marginal costs appears to be problematic and the estimation results seem to be highly sensitive to the specification of labour costs.

Empirical studies have raised questions about the adequateness of the underlying theory. The theoretical model under rational expectations does not imply any lags of inflation, which have been interpreted as representing the agents who act as backward looking price setters. The poor empirical fit may thus be associated with the possible inaccuracy of the rational expectations hypothesis, which is mainly assumed in empirical studies.

Fuhrer and Moore (1995) have shown with the US data that the new Keynesian model under rational expectations hypothesis without lags is not able to capture inflation dynamics. In the recent study by Gagnon and Khan (2001) inflation responds better to anticipated movements in labour costs than output gap. When output gap is used in this study, the estimated slope of the new Keynesian Phillips curve is negative for the euro area and the USA and positive for Canada. When the lagged inflation is added to the output gap based model, the slope of the curve is positive for the euro area and Canada, but negative (wrong) for the USA. In most of the output gap based estimations by Gagnon and Khan, the estimated coefficient on output gap is insignificant.

Gali and Gertler (1999) conclude that the new Keynesian Phillips curve provides a reasonably approximation to inflation dynamics in the USA, when labour income share is used to measure real marginal costs. Although backward looking price setting is statistically significant in their study, it is not quantitatively important. Gali, Gertler and Lopez-Salido (2001) are in favour of the new Keynesian Phillips curve conditional on real unit labour costs instead of the output gap both for the euro area and the USA. While there seems to be some

backward lookingness in inflation dynamics, the new Keynesian Phillips curve fits the euro area data according to their findings. Sbordobe (2002) argues also that the new Keynesian Phillips curve performs better when real labour costs are used. By contrast, Rudd and Whelan (2002) argue that the empirical fit of the new Keynesian model is not improved when using real labour cost instead of the output gap.

Benigno and Lopez-Salido (2002) have compared inflation dynamics in five major EMU countries. When studying France, Germany, Italy, the Netherlands and Spain they provide evidence on heterogeneity in price changes across the countries. This study suggests that only in Germany inflation has a dominant forward looking component and there is a significant backward looking component in inflation process in the four other countries.

Roberts (1997, 1998) has analysed inflation dynamics in the USA with the new Keynesian specification by using survey estimates of inflation expectations instead of rational expectations assumption. He finds evidence that inflation expectations are not rational, which appears to be in connection with the poor empirical fit of the new Keynesian theory. However, the results are highly dependent on inflation surveys, which have been criticised as being unreliable estimates of inflation expectations.

3 Empirical evidence

3.1 Empirical frameworks and testing strategy

This section contains a more detailed discussion about the empirical specification of the two Phillips relations described above. When applying the alternative Phillips curves to the euro area data, the same method of operationalising expectations is used in both specifications. Furthermore, the measure of excess demand is the same in both cases, as the main interest is on the role of expectations. In order to facilitate the comparison of the empirical performance of two Phillips relations, two statistical tests are applied to the data. They are also discussed in this section.

The role of expectations is central when comparing the two theories. The expectations-augmented Phillips curve and the new Keynesian Phillips curve differ in a way expectations are linked to inflation process. In the expectations-augmented specification current inflation is related to the previously expected current inflation, as shown in equation (3): $\pi_t = E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$. When applying to the data, the specification is modified slightly:

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t \quad (8)$$

The parameter β allows us to test for non-neutrality in inflation process; in theory, we would expect β = 1. It also makes the model comparable to the new Keynesian specification.

In the new Keynesian specification current inflation is dependent on the currently expected future inflation according to equation (7): $\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \hat{y}_t$. In this Phillips relation the parameter β is the discount factor, which is less than but very close to unity. Inflation varies positively with the output gap in both specifications and the parameters λ and κ measure the sensitivity of inflation to variation of excess demand. In the new Keynesian model the future output gap changes are assumed to capture exactly the future changes in real marginal costs.

Two inflation measures are used in estimations: the annual changes of the GDP deflator and the private consumption deflator. The corresponding OECD forecasts are used to measure inflation expectations. When using direct measures of inflation expectations, we can avoid a problem in many previous studies of inflation dynamics, which have had to test dual hypothesis, concerning the Phillips curve specification and the expectations formation at the same time. Thus, in this study we can allow for the possibility that the expectations themselves may adjust slowly or move for spurious reasons. The OECD forecasts are likely to be more reliable proxies for inflation expectations than the earlier used survey estimates, as they are based on systematic monitoring of economic developments and econometric models. While using these proxies for inflation expectations, we can also analyse whether the lagged inflation rate is needed to improve the empirical fit of the Phillips relation.

The following encompassing test (Davidson and MacKinnon 1993) is used to analyse, whether the expected future inflation or the expected current inflation dominates inflation process:

$$\pi_t = \theta E_t\{\pi_{t+1}\} + (1-\theta) E_{t-1}\{\pi_t\} + \phi \hat{y}_t \quad (9)$$

Equation (9) includes both expectations variables and then encompasses both models under consideration as special cases. If the hypothesis (1–θ) = 0 is not rejected and the hypothesis θ = 0 is rejected, inflation process is dominated by the expected future inflation. Accordingly, in the opposite case ie the hypothesis θ = 0 is not rejected and the hypothesis (1–θ) = 0 is rejected, the model reduces to the expectations-augmented Phillips curve with the previously expected current inflation. If the sum of the estimated coefficients is restricted to one, it is possible to analyse relative weights of the alternative components in inflation process.

The two Phillips relations can also be compared with a non-nested test (Davidson and MacKinnon 1993). This test analyses, whether one Phillips curve

specification has explanatory power over the other, which would indicate that the other specification is misspecified. However, compared to the tests based on parameter restrictions with certain assumptions about distributions, non-nested tests are substantially weaker. At best they only indicate, which model fits data better.

When applying the non-nested test to the two Phillips relations, two general models including the alternative Phillips curve specifications are formulated in the following way:

$$\pi_t = (1-\alpha)\left[\beta E_t\{\pi_{t+1}\} + \kappa \hat{y}_t\right] + \alpha \hat{\pi}_t \tag{10}$$

and

$$\pi_t = (1-\omega)\left[\beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t\right] + \omega \tilde{\pi}_t \tag{11}$$

where the terms $\hat{\pi}_t$ and $\tilde{\pi}_t$ denote the fitted values of the single equation estimations of the expectations-augmented Phillips curve and the new Keynesian Phillips curve. With equations (10) and (11) both specifications can be tested against a more general model. Combining the test results, the validity of the alternative specifications can be analysed.

