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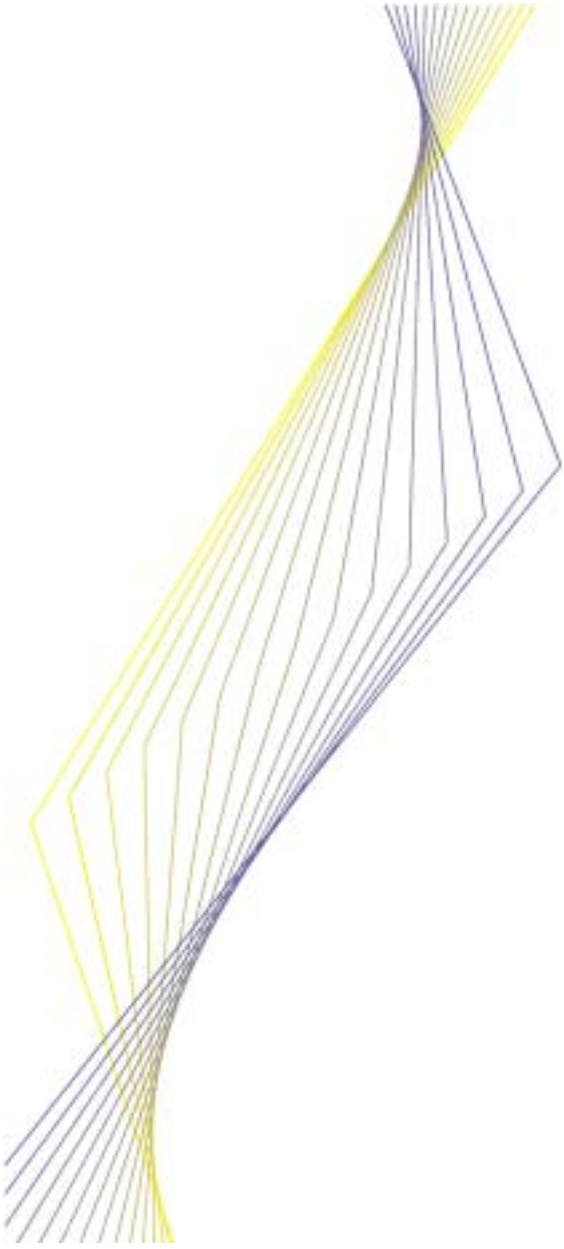

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BY M. FORSELLS AND G. KENNY*

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Abstract:
This paper uses survey data to assess consumers' inflation expectations in the euro area. The probability approach is used to derive quantitative estimates of inflation expectations 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. The results suggest an intermediate form of rationality. In particular, the surveyed expectations are an unbiased predictor of future price developments and they incorporate – though not always completely – a broad set of macroeconomic information. In addition, although persistent deviations between consumers' expectations and the rational outcome have occurred, consumers are shown to rationally adjust their expectations in order to eventually "weed out" any systematic expectational errors. Interestingly, perhaps reflecting changes in the monetary regime, there is also evidence of "growing" rationality over the 1990s compared with the 1980s.

Key words: Inflation expectations, Surveys, Rationality, Euro area

JEL Classification: D12, D84, E31

Non technical summary

Macroeconomic theory accords a pivotal role to expectations of inflation, and the properties of those expectations, in understanding the functioning of the economy. From the perspective of aggregate price formation, the expectations augmented Phillips curve posits a relationship whereby the actual change in the price level is driven - in part - by expectations of its future change. Conversely, from the perspective of business cycle analysis, a key prediction is that the scale of any real stimulus to the economy from inflation will crucially depend on the extent to which such inflation is anticipated. Under fully rational expectations, where agents form their expectations by correctly taking into account all the relevant information and where there are no systematic errors in agents' forecasts of inflation, only unexpected changes in inflation will have an impact on real variables such as output and unemployment.

In this paper a measure of expected inflation in the euro area is derived from the European Commission's Consumer Survey (EC survey). In order to shed light on the *rationality* of inflation expectations in the euro area, 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 and, in particular, provide estimates of the speed with which consumers revise their expectations to be in line with the fully rational outcome. Lastly, in a test of the *efficiency* of consumers' inflation expectations in the euro area, the extent to which they incorporate the information contained in a broad set of macroeconomic variables is evaluated.

Our results suggest that consumer expectations from the EC survey provide important information on actual future developments in euro area inflation. In particular they provide an unbiased predictor of inflation one-year ahead and, most strikingly, correctly anticipated the trend decline in inflation over the 1990s. In line with this, our analysis of the dynamic adjustment of expectations suggests that consumers revise their expectations in the light of new information and that, while both actual and expected inflation may drift apart in the short-run, consumers gradually adjust their expectations so as to "weed out" any systematic errors. However, there is some

evidence to suggest that consumers' expectations are not fully rational with respect to all the available information. In particular, while consumers appear to take full account of past developments in inflation, the empirical evidence suggests that a wider set of macroeconomic information (most notably monetary and financial variables) can explain consumers' errors in forecasting inflation. Given the monetary policy strategy that has been adopted by the ECB, the fact that consumers do not adequately take account of monetary variables (such as M3) is of interest. In particular, such results tend to support the independent and incremental information role that is assigned to M3 under the first pillar of the strategy.

