# Household versus expert forecasts of inflation: New Evidence from European survey data

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**Abstract**

This paper draws on data from the European Commission's consumer survey and from the expert surveys conducted by Consensus Economics to construct time series of inflation expectations for Germany, France, Italy and the UK. After comparing the predictive power of household relative to expert forecasts of inflation, we turn to the issue of rationality. We find that while none of our survey measures of expectations is fully efficient, most of them are forward-looking in the sense that they adjust towards subsequently realized inflation rates. Finally, to shed more light on the expectations formation process, we analyse the interactions between inflation, one-year-ahead inflation expectations and the output gap in a VAR framework. Again, we find evidence against simple backward-looking models of expectations formation, in particular as regards the Consensus Forecasts.

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# I. Introduction

There is a broad consensus that inflation expectations play a key role in the transmission of monetary policy measures to aggregate output and prices. Hence, the question of how economic agents form expectations is of interest to model builders and monetary policy makers alike. However, empirical studies of the process of expectations formation face the problem that expectations are inherently unobservable variables. One approach to solving this problem is to derive market players' inflation expectations from financial asset prices (especially the term structure of interest rates and the prices of interest-rate derivatives).[1] Alternatively, one can ask market participants directly what their expectations are over a certain time horizon through a survey. The main advantage of surveys is that they yield direct observations of inflation expectations which do not depend on certain a priori assumptions, for instance regarding the level and the structure of ex ante real interest rates.[2]

In the United States, the use of survey data on price expectations obtained as part of the Michigan, Livingston and ASA-NBER surveys has a long tradition.[3] By contrast, measures of inflation expectations derived from surveys conducted in the member states of the European Union have received little attention until recently. The present paper contributes to this literature by analysing survey measures of expected inflation for four major EU member countries, namely Germany, France, Italy and the UK. The data are taken from the European Commission's Consumer Survey and from the Survey of Professional Experts conducted by the London-based institute Consensus Economics. Drawing on these two sources enables us to compare the relative performance of household versus expert forecasts of inflation.

The survey data as well as the method used for quantifying the qualitative data from the Consumer Survey are described in Part 2 of the paper. In Part 3, we compare the predictive power of the two sets of survey expectations and submit them to standard tests of unbiasedness and informational efficiency. While most of them pass the test of unbiasedness, the orthogonality tests indicate the surveyed households and experts did not make efficient use of all the information available at the time they formed their expectations. As a next

[1] For more see ECB, Monthly Bulletin, May 2000, pp. 37-55, or also Mylonas/Schich (1999).

[2] Pesaran (1989, p. 210) therefore calls these types of calculations "theory-loaded implicit methods" and notes: "such 'implicit' methods of the measurement of inflation expectations are, however, only as good as the theory and the auxiliary assumptions that underlie them".

step, we analyse the dynamic interactions of the survey expectations and the subsequently realized inflation rates in an error correction framework. Finally, to shed more light on expectations formation as well as on the inflation process, we estimate simple trivariate VARs of inflation, one-year-ahead inflation expectations and output. Part 5 summarises the findings and discusses their monetary policy implications.

## II. The Data

### II.1 The European Commission Consumer Survey of expected price developments

In the European Union member states, a harmonised consumer survey, which also includes an assessment of past and future price developments, is conducted monthly. The surveys are carried out by national institutions, such as the Gesellschaft für Konsumforschung (GFK) in Germany. Each country's sample comprises at least 1,500 persons selected by a special procedure. For the larger countries — France, Italy, Spain and the United Kingdom — the sample size is 2,000, for Germany 2,500. From January 1997, the GfK included 500 respondents from East Germany in the survey (that is, until Dec. 1996, the data are for West Germany only). Results from these surveys are available from 1985 onwards.