For example, if the hypothesis $\alpha = 0$ is not rejected in equation (10), the expectations-augmented specification has no explanatory power over the new Keynesian one. Accordingly, if the hypothesis $\omega = 0$ is rejected in equation (11), the new Keynesian specification has explanatory power over the other one. So, when considering the results of both equations we can conclude that the new Keynesian specification supports evidence against the expectations-augmented one in this example.

Alternatively, if estimation results show that both models are rejected against the general model, neither of them is satisfactory. Instead, if neither model is rejected against the general model, the conclusion is that the data is equally fitted with both specifications. In this case there is no remarkable difference between the expectations-augmented and the new Keynesian Phillips relation or the empirical data is poor for testing inflation dynamics with the two Phillips curves.

3.2 The data

The annual data cover the period 1981–2000[1]. For all countries, the inflation rates and the output gap series are constructed using the OECD Economic Outlook data set. Two alternative inflation measures are used, the annual changes of the GDP deflator and the private consumption deflator. The corresponding OECD inflation forecasts for every country have been collected from the OECD Economic Outlook publications. The OECD makes forecasts twice a year. Here, the December estimates for the next year are considered. Thus, in the expectations-augmented Phillips curve specification, in equation (8), the previous year's December forecasts for the current year are used. Similarly, the current year's December forecasts for the next year measure inflation expectations in the new Keynesian specification ie in equation (7). The output gap is defined as the difference between the log real GDP and the HP-filtered log real GDP.

When aggregating inflation rates, inflation forecasts and the output gap for the euro area, the ECB country weights for eleven EMU countries have been used. The four biggest economies, Germany, France, Italy and Spain cover over 80 per cent of the euro area. Hence, they dominate the aggregated data. Weights of all the other economies are less than 10 per cent. See Appendix 1 for a detailed data description.

Figures 1 and 2 present the inflation rates and inflation forecasts for the euro area. In the beginning of the 1980's inflation was about 10 per cent, but it decreased to approximately 3 per cent during the next few years. Since a small peak of about 4.5 per cent in the beginning of the 1990's inflation has remained subdued in the euro area. When looking at the inflation forecasts for the current year, it can be seen that the decreasing inflation was overpredicted in the first half of the 1980's. In addition, the accelerating inflation in the late 1980's was not directly captured by the forecasts. Recent inflation forecasts are quite in line with the actual inflation.

The euro area real output and potential output are shown in Figure 3. Before the end of the 1980's real growth was quite modest and the output gap was negative. In the late 1980's and in the beginning of the 1990's output was above potential and economic growth was fairly brisk. After that the output gap was negative again until the year 1999 because of slow growth in many euro area economies. Figures in Appendix 2 present the individual country variables. The inflation history varies clearly across the EMU countries, especially in the 1980's. In the 1980's and 1990's the output gap path was quite similar in the seven biggest euro area economies with the exception Germany, where we can see the effect of the Reunification. Compared to these countries, the four smallest

[1] The data for Luxembourg is available only for the period 1983–2000.

economies have experienced quite different and more diverse developments in the output gap.

Figure 1. **The euro area inflation and inflation forecasts, when using the GDP deflator**

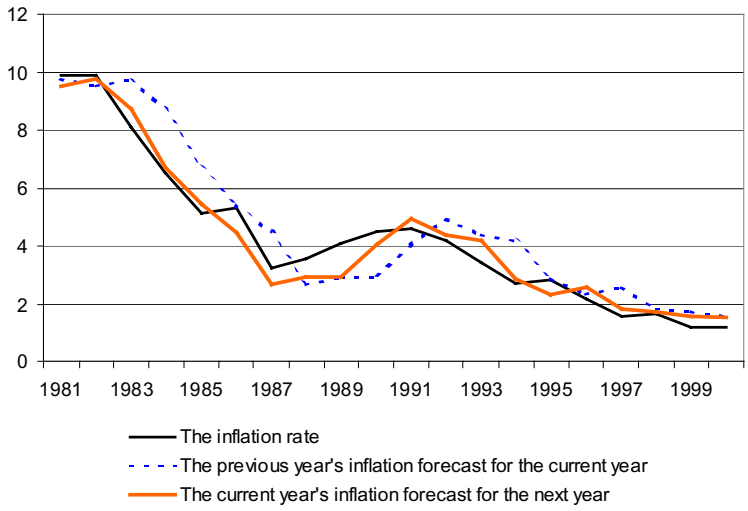


Figure 2. **The euro area inflation and inflation forecasts, when using the private consumption deflator**

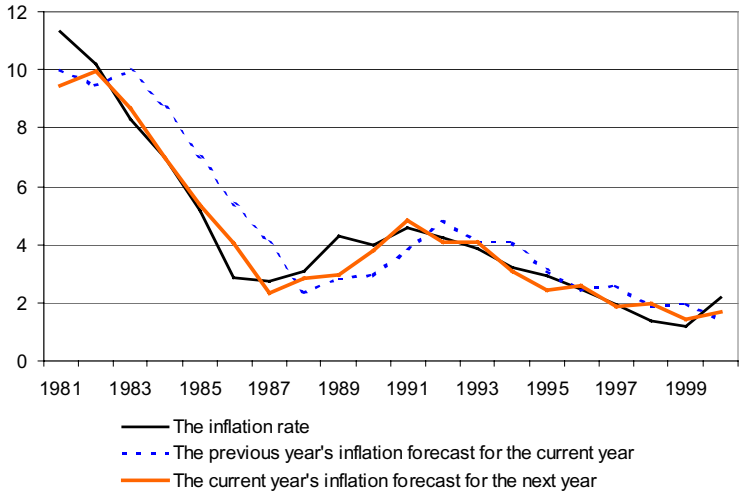
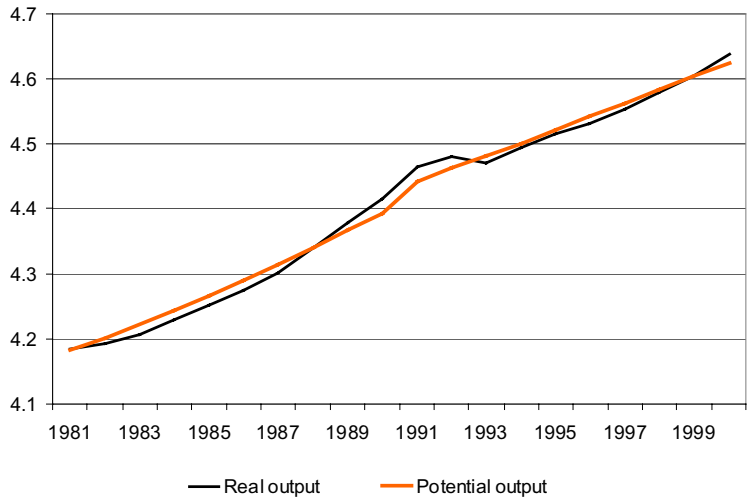


