Survey Expectations, Rationality and the Dynamics of Euro Area Inflation

M. Forsells* and G. Kenny *

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Abstract

This paper uses survey data in order to analyse and assess the empirical properties of consumers' inflation expectations in the euro area and explores their role in explaining the observed dynamics of inflation. The probability approach is used to derive quantitative estimates of euro area inflation expectations from the qualitative data from the European Commission's Consumer Survey. The paper subsequently analyses the empirical properties of the estimated inflation expectations by considering the extent to which they fulfil some of the necessary conditions for rationality. Overall, the results suggest that consumers' expectations are unlikely to satisfy the very strong restrictions implied by the Rational Expectations Hypothesis, whilst at the same time highlighting the significant and possibly improving information content of such surveyed indicators as a predictor of future inflation. Moreover, the predictive performance of the surveyed expectations at the area-wide level also seems to reflect counterbalancing errors at the country level, a finding which cautions against drawing strong conclusions about rationality on the basis of area-wide indicators alone. Lastly, estimates of a hybrid Phillips curve - which nests both backward and forward-looking inflation dynamics - suggests that consumer expectations played a role in determining the actual dynamics of euro area inflation over the period 1985-2004.

Key Words: Inflation expectations, Surveys, Rationality, Hybrid Phillips curves, Euro area

JEL Classification: D12, D84, E31

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1 Introduction

Central banks have long had an interest in monitoring the behaviour of inflation expectations in the economy and in understanding the nature of the process by which expectations are formed. Two simple examples serve to highlight the crucial importance of access to reliable measures of expected inflation: First, to the extent that they provide a useful or unbiased predictor of future inflation, measures of expected inflation may represent an important information variable in a forward-looking analysis of price developments. Second, higher expectations of inflation may lead employees to demand higher wage settlements, giving rise to cost-push effects on inflation. Moreover in a situation where overall inflation is expected to rise, firms may be more willing to pay higher wages because they believe that they can more easily pass on any change in costs in the form of higher selling prices.[1]

More fundamentally, however, macroeconomic theory accords a pivotal role to expectations of inflation in understanding the functioning of the economy. From the perspective of aggregate price formation, the Phelps-Friedman expectations augmented Phillips curve posits a relationship whereby the actual change in the price level is driven - in part - by aggregate expectations of its future change. Conversely, from the perspective of business cycle analysis, natural rate theory predicts that the scale of any real stimulus from inflation will crucially depend on the extent to which such inflation is anticipated. Under fully rational expectation, with no systematic errors in forecasting inflation, only unexpected changes in inflation have an impact on real variables such as output and unemployment. More recently, the importance of inflation expectations for aggregate price dynamics has been given rigorous microeconomic foundations by considering the optimal price-setting behaviour of firms in a dynamic framework under imperfect competition and some constraint on the frequency of price adjustment (see, for example, Roberts (1995), Sbordone (2000a) and (2000b), Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).[2] A defining feature of

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[1] Christiano and Gust (2000) term this the cost-push version of the *expectations trap hypothesis* because it poses a dilemma to the central bank which must choose between producing the inflation that firms want or risk putting the economy into a recession. There are numerous other examples of the relevance of inflation expectations from a central bank's perspective. Most notably, inflation expectations can be viewed as a determinant of money demand and they are likely to play an important role in the monetary transmission mechanism (e.g. by effecting real interest rates). In the recent literature on monetary policy rules, inflation expectations have also been posited to be among the key arguments in a central banks reaction function (see Taylor, 1999). Inflation expectations, particularly over medium-term horizons, also provide information on the credibility of a central bank's commitment to achieving price stability.

[2] Wolman (1999) provides a recent review of new Keynesian theories of inflation.

this New Keynesian theory of price dynamics is that inflation is a forward-looking phenomenon, driven by its expectations of its future realisations.[3] In a recent contribution, Taylor (2000) has argued that this "expectations theory of pricing" can help explain the observed lower rates of inflation in many industrialised countries in the 1990s compared with the 1980s and the 1970s.[4] Similarly in a recent empirical analysis, Galí, Gertler and López-Salido (2001) find that "forward-looking behaviour is dominant in shaping the dynamics of inflation" (p. 17) both in the euro area and in the United States.

All this serves to emphasise the importance attached to measures of expected inflation in macroeconomic analysis. Not surprisingly, a large body of empirical literature exists seeking to both estimate and examine the empirical properties of inflation expectations. One track in this literature has been to focus on direct survey measures of expectations. While much of this literature dates from the 1970s and the 1980s, there has been a relative dearth of empirical research examining data from the 1990s (see, for example, Lloyd, 1999).[5] Given the significant difference in the behaviour of inflation in the 1990s compared with the preceding two decades, and the possible role of inflation expectations in explaining these developments, there is a need for more up-to-date evidence on the properties of survey measures of inflation expectations and particularly – given the adoption of a single currency by twelve member states of the European Union – of expectations in the euro area.

This paper contributes to this renewed interest in survey-based measures of inflation expectations for the specific case of the euro area and the five largest countries participating in the single currency; namely Germany, Spain, France, Italy and the Netherlands. In particular, measures of expected inflation are derived from the

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[3] The enthusiasm for this New Keynesian theory of price dynamics is by no means universal. For instance, Fuhrer (1997a) using US data finds that expectations of future price changes are unimportant in explaining price and inflation behaviour. Similarly, Fuhrer (1997b) argues that the fit of such New Phillips curves can be routinely improved by adding lags of inflation. As a result, the inflationary process exhibits a high degree of persistence whereby the effects from a one-time shock will last well beyond the lifetime of the initial shock. More recently, again for the US, Roberts (2001) finds that the New Keynesian model requires additional lags of inflation that suggest that some fraction of the population uses a simple univariate rule when forming their inflation expectations.

[4] Using a simple staggered pricing model with market power, Taylor (2000) illustrates the crucial role of expectations. In particular, he shows that the extent to which a firm matches an increase in costs or an increase in another firm's price depends positively on how persistent such changes are *expected* to be. In other words, a decline in persistence of either costs or inflation may be associated with a decline in observed market power.

[5] Some notable recent exceptions are Berk (1999) and Berk (2000), Roberts (1998), Grant and Lloyd (1998). See also Deutsche Bundesbank (2001).

European Commission's Consumer Survey (EC survey) and their predictive performance for future inflation is examined. Following on from this, in order to shed light on the rationality of inflation expectations, the properties of the derived series are examined and assessed along a number of dimensions. Firstly, we consider whether or not consumers have correctly anticipated the inflation outcome on average by testing for any *bias* in the survey indicator. Second, we consider the *dynamic adjustment properties* of expectations. Following on from this, in a test of the *efficiency* of consumers' inflation expectations, the extent to which they incorporate the information contained in a broad set of macroeconomic variables is evaluated. Lastly, we also explore the possible role of surveyed expectations in explaining the observed behaviour of actual inflation in the euro area over the period 1985-2004. This is carried out by estimating various Phillips curves, which nest both backward and forward-looking price dynamics.

To anticipate our findings, our results suggest that consumers' inflation expectations in the euro area are not fully rational, although they may still contain important information about future price developments. Using a hybrid version of the Phillips curve, we also find a role for consumers' expectations in explaining the actual dynamics of inflation within the euro area. Hence, as also suggested by Galí, Gertler and López-Salido (2001), our findings suggest a quantitatively significant forward-looking component to the inflationary process in the euro area. At the area wide level, the backward-looking component is also significant but less so. Moreover, this finding is generally robust across countries and with respect to various empirical specifications of the Phillips curve.

2 Estimating inflation expectations from survey data

Economic surveys provide a direct source of information on expected inflation.[6] For example, the EC Survey asks nearly 20,000 consumers in the euro area for information on their expectations for consumer price trends over the next twelve months. The survey is conducted at a national level, and the results for the euro area are compiled by aggregating the country data using weights based on each country's share in total euro area private final consumption expenditure (at constant prices).