The EC survey takes the form of a tendency survey in which the respondents may choose from among several categories of responses. Table 1 shows the exact wording of the questions and the categories of responses available. The terms A', B', etc. denote the percentages of the respondents in each response category. Owing to the large sample size and the selection criteria applied by the polling institutes, it may be assumed that the basket of goods relevant for the surveyed households more or less corresponds to the basket of goods of the average household used by statistical offices to measure consumer price movements. The survey data may thus be interpreted as an assessment of the direction of change of the respective national consumer price index.[4]

An argument in favour of gathering qualitative rather than quantitative data is that the surveyed households are more likely to have an opinion on the expected direction of future price changes than they are to give precise forecasts for a certain time horizon.[5] This advantage is offset somewhat, however, by the fact that empirical applications often require a

[3] An overview of this literature is given in Thomas (1999).
[4] Cf. Reckwerth (1997), p. 13f.

quantification of the survey results which, in turn, is only possible under certain assumptions, some of which may not be testable.[6]

**Table 1: Questions and response categories of the EU Consumer Survey on price developments (Question 5 and 6)**

| **Q5: How do you think that consumer prices have developed over the last 12 months? They have …** | **Q6: By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will …** |
|---|---|
| *Fallen (A')* | *Fall (A)* |
| *Stayed about the same (B')* | *Stay about the same (B)* |
| *Risen slightly (C')* | *Increase at a slower rate (C)* |
| *Risen moderately (D')* | *Increase at the same rate (D)* |
| *Risen a lot (E')* | *Increase more rapidly (E)* |
| *Don't know (F')* | *Don't know (F)* |

To obtain quantitative data, I follow the probability method developed by Carlson and Parkin (1975) which was extended to the five-category case by Batchelor and Orr (1988).[7] Due to the wording of Question 6 (see above), the procedure requires the specification of a variable that captures respondents' perceptions of the rate of inflation over the past 12 months. In terms of the conversion method, the mean expected inflation rate, $E_t\pi_{t+12}$, is the product of the (mean) assessment of price developments over the past 12 months, $\pi'_{t-1}$, and a factor $x_t$ (calculated using the cumulative density function) which reflects the change in the assessment of future relative to past price developments:[8]

$$\pi^{e}_{t+12} = \pi'_{t-1} x_t \qquad (1)$$

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[5] For more on this see Pesaran (1989), p. 210.

[6] At the microeconomic level it is also possible to work directly with ordinal responses. Nerlove (1983) may be regarded as a pioneer in this field. However, the use of ordinal measures of expectations in conventional, aggregated time series models is extremely time-consuming, if not impossible altogether; therefore, qualitative data generally need to be quantified for studies of this type.

[7] For a detailed description, see Reckwerth (1997) or Nielsen (2003). By contrast, the regression approach proposed by Pesaran is better suited to the enterprise survey data he uses. Cf. Pesaran (1989), p. 221 ff. and Batchelor/Orr (1988), p. 322.

[8] The precise method of deriving this term is described in Reckwerth (1997), p. 56 ff.

In principle, this problem can be solved by using the assessment of past price trends from Question 5 to construct a measure of $\pi'_{t-1}$. Unfortunately, quantification of the responses to this question is further complicated by the fact that the response categories C', D' and E' refer to the assessment of past price trends in relation to a benchmark considered "moderate". Developing equation (1), this link may be expressed as:

$$\pi'_{t-1} = \pi^{m}_{t-1} x'_{t-1} \tag{2}$$

where $x'_t$ reflects the assessment of past price trends relative to the rate of price rise considered to be moderate by the average respondent. In order to be able to evaluate the responses to this part of the question, one therefore needs additional information as to what respondents consider a moderate rate of inflation. Since such information is not available and other conceivable methods of determining the "moderate" rate of inflation require additional critical assumptions, this approach will not be pursued further here.[9]

Instead, we follow Berk (1999, 2002) and use two alternative methods to measure the perceived rate of inflation. The first is based on aggregating the categories C', D' and E' of Question 5 into one category "prices have risen", thereby transforming the responses into the traditional three-category case for which the Carlson-Parkin-method was originally developed.[10] In this case, the indifference interval around zero (the response threshold) takes the role of a scaling parameter. This parameter can be obtained by equating the mean of the perceived past inflation rate with the mean of the actual past inflation rate (Carlson/Parkin (1975)).[11] Alternatively, we assume that the respondents' assessment of past price developments matches the actual rate of change of the respective national consumer price index over the past twelve months. Under this assumption, the most recent inflation figures available to consumers are used as scaling parameter (i.e. $\pi'_{t-1}=\pi_{t-1}$).[12] As the rate of change in the consumer price index is a variable which is measured monthly and published on a timely basis in the countries under observation, this assumption does not seem very demanding in terms of informational requirements.

[9] Batchelor/Orr (1988) use a complicated method to determine the moderate rate of inflation; this method requires, inter alia, quantifying the "natural" rate of inflation. For more see Batchelor/Orr (1988), p. 322f.