Figure 3. **The euro area real output and potential output**



3.3 Single equation estimation results

First, the parameters for both Phillips relations ie equations (7) and (8) are estimated separately using generalised method of moments (Hansen 1982). In both versions of the Phillips curve, instruments used are chosen to represent variables which are predetermined at time t. For comparability, the instrument set for both specifications consists of the same three variables: the lagged inflation forecast, $E_{t-1}\{\pi_t\}$, and two lags of the output gap, $\hat{y}_{t-1}$ and $\hat{y}_{t-2}$. It means that the lagged inflation expectations are treated as exogenous (predetermined) and the output gap is the only endogenous right hand side variable in the expectations-augmented Phillips curve. The standard errors of the estimated parameters are modified using the white-covariance correction. The J-statistic is used to test the overidentifying restrictions ie validity of the instruments.

Table 1 summarises estimates of both models using the GDP deflator as the measure of inflation. Overall, the estimation results are fairly plausible for the euro area and for individual economies. The estimated coefficients on the expected inflation are higher in the new Keynesian specification with only two exceptions. In the expectations-augmented specification none of the point estimates is significantly over unity, but some implausibly low values can be found. By contrast, in the new Keynesian specification the point estimate for Italy, Portugal and Spain exceeds unity and the hypothesis of $\beta = 1$ is statistically rejected. When looking at the new Keynesian specification, only for the Netherlands the point estimate is below 0.90 and for the euro area it is quite reasonable, 0.991.

Table 1. **Single equation estimation results using the GDP deflator as the measure of inflation**

Expectations-augmented specification

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

	Parameters					Test
	β			λ		J
EU 11	**0.953**	**(0.035)**	*	**52.945**	**(19.078)** *	**0.071**
Austria	0.912	(0.077)	*	65.708	(26.107) *	0.031
Belgium	0.856	(0.059)	*	56.821	(19.956) *	0.097
Finland	0.817	(0.062)	*	13.470	(13.197)	0.192
France	0.833	(0.043)	*	11.345	(9.231)	0.001
Germany	0.929	(0.062)	*	18.463	(10.575)	0.103
Ireland	0.975	(0.132)	*	20.606	(27.599)	0.120
Italy	1.017	(0.051)	*	157.924	(37.412) *	0.010
Luxembourg	0.953	(0.163)	*	101.804	(45.517) *	0.058
Netherlands	0.798	(0.062)	*	59.580	(21.799) *	0.124
Portugal	1.037	(0.071)	*	22.303	(32.983)	0.036
Spain	0.984	(0.043)	*	31.542	(15.885)	0.057

New Keynesian specification

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

	Parameters					Test
	β			κ		J
EU 11	**0.991**	**(0.021)**	*	**1.292**	**(10.132)**	**0.244**
Austria	0.964	(0.057)	*	34.284	(17.822)	0.088
Belgium	0.910	(0.064)	*	18.291	(20.041)	0.080
Finland	0.904	(0.019)	*	–3.572	(6.010)	0.062
France	0.915	(0.031)	*	–1.802	(8.384)	0.167
Germany	0.985	(0.050)	*	6.457	(8.159)	0.061
Ireland	0.950	(0.082)	*	–8.850	(23.068)	0.125
Italy	1.119	(0.013)	*	99.752	(9.984) *	0.231
Luxembourg	0.948	(0.174)	*	90.311	(32.036) *	0.130
Netherlands	0.805	(0.036)	*	18.396	(11.898)	0.165
Portugal	1.128	(0.047)	*	15.477	(21.732)	0.158
Spain	1.101	(0.043)	*	7.325	(8.683)	0.046

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to the Hansen test of the overidentifying restrictions. The J-statistic times the number of observations is asymptotically χ^2 with one degrees of freedom, the critical value of which is 3.84. Instruments: the lagged inflation expectation, $E_{t-1}\{\pi_t\}$ and the two lags of the output gap, $\hat{y}_{t-1}$ and $\hat{y}_{t-2}$.

The estimated output gap enters always with a positive sign when the expected-augmented model is considered. For the new Keynesian specification the coefficient on output gap is positive for the euro area and for eight out of eleven countries. The estimated coefficients on the output gap are clearly higher in the expectations-augmented specification compared to the other case. Hence, inflation appears to be more sensitive to changes in current excess demand, when expectations are measured by the inflation forecast for the current year instead of the inflation forecast for the next year. This must be because part of the excess demand effect is incorporated in expected future inflation. The statistical reliability of the output gap coefficients is better in the expectations-augmented specification for the euro area as well as for almost all countries.

As reported in Table 2, the results are only little changed, when using the private consumption deflator as the measure of inflation. The estimates of the expectations variable continues to be higher with the new Keynesian specification. Although the estimated coefficient on the expected inflation for the euro area is too high in the new Keynesian specification, 1.022, it is not statistically different from unity. Interestingly, compared with the new Keynesian specification results with the GDP deflator in Table 1, the hypothesis of $\beta = 1$ is statistically rejected for the same three countries: Italy, Portugal and Spain.

As shown in Table 2, with the private consumption deflator all the estimated output gap coefficients are positive in the expectations-augmented specification and there is only one estimate with the wrong sign in the other case. Accordingly, when considering the expectations-augmented specification, notably higher and statistically more reliable coefficients for the output gap can be found compared with the other case.

When using the same instrument set in all single equation estimations, the J-statistic rejects the overidentifying restrictions only in few cases in Tables 1 and 2. The potential weakness of the instruments has also been checked by another test, in which the regressors of the Phillips curves are regressed on the three instruments. The R-squared values of least squares estimations are reported in Appendix 3. When the dependent variable is the expected future inflation, in over half of the cases the R-squared values are above 0.80 and only in one case below 0.70. Accordingly, with the output gap only 8 out of 24 of the R-squares values are below 0.60. Overall, the chosen instruments seem to be relevant to the variables we seek to model.