[6] The other main source is to derive inflation expectations from the prices of traded financial assets. A common argument favouring such measures is that they are likely to reflect the true beliefs of economic agents whereas respondents to surveys have little incentive to report their true expectations or the expectations upon which they base economic decisions.

Participants in the survey are asked the following question, which is harmonised across all countries:[7]

"By comparison with what is happening now, do you think that in the next 12 months…

1. …there will be a more rapid increase in prices (S_1),
2. …prices will increase at the same rate (S_2),
3. …prices will increase at a slower rate (S_3),
4. …prices will stay about the same (S_4), or
5. …prices will fall slightly (S_5)."

As the results of this survey are usually summarised in the form of a "balance statistic", computed as a difference among the proportion of respondents opting for the different response categories, this provides only qualitative information on the likely direction of change in inflation in the next 12 months.[8] However, the analysis presented in this paper is conducted on a quantified measure of inflation expectations derived using the so called probabilistic approach. Recent literature (e.g. Berk (1999) and Berk (2000)), building on the earlier contributions of Carlson and Parkin (1975), Batchelor (1981, 1982 and 1986a) and Batchelor and Orr (1988) and others, has further developed this approach to obtaining a quantitative estimate of the expected rate of inflation from qualitative surveys such as those carried out by the European Commission. An important feature of these recent advances in methodology is that, unlike earlier approaches, long-term unbiasedness is not imposed in deriving a measure of expected inflation. Annex 1 presents the details underlying this method in more detail.

2.1 Results for the euro area

Chart 1 plots the derived measure of inflation expectations in the euro area together with the actual year-on-year rate of increase in the Harmonised Index of Consumer Prices (HICP) over the period January 1986 to September 2005 (see Annex

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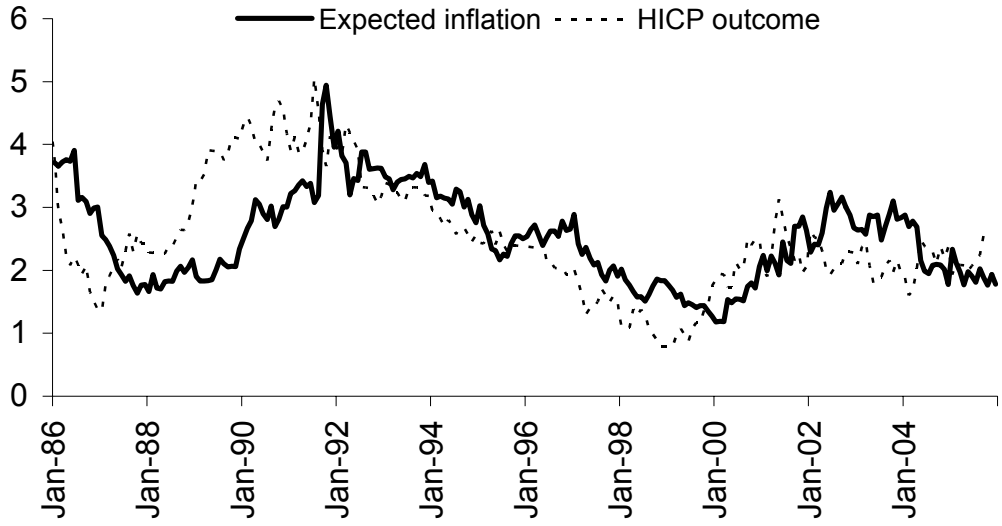
[7] Respondents are also given the option to reply that they do not have any opinion about the future behaviour of prices.

[8] Denoting S_i (for i = 1,2 3, 4 and 5) as the sample proportions opting for each of the five response categories, one widely reported balance statistic is calculated as $(S_1+½S_2) - (½S_4+S_5)$.

2 for a full description of the data sources).[9] The results suggest a strong relationship between actual and expected inflation. In particular, although there is some evidence to suggest that consumers underpredicted inflation towards the end of the 1980s, they appear to have broadly anticipated the trend decline in inflation over the course of the 1990s (from a high of 5.0% in July 1991 to only 0.8% in November of 1998). Indeed, over the period from the beginning of the 1990s to the start of Economic and Monetary Union in January 1999, the euro area evidence supports a significant degree of forward-looking information in the derived expectations series. In particular, at the area-wide level, consumers appear to have performed much better than if they had attached a very high weight to past inflationary trends when forming their expectations. For example, in July of 1991, inflation stood at 5.0%. However, in that same month consumers were anticipating an inflation rate of 3.9% one year ahead, which compared more favourably with the actual outcome for July 1992 (3.3%). This pattern is repeated over much of the 1990s. Hence, it suggests a reasonably rational anticipation of the trend decline in inflation that would not have been possible if consumers simply would have extrapolated in a backward-looking manner past inflation when forming their expectations.

Chart 1: Expected and actual inflation: Euro area – 1986 - 2001
(annual rates of change)



To provide a more quantitative evaluation of the expectations series, Table 1 presents two standard forecast performance statistics. The first statistic is the mean error, which shows the average forecast error over the sample periods. Hence, a large mean error provides evidence of systematic over- or under-prediction. The second

[9] The expectations reported for month *t* in chart 1 were formed in month *t-12*. Hence, the difference between the two lines in Chart 1 represents the expectational error.

measure is the root mean squared error (RMSE), which also provides a measure of accuracy. An important difference between the mean error and the RMSE is that the former is less sensitive to very large expectational errors or outliers. For comparison reasons the performance measures have also been calculated for two alternative measures of expectations: (i) a naive expectation which simply extrapolates the current year-on-year rate as the expectation for the next twelve months ($\pi_t^e = \pi_{t-12}$) and (ii) a forecast based on an AutoRegressive (AR) equation ($\pi_t^e = \alpha + \sum_{i=12}^{23} \beta_i \pi_{t-i}$). The performance statistics are then calculated for the whole sample (Jan 1986-Oct. 2005) as well as three sub-samples: the 1985-1989, 1990-1999 and 2000-2005. This breakdown of the sample is somewhat arbitrary. Nonetheless, given the observed decline in inflation during the 1990s as well as subsequent changes in the monetary policy regime, not least associated with the introduction of the single currency in January 1999, it is interesting to examine the stability over time in the behaviour and forecasting performance of consumers' inflation expectations.

Table 1a: Mean error: Alternative measures of expected inflation

Mean error (full sample)						
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	**-0.01**	-0.27	0.33	-0.97	0.49	0.20
Naïve	-0.14	**-0.01**	**-0.19**	**-0.35**	**-0.28**	**-0.05**
AR	-0.24	0.37	-0.44	-0.74	-0.36	0.76
Mean error (1980s)						
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	0.34	0.14	**0.41**	-1.20	1.61	**-0.40**
Naïve	**-0.27**	**0.11**	-0.59	**-0.78**	**-0.51**	-0.43
AR	-	-	-	-	-	-
Mean error (1990s)						
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	**-0.09**	-0.40	**0.24**	-1.33	0.87	0.32
Naïve	-0.27	**-0.20**	-0.29	**-0.44**	**-0.46**	**0.13**
AR	-0.28	0.58	-0.79	-0.93	-0.63	0.80
Mean error (2000s)						
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	**-0.11**	-0.34	0.43	-0.18	-0.65	0.38
Naïve	0.18	0.22	0.24	**0.09**	0.19	**-0.10**
AR	-0.17	**0.03**	**0.16**	-0.42	**0.10**	0.70