[10] See Berk (1999).

[11] Another method, which does not rely on the assumption of unbiasedness, is to estimate the threshold parameter by regressing the official inflation rate on the unscaled mean of the perceived inflation rate (Bennett (1984)). As both methods lead to very similar results, we pursue only the first one here.

[12] Simmons/Weiserbs (1992) and Berk (1999, 2000) use this approach.

In Figure 1, the survey-based measures of perceived inflation (method 1) are contrasted with the actual inflation rates (method 2). Interestingly, the rate of inflation perceived by the surveyed households at times differs considerably from the official figures. For Germany, the difference is especially marked after the currency changeover at the beginning of 2002. As a consequence, the survey-based measures of expected inflation also differ depending on the choice of the scaling parameter.

In Figure 2, the quantified survey expectations for period t, scaled with either actual or perceived inflation, are contrasted with actual inflation at time t (quarterly averages). Missing observations reflect the fact that the quantification method breaks down when the share of respondents in one of the categories is equal to zero.[13] As the expectations series is dated back one year (four quarters), the vertical differences between the two series measure the forecast error. At first glance, the survey expectations seem to follow actual price developments quite closely. However, there are also periods when the future trend in the inflation rate is anticipated correctly. Table 2 compares the two scaling methods in terms of the root mean squared errors (RMSE) of the resulting expectations series. Whereas the RMSEs of the alternative expectations measures are fairly similar for Germany and France, the expectations series scaled with perceived past inflation perform much better than those based on actual past inflation for both Italy and the UK.

Despite the fact that the EC consumer survey is supposed to be harmonized across all participating countries, the wording of the questions and the response categories in some countries – notably France - displays some peculiarities which have to be kept in mind when further analysing the data. Thus, the surveyed French households are asked for their assessment of expected price developments "in the coming months" without this time period being specified more precisely.[14] Since the first part of the question refers to the assessment of price trends in the past six months (again different from the Commission's blueprint), one cannot rule out the possibility that some of the respondents will likewise relate the question concerning future price developments to that time horizon. The danger that the price expectations calculated from the EU survey are subject to measurement errors is consequently greater for France than for the other countries.

[13] See Berk (1999), p. 9.
[14] See Gerberding (2001), p. 36.

## II.2. Consensus Forecasts for consumer prices

A potential weakness of consumer and business surveys is that there might be little economic incentive for the respondents to state their expectations correctly. Some critics therefore recommend to restrict attention to surveys of professional forecasters who also sell their forecasts on the market.[15] However, it has also been pointed out that professional forecasters may have strategic incentives to report forecasts that deviate from their "true" expectations.[16]

Since the autumn of 1989, the London-based firm Consensus Economics has been conducting a survey at the beginning of each month in which renowned experts are asked to give their forecasts for the development of a range of important macroeconomic variables in over 20 countries. For each of the seven largest industrial countries (United States, Japan, Germany, France, United Kingdom, Italy and Canada), a separate panel of professional forecasters is recruited from the major banks, investment firms, economic research institutes and other business services in that country.[17] For our purposes, the usefulness of the regular monthly Consensus Forecasts is limited by the fact that they are "fixed event" forecasts with changing forecast horizons. However, once every quarter, Consensus Economics asks the country panellists to provide additional forecasts of key macro variables, including consumer prices, for each of the following one to six quarters. The arithmetic

**Table 3: Structure of Quarterly Consensus Forecasts for Consumer Prices[18]**

**Germany: Quarterly Consensus Forecasts**

*Percentage Change (year-on-year). From Survey of September 12, 2005*

| | **2005** | | | | **2006** | | | | **2007** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** |
| **Consumer Prices** | 1.7 | 1.7 | ***2.0*** | ***2.1*** | ***2.3*** | ***1.9*** | ***1.5*** | ***1.4*** | ***1.4*** | ***1.4*** |