Lastly, perhaps reflecting changes in the monetary policy regime, there is evidence of "growing" rationality of euro area inflation expectations in the 1990s compared with the 1980s. This improvement is particularly notable during the period of convergence in preparation for Economic and Monetary Union and, in particular, in the manner in which consumers' anticipated the trend decline in inflation over this period. Part of the explanation for this may indeed be that consumers have become better at predicting inflation. However, euro area inflation has also declined over the last decades and has become less volatile. This, in combination with greater central bank credibility, may have made it easier to predict future inflation.

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,

[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 risking 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

Roberts (1995), Sbordone (2002) and (2000), Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).[2] A defining feature of this New Keynesian theory of price dynamics is that inflation is a forward-looking phenomenon, driven by its own expectations.[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

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.

[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 for forecasting inflation.

[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).

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.[6] In particular, a measure of expected inflation in the euro area is derived from the European Commission's Consumer Survey (EC survey) and its predictive performance for future inflation in examined. Following on from this, in order to shed light on the rationality of inflation expectations in the euro area 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 and, in particular, provide estimates of the speed with which consumers revise their expectations to be in line with the fully rational outcome. Lastly, in a test of the *efficiency* of consumers' inflation expectations in the euro area, the extent to which they incorporate the information contained in a broad set of macroeconomic variables is evaluated.

To anticipate our findings, our results suggest that consumer expectations from the EC survey provide important information on actual future developments in euro area inflation. In particular they provide an unbiased predictor of inflation one-year ahead and, most strikingly, correctly anticipated the trend decline in inflation over the 1990s.[7] In line with this, our analysis of the adjustment of expectations suggests that consumers revise 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. Lastly, there is also some evidence to suggest that consumers' expectations are not fully rational with respect to all the available information. In particular, while consumers appear to take full account of past developments in inflation, the empirical evidence suggests that a wider set of macroeconomic information (most notably monetary and

[6] In this paper, attention is focussed on the properties of an aggregate measure of expectations in the euro area and any possible heterogeneity in the properties of inflation expectations across the individual euro area countries, although potentially important, is overlooked.

financial variables) can explain consumers' errors in forecasting inflation. In this sense, expectations are weak but not strong-form efficient. Nonetheless, there is evidence of "growing" rationality over the sample period: when data from the late 1980s is excluded from the sample, the evidence against strong-form efficiency is much weaker.

2. Estimating euro area inflation expectations from survey data

Economic surveys provide a direct source of information on expected inflation.[8] For example, the EC Survey asks approximately 50,000 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 GDP. Participants in the survey are asked the following question, which is harmonised across all countries: [9]

"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,
2. …prices will increase at the same rate,
3. …prices will increase at a slower rate,
4. …prices will stay about the same or
5. …prices will fall slightly."

While 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.[10] However, recent literature (e.g.

[7] This is striking because purely backward looking or adaptive expectations would tend to systematically over-predict inflation when it is declining.

[8] 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.

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

[10] 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 $(S_1+\frac{1}{2}S_2) - (\frac{1}{2}S_4+S_5)$.

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 the probabilistic 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, unbiasedness is not imposed in deriving a measure of expected inflation.

2.1 The probability approach to estimating inflation expectations

The central idea behind the probability approach is to interpret the share of respondents replying to each category as maximum likelihood estimates of areas under the density function of aggregate inflation expectations, i.e. as probabilities (see Figure 1 in Annex 1). 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.[11] 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).

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 paper π_{t-12}^P is estimated

[11] 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.

independently using the results from a question on past price developments also contained in the Commissions survey.[12]

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_t^i (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 (2.1) to (2.4) below.[13]

$$\pi_t^e = -\pi_{t-12}^p \left[\frac{(Z_{t-12}^3 + Z_{t-12}^4)}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right] \tag{2.1}$$

$$\sigma_t^e = \pi_{t-12}^p \left[\frac{2}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right] \tag{2.2}$$

$$\delta_t = \pi_{t-12}^p \left[\frac{(Z_{t-12}^1 + Z_{t-12}^2)}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right] \tag{2.3}$$

$$\varepsilon_t = \pi_{t-12}^p \left[\frac{(Z_{t-12}^3 - Z_{t-12}^4)}{Z_{t-12}^1 + Z_{t-12}^2 - Z_{t-12}^3 - Z_{t-12}^4} \right] \tag{2.4}$$

Where all variables are defined previously and σ_t^e denotes the standard deviation of the aggregate distribution for inflation expectations. $N^{-1}[]$ is the inverse of the assumed probability distribution function and $Z_{t-12}^1 = N^{-1}\left[1 - S_{t-12}^1\right], Z_{t-12}^2 = N^{-1}\left[1 - S_{t-12}^1 - S_{t-12}^2\right]$, $Z_{t-12}^3 = N^{-1}\left[1 - S_{t-12}^1 - S_{t-12}^2 - S_{t-12}^3\right]$ and $Z_{t-12}^4 = N^{-1}\left[S_{t-12}^5\right]$. The above expressions for the mean and standard error of expected future inflation are quite similar to the original CP results. They express the mean and the uncertainty of expected inflation as a function of the Z_{t-12}^i and the perceived rate of inflation, which has a scaling function. However, in

[12] 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.