Table 2. **Single equation estimation results using the private consumption deflator as the measure of inflation**

Expectations-augmented specification

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

	Parameters					Test
	β			λ		J
EU 11	**0.956**	**(0.043)**	*	**64.252**	**(18.566)** *	**0.032**
Austria	0.975	(0.088)	*	56.249	(33.707)	0.028
Belgium	0.893	(0.092)	*	57.305	(31.093)	0.026
Finland	0.826	(0.058)	*	28.011	(6.479) *	0.048
France	0.928	(0.055)	*	28.561	(11.416) *	0.013
Germany	0.904	(0.076)	*	37.369	(10.137) *	0.044
Ireland	1.004	(0.105)	*	24.607	(26.085)	0.094
Italy	1.005	(0.042)	*	105.023	(24.650) *	0.029
Luxembourg	0.751	(0.077)	*	44.156	(28.803)	0.006
Netherlands	0.941	(0.053)	*	59.313	(16.117) *	0.218
Portugal	1.034	(0.077)	*	63.813	(43.146)	0.100
Spain	1.011	(0.029)	*	27.238	(12.593) *	0.041

New Keynesian specification

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

	Parameters					Test
	β			κ		J
EU 11	**1.022**	**(0.023)**	*	**15.170**	**(10.840)**	**0.024**
Austria	1.017	(0.064)	*	41.532	(23.794)	0.037
Belgium	0.943	(0.084)	*	27.049	(27.230)	0.036
Finland	0.876	(0.038)	*	13.582	(4.971) *	0.093
France	1.021	(0.044)	*	10.591	(10.630)	0.054
Germany	0.939	(0.064)	*	16.400	(6.118) *	0.062
Ireland	1.014	(0.086)	*	7.239	(16.323)	0.118
Italy	1.079	(0.025)	*	44.703	(19.182) *	0.156
Luxembourg	0.785	(0.065)	*	–1.748	(18.613)	0.116
Netherlands	0.958	(0.030)	*	24.818	(10.845) *	0.177
Portugal	1.164	(0.051)	*	84.781	(33.272) *	0.080
Spain	1.077	(0.034)	*	7.327	(9.161)	0.003

Notes: See Table 1.

Taken together the estimation results in Tables 1 and 2, both specifications and both inflation measures seem to capture inflation dynamics quite reasonably, when the output gap is a proxy for excess demand and inflation expectations are measured directly. The estimated Phillips curve is flatter, when the currently expected future inflation is used as a measure for inflation expectations instead of the previously expected current inflation. Qualitatively similar estimation results are obtained from single equation estimations with ordinary least squares and

pooled least squares methods, as reported in Appendix 4. Also these estimations yield higher estimates on the expected inflation when the new Keynesian specification is applied. Accordingly, positive coefficients on the output gap are mostly obtained, and they are higher and more reliable with the expectations-augmented specification.

The results can be compared with the earlier studies of inflation dynamics in the euro area. Contrast to this study, the output gap based Keynesian Phillips curve has been analysed earlier under rational expectations by Gali, Gertler and Lopez-Salido (2001) and Gagnon and Khan (2001). Interestingly, comparison shows that with the GDP deflator the estimated coefficient on the expected inflation of this paper, 0.991, is equal to their estimates. However, the slope of the Phillips curve is negative in both of the studies. This paper finds more supporting evidence for the empirical validity of the output gap. When looking at the euro area and individual country results in Tables 1 and 2, in 44 out of 48 cases the slope of the Phillips curve is positive.

3.4 Statistical tests

On the basis of the results reported above, the clear statistical preference cannot yet be claimed for either of the Phillips relations. Both of them seem to capture inflation dynamics fairly well in the euro area. In order to facilitate the comparison of the two specifications, two statistical tests are applied to the data.

Tables A5.1 and A5.2 in Appendix 5 present the results for encompassing test ie equation (9). The sum of the estimated coefficients is restricted to unity in order to find out the relative weights of the alternative expectation variables in inflation process. The instruments are the same as in the previous estimations ie the lagged inflation forecast and two lags of the output gap.

When looking at the euro area results with both inflation measures, the currently expected future inflation seems to dominate inflation process compared with the previously expected current inflation. Similar result can be also seen in most of the countries. However, the interesting opposite results can be found for the same three countries, the single equation results of which indicate poor empirical fit of the new Keynesian Phillips curve in Tables 1 and 2. The encompassing test results indicate bigger weight on the previously expected current inflation for Italy and Spain with both inflation measures and for Portugal with the GDP deflator. Some of the estimated output gap coefficients are negative, like the one for the euro area with the GDP deflator. Overall, the J-statistics in Tables A5.1 and A5.2 indicate that the instrument set for encompassing test is acceptable is almost all cases. Non-restricted encompassing test has also been

applied to the euro area and individual countries. The results, which are not reported here, are qualitatively similar.

All in all encompassing test results in Tables A5.1 and A5.2 seem to support the new Keynesian specification. However, because of many implausibly estimated coefficients and variation in results when changing the inflation measure, this test may not be a very reliable way to compare the two Phillips relations.

In Appendix 6, the alternative Phillips curve relations are compared with a non-nested test by estimating equations (10) and (11). In addition to the instruments used in the previous test, the lagged US inflation rate was used in both specifications. Table A6.1 presents the results with the GDP deflator and Table A6.2 shows the corresponding estimates with the private consumption deflator. In section A of the both tables the expectations-augmented model is tested against the general model and in section B the roles of the specifications are reversed ie the new Keynesian model is tested against the general model. The summary of the outcomes is shown in C section of Tables A6.1 and A6.2.

The results indicate that with both inflation measures, the new Keynesian Phillips curve is preferred in the euro area, as the expectations-augmented specification has no explanatory power over the new Keynesian one, but the new Keynesian specification has explanatory power over the expectations-augmented one. The results of the same kind can be seen for most individual countries. With the GDP deflator in nine out of eleven countries and with the private consumption deflator in eight out of eleven countries the new Keynesian specification gives evidence against the other specification. Correspondingly, the opposite result is true in only two of the countries with both inflation measures.

On balance, when combining the results with the GDP deflator for both specifications against the general model ie the estimations results in section A and B in Table A6.1, a better performance of the new Keynesian Phillips curve specification is suggested for seven out of eleven cases. For four of the countries the test result is mixed and the expectations-augmented specification is preferred for none of the cases. Correspondingly, with the private consumption deflator the combined test results of sections A and B in Table A6.2 present evidence in favour of the new Keynesian model for six out of eleven countries and the mixed results is obtained for five countries. The expectations-augmented specification is not favoured for any country with the private consumption deflator.

All in all the encompassing and the non-nested test results in the euro area provide more evidence in favour of the new Keynesian Phillips curve than for the expectations-augmented Phillips curve. Similar results are also obtained for most of the individual countries.

4 Conclusions

In recent years there has been an increasing interest in the issue of inflation dynamics because of the puzzling price developments and the new euro area. Also the development in the underlying theoretical frameworks has renewed the study of the tradeoff between inflation and output, which is central in monetary policy analysis. In empirical studies of inflation dynamics only little support has been found for the output gap based new Keynesian Phillips curve under rational expectations.