*Consensus Forecasts shown in bold italics*

[15] Cf. Keane/Runkle (1990), p. 715.
[16] See Laster et al (1999).
[17] In Germany, 26 institutions are surveyed at present (in France: 17, in Italy:13, in Spain: 10, in the Netherlands: 9): DG Bank, BHF Bank, Deutsche Bank Research, DGZ Deka Bank, JP Morgan, MM Warburg, WGZ Bank, Bank Julius Baer, BfG Bank, Commerzbank, Dresdner Bank, Invesco Bank, RWI Essen, Sal Oppenheim, Bayerische LBank, FAZ Institut, HypoVereinsbank, Bankgesellschaft Berlin, Helaba Frankfurt, IW Cologne, DIW Berlin, HSBC Trinkaus, IFO Munich, IfW Kiel, Merrill Lynch, Westdeutsche LBank.
[18] See: Consensus Economics, Consensus Forecasts, December 2000, p. 8.

means of these quarterly forecasts are then published in separate tables (individual forecasts are not available) . Table 3 illustrates the structure of these data.

In order to match the 12-month horizon of the price expectations from the EC consumer survey. we focus on the four-quarter-ahead forecasts of the country panellists. Consensus Forecasts with this horizon are available for the G7-countries from November 1989. Figure 3 shows the resulting time series of inflation forecasts for Germany, France, Italy and the UK (reported in t-4) along with actual price developments. As the changeover from forecasts for West-German consumer prices to forecasts for all-German consumer prices occured in December 1996, we use all-German CPI data from the fourth quarter of 1997. Note that for the UK, the Consensus Forecasts from 1997Q2 onwards refer to the underlying rate of inflation (RPIX) which explains the smoothness of both series from 1998Q2 to the end of the sample.[19]

One striking feature is that the professional experts polled by Consensus Economics failed to anticipate either the deceleration of inflation in the first half of the nineties or the further sharp slowing of inflation rates in the run-up to European monetary union. The tendency to overestimate the actual rate of price increases was particularly marked in the case of France but can also be observed clearly in the forecasts for Germany, especially at the turn of 1998 to 1999. Nor were the price increases after the beginning of EMU predicted correctly, which were, however, caused by a series of exogenous shocks.

## III. Empirical Results

### III.1. Comparison of Predictive Power

In Table 4, the accuracy of the household expectations from the EC survey and the expert forecasts polled by Consensus Economics is compared in terms of their mean absolute forecast errors (MAE), their root mean square errors (RMSE) and of Theil's inequality coefficient which gives the forecast error relative to the "naïve" extrapolative forecast ("no change in the inflation rate"). For Germany, Italy and the UK, the expert forecasts are substantially more precise than the household expectations. The difference is less marked for

[19] In 1990 (1991) the country panellists were asked to provide additional forecasts for individual quarters as part of the February (March), July and November surveys. In 1992 and 1993, the quarter-by-quarter forecasts were part of the February, May, August and November surveys, and since the beginning of 1994, they have been included in the March, June, September and December surveys. In Figure 2, the two missing observations for the second quarter of 1990 and 1991 were approximated by interpolating the preceding and succeeding "observation".

France, where the MAE of the household expectations scaled with actual past inflation is even smaller than the MAE of the expert forecasts. In fact, with respect to French consumer prices, all of the survey expectations considered here performed worse than the naïve extrapolative forecast during the sample period. As explained above, the lack of predictive power of the French households' expectations may be due to the ambiguity regarding the forecast horizon (see above). However, this does not explain the disappointing performance of the Consensus Forecasts for France. By contrast, the Consensus Forecasts for Germany, Italy and the UK managed to outperform the naive extrapolative forecast by considerable margins. The same is true for the inflation expectations of the UK households when perceived past inflation is used as the scaling variable.

## III.2. Tests of Unbiasedness and Efficiency

In this section, we examine whether our survey measures of expectations are "rational" in the sense of Muth (1961). Since the monetary policy implications of rational expectations are very different from those of other, more backward-looking models of expectations formation, the issue is of considerable interest to monetary policy makers. In his definition of rational expectations, Muth assumes that the subjective expectations of economic agents match the predictions of the relevant economic theory.[20] The evidence presented so far suggests that the surveyed households and expert often did not anticipate future price developments. However, the hypothesis of rational expectations does not imply that economic agents' forecasts are always correct, but that they do not exhibit systematic mistakes.

The popularity of the rational expectations hypothesis in macroeconomic modelling has motivated numerous authors to test it on survey data.[21] The tests build on certain properties of the forecast errors which must be met in a rational expectations szenario. Most importantly, under the hypothesis of RE, the expectations errors must have a mean value of zero (criterion of unbiasedness):

$$E(\eta_t) = 0 \tag{3a}$$

and they must not be correlated with variables which were included in the agents' information set $\Omega_{t-j}$ at the time the expectations were formed (criterion of orthogonality):

[20] In Muth's own words: "Expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory." Muth (1961), p. 316.