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

contrast to the original CP approach, where the scaling parameter was estimated by imposing unbiased expectations, an important advantage of equation (2.1) is that it does not impose unbiasedness as an *a priori* property of the measure of expectations.[14] 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_t^e in (2.1) with respect to S_{t-12}^1, shows that this is not necessarily the case.[15]

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.

2.2 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 February 2001 (see Annex 2 for a full description

[14] 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.
[15] See Batchelor, 1986a, for a discussion of this problem.

of the data sources).[16] The results suggest a strong relationship between actual and expected inflation. In particular, although there is some evidence to suggest that consumers underpredicted inflation in the second half of the 1980s, they appear to have broadly anticipated the trend decline in inflation over the course of the 1990s (from a high of 5.2% in July 1991 to only 0.8% in February of 1999). Indeed, over the period from the beginning of the 1990s to the start of Economic and Monetary Union in January 1999, the evidence supports a significant degree of forward-looking information in the derived expectations series. In particular, 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 January of 1992, inflation had average 4.3% over the preceding year. However, in that same month consumers were anticipating an inflation rate of 3.2% for the next 12 months and this compared more favourably with the actual outcome for January 1993 (3.4%). 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.

To provide a more quantitative evaluation of the expectations series, Table 1 presents some standard forecast performance statistics. The first statistic is the mean error (ME), 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 measure is the mean absolute error (MAE), which says something about the accuracy of the consumers expectations as a predictor of the future inflation outcome. Large but counterbalancing forecast errors would produce a low mean error but a higher mean absolute error. The third measure is the root mean squared error (RMSE), which also provides a measure of accuracy. An important difference between the MAE 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

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

the current year-on-year rate as the expectation for the next twelve months ($\pi_t^e = \pi_{t-12}$) and (ii) a proxy for financial market expectations derived from a Fisher relation for the 1-year ahead money-market interest rate.[17] Consistent with the graphical evidence in Chart 1 that performance has improved in the 1990s compared with the 1980s, the sample is split into two sub-periods. This split is also motivated by the observed decline in inflation over the past decades, which may have changed the inflationary process and, thereby, also the behaviour and forecasting performance of consumers' inflation expectations. The chosen break (1992:12) represents approximately the mid-point of the sample. The performance statistics are then calculated for the whole sample as well as for each sub-sample.

The performance statistics in Table 1 indicate quite strongly the change in the performance of the derived expectation series in the 1990s compared with the late 1980s. From the table it is clear that any bias in expectations relates almost entirely to the late 1980s with the mean error falling from 0.94 over the period 1986:1-1992:12 to only –0.06 in the period 1993:1-2000:12. Similarly, there is a dramatic improvement in accuracy statistics in the second sub-sample compared with the first: in the 1990s both the MAE and the RMSE are around 40% of their levels in the late 1980s. Indeed 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 1990s. Most notably, they significantly outperform the expectations based on the naive model and those derived from the Fisher relation. The performance of the measure of consumer expectations also compares reasonably well with those reported for measures of US inflation expectations. For example, Lloyd (1999) for the US obtains RMSE for various one-year ahead inflation expectations that range between 1.09 and 1.57.[18] Lastly,

[17] In order to calculate a measure of expectations from the 1-year interest rate, the real interest rate is estimated as a weighted moving average of the past twelve ex post real rates where the weights diminish with the lag length, i.e. $\pi_t^e = i_{t-12} - w_i \sum_{i=0}^{11} (i_{t-12-i} - \pi_{t-12-i})$, where i_{t-12} is the 12-month nominal interest rate and w_i is the weight which is defined as $w_i = \frac{12-i}{78}$, where $\sum_{i=0}^{11} w_i = 1$.

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

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).

In order to complete the presentation of the results from applying the probability approach to the euro area consumer survey, Chart 2 plots the estimate of uncertainty (σ_t) along with the estimated response thresholds (ε_t and δ_t) over the period 1985:1 – 2000:12. Inflation uncertainty (σ_t) appears to have trended down somewhat over the 1990s from a high of over 2.5 percentage points in October 1990 to 1.1 percentage points in January 1999. This suggests a high degree of correlation between uncertainty surrounding expected future inflation and the level of actual inflation. Inflation uncertainty did, however, increase abruptly following the oil shock in early 1999. As regards the response thresholds, they also correlate positively both with each other and with the measure of uncertainty.