Table 1b: Root mean squared error: Alternative measures of expected inflation

	RMSE (full sample)					
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	**0.81**	1.36	0.94	1.98	1.85	**1.21**
Naïve	0.89	**1.16**	1.04	**1.31**	**1.35**	1.31
AR	0.85	1.36	**0.91**	1.37	1.37	1.37
	RMSE (1980s)					
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	**1.20**	**1.42**	**1.32**	2.17	2.59	**0.92**
Naïve	1.61	1.94	1.84	**2.11**	**2.34**	1.54
AR	-	-	-	-	-	-
	RMSE (1990s)					
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	0.71	1.36	0.72	2.34	1.49	1.13
Naïve	**0.56**	**0.88**	**0.70**	**1.20**	**0.92**	**1.02**
AR	1.02	1.65	1.10	1.65	1.60	1.33
	RMSE (2000s)					
	euro area	Germany	France	Italy	Spain	Netherlands
Expectations	0.63	1.32	0.94	0.88	2.02	1.49
Naïve	0.59	0.80	0.74	**0.60**	1.00	1.56
AR	**0.43**	**0.64**	**0.45**	0.68	**0.85**	**1.42**

At the area-wide level, the performance statistics in Table 1 indicate quite strongly the change in the performance of the derived expectation series in the 1990s and the 2000s compared with the late 1980s. The table suggests that most of the bias in expectations relates largely to the late 1980s with the mean error falling from 0.34 in the 1980s (indicating a substantial underprediction of inflation on average) to only around -0.1 in the 1990s and the 2000s (indicating a significantly smaller over prediction on average). Similarly, there is also an improvement in terms of the RMSE, which falls from 1.20 to 0.63 between the 1980s and the 2000s. A striking feature of the surveyed expectations for the euro area is their relative precision as a predictor of one-year ahead inflation compared with the two other benchmarks. Over the whole sample period both the mean error and the RMSE are lower for the expectation series than for the two benchmarks. The performance of the measure of consumer expectations also compares reasonable well with those reported for measures of US inflation expectations. For example, Thomas (1999) for the US obtains RMSE for various one-year ahead inflation expectations that range between 1.09 and 1.57.[10] Lastly, in terms of accuracy, the expectations series also compare reasonably favourably with the out-of-sample forecasts of various indicator models for inflation. For US inflation see, for example, Cecchetti (1995) and Cecchetti, Chu and Steindel (2000). For euro area inflation see Nicoletti Altimari (2001).

[10] These were calculated over the period 1983:3- 1997:4.

When turning to the countries it appears that the performance is generally worse compared to the euro area aggregate results. Regarding the mean error, it turns out that a naïve method produces a better forecast for all five countries compared with the estimated survey indicators (when considering the whole sample period). The RMSE analysis broadly suggests a similar conclusion with the exception of the Netherlands where the expectation series turns out to be most accurate in predicting future inflation. Indeed, the out-of sample errors at the country level are generally considerably larger than for the area as a whole. This finding suggests that parts of the accuracy of the expectation series at the area-wide level is due to counterbalancing behaviours at the country level. It also suggests a need for caution about inferences about rationality of expectations based on the area-wide level indicator alone.

3 Properties of inflation expectations

The evidence described in section 2, particularly at the euro area-wide level, suggests that the measure of expectations derived from the EC survey may provide potentially useful information on actual future price developments compared with some simple benchmark alternative measures. In this section, the properties of the derived measure of expectations are examined more formally. We first report the results of regression-based tests for unbiasedness – a necessary condition for rationality. However, tests of bias shed light only on the behaviour of expectations on average. Hence, we also consider the dynamic properties of expectations and, in particular, employ time series techniques in order to investigate the speed with which expectations are revised over time in the light of new information about future inflation. Following on from this, the weak and strong-form efficiency of expectations is investigated by testing the extent to which the expectations incorporate the information contained in past price developments as well as that contained in a broader set of macroeconomic variables – available at the time the expectations are formed.

3.1 Long-run properties: Testing for bias

Bias refers to the limiting properties of expectations. In particular, biased expectations imply that consumers, on average, systematically under or overpredict inflation over the long run. A formal test for bias in the expectations series can be carried out using the following equation:

$$\pi_t = \alpha + \beta \pi_t^e + u_t , \tag{3.1}$$

where π_t is the observed inflation rate in month *t* and π_t^e represents expectations for inflation in month *t* and formed in month *t-12.* If the joint null hypothesis H_0: (α, β) = (0,1) cannot be rejected it can be concluded that the expectations are unbiased in a statistical sense. In line with the previous evidence of an improved performance of the euro area expectations indicator in the 1990s and the 2000s compared with the 1980s, the hypothesis of unbiased inflation expectations is conducted for the full sample period and the three sub-samples defined earlier. The results are presented in Table 2 in the form of p-values. Over the whole sample, the results suggest that consumers' inflation expectations have been a somewhat biased predictor of inflation 12 months ahead. This conclusion is relatively robust across countries and different time periods. However, in line with the results in Table 1, at the area wide level we are unable to reject the hypothesis of unbiased expectations in the 1990s subsample

Table 2: Test for unbiasedness, sub-periods, ($\pi_t = \alpha + \beta\pi_t^e + u_t$)

(p-values)

	1980s	1990s	2000s	1985-2005
euro area	0.00	**0.26**	0.00	0.02
Germany	**0.06**	0.00	0.00	0.00
France	0.00	**0.06**	0.00	0.00
Italy	0.00	0.00	0.00	0.00
Spain	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	**0.05**	**0.11**

A closer look at the country dimension reveals no major differences in terms of bias compared with the results for the euro area when considering the full sample and the three sub-samples. However, when looking at the 1990s sub-sample it turns out that the expectation series are biased for all countries despite the fact that it is unbiased at the area-wide level. This behaviour is consistent with the finding in Section 2.1 that part of the accuracy of the expectation series at the area-wide level is due to counterbalancing behaviours at the country level. Once again, it suggests a need to exercise caution when drawing inferences about the rationality of euro area consumers' inflation expectations based on area-wide indicators alone.

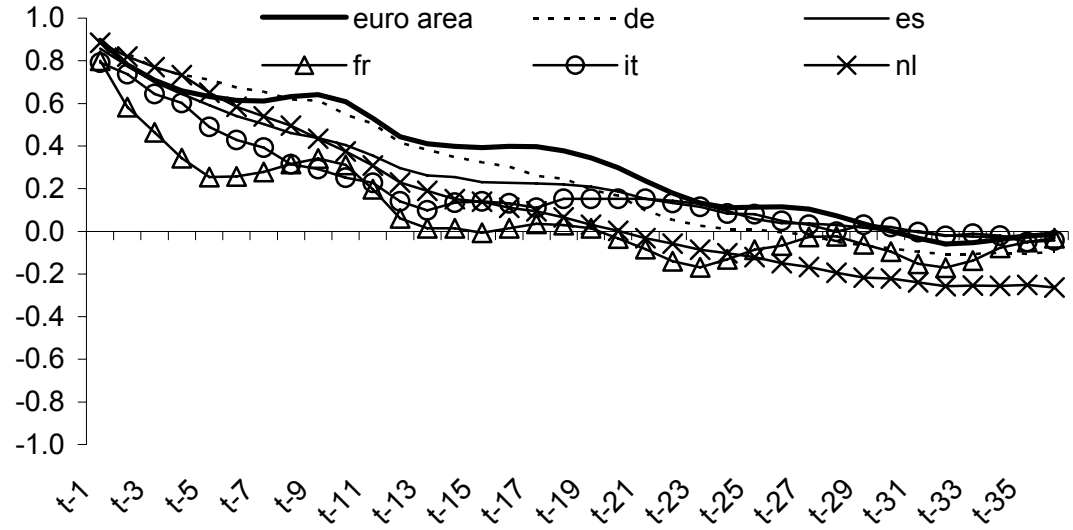
3.2 Dynamic properties: The adjustment of expectations

The above tests for bias shed light on the question of whether or not – *on average* – the derived measure of consumers' inflation expectations provide an accurate estimate of inflation 12 months ahead. However, tests of bias do not shed any light on the dynamics of the expectations' formation process over time. From a more dynamic perspective, an important issue is the extent to which consumers revise their expectations to reflect the flow of new information, including their knowledge of their own previous forecast errors. A common articulation of the rational expectations

hypothesis is that non-overlapping errors in predicting inflation should be uncorrelated - otherwise consumers could have improved their expectations by taking better account of their past errors. In the present context with monthly data on expectations for one-year ahead, the errors are overlapping and this may induce some positive autocorrelation although this should dampen out for lags greater than 12.