In this paper inflation dynamics in the euro area and eleven EMU economies have been studied by comparing the empirical performance of the two alternative output gap based Phillips relations: the expectations-augmented Phillips curve and the new Keynesian Phillips curve. In applied work the Phillips relation and the hypothesis of expectations formation have been typically tested jointly. By contrast, in this study the rational expectations hypothesis has not been maintained, as direct measures of market expectations have been used. In the expectations-augmented specification the OECD inflation forecast for the current year has been used to measure inflation expectations. Correspondingly, the OECD inflation forecast for the next year has measured inflation expectations in the new Keynesian specification. In addition to the single equation estimations with two alternative inflation measures, the empirical superiority of the alternative Phillips relations has been compared with encompassing and non-nested tests.

The empirical evidence suggests that the output gap based expectations-augmented Phillips curve provides a reasonable approximation to the inflation dynamics in the euro area, when expectations ie the previously expected current inflation is measured directly using the OECD inflation forecasts. Also, the output gap based new Keynesian Phillips curve with the currently expected future inflation tracks inflation variation plausibly, when the OECD forecasts are used. The conclusive comparison between the alternative models cannot be made on the basis of the single equation estimation results, but the empirical test results show more evidence in favour of the new Keynesian specification both for the euro area and for most EMU countries. Results are qualitatively fairly similar regardless of the inflation measure, the GDP deflator or the private consumption deflator. There appears to be some heterogeneity in inflation process across the euro area countries.

Contrary to many other studies under rational expectations, inflation dynamics is adequately captured in this study without need to use lagged inflation as an explanatory variable. Interestingly, this study presents also supporting evidence for the output gap as a measure of cyclical variation in the Phillips relation. The plausible empirical fits of the models may be associated with the assumption of expectations formation. Both Phillips curves seem to capture price

changes, as inflation expectations may adjust slowly and agents need not necessarily be rational. The present results are in line with the studies by Roberts (1997, 1998), which show evidence on the new Keynesian Phillips relation with survey based expectations with the US data. Thus, the approach using the OECD forecasts as direct measures of inflation expectations is clearly worth studying further.

The role of expectations in inflation dynamics is crucial when designing monetary policy. Under the expectations-augmented Phillips curve, monetary policy change does not change inflation directly, even if economic agents modify their expectations as a reaction to a policy change. The only effect comes through the excess demand channel. Instead, if inflation dynamics follows the new Keynesian Phillips curve, a transition to a new policy regime affects inflation immediately, as current inflation is dependent on currently expected future inflation. The better the policy change is understood by the private sector, the more current inflation is affected according to the new Keynesian Phillips relation.

All in all the combination of the Phillips relation and the rational expectations hypothesis seems not necessarily to be the most reasonable way to analyse inflation dynamics. Instead, when direct measures of inflation expectations are used, our understanding of inflation process is likely to improve. By using direct estimates of inflation expectations, this paper presents evidence on the Phillips relation in the euro area. The new Keynesian Phillips curve fits the euro area data slightly better than the expectations-augmented Phillips curve. The role of expectations in inflation dynamics is important in conducting monetary policy and still open to debate. Research on expectations formation would be an important complement to the present results.

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Appendix 1

Data description

The annual data cover the period 1981–2000, with the exception of the Luxembourg: 1983–2000.

For all countries the following data were used:

– Inflation formulas: $\pi_t = 100*(P_t - P_{t-1})/P_{t-1}$, where P_t is the GDP deflator or the private consumption deflator from the OECD Economic Outlook data set

– Inflation expectations: annual percentage changes of the GDP deflator and the private consumption deflator, collected from the OECD Economic Outlook publications.

– The output gap: the log real GDP minus the HP-filtered log real GDP[2].

For the euro area the following data were used:

– The inflation rates and the inflation forecasts were aggregated from individual country series by using the ECB country weights for 11 EMU countries. The weights from the year 1999 are the following: Germany 32.4%, France 22%, Italy 18%, Spain 9.1%, The Netherlands 6%, Belgium 3.8%, Austria 3.2%, Finland 2%, Portugal 1.7%, Ireland 1.4% and Luxembourg 0.3%.

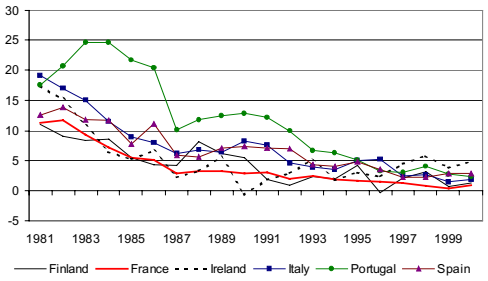
– The output gap: the log real aggregated GDP minus the HP-filtered log real aggregated GDP. The real GDP was aggregated using ECB country weights for 11 EMU countries and taking into account the Reunification in Germany in a way described above. For the years 1981 and 1982, the missing Luxembourg data was replaced by the real GDP data of Belgium.

[2] The Reunification was taken into account by making the HP-filtering for Germany in two parts: The real GDP until the year 1990 was extended by three years onwards by excluding the East Germany share of 6.5 per cent from the original real GDP series. Similarly, the real GDP since the year 1991 was extended backwards by three years by including the share of the East Germany to the original series. After making the HP-filtering to the both constructed series separately, the HP-filtered log real GDP series were combined by using the first part until the year 1990.

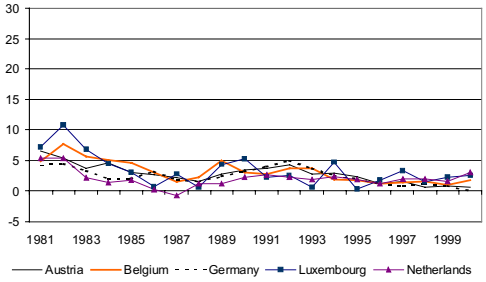
Appendix 2

Data for eleven EMU countries

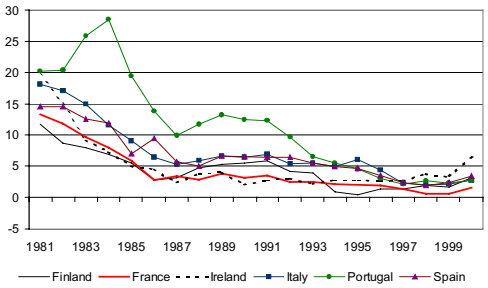
The GDP deflator inflation in 6 EMU countries