3. Properties of euro area inflation expectations

The evidence described in section 2 suggests that the measure of expectations derived from the EC survey provides 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. 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 – but 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 expectations indicator in the 1990s compared with the 1980s, a Chow breakpoint test conducted on equation (3.1) confirms that a structural break has occurred in the relation between consumers' expectations and actual inflation.[19] Hence, the hypothesis of unbiased inflation expectations is conducted for the full sample period and the two sub-sample periods as defined earlier. The results are presented in Table 2. Overall, the results suggest that consumers' inflation expectations have been an unbiased predictor of inflation 12 months ahead. Over the full sample, the null hypothesis cannot be rejected at a reasonable level of significance. However, looking at the results for the first sub-period, the null hypothesis is rejected thus confirming the previous finding of poor performance in the late 1980s. The positive α suggests that expectations have on average underestimated inflation and, in addition, β is well below unity. In contrast, for the second sub-sample the unrestricted parameter estimates accord almost exactly with their theoretical values under the null hypothesis of unbiased expectations. Moreover, if a similar test is conducted but replacing the derived expectation series with expectations based on a naïve model the null hypothesis of unbiased expectations is rejected for all of

[19] The test strongly rejects the null hypothesis of no structural change with a log likely ratio of 91.91, which is to be compared with the critical value of 5.99.

the three sample periods.[20] This finding is consistent with the view that the inflation expectations are more rational compared with a simple model that just extrapolates past outcomes.

3.2 Dynamic properties: The adjustment of expectations

The above simple 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 3 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. However, even if uncertainty about the nature of the shocks effecting the inflationary process may give rise to such persistence in expectational errors, they should

[20] A test of unbiasedness of naïve expectations uses the regression $\pi_t = \alpha + \beta\pi_{t-12} + u_t$. The χ^2 statistics for the full sample, the first and second sub-samples are 31.97, 35.84 and 46.38 respectively and

not persist 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).

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.[21] 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 $\alpha^e, \alpha\ \neq 0$.[22] An interesting feature of this system is that the equation for expectations has a forward-looking dimension. In

these all imply a clear rejection of unbiasedness at standard significance levels.

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

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

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 adjusts 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 and to compute the dynamic impulse response of either variable following an orthogonalised shock to the equations residuals ($\varepsilon_t^e, \varepsilon_t$).

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 inflation over the period 1985-2001. 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].[23]

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.[24] The equilibrium correction coefficients (α_o^e, α_o) and 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 full and two sub-samples identified earlier. In the regression for the change in expectations, the adjustment parameter on the expectational error is significant and suggests that consumers revise their expectations and adjust them toward the fully rational outcome. In terms of the speed of this adjustment, given the monthly frequency

[23] 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.

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

of the data, the estimated co-efficient (-0.05) implies quite low persistence in deviation of actual and expected inflation.[25] 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. Considering the other adjustment coefficient (α_o), while positively signed it is not significant, thereby suggesting that 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 robust across both of the sub samples considered (1986:1 – 1992:12 and 1993:1 - 2000:12).[26]

To shed further light on the dynamic interaction between actual and expected inflation, Table 4 also reports the F-statistics 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. These are denoted F^1, F^2, F^3 and F^4 in Table 4. The results suggest 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). Lastly, to shed further light on the adjustment of expectations, Chart 4 plots the dynamic impulse responses of both actual and expected inflation following a shock to actual inflation. Following such a shock, these responses give the conditional forecasts for the path of both variables that is implicit in the bi-variate model.[27] From the chart, and consistent with the finding that it has a unit root, a shock to inflation is highly persistent and has a permanent effect on its level. However, in line

[25] Abstracting from the other short-term dynamics, this co-efficient implies a half-life of deviations from long-run equilibrium of about 12 months. 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.

[26] Given the previous evidence of less bias in the measure of expectations in the 1990s compared with the 1980s, one surprising difference is that the adjustment of expectations is estimated to be faster in the first sub-sample compared with the second.

[27] The impulse response functions are based on the Choleski decomposition of the covariance matrix of the shocks. As is well known, they are not unique and, in general, depend on which variable is placed first in

with the preceding analysis, expected inflation adjusts gradually to the new permanently higher level of inflation. After approximately 12 months 45% of the deviation between actual and expected inflation has been corrected, while it takes over 30 months before 90% of the gap between expected inflation and its new steady state level has been closed. Overall, this finding of gradual adjustment of expected inflation to its fully rational outcome is in line with the view that, while consumers' may face information problems when forming their expectations, they eventually adjust them in order to "weed out" any systematic deviations of expected inflation from its fully rational outcome.

3.3 Simple 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

the bi-variate system. While we report the impulse responses for a bi-variate model in which expected inflation is placed first, the results do not depend significantly on the ordering of the variables.

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, GDP and the nominal effective exchange rate 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.[28]

A statistically significant ϕ suggests that the effect on inflation from past developments in the information variable (Ω_{t-12}) has been either under or over 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 are presented below in Table 5.

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, industrial production, the

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

12-month interest rate and the two euro exchange rate measures also do not explain any of the prediction error. However, consumers' inflation expectations do not appear to be fully efficient with respect to the information contained in the monetary aggregates or some of the other interest rate variables. Looking at the two sub-samples there is, however, clear evidence of a substantial improvement in terms of efficiency in the 1990s compared with the 1980s. In the second sub-sample there are only two variables that significantly explain the errors; M3 and the long-term interest rate.[29] For both of them ϕ is positive, suggesting that consumers have underestimated their impact on inflation (assuming a positive relationship between each of these variables and inflation). As regards the former variable this finding is particularly interesting given the monetary policy strategy that has been adopted by the ECB. In particular, since consumers do not take account of the information contained in monetary aggregates when forming their expectations, the results tend to support the independent and incremental information role that is assigned to M3 under the first pillar of the strategy.