The view that the forecast errors of rational agents should be broadly uncorrelated for lags greater than 12 is not undisputed. For example, since the process generating aggregate inflation is uncertain, Cuckierman (1986) argued that even perfectly rational agents may not be able to distinguish permanent from transitory shocks. If this is the case and if permanent shocks are mistakenly perceived to be transitory, agents may make repeated one-sided errors in forming their expectations (see also Lloyd, 1999). The evidence from the EC consumer survey is broadly consistent with this view. For example, Chart 2 reports the autocorrelation function for these errors and while they decay gradually over time, there does appear to be some positive autocorrelation for lags greater than 12. Interestingly, the correlation fades away somewhat faster for the five countries than for the euro area as a whole. However, even if uncertainty about the nature of the shocks affecting the inflationary process may give rise to such persistence in expectational errors, they should not persistent indefinitely. In particular, as argued in McCallum (1980), because errors are costly (e.g. they can lead to poor decisions) “purposeful agents” have an incentive to acquire sufficient information to weed out systematic expectational error (see also Carlson, 1987).

Chart 2: Expectation errors: Autocorrelations



Time series econometrics and, in particular, cointegration analysis suggest an insightful way to investigate the dynamic properties of inflation expectations and, in particular, the speed with which consumers revise their expectations to take account of

the flow of new information and weed out any systematic error. If actual and expected inflation are cointegrated with cointegrating vector [1,-1], it is possible to estimate an error correction model whereby the adjustment of expected inflation toward its fully rational value can be examined.[11] The adjustment parameter from the error correction model reveals important information on the extent and speed with which consumers adjust their expectations toward the fully rational outcome. In addition, within such a framework, it is also insightful to test whether there is any feedback from expected inflation to the actual inflation outcome. Given this potential for feedback in both directions, we first test for the existence of a cointegrating relation between actual and expected inflation. In a second step, a bi-variate error correction system of the form given by (3.1) below is estimated and its dynamic properties examined.

$$\Delta\pi_t^e = \alpha_o^e + \sum_{i=1}^{p} \phi_i^e \Delta\pi_{t-i}^e + \sum_{i=1}^{p} \psi_i^e \Delta\pi_{t-i} + \alpha^e[\pi_{t-1}^e - \pi_{t-1}] + \varepsilon_t^e \qquad (3.1a)$$

$$\Delta\pi_t = \alpha_o + \sum_{i=1}^{p} \phi_i \Delta\pi_{t-i}^e + \sum_{i=1}^{p} \psi_i \Delta\pi_{t-i} + \alpha\ [\pi_{t-1}^e - \pi_{t-1}] + \varepsilon_t \qquad (3.1b)$$

Under the hypothesis of cointegration, one of the $\alpha^e, \alpha\ \neq 0$.[12] An interesting feature of this system is that the equation for expectations has a forward – as opposed to a backward-looking dimension. In particular, in the case of equation (3.1a), the test of the hypothesis $\alpha^e \neq 0$ tests whether the change in expectations (formed between periods *t-13* and *t-12*) is such that the level of inflation expected for period *t* will be closer to the rational outcome (which is unknown at the time expectations were formed). In the case of equation (3.1b), the test of the hypothesis $\alpha \neq 0$ examines whether the change in actual inflation also adjust in order to maintain a cointegrating relation with expected inflation. Within such a system, it is also possible to test for additional short-run dynamic effects associated with the coefficients $\phi_i^e, \psi_i^e, \phi_i$ and ψ_i.

As the preliminary step in testing for the existence of such an error correction representation, Table 3 reports standard unit root tests for both actual and expected

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[11] Other recent papers applying cointegration techniques to shed light on the rationality of expectations include Grant and Thomas (1998), Dutt and Ghosh (2000), Berk (1999) and (2000). See also Paquet (1992).

[12] Granger (1988) pointed out that, if two series are cointegrated, then there must be Granger causality in at least one direction.

inflation over the period 1985-2005. In general, the tests suggest that both actual and expected inflation have unit roots but that they are stationary when differenced once. However, it is possible to reject the null hypothesis of a unit root in the expectation error suggesting that both actual and expected inflation cointegrate with known cointegrating vector [1, -1].[13]

Table 3: Unit root tests

	Infl.		d(infl.)		Exp.		d(exp.)		error	
euro area	-1.59		-3.72	***	-2.24		-16.21	***	-3.52	***
Germany	-1.90		-14.96	***	-1.75		-24.72	***	-2.62	*
France	-1.62		-6.17	***	-3.57	***	-12.62	***	-4.98	***
Italy	-2.60	*	-12.84	***	-1.92		-23.82	***	-3.42	**
Spain	-2.67	*	-13.52	***	-3.25	**	-21.25	***	-4.05	***
Netherlands	-2.05		-15.50	***	-2.12		-6.50	***	-3.20	**

Notes: ADF presents the augmented Dickey-Fuller test-statistic for the null hypothesis of a unit root in the indicated series against the alternative hypothesis of stationarity. d() denotes the first difference of each series. *, ** and *** indicate that it is possible to reject the null of a unit root at the 10%, 5% and 1% levels of significance, respectively.

In a second step, the bi-variate error correction model (3.1a and 3.1b) is estimated. Consistent with the monthly frequency of the data, the lag length *p* is set equal to twelve.[14] The equilibrium correction coefficients (α_o^e, α_o) and p-values based on F-tests for Granger-causality associated with the parameters $\phi_i^e, \psi_i^e, \phi_i$ and ψ_i are reported in Table 4 for both the euro area and the individual countries. In the regression for the change in expectations, the adjustment parameter on the expectational error is significant in all instances and suggests that consumers revise their expectations and adjust them to be in line with the actual outcome. In terms of the speed of this adjustment, given the monthly frequency of the data, the estimated coefficient (-0.10) implies quite low persistence in deviation of actual and expected inflation.[15] Overall therefore, these results suggest that consumers react quite quickly when revising their expectations in the light of new information and that, while both actual and expected inflation may drift apart in the short-run, they ultimately revert toward one another. The other adjustment coefficient (α_o), however, is not significant, thereby suggesting that

[13] Additional tests also support the hypothesis of cointegration between actual inflation and the rate expected by consumers. In particular, using Johansen's maximum likelihood technique, both the maximum eigenvalue and trace statistics (see Hansen and Juselius, 1995) support the hypothesis of a single cointegrating vector at the 90% level.

[14] This was the lowest number of lags that was consistent with serially uncorrelated residuals in the bi-variate system.

[15] Abstracting from the other short-term dynamics, this co-efficient implies a half-life of deviations from long-run equilibrium of less than a year. This evidence is close to that reported by Roberts (1998) for the US which implies that expectations adjust 50% to 60% toward the fully rational outcome within a year.

the adjustment of actual inflation plays no significant role in maintaining the cointegrating relation. The finding that expectations adjust towards actual inflation, rather than the other way around, suggests that the process generating inflation is not strongly influenced by expectations, which in turn contrasts with New Keynesian theories of price dynamics. In general, all of the above findings are also robust when considering the country dimension.

Table 4: Error correction coefficients
(coefficients and p-values)

	expectations regression				Inflation regression			
			F^1	F^2			F^3	F^4
	α^e		$\phi_i^e \equiv 0$	$\psi_i^e \equiv 0$	α		$\phi_i \equiv 0$	$\psi_i \equiv 0$
euro area	-0.10	***	0.10	0.00	0.00		0.10	0.00
Germany	-0.11	***	0.00	0.00	-0.02		0.79	0.00
France	-0.13	***	0.11	0.05	0.03		0.02	0.00
Italy	-0.12	**	0.00	0.03	0.00		0.84	0.00
Spain	-0.07	*	0.00	0.00	0.01		0.32	0.00
Netherlands	-0.13	***	0.00	0.12	0.07	**	0.84	0.00

Note: *, ** and *** indicate that the coefficients (α^e and α) are significant at the 10%, 5% and 1% level, respectively. For the F-statistics, F^i (i= 1,2,3,4), the p-values are reported.