[21] Many of these studies make use of the Michigan and Livingston surveys of inflation expectations. See Roberts (1997), Croushore (1998), Grant/Thomas (1999) and the older studies quoted there.

$$E(\eta_t \mid \Omega_{t-j}) = 0 \tag{3b}$$

The most common test of unbiasedness consists of regressing actual inflation on the inflation forecast and a constant and testing the null hypothesis $c_0=0$ and $\beta=1$:

$$\pi_t = c_0 + \beta E_{t-4}\pi_t + \varepsilon_t \tag{4a}$$

However, Holden and Peel (1990) have shown that while the condition $c_0=0$ and $\beta=1$ is sufficient for unbiasedness, it is not necessary (that is, unbiasedness is still possible even if $c_0=0$ and $\beta=1$ is rejected by the data). They propose to regress the forecast error on a constant instead and test whether the constant can be restricted to zero:[22]

$$\pi_t - E_{t-4}\pi_t = c_0 + \varepsilon_t \tag{4b}$$

As demonstrated by the Holden and Peel, the condition $c_0=0$ is both necessary and sufficient for unbiasedness. Table 5 summarises the results of this test for the household and expert inflation forecasts considered here. Accordingly, most of the survey expectations pass the test of unbiasedness. In fact, only the mean forecast error of the surveyed French households is significantly different from zero (independently of the scaling method). As explained above, this may be a consequence of the imprecise wording of the survey.

The orthogonality or informational efficiency of the survey data may be tested by regressing the forecast error on a range of variables which may have been of help in forecasting inflation and were commonly available at the time the forecasts were made:

$$\pi_t - E_{t-4}\pi_t = \beta\Omega_{t-5} + \varepsilon_t \tag{5}$$

If ß is significantly different from zero, the null hypothesis of informational efficiency must be rejected. However, it must be ensured that the vector Ω contains only variables which were actually available to the survey respondents when answering the survey ("real-time data"). Time series which are subject to major revisions after initial publication, such as industrial output or gross domestic product, are therefore not admissible (unless real-time data are still available). To circumvent this problem, I use three-month national money market rates (which are never revised), rates of change in the national consumer price indices (which are subject only to minor revisions) and past forecast errors as elements of the vector Ω. As a first step, I run a sequence of univariate regressions where I regress the forecast errors on each of these variables in turn. In addition, I conduct a multi-

[22] For more see Holden/Peel (1990), p. 124.

variate test where I include the most up-to-date values of all information variables (dated *t-5*) as well as their respective previous year's values (dated *t-9*) in the information set. The results of these tests are summarized in Table 6.

According to these tests, most of our survey measures of inflation expectations are efficient with respect to the information contained in past forecast errors (thereby providing evidence of weak-form efficiency). However, none of the forecast errors is completely orthogonal to all of the information variables considered here, the one possible exception being the expectations of Italian consumers (when scaled with perceived past inflation). Hence, our results are consistent with those of previous empirical studies which almost invariably find that survey expectations are not fully efficient in the sense implied by Muth's definition of rational expectations.[23]

## III.3. Inflation Expectations Dynamics

It can be questioned, however, whether the concept of "strong rationality" is not too strict a criterion. The hypothesis that economic agents possess full knowledge of the relevant structural relationships is doubtless an extreme assumption that cannot be maintained outside the tranquillity of a prolonged steady state.[24] Many critics have pointed to the importance of information problems and have stressed the need to take into account the costs of making optimal forecasts and also to explicitly model learning processes.[25] For instance, with incomplete information about the nature of the shocks hitting the economy, it may be entirely rational for forecasters to adjust their forecasts only gradually in response to new information. However, even if data and model uncertainty give rise to such persistence in expectational errors, they should not persist indefinitely. The adjustment process may take considerable time; but rationality implies that the long-run movements in actual and expected inflation should be linked.