Overall, the evidence from the efficiency tests suggests an 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 when the performance of expectations in the 1990s is compared with that in the late 1980s. However, the higher degree of efficiency in the second sub-sample 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 years ago.

[29] 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.

4. 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 2000. Using the approach set out in Berk (1999), the probability approach is used to derive quantitative estimates of euro area inflation expectations 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 satisfy an intermediate rather that a complete form of rationality. Firstly, compared with other benchmark indicators of expected inflation, consumers' expectations are shown to provide a reasonably accurate predictor of inflation one-year ahead. Second, the surveyed expectations are found to be an unbiased predictor of future price developments over the long-run. In line with this, there is also evidence that the level of expected inflation and the rational inflation outcome are cointegrated and, 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 appear to incorporate – though not always completely – the information contained in a broad set of macroeconomic variables. In particular, past price developments as well as various cost and activity indicators do not explain consumers' prediction errors. However, consumers' inflation expectations do not appear to be fully efficient with respect to the information contained in the monetary aggregates or some interest rate variables. This suggests that there is an independent and incremental role for these variables in explaining future inflation, which is not taken into account by consumers when forming their expectations.

Overall, the evidence on efficiency of consumers' expectations when combined with the evidence on their unbiasedness and the nature of the process whereby expectations are

adjusted to converge toward the fully rational outcome suggests an intermediate form of rationality (similar to that cited in Roberts (1998) for the US). 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 significant 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 compared with the 1980s. This improvement is particularly notable during the period of convergence in preparation for Economic and Monetary Union and, in particular, in the manner in which consumers' anticipated the trend decline in inflation over this period. Part of the explanation for this may indeed be that consumers have become better at predicting inflation. However, euro area inflation has also declined over the last decades and became less volatile. This, in combination with greater central bank credibility, may have made it easier to predict future inflation. Hence, while consumers may have become more efficient at predicting inflation, monetary policy makers may also have made the job easier than it was ten years ago.

Given these findings on the relatively significant and improving information content of the consumer survey data for expected inflation, such data provide a strong basis on which to carry out further macroeconomic research on inflation expectations and on how they influence macroeconomic developments. An important area for future research remains the further investigation of the link between expected inflation and the actual inflation outcome that is suggested by recent new Keynesian models of inflation.

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Annex 1: Tables and Charts

Table 1: Forecast performance statistics: Alternative measures of expected inflation

	Expected inflation	Fisher	Naïve
Full period:			
1986:1 to 2000:12			
ME	0.40	-0.19	-0.22
MAE	0.70	0.76	0.69
RMSE	0.94	1.03	0.95
Subperiods:			
1986:1 to 1992:12			
ME	0.94	-0.40	-0.28
MAE	1.07	0.95	0.87
RMSE	1.29	1.29	1.20
1993:1 to 2000:12			
ME	-0.06	-0.01	-0.16
MAE	0.38	0.59	0.53
RMSE	0.47	0.74	0.65

Note: ME = Mean Error, MAE = Mean Absolute Error, RMSE = Root Mean Squared Error.

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

Period	α	β	R^2	χ^2 for H_0	n
Full period:					
1986:1 to 2000:12	0.55 (.40)	0.90 (.14)	.41	5.86 [.053]	180
Subperiods:					
1986:1 to 1992:12	2.48 (.48)	0.37 (.15)	.12	32.4** [.000]	84
1993:1 to 2000:12	-0.07 (.39)	1.00 (.14)	.63	0.91 [.635]	96

Notes: ** significant at .01 level. Figures in parentheses are standard errors. Figures in brackets are P values. *n* is number of observations. Chi-squared statistics pertain to null hypothesis H_0: $(\alpha,\beta) = (0,1)$. Equations are estimated by OLS using covariance matrix corrections suggested by Newey and West (1987).

Table 3: Unit root tests

	π_t	$\Delta\pi_t$	π_t^e	$\Delta\pi_t^e$	$\pi_t^e - \pi_t$
ADF	-1.30	-9.78**	-2.02	-11.47**	- 3.01**

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. Δ denotes the first difference of each series. A ** indicates that it is possible to reject the null of a unit root at the 5% level of significance.

Table 4: Error correction coefficients and F-Statistics for Granger Causality

Sample	**Expectations Regressions**			**Actual Inflation Regressions**		
		F^1:	F^2		F^3	F^4
	α_o^e	$\phi_i^e \equiv 0$	$\psi_i^e \equiv 0$	α_o	$\phi_i \equiv 0$	$\psi_i \equiv 0$
Full period: 1986:1 – 2000:12	-0.05	1.92	4.13	0.02	0.86	1.29
	(2.29)	[0.04]	[0.00]	(0.77)	[0.49]	[0.23]
Sub periods: 1986:1 – 1992:12	-0.18	0.66	4.03	0.06	0.68	1.04
	(2.89)	[0.76]	[0.00]	(0.81)	[0.75]	[0.42]
1993:1 – 2000:12	-0.08	1.83	1.00	0.07	0.46	1.08
	(1.94)	[0.06]	[0.45]	(1.18)	[0.92]	[0.39]

Notes: For the coefficients α_o^e and α_o absolute t-statistics are given in (.). For the F-statistics, F^i (i= 1,2,3,4), P-values are reported in [.].