To shed further light on the dynamic interaction between actual and expected inflation, Table 4 also reports the p-values for the tests that the other short-run coefficients $\phi_i^e, \psi_i^e, \phi_i$ and ψ_i can be excluded from the bi-variate model. The results suggest, at the area-wide level, a significant role for actual inflation as determinants of changes in expectations in a Granger-causal sense (F^2). However, the feedback from expectations to actual changes in inflation is quite weak and insignificant at standard levels (F^3). This causal relationship is relatively robust across the countries.

3.3 Tests of macroeconomic efficiency

A more general formulation of the rational expectations hypothesis is that the expectational errors should be orthogonal with respect to the information set that was known to consumers at the time they formed their expectations, i.e. the *ex post* error cannot be explained by past economic developments. By distinguishing between the breath of the information set that is assumed to be available to consumers, it is possible to distinguish different degrees of efficiency. In particular, expectations are said to be *weak-form efficient* if the expectational error cannot be explained by an information set that includes only past values of inflation. *Strong-form efficiency*, on the other hand, requires that the expectational error be orthogonal with respect to a much wider information set encompassing many of the macroeconomic variables that are thought to have an influence on price developments.

The efficiency of consumers' inflation expectations may be tested by estimating the following equation:

$$\pi_t - \pi_t^e = \delta + \phi\, \Omega_{t-12} + u_t\,, \tag{3.2}$$

where Ω_{t-12} represents the set of information variables that are relevant for predicting inflation and are available at the time the expectations are formed. In the empirical analysis, this includes past inflation as well as a wide range of other macroeconomic indicators capturing demand and cost pressures as well as monetary and financial conditions. In order to exploit the monthly frequency of the expectations series monthly data are employed for each of the information variables if available. However, for wages and GDP only a quarterly frequency is available so the monthly expectations series is averaged to produce estimates at a quarterly frequency. While in principle it is appropriate to include all variables in a multivariate context this could lead to severe econometric complications (e.g. multicollinearity). Hence, the efficiency of consumers' expectations is evaluated by running a sequence of univariate regressions where the dependent variable is the year-on-year change in the information variable at the time that expectations were formed.[16]

A statistically significant ϕ suggests that the effect on inflation from past developments in the information variable (Ω_{t-12}) has been incorrectly estimated. Moreover, if the sign on the true correlation between the information variable and inflation is known, it is also possible to judge whether a certain variable's effect on inflation is over or under estimated by consumers. Assuming a positive correlation between the information variable and inflation, a positive (negative) ϕ suggests that the effect from that particular variable on inflation has been under (over) estimated. If a negative correlation is assumed, however, the interpretation is reversed, i.e. a positive (negative) ϕ would suggest that the effect from that particular variable on inflation has been over (under) estimated. The constant (δ) cannot be interpreted in a meaningful way. The results from the macro efficiency tests at area-wide data are presented below in Table 5a for the whole sample period as well as for the earlier defined sub-periods.

[16] Hence, this test ignores the effect of publication lags and possible revisions on the information set available to consumers.

Table 5a: Test for efficiency, sub-periods, ($\pi_t - \pi_t^e = \delta + \phi\, \Omega_{t-12} + u_t$)

(estimates of ϕ)

Demand variables	**full sample**		**1980s**		**1990s**		**2000s**	
GDP	0.30	***	0.89	***	0.23	**	0.16	
Industrial production	0.08	***	0.20	***	0.06	**	0.09	***
Unemployment	-0.45	***	-3.18	***	-0.40	**	-0.44	***
Monetary and Financial variables								
M1	0.07	***	-0.34		0.06		0.10	***
M3	0.18	***	0.67	***	0.18	***	-0.10	
3-month interest rate	0.17	***	0.09		0.22	***	0.05	
Long-term interest rate	0.21	***	0.21		0.26	***	0.18	
12-m. real interest rate	0.11	***	-0.66	**	0.17	***	0.03	
USD/euro	0.00		-0.06	***	0.01		-0.01	
Nominal eff. exchange rate	0.00		-0.08	***	0.02		-0.02	
Price & Cost variables								
Inflation	0.09		-0.13		0.29	***	-0.78	***
Compensation p. employee	0.08		-0.74		0.08		-0.67	**
Producer prices	0.03		0.19	***	0.20	**	0.01	
Commodity prices	0.00		0.02	***	0.01		0.01	
-Energy	0.00		0.01		0.01		0.00	**
-Non-energy	0.01		0.03	***	0.00		0.01	

Note: ** and *** indicate that the coefficient is significant at the 5% and 1% level, respectively.

Earlier findings based on forecasting performance and tests of unbiasedness indicate that expectations have become more rational over the sample period. This also seems to be the case as regards their efficiency. Over the full sample-period past price developments do not explain consumers' prediction errors thereby providing evidence of weak form efficiency. As regards the other variables all cost indicators and the two euro exchange rate measures also do not explain some of the prediction error. However, consumers' inflation expectations do not appear to be fully efficient with respect to the information contained in the demand variables and the monetary aggregates or some of the other interest rate variables.[17] Looking at the three sub-samples there is, however, clear evidence of an improvement in terms of efficiency. In the first sub-sample there are ten variables that significantly explain the errors, while in the third sub-sample there are six variables which enter with a statistically significant coefficient. As regards the role of M3 in explaining the expectational error the results are particularly interesting given the monetary policy strategy that has been adopted by the ECB. Over the whole sample and for most sub-samples, ϕ is positive, suggesting that consumers have underestimated its impact on inflation (assuming a positive relationship between money and inflation). As regards the former variable this finding is particularly interesting given the monetary policy strategy that has been adopted by the

[17] The consistent lack of efficiency with respect to monetary variables that is found for the euro area is at odds with the evidence reported in Ball and Croushore (1998) for US inflation expectations.

ECB. In particular, since consumers have not generally taken into account the information contained in monetary aggregates when forming their expectations, this results tends to support the independent and incremental information role that is assigned to M3 in the strategy.

Table 5b: Test for efficiency, euro area countries, ($\pi_t - \pi_t^e = \delta + \phi\, \Omega_{t-12} + u_t$)

(estimates of ϕ)

Demand variables	euro area		Germany		France		Italy		Spain		Netherl.	
GDP	0.30	***	0.42	***	0.09	***	0.18	***	0.13	***	0.26	***
Industrial production	0.08	***	0.18	***	0.00		0.08		0.03		0.08	***
Unemployment	-0.45	***	-0.07	***	0.00		0.00		-0.01		-0.02	***
Monetary and Financial variables												
M1	0.07	***	0.05		-0.01		0.08	**	0.10	**	-0.02	
M3	0.18	***	-0.05		0.02		-0.21	***	0.12	**	0.09	**
3-month interest rate	0.17	***	0.53	***	0.02		-0.20		-0.10		0.54	***
Long-term interest rate	0.21	***	0.62	***	0.03		-0.05		0.09		0.57	***
12-m. real interest rate	0.11	***	0.14		0.06		-0.25	***	0.26	***	0.11	**
USD/euro	0.00		-0.02		-0.02	**	-0.02		0.04	**	0.03	**
Nominal eff. exchange rate	0.00		-0.01		0.00		0.05	***	-0.05		-0.10	**
Price & Cost variables												
Inflation	0.09		-0.17		0.09		-0.58	***	0.16		0.03	
Compensation per employee	0.08		-0.04		0.17		-0.22	***	0.15		-0.01	
Producer prices	0.03		0.10		0.04		-0.21	***	0.09		0.12	***
Commodity prices	0.00		0.01		0.00		0.00		0.00		0.02	***
-Energy	0.00		0.01	**	0.00		0.00		0.00		0.02	***
-Non-energy	0.01		0.00		0.01		0.03	**	0.02		0.01	

Note: ** and *** indicate that the coefficient is significant at the 5% and 1% level, respectively.