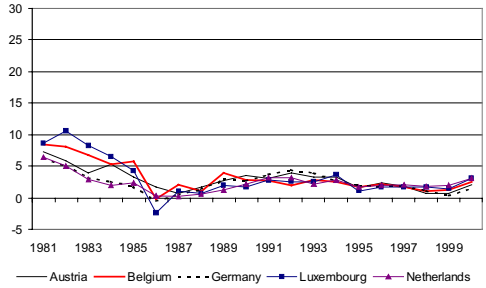
The GDP deflator inflation in 5 EMU countries



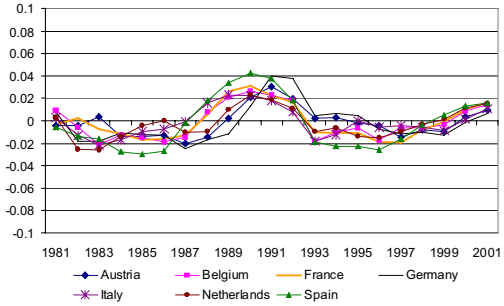
The PCP inflation in 6 EMU countries



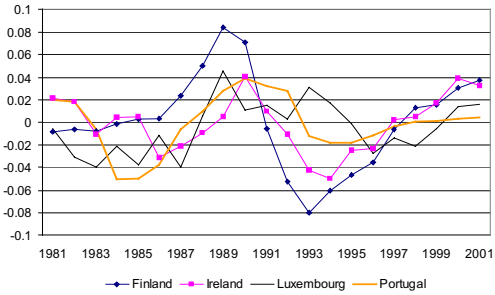
The PCP inflation in 5 EMU countries



Output gap in 7 EMU countries



Output gap in 4 EMU countries



Appendix 3

Validity test results for the instruments used in single equation estimations

Table A3.1 **R-squared values of least squares regressions using the GDP deflator as the measure of inflation**

$$E_t\{\pi_{t+1}\} = aE_{t-1}\{\pi_t\} + b\hat{y}_{t-1} + c\hat{y}_{t-2}$$

$$\hat{y}_t = aE_{t-1}\{\pi_t\} + b\hat{y}_{t-1} + c\hat{y}_{t-2}$$

Dependent variable	$E_t\{\pi_{t+1}\}$	$\hat{y}_t$
EU11	0.954	0.654
Austria	0.761	0.519
Belgium	0.814	0.536
Finland	0.810	0.826
France	0.867	0.715
Germany	0.807	0.604
Ireland	0.797	0.437
Italy	0.940	0.662
Luxembourg	0.833	0.316
Netherlands	0.750	0.694
Portugal	0.796	0.776
Spain	0.787	0.849

Table A3.2 **R-squared values of least squares regressions using the private consumption deflator as the measure of inflation**

$$E_t\{\pi_{t+1}\} = aE_{t-1}\{\pi_t\} + b\hat{y}_{t-1} + c\hat{y}_{t-2}$$

$$\hat{y}_t = aE_{t-1}\{\pi_t\} + b\hat{y}_{t-1} + c\hat{y}_{t-2}$$

Dependent variable	$E_t\{\pi_{t+1}\}$	$\hat{y}_t$
EU11	0.943	0.655
Austria	0.708	0.519
Belgium	0.845	0.532
Finland	0.758	0.825
France	0.871	0.714
Germany	0.686	0.604
Ireland	0.806	0.438
Italy	0.949	0.660
Luxembourg	0.781	0.313
Netherlands	0.773	0.704
Portugal	0.825	0.772
Spain	0.875	0.849

Appendix 4

Ordinary least squares and pooled least squares results

Table A4.1 **Single estimation results with ordinary least squares when using the GDP deflator as the measure of inflation**

Expectations-augmented specification

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

	Parameters					Test	
	β			λ		R^2	D-W
EU 11	**0.941**	**(0.034)**	*	**46.943**	**(14.976)** *	**0.914**	**1.489**
Austria	0.909	(0.066)	*	32.587	(17.352)	0.624	1.370
Belgium	0.869	(0.058)	*	49.909	(16.420) *	0.692	2.094
Finland	0.806	(0.083)	*	16.032	(12.429)	0.534	1.816
France	0.844	(0.038)	*	23.960	(15.109)	0.918	1.738
Germany	0.895	(0.067)	*	13.854	(11.516)	0.606	1.000
Ireland	0.850	(0.100)	*	16.516	(30.197) *	0.494	1.105
Italy	0.999	(0.044)	*	114.298	(30.853)	0.890	1.913
Luxembourg	0.693	(0.130)	*	23.419	(22.173)	-0.200	1.767
Netherlands	0.756	(0.081)	*	46.030	(19.595) *	0.467	1.700
Portugal	0.998	(0.067)	*	16.393	(36.333)	0.748	1.234
Spain	0.982	(0.053)	*	22.260	(17.823)	0.780	2.393

New Keynesian specification

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

	Parameters					Test	
	β			κ		R^2	D-W
EU 11	**1.006**	**(0.025)**	*	**6.328**	**(9.968)**	**0.960**	**1.054**
Austria	0.951	(0.049)	*	13.904	(12.514)	0.802	2.037
Belgium	0.888	(0.058)	*	20.251	(15.571)	0.705	2.141
Finland	0.909	(0.065)	*	6.680	(9.119)	0.752	1.925
France	0.921	(0.026)	*	-5.7242	(9.621)	0.966	1.847
Germany	0.971	(0.055)	*	-1.216	(8.933)	0.766	1.582
Ireland	0.961	(0.083)	*	-9.536	(23.272)	0.702	1.582
Italy	1.089	(0.029)	*	73.412	(17.983) *	0.961	1.231
Luxembourg	0.769	(0.118)	*	16.957	(18.691)	0.090	2.200
Netherlands	0.810	(0.042)	*	14.242	(9.448)	0.857	1.754
Portugal	1.114	(0.043)	*	-10.010	(20.916)	0.915	1.633
Spain	1.084	(0.043)	*	8.508	(13.181)	0.877	2.987

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level.