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

	Full period 1986:1 to 2000:12		Subperiods 1986:1 to 1992:12		1993:1 to 2000:12	
	ϕ	P value	ϕ	P value	ϕ	P value
Demand variables						
GDP	0.28	.028*	0.53	.000**	0.01	.921
Industrial production	0.02	.553	0.00	.986	-0.01	.420
Unemployment	-0.39	.000**	-1.26	.000**	-0.05	.631
Monetary and Financial variables						
M1	0.07	.001**	0.10	.090	0.05	.081
M3	0.20	.000**	0.16	.147	0.07	.016*
3-month interest rate	0.20	.000**	0.24	.013*	-0.01	.721
Long-term interest rate	0.25	.003**	0.27	.019*	0.14	.018*
12-m. real interest rate [1)]	0.08	.208	-0.12	.594	-0.02	.636
USD/euro	0.01	.176	-0.00	.678	0.01	.289
Nominal eff. exchange rate	0.01	.487	-0.01	.695	0.00	.970
Price & Cost variables						
π_{-}	0.02	.842	-0.49	.000**	0.00	.966
Compensation p. employee	0.10	.195	-0.44	.032*	0.80	.433
Producer prices	-0.00	.970	-0.02	.679	-0.06	.300
Commodity prices	0.00	.643	0.01	.201	0.01	.215
-Energy	0.00	.893	0.00	.917	0.00	.127
-Non-energy	0.01	.242	0.04	.000**	0.00	.790

Notes: * denotes significance at .05 level. ** denotes significance at .01 level. For unemployment and interest rates Ω_{t-12} is represented by the year-on-year difference in the variable at the time the survey was conducted. For all other variables Ω_{t-12} represents the annual percentage change.

1) Derived from the Fisher relation for the 12-months ahead money-market interest rate.