Table 5b reports the degree of significance of ϕ for the euro area as well as the countries for the whole sample period. The role of the various variables in explaining the expectational error differs quite a lot between the countries with little evidence against overall efficiency in France and much stronger evidence in countries such as The Netherlands, Italy and Spain.

Overall, the evidence from the efficiency tests suggests a weak or intermediate rather than a full form of rationality with consumers taking into account a wide ranging – but not complete – set of information in forming their expectations. In addition, consistent with the results relating to bias, there is evidence of "growing" rationality over time. However, the higher degree of efficiency may not only be due to greater rationality on the part of consumers. Euro area inflation has declined over the last decades and become less volatile. This, in combination with greater central bank independence and credibility, has made it easier to predict future inflation. Hence, consumers may have become more efficient at predicting inflation but policy makers may also have made the job easier than it was 10 or 20 years ago.

4 Expectations and inflation dynamics

The preceding sections have shown that the consumer survey measure of inflation expectations fulfils some – although far from all – of the necessary conditions for rationality. However, as discussed in the introduction, a key insight of the rational expectations hypothesis is that rational expectations of inflation have a strong influence on actual inflation. This view has been re-articulated in recent new Keynesian models of price dynamics.[18] The contribution of the New Keynesian models is to emphasise the role of nominal rigidities in interpreting the Phillips curve. In particular, the reason why expectations matter is because there is some constraint on the frequency of price adjustment and as a result, an optimising firm will partly incorporate expected future changes in costs (or in other firms prices) into current prices (see, for example, Roberts (1995), Roberts (1998), Sbordone (2000a) and (2000b), Galí and Gertler (1999) Galí, Gertler and Sólido Lopez (2001)). As a result, these authors contrast the traditional Phillips curves where the impact of expectations is captured solely by past lags of inflation with the New Phillips Curve (NPC) where inflation is a truly forward-looking phenomenon. Denoting D_t as an excess demand measure, these two divergent views of inflation dynamics are represented by equations (4.1) and (4.2) below:

$$\pi_t = \gamma_b \pi_{t-1} + \beta_1 D_t \tag{4.1}$$

$$\pi_t = \gamma_f \pi^e_{t+1} + \beta_2 D_t \tag{4.2}$$

The difference between (4.1) and (4.2), i.e. between whether or not inflation is a backward as opposed to a forward-looking phenomenon, is of more than just academic interest. For example, under (4.2) if a central bank announced a move to reduce inflation and if this announcement was fully credible and thereby led to a reduction in expectations, then actual inflation could fall without the need for any reduction in output. However, under (4.1), the process of disinflation always implies a reduction in output. More generally, the distinction between backward- and forward-looking inflation dynamics also has important implications for a central bank attempting to assess – in real time – the interaction between the business cycle and inflation. For example, if inflation is forward-looking then it will tend to lead (i.e. help predict) future changes in output. This can be seen by recursively solving (4.2) forward to obtain an expression for current period inflation as a (discounted) weighted sum of current and future deviations of output from its steady-state value (see for example Galí, Gertler and López-Salido, 2001). Conversely, if inflation is purely backward looking and primarily

[18] Wolman (1999) provides a recent survey of these models.

driven by past price developments, it will tend to lag (or be driven by) the business cycle.

Given the previous findings on the information content of the EC consumer survey data on inflation expectations, such data provide an interesting basis on which to test the role of expectations in the inflationary process.[19] To examine this role, appending a cost shock variable (Z_t), a hybrid model which nest (4.1) and (4.2) may be estimated.[20] This is given by (4.3) below:

$$\pi_t = \alpha + \gamma_f \pi^e_{t+4} + \gamma_b \pi_{t-4} + \beta D_t + \delta Z_t + u_t \qquad (4.3)$$

In applying (4.3) to the data, we use non-overlapping quarterly observations of the year-on-year change in prices: π_t denotes the annual inflation rate in quarter *t* while π_{t-4} is the annual inflation rate in quarter *t-4*. Similarly π^e_{t+4} is the average of the three monthly expectations surveyed in quarter *t* for the next 12 months. In order to ensure robustness of the results with respect to the chosen measure of excess demand, two alternative proxies for D_t are considered. First, a standard output gap is considered defined as the log of actual GDP in the euro area minus the log of potential GDP (estimated using a HP filter). Second, we also consider the primitive version of the NPC suggested by Galí *et al.* (2001) according to which the deviations in real marginal costs from their steady state value should replace the traditional and more *ad hoc* output gap measures. The deviation of real unit labour costs from their sample mean is used as a proxy for marginal costs. The real price of oil is used to capture the impact of transitory cost shocks (Z_t). The equations are estimated over the period 1985Q1-2004Q4 (80 observations).

Table 6a reports the coefficients from the estimated hybrid Phillips curves. The two equations appear to capture quite adequately the dynamics of inflation over the sample period. A striking feature at the area-wide level is that for both specifications,

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[19] In particular, from the new Keynesian perspective, the one-year ahead horizon for the expectations from the consumer survey should broadly capture the horizon over which costs or prices are sticky.

[20] Galí and Gertler (1999) derive a hybrid version of the NPC by assuming an economy populated by two groups of firms. One group sets prices in a forward looking way given the constraints on price adjustment and using all the available information on expected future costs. The remaining set of firms base their prices on past price developments alone.

the surveyed measure of inflation expectations enters with a highly significant positive coefficient, which is close to unity. The results at the country level are fully consistent with this, although they indicate slightly lower coefficients (with the exception of the Netherlands). This suggests to a certain degree a forward-looking dimension to the inflationary process within the euro area and supports the findings in Galí *et al.* (2001). However, the backward-looking component is also mostly significant but quantitatively less important. Surprisingly, the real price of oil does only enter significantly in the cases of euro area, France and the Netherlands.

Table 6a: Estimates of hybrid Phillips curve,
($\pi_t = \alpha + \gamma_f \pi^e_{t+4} + \gamma_b \pi_{t-4} + \beta_1 D_t + \delta Z_t + u_t$)

Output gap												
	α		γ_f		γ_b		β_1		δ		r^2	n
euro area	-0.54	**	0.87	***	0.35	***	0.05		0.00	*	0.83	80
Germany	0.27		0.53	***	0.22		0.14		0.01		0.57	80
France	0.26		0.55	***	0.41	***	-0.05		0.01	**	0.75	80
Italy	0.41	*	0.41	***	0.39	***	0.15		0.00		0.88	80
Spain	0.15		0.40	***	0.59	***	0.07		0.00		0.67	75
Netherlands	-0.01		1.06	***	0.09		0.45	***	-0.01		0.73	80

Real unit labour cost gap												
	α		γ_f		γ_b		β_1		δ		r^2	n
euro area	-0.40		0.94	***	0.24	**	0.06	*	0.00	**	0.84	80
Germany	0.14		0.57	***	0.25	*	-0.01		0.01		0.56	80
France	0.70	**	0.49	***	0.31	***	0.07	*	0.01	**	0.76	80
Italy	-0.57	*	0.58	***	0.41	***	-0.11	***	0.00		0.90	80
Spain	0.13		0.44	***	0.57	***	0.05		0.00		0.68	75
Netherlands	0.01		1.07	***	0.07		-0.07		-0.01	**	0.65	66

Note: *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% levels, respectively.

Table 6b reports the results of similar regressions but under the restrictions that the weights on the backward and forward looking components sum to unity. This restriction is accepted only (at the 5% level of significance) in the equations using the output gap for France, Spain and Netherlands. However, in all equations using the deviation from real unit labour costs, including euro area, this restriction is accepted. For both specifications the role for expectations in determining actual inflation dynamics is strongly maintained. However, the weight on past inflation and, hence the backward-looking component in the inflation process, is significant in most euro area countries. These finding are therefore more in favour of the hybrid version of the NPC than a pure forward-looking version.