Table A4.2 **Single equation estimation results with ordinary least squares using the private consumption deflator as the measure of inflation**

Expectations-augmented specification

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

	Parameters					Test	
	β			λ		R^2	D-W
EU 11	**0.973**	**(0.038)**	*	**61.124**	**(16.666)** *	**0.909**	**1.228**
Austria	0.920	(0.082)	*	31.211	(21.744)	0.514	1.568
Belgium	0.912	(0.085)	*	44.154	(23.983)	0.621	1.463
Finland	0.812	(0.066)	*	10.821	(9.755)	0.648	1.747
France	0.907	(0.048)	*	34.332	(18.899)	0.888	1.672
Germany	0.909	(0.078)	*	25.078	(13.585)	0.627	1.066
Ireland	0.826	(0.087)	*	43.052	(27.370)	0.606	0.982
Italy	0.993	(0.040)	*	81.051	(26.957) *	0.906	1.426
Luxembourg	0.686	(0.125)	*	11.385	(21.570)	0.297	1.275
Netherlands	0.899	(0.069)	*	53.891	(16.037) *	0.667	1.301
Portugal	0.977	(0.080)	*	43.703	(43.732)	0.675	1.091
Spain	0.989	(0.040)	*	23.653	(13.927)	0.882	2.268

New Keynesian specification

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

	Parameters					Test	
	β			κ		R^2	D-W
EU 11	**1.045**	**(0.028)**	*	**20.144**	**(11.206)**	**0.956**	**1.643**
Austria	0.989	(0.057)	*	13.468	(14.467)	0.782	1.792
Belgium	0.951	(0.076)	*	16.004	(20.311)	0.712	2.425
Finland	0.899	(0.052)	*	3.036	(7.158)	0.811	1.356
France	1.003	(0.035)	*	3.074	(12.634)	0.949	2.489
Germany	1.000	(0.065)	*	12.112	(10.652)	0.771	1.233
Ireland	0.940	(0.069)	*	16.408	(19.916)	0.793	1.502
Italy	1.083	(0.027)	*	46.379	(16.697) *	0.963	1.432
Luxembourg	0.785	(0.102)	*	4.344	(16.354)	0.565	1.851
Netherlands	0.927	(0.045)	*	16.184	(9.778)	0.857	2.214
Portugal	1.123	(0.048)	*	43.054	(23.873)	0.903	1.699
Spain	1.071	(0.033)	*	6.226	(10.372)	0.933	2.918

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level.

Table A4.3 **Pooled least squares results in the euro area**
(Cross section weights)

Expectations-augmented specification

$$\pi_t = \beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t$$

Inflation measure	Parameters					Test	
	β		λ			R^2	D-W
GDP deflator	**0.834**	**(0.020)**	*****	**27.873**	**(4.872)**	*****	**0.703**	**1.401**
PCP	**0.836**	**(0.020)**	*****	**26.620**	**(4.735)**	*****	**0.715**	**1.447**

New Keynesian specification

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

Inflation measure	Parameters					Test	
	β		κ			R^2	D-W
GDP deflator	**0.974**	**(0.017)**	*****	**7.793**	**(3.830)**		**0.842**	**1.542**
PCP	**0.974**	**(0.016)**	*****	**10.091**	**(3.427)**	*****	**0.850**	**1.743**

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level.

Appendix 5

Encompassing test results

$$\pi_t = \theta E_t\{\pi_{t+1}\} + (1-\theta)E_{t-1}\{\pi_t\} + \phi\hat{y}_t$$

Table A5.1. **Encompassing test results using the GDP deflator as the measure of inflation**

	Parameters					Test
	θ	(1-θ)		ϕ		J
EU 11	**1.150**	**–0.150**	**(0.367) ***	**–5.571**	**(26.403)**	**0.236**
Austria	0.361	0.639	(1.541)	75.119	(59.863)	0.074
Belgium	0.590	0.410	(0.652)	67.232	(41.536)	0.083
Finland	1.674	–0.674	(0.414) *	–13.150	(15.286)	0.006
France	1.130	–0.130	(0.308) *	1.452	(9.335)	0.234
Germany	1.026	–0.026	(0.335) *	5.485	(11.328)	0.060
Ireland	1.233	–0.233	(0.528) *	–17.136	(39.162)	0.133
Italy	–0.083	1.083	(0.508)	160.304	(62.084) *	0.011
Luxembourg	–0.639	1.639	(1.363)	122.511	(62.853)	0.035
Netherlands	1.800	–0.800	(0.395) *	0.929	(25.167)	0.125
Portugal	0.305	0.695	(0.301)	–7.742	(22.859)	0.058
Spain	0.287	0.713	(0.383)	25.544	(13.653)	0.051

Table A5.2 **Encompassing test results using the private consumption deflator as the measure of inflation**

	Parameters					Test
	θ	(1-θ)		ϕ		J
EU 11	**0.623**	**0.377**	**(0.425)**	**34.999**	**(29.161)**	**0.020**
Austria	0.937	0.063	(0.717)	38.052	(33.963)	0.046
Belgium	0.764	0.236	(1.0959)	49.094	(45.969)	0.046
Finland	1.944	–0.944	(0.5029) *	0.330	(10.577)	0.124
France	0.718	0.282	(0.280) *	15.676	(9.968)	0.022
Germany	0.641	0.359	(0.466)	24.468	(12.111)	0.053
Ireland	2.134	–1.134	(1.007) *	–30.631	(50.482)	0.033
Italy	0.113	0.887	(0.350)	100.880	(31.942) *	0.030
Luxembourg	1.129	–0.129	(0.778)	37.561	(38.284)	0.180
Netherlands	2.083	–1.083	(0.595) *	–13.708	(25.446)	0.004
Portugal	0.647	0.353	(0.164) *	70.320	(22.579) *	0.110
Spain	0.012	0.988	(0.408)	26.526	(14.900)	0.052

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to the Hansen test of the overidentifying restrictions. The J-statistic times the number of observations is asymptotically χ^2 with one degrees of freedom, the critical value of which is 3.84. Instruments: the lagged inflation expectation, $E_{t-1}\{\pi_t\}$ and the two lags of the output gap, $\hat{y}_{t-1}$ and $\hat{y}_{t-2}$.