Figure 1: The aggregate probability distribution for inflation expectations

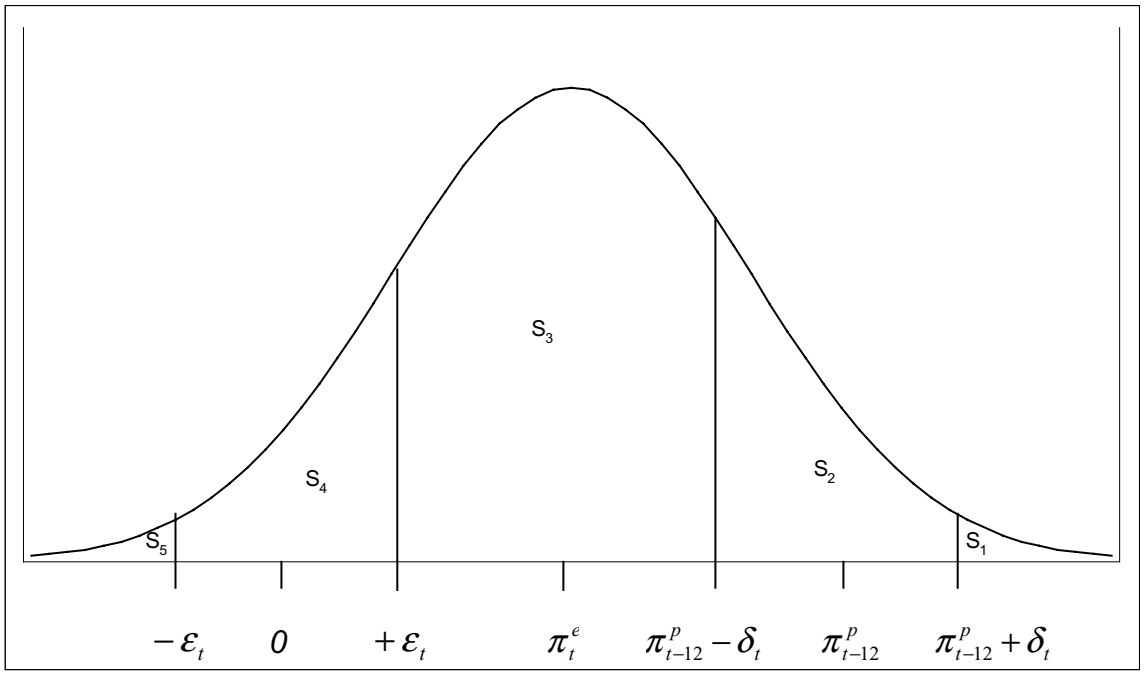


Chart 1: Expected and actual inflation: Euro area – 1985 - 2001

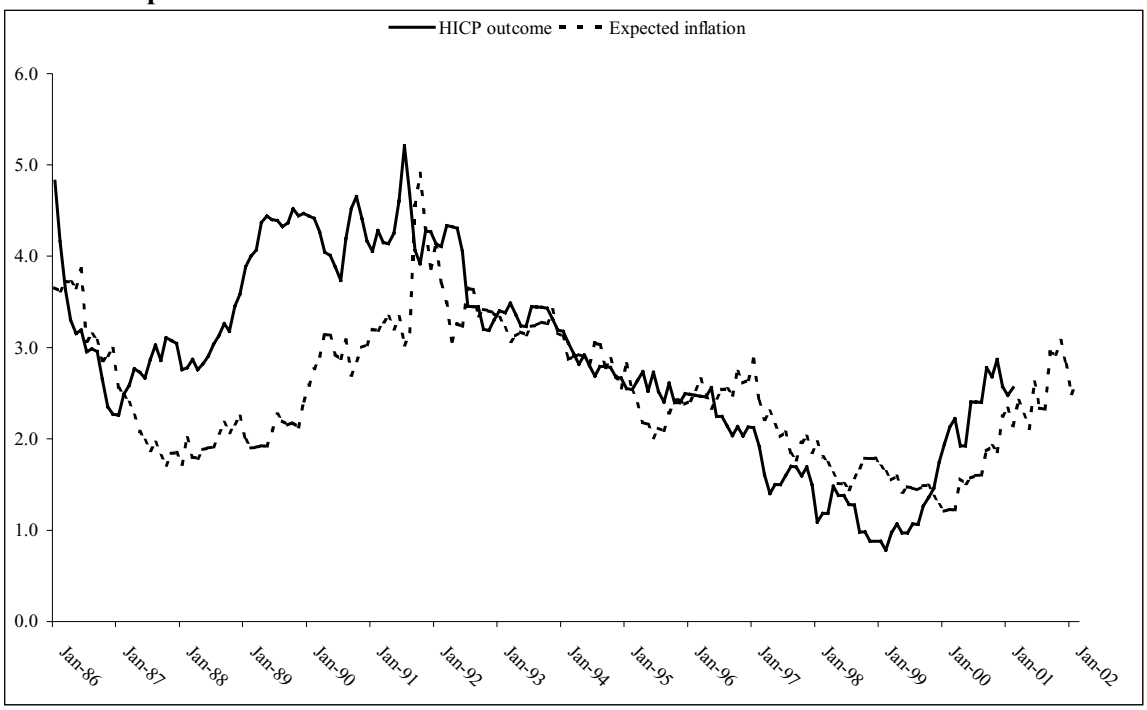


Chart 2: Uncertainty of expectations and time-varying response thresholds

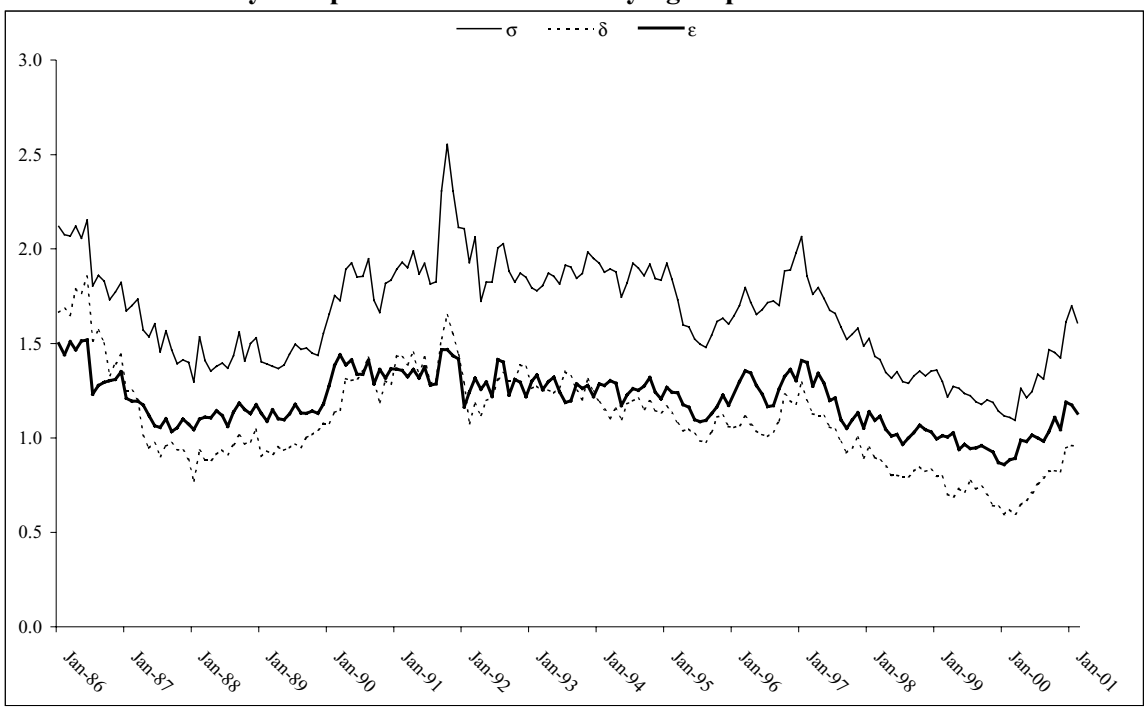


Chart 3: Expectation errors: Autocorrelations

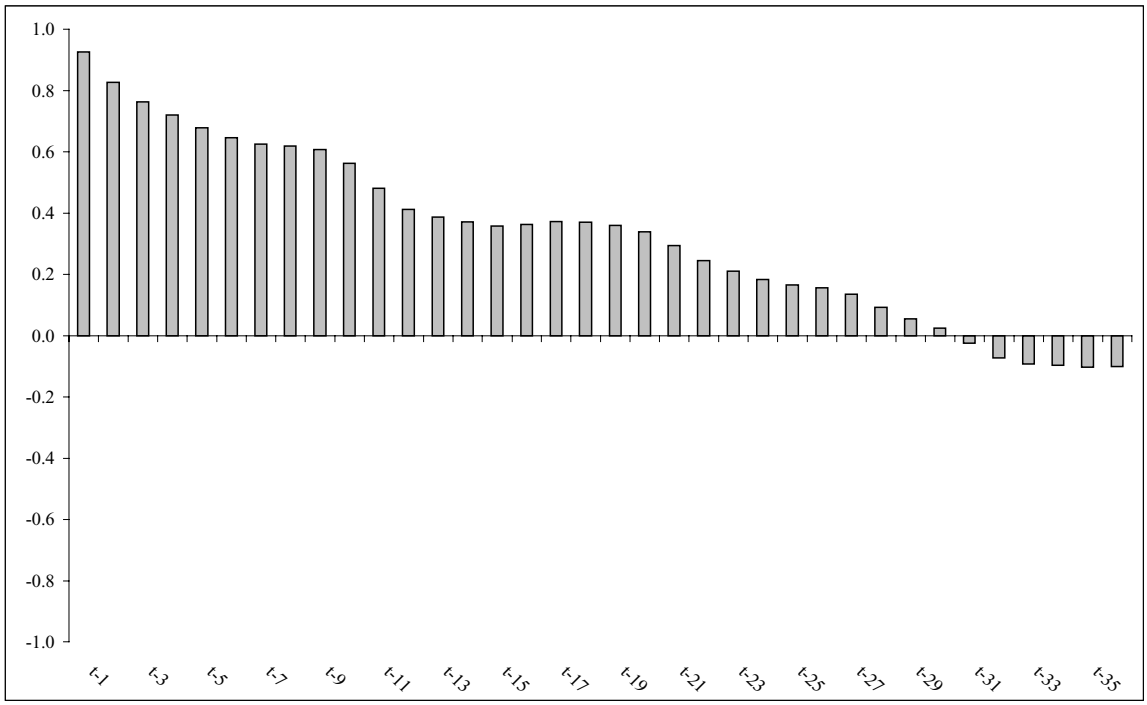
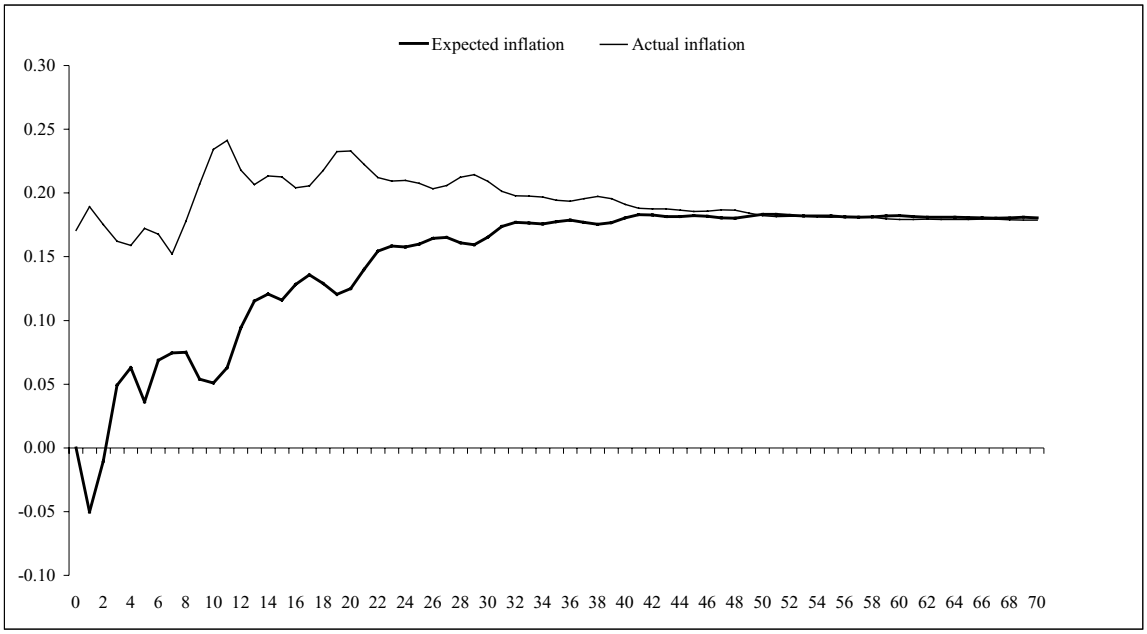


Chart 4: Impulse response to one standard error shock in actual inflation



Annex 2: The data set

Variable	Source	Freq.	Remark
Survey data	European Commission (DG ECFIN)	M	Detailed responses
GDP	Eurostat	Q	
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	Derived from the Fisher relation for the 12-months money-market interest rate (EURIBOR)
USD/euro	ECB	M	USD/ECU until December 1998
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

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