Table 6b: Restricted estimates of hybrid Phillips curve,
($\pi_t = \alpha + \gamma_f \pi^e_{t+4} + (1-\gamma_f)\pi_{t-4} + \beta_2 D_t + \delta Z_t + u_t$)

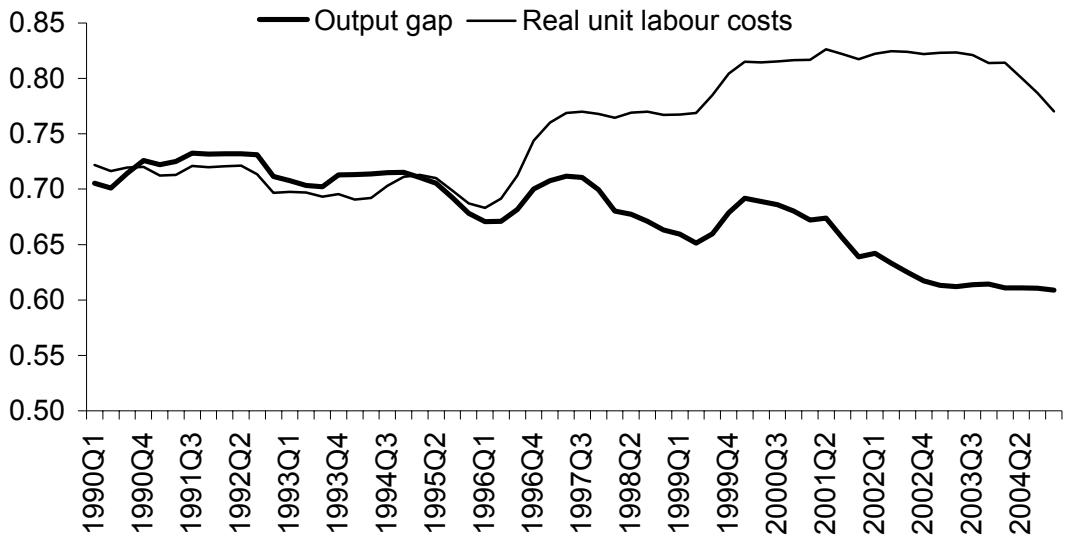
Output gap											
	α		γ_f		$1-\gamma_f$		β_2		δ		r^2	n
euro area	0.00		0.61	***	0.39	***	0.15	**	0.00		0.81	80
Germany	-0.18		0.63	***	0.37	**	0.04		0.01	*	0.54	80
France	0.19	*	0.60	***	0.40	***	-0.06		0.01	**	0.75	80
Italy	-0.52	***	0.47	***	0.53	***	0.15		0.00		0.83	80
Spain	0.11		0.41	***	0.59	***	0.07		0.00		0.68	75
Netherlands	0.24	**	0.91	***	0.09		0.47	***	-0.01		0.73	80

Real unit labour cost gap											
	α		γ_f		$1-\gamma_f$		β_2		δ		r^2	n
euro area	0.07		0.77	***	0.23	*	0.07	**	0.00	*	0.83	80
Germany	-0.19		0.65	***	0.35	**	-0.03		0.01	*	0.54	80
France	0.27	*	0.66	***	0.34	***	0.03		0.01	**	0.75	80
Italy	-0.60	***	0.58	***	0.42	***	-0.11	***	0.00		0.90	80
Spain	0.14		0.43	***	0.57	***	0.05		0.00		0.68	75
Netherlands	0.26		0.90	***	0.10		-0.11		-0.01	**	0.65	66

Note: *, ** and *** indicate that the coefficient is significant at the 10%, 5% and 1% levels, respectively.

Lastly, in order to check for stability, Chart 3 plots recursive estimates of the restricted parameter on consumers' expectations in each of the two models for the euro area. While there is some evidence that the weight attaching to the forward looking component has risen in the real unit labour costs specifications but fallen for the output gap equation, the estimated parameters range between 0.61 and 0.77. The stability of the coefficients at the country level is broadly similar.

Chart 3: Hybrid Phillips curve - Recursive parameter estimates (γ_f)



5 Conclusions

Surveys are useful because they provide independent (or relatively non-model dependent) measures of inflation expectations, a key variable that a central bank can use in its design of an optimal monetary policy geared toward the achievement of price stability. This paper analyses and assesses the empirical properties of consumers' inflation expectations in the euro area over the period from the mid 1980s to the end of 2005. Using the approach set out in Berk (1999), quantitative estimates of euro area inflation expectations are derived from the qualitative data from the European Commission Consumer Survey. The paper subsequently analyses the empirical properties of the estimated inflation expectations by considering the extent to which they fulfil some of the necessary conditions for rationality.

The results suggest consumers' inflation expectations in the euro area are not fully rational, although they may still contain important information about future price developments. In particular, compared with other benchmark indicators of expected inflation, consumers' expectations at the area wide level are shown to provide a reasonably accurate predictor of inflation one-year ahead. Although the surveyed expectations are found to be an unbiased predictor of future price developments in the 1990s, over the whole sample the evidence of bias in expectations is much stronger. These results at the area-wide level also seem to reflect counterbalancing behaviours at the country level, a finding which cautions against drawing strong conclusions about rationality on the basis of area-wide indicators alone. However, at both the area-wide and country levels, there is evidence that the level of expected inflation and the rational inflation outcome are cointegrated. As a result, consumers are shown to gradually adjust their expectations in order to "weed out" any systematic expectational error. Lastly, consumers' expectations in the euro area have not always completely incorporated the information contained in a broad set of macroeconomic variables.

A further important feature of the empirical analysis has been the investigation of potential changes over time in the properties of the derived expectations series. In this regard, there is some evidence of "growing rationality" in the sense that expectations have become a more accurate, less biased and more efficient predictor of inflation over the 1990s and 2000s compared with the 1980s.

Overall, therefore are analysis would suggest that consumers expectations are unlikely to satisfy the very strong restrictions implied by the Rational Expectations Hypothesis, whilst at the same time highlighting their significant and possibly improving information content. In line with this, as suggested by recent new Keynesian models of inflation we have also examined the role of the survey expectations in explaining actual inflation dynamics. Estimates of a hybrid Phillips curve – which, nests backward as well

as forward-looking inflation dynamics - suggests that consumer expectations have played a role in determining the observed behaviour of inflation over the period 1985-2004. Overall, therefore, our results underline the important information content of survey data in the analysis of euro area inflation.

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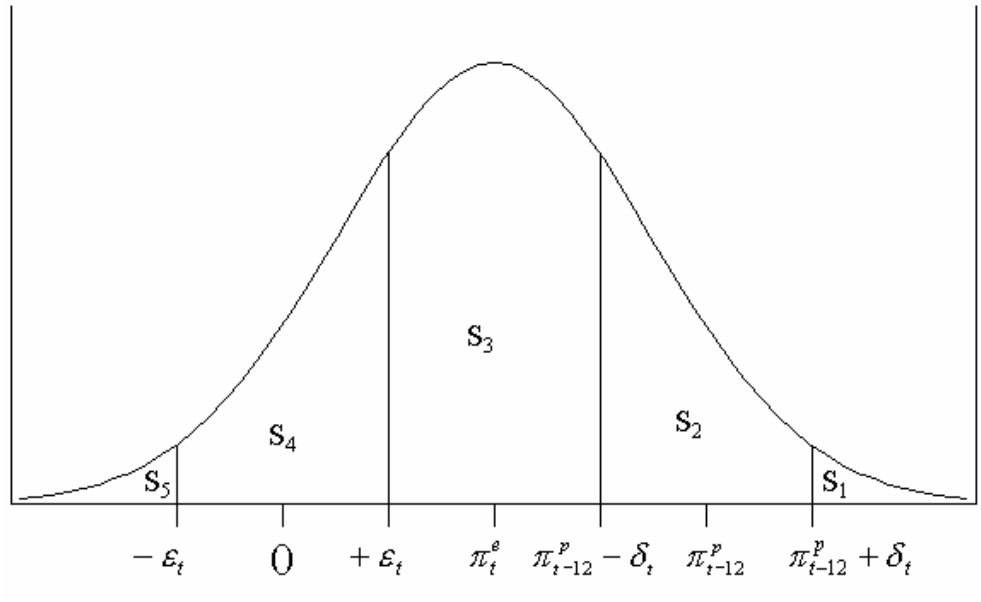
Annex 1: Estimating inflation expectations from survey data