Appendix 6

Non-nested test results

Table A6.1 **Non-nested test results using the GDP deflator as the measure of inflation**

Section A

$$\pi_t = (1-\alpha)\left[\beta E_t\{\pi_{t+1}\} + \kappa \hat{y}_t\right] + \alpha \hat{\pi}_t$$

	Parameters							Test
	α		β			κ		J
EU 11	**–0.244**	**(0.271)**	**0.996**	**(0.016)**	*	**2.660**	**(8.222)**	**0.220**
Austria	–0.249	(0.526)	0.962	(0.038)	*	31.598	(13.694) *	0.127
Belgium	0.010	(0.356)	0.918	(0.076)	*	20.107	(21.792)	0.080
Finland	–0.060	(0.158)	0.903	(0.016)	*	–3.268	(6.411)	0.055
France	0.254	(0.103) *	0.944	(0.029)	*	2.715	(8.126)	0.099
Germany	–0.372	(0.295)	0.988	(0.038)	*	4.518	(7.429)	0.144
Ireland	–0.169	(0.274)	0.961	(0.086)	*	–9.727	(21.105)	0.124
Italy	0.103	(0.154)	1.126	(0.018)	*	98.457	(11.530) *	0.212
Luxembourg	–	–	–	–		–		
Netherlands	–0.446	(0.136) *	0.807	(0.029)	*	19.817	(6.241) *	0.163
Portugal	0.293	(0.175)	1.152	(0.058)	*	9.659	(28.420)	0.089
Spain	–0.136	(0.525)	1.098	(0.047)	*	7.562	(8.583)	0.043

Section B

$$\pi_t = (1-\omega)\left[\beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t\right] + \omega \tilde{\pi}_t$$

	Parameters							Test
	ω		β			λ		J
EU 11	**1.240**	**(0.263)** *	**0.969**	**(0.076)**	*	**62.191**	**(44.177)**	**0.220**
Austria	1.246	(0.534) *	0.923	(0.186)	*	79.686	(83.625)	0.127
Belgium	0.889	(1.361)	–0.260	(30.326)		–282.190	(9336.617)	0.367
Finland	1.058	(0.149) *	0.847	(0.248)	*	8.555	(114.606)	0.055
France	0.770	(0.119) *	0.919	(0.128)	*	27.398	(27.924)	0.099
Germany	1.377	(0.313) *	0.916	(0.128)	*	25.344	(25.754)	0.144
Ireland	1.182	(0.377) *	0.903	(0.443)	*	24.047	(135.074)	0.124
Italy	0.902	(0.147) *	1.070	(0.128)	*	149.144	(108.201)	0.212
Luxembourg	–0.152	(1.481)	0.920	(0.175)	*	115.428	(37.312) *	0.080
Netherlands	1.449	(0.145) *	0.794	(0.092)	*	54.755	(22.452) *	0.163
Portugal	0.798	(0.168) *	1.017	(0.169)	*	–302.244	(425.942)	0.076
Spain	1.132	(0.498) *	1.011	(0.329)	*	30.149	(70.461)	0.043

Section C

Combined non-nested test results from the sections A and B

	Preferred model		
	New Keynesian	**Expectations-augmented**	**Mixed results**
EU 11	**X**		
Austria	X		
Belgium			X
Finland	X		
France			X
Germany	X		
Ireland	X		
Italy	X		
Luxembourg			X
Netherlands			X
Portugal	X		
Spain	X		

Notes: Sample period 1981–2000 with the exception of Luxembourg: 1983–2000. Numbers in parentheses are standard errors, * indicates significance at 5 per cent level. J-statistic corresponds to the Hansen test of the overidentifying restrictions. The J-statistic times the number of observations is asymptotically χ^2 with one degrees of freedom, the critical value of which is 3.84. Instruments: the lagged inflation expectation, $E_{t-1}\{\pi_t\}$, the lagged US inflation rate and the two lags of the output gap, $\hat{y}_{t-1}$ and $\hat{y}_{t-2}$.

Table A6.2 **Non-nested test results using the private consumption deflator as the measure of inflation**

Section A

$$\pi_t = (1-\alpha)\left[\beta E_t\{\pi_{t+1}\} + \kappa \hat{y}_t\right] + \alpha \hat{\pi}_t$$

	Parameters								Test
	α			β			κ		J
EU 11	**–0.478**	**(0.313)**		**1.024**	**(0.024)**	*	**15.954**	**(9.291)**	**0.044**
Austria	–0.513	(0.309)		1.012	(0.048)	*	36.388	(16.870)	* 0.055
Belgium	–0.405	(0.711)		0.929	(0.058)	*	25.772	(20.297)	0.059
Finland	–0.536	(0.166)	*	0.881	(0.021)	*	15.757	(3.979)	* 0.066
France	0.042	(0.174)		1.015	(0.045)	*	10.748	(10.756)	0.052
Germany	–0.171	(0.235)		0.906	(0.050)	*	15.961	(5.066)	* 0.090
Ireland	–0.815	(0.302)	*	1.046	(0.050)	*	5.279	(12.436)	0.035
Italy	–0.074	(0.205)		1.096	(0.023)	*	56.806	(20.206)	* 0.256
Luxembourg	0.784	(0.781)		0.832	(0.400)		21.006	(167.647)	0.001
Netherlands	–0.321	(0.170)		0.948	(0.019)	*	23.839	(7.199)	* 0.126
Portugal	0.192	(0.169)		1.144	(0.052)	*	86.296	(30.510)	* 0.011
Spain	–0.135	(0.562)		1.078	(0.032)	*	6.971	(8.698)	0.005

Section B

$$\pi_t = (1-\omega)\left[\beta E_{t-1}\{\pi_t\} + \lambda \hat{y}_t\right] + \omega \tilde{\pi}_t$$

	Parameters								Test
	ω			β			λ		J
EU 11	**1.480**	**(0.325)**	*	**0.951**	**(0.067)**	*	**61.605**	**(30.562)**	**0.044**
Austria	1.505	(0.353)	*	0.989	(0.142)	*	71.849	(55.977)	0.055
Belgium	1.385	(0.676)		0.939	(0.199)	*	63.546	(77.888)	0.059
Finland	1.545	(0.162)	*	0.813	(0.055)	*	21.639	(10.748)	0.066
France	0.952	(0.197)	*	0.815	(0.621)		29.502	(213.678)	0.052
Germany	1.129	(0.282)	*	1.193	(0.984)		48.070	(54.144)	0.090
Ireland	1.872	(0.377)	*	0.938	(0.089)	*	27.543	(26.320)	0.035
Italy	1.091	(0.197)	*	0.818	(0.529)		–48.653	(460.305)	0.256
Luxembourg	0.281	(0.782)		0.776	(0.134)	*	47.064	(25.925)	0.003
Netherlands	1.306	(0.166)	*	0.986	(0.085)	*	65.188	(32.658)	0.125
Portugal	0.793	(0.171)	*	0.962	(0.180)	*	71.198	(119.702)	0.011
Spain	1.137	(0.562)		1.001	(0.250)	*	29.999	(71.888)	0.005

Section C

Combined non-nested test results from the sections A and B

	Preferred model		
	New Keynesian	**Expectations-augmented**	**Mixed results**
EU 11	**X**		
Austria	X		
Belgium			X
Finland			X
France	X		
Germany	X		
Ireland			X
Italy	X		
Luxembourg			X
Netherlands	X		
Portugal	X		
Spain			X

Notes: See Table A6.1.

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