The central idea behind the probability approach is to interpret the share of respondents replying to each category (as described in Section 2) as maximum likelihood estimates of areas under the density function of aggregate inflation expectations, i.e. as probabilities (see figure). The distribution is segmented by various response thresholds. For example, as in the original Carlson and Parkin (hereafter CP) methodology, respondents expect prices to rise (fall) if the expected rate of inflation for month *t* (π_t^e) but surveyed in month *t-12* (for monthly data) is at least ε_t units above (below) zero.[21] In addition, respondents are assumed to condition their replies on their perceptions of past inflation. In particular, respondents report that prices are expected to increase at a more (less) rapid pace if the expected rate of inflation is at least δ_t units above (below) the currently perceived rate of inflation at the time the survey was carried out (π_{t-12}^p).

Figure: The aggregate probability distribution of inflation expectations



One option to estimate the perceived inflation rate is to use the currently available rate of inflation, i.e. to assume that respondents correctly perceive the actual rate of inflation at the time they form their expectations. However, it is a quite strong assumption to assume that consumers perceive inflation correctly and, therefore, in this

[21] There is some ambiguity as to whether or not the question in the consumer survey in month *t-12* refers to the expected year-on-year rate of price increase in month *t* or the expected *average* rate of inflation in the 12 month period between months *t-12* and *t.* Throughout this paper, the consumer survey is assumed to refer to the former.

paper π^{P}_{t-12} is estimated independently using the results from a question on past price developments also contained in the Commissions consumer survey.[22]

Using the above framework, conditional on an assumed form of the aggregate distribution, it is possible to solve for the level of the expected inflation rate, its standard error (σ_t) as well as for the two response thresholds (ε_t and δ_t). Denoting S^i_t (for *i* = 1,2 3, 4 and 5) as the sample proportions opting for each of the five response categories in the survey undertaken in month *t*, the solutions are given by equations (A1) to (A4) below.[23]

$$\pi^e_t = -\pi^p_{t-12}\left[\frac{(Z^3_{t-12} + Z^4_{t-12})}{Z^1_{t-12} + Z^2_{t-12} - Z^3_{t-12} - Z^4_{t-12}}\right] \tag{A1}$$

$$\sigma^e_t = \pi^p_{t-12}\left[\frac{2}{Z^1_{t-12} + Z^2_{t-12} - Z^3_{t-12} - Z^4_{t-12}}\right] \tag{A2}$$

$$\delta_t = \pi^p_{t-12}\left[\frac{(Z^1_{t-12} + Z^2_{t-12})}{Z^1_{t-12} + Z^2_{t-12} - Z^3_{t-12} - Z^4_{t-12}}\right] \tag{A3}$$

$$\varepsilon_t = \pi^p_{t-12}\left[\frac{(Z^3_{t-12} - Z^4_{t-12})}{Z^1_{t-12} + Z^2_{t-12} - Z^3_{t-12} - Z^4_{t-12}}\right] \tag{A4}$$

Where all variables are defined previously and σ^e_t denotes the standard deviation of the aggregate distribution for inflation expectations. $N^{-1}[]$ is the inverse of the assumed probability distribution function and $Z^1_{t-12} = N^{-1}\left[1 - S^1_{t-12}\right]$, $Z^2_{t-12} = N^{-1}\left[1 - S^1_{t-12} - S^2_{t-12}\right]$, $Z^3_{t-12} = N^{-1}\left[1 - S^1_{t-12} - S^2_{t-12} - S^3_{t-12}\right]$ and $Z^4_{t-12} = N^{-1}\left[S^5_{t-12}\right]$. The above expressions for the mean and standard error of expected future inflation are

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[22] The question on past price developments asks consumers the following: Compared with what it was 12 months ago, do you think that the cost of living is now 1. Very much higher, 2. Quite a bit higher, 3. A little higher, 4. About the same, 5. Lower or 6. Don't know.

[23] See the Appendix in Berk (1999) for a full derivation and further discussion of these equations.

quite similar to the original CP results. They express the mean and the uncertainty of expected inflation as a function of the Z^{i}_{t-12} and the perceived rate of inflation, which has a scaling function. However, in contrast to the original CP approach, where the scaling parameter was estimated by imposing unbiased expectations, an important advantage of equation (A1) is that it does not impose unbiasedness as an *a priori* property of the measure of expectations.[24] This facilitates subsequent empirical testing of the extent of any bias in the inflation expectations of consumers. However, a disadvantage of the probability approach is that it may give rise to counterintuitive movements in the derived expectations series. For example, one would expect that a *ceteris paribus* increase in the share of respondents expecting prices to rise at a more rapid pace (e.g. as a result of a decline in the share of respondents giving a "don't know" reply) would be associated with a higher quantitative estimate of expected inflation. However, consideration of the partial derivative of π^{e}_{t} in (A1) with respect to S^{1}_{t-12}, shows that this is not necessarily the case.[25]

A second important advantage compared with the CP methodology is that the response thresholds are permitted to vary over time. Such time-variation may represent an important feature of the problem faced by consumers in responding to the survey. Batchelor (1986b) provided arguments for time-varying response thresholds based on signal extraction theory, suggesting that the response threshold will tend to be high when the aggregate uncertainty surrounding inflation is also high. Similarly, Seitz (1988) models the response thresholds as a linear function of the actual inflation rate and the dispersion of price changes across industries. In contrast, the above measures permit time-varying response thresholds to be derived directly from the survey replies without the need to make any *ad hoc* assumptions on their determinants.

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[24] Batchelor (1982) suggests a least squares rather than an unbiasedness criterion, i.e. by choosing a scaling factor such that the sum of squared expectation errors is minimised.

[25] See Batchelor (1986a) for a discussion of this problem.

Annex 2: The data set

Variable	Source	Freq.	Remark
Survey data	European Commission (DG ECFIN)	M	Detailed responses
GDP	Eurostat	Q	
- Potential GDP		Q	Estimated using a HP filter (λ = 1,600)
- Output gap		Q	Log of actual GDP minus the log of potential GDP
Industrial production	Eurostat	M	Excluding construction
Unemployment rate	Eurostat	M	
M1	ECB	M	
M3	ECB	M	
3-month interest rate	ECB calculations	M	Aggregation based on national data from the BIS databank
Long-term interest rate	ECB	M	
12-month real interest rate	ECB calculations	M	12-month interest rate minus inflation
Exchange rate vis-à-vis the USD	ECB	M	USD/ECU until December 1998 for euro area
Nominal effective exchange rate	Fagan, Henry and Mestre (2001)	Q	From Q1 1990 onwards linked with EER as published in the ECB's Monthly Bulletin
Inflation:			
- CPI	ECB calculation	M	Aggregation based on national data from the BIS databank
- HICP	Eurostat	M	Linked with CPI in January 1990
Compensation per employee	ECB calculation	Q	Aggregation based on national data from the BIS databank
Producer prices	Eurostat	M	Excluding construction
Commodity prices	HWWA - Institut für Wirtschaftsforschung (Hamburg)	M	Converted into euro
Real unit labour costs gap		Q	Log of real unit labour costs minus its mean
- Real unit labour costs		Q	Unit labour costs deflated with HICP
- Unit labour costs	ECB calculation	Q	Aggregation based on national data from the BIS databank