One simple way to test this is to carry out pairwise Granger-causality tests for inflation expectations ($E_{t-4}\pi_t$) and subsequently realized inflation rates ($\pi_t$). Alternatively, the issue can be analysed in a vector error correction framework. In fact, many of the more recent empirical studies on the interaction between inflation expectations and inflation are conducted in terms of bi-variate error correction models of the following form:[26]

[23] Examples include Baghestani (1992), Batchelor/Dua (1989) und Roberts (1997).
[24] Cf. Pesaran (1989), p. 2.
[25] Among these critics are Akerlof/Yellen (1985a/b, 1987), Pesaran (1989), Ball (1991) and Evans/Honkapohja (2000).
[26] See, for instance, Grant and Lloyd (1998), Berk (1999, 2000) or Forsells and Kenny (2002).

$$\Delta E_{t-4}\pi_t = \delta_{\pi e}(\pi_{t-1} - E_{t-5}\pi_{t-1}) + \sum a_{11}(i)\Delta E_{t-4-i}\pi_{t-i} + \sum a_{12}(i)\Delta\pi_{t-i} + \alpha_{10} + \varepsilon_{t\pi e} \quad (6a)$$

$$\Delta\pi_t = \delta_{\pi}(\pi_{t-1} - E_{t-5}\pi_{t-1}) + \sum a_{22}(i)\Delta\pi_{t-i} + \sum a_{21}(i)\Delta E_{t-4-i}\pi_{t-i} + \alpha_{20} + \varepsilon_{t\pi} \quad (6b)$$

Provided that actual and expected inflation are cointegrated with cointegrating vector [1, -1], the error correction model given by equations (6a) and (6b) can be usefully employed to evaluate the issue of forecast rationality and the behaviour of prices and inflation expectations in general. First of all, the adjustment coefficient $\delta_{\pi e}$ provides information useful in assessing the rationality of forecasters' behaviour. In particular, a significantly positive value of $\delta_{\pi e}$ implies that the change in expectations (between period t-5 and t-4) 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 are formed).[27] Secondly, the VEC system highlights the potential two-way feedback between inflation and inflation expectations. If both $\delta_{\pi e}$ and $\delta_{\pi}$ are significant (with $\delta_{\pi e} > 0$ and $\delta_{\pi} < 0$), then not only do expectations adjust toward the fully rational outcome, but actual inflation also adjusts toward the level expected by consumers and/or professional forecasters (as implied by the Friedman-Phelps model of inflation). Thirdly, the coefficients $\alpha_{12}$ and $\alpha_{21}$ capture additional short-run effects of changes in actual inflation on changes in expectations and vice versa.

Whether the VEC model given by the Eqs (6a) and (6b) constitutes the appropriate framework to analyse the issue of expectations adjustment, of course depends on the order of integration of the variables concerned. We therefore start off our analysis by estimating simple bi-variate VAR models of inflation expectations and inflation and determining the number of cointegration vectors via the Johansen method. The lag length of the VARs is chosen according to standard lag length criteria and the requirement of serially uncorrelated errors. The results of the trace tests on the number of cointegrating equations (CEs) are reported in Table 7.[28] The hypothesis of no cointegration between inflation expectations and inflation is rejected at a high level of confidence for all measures of expectations but one, namely the second measure of the French consumers' expectations (where perceived inflation has drifted far away from actual inflation; see Figure 1). In most cases, the null of at most one CE is also rejected at the 5%-level of significance, implying that the variables in question are in fact stationary. Only in one case, namely for the second meas-

[27] See Forsells and Kenny (2002), p. 20.

[28] Based on visual inspection of the data, we decided to allow for deterministic trends in the data (but not in the CE). However, the results are reasonably robust to changes in the trend assumptions.

ure of Italian consumers' expectations, the trace test favours the null of at most one CE. Interestingly, these results are somewhat at odds with the results of Doepke et al (2005) who subject the same set of variables to standard univariate unit root tests and find that for most of them, it is hard to reject the null of nonstationarity.[29]

Taking the results of the trace tests seriously, simple bi-variate VARs for the levels of expected and actual inflation constitute the appropriate framework for our analysis. Testing for Granger causality in this framework, the null hypothesis that actual inflation does not Granger-cause inflation expectations has to be rejected for all but three of our measures of expectations, suggesting that in most cases, there is significant adjustment towards the fully rational level. The three exceptions are the survey expectations of the French and British households (when scaled with perceived past inflation) and the Consensus Forecasts for Germany. In the latter case, however, the p-value of the null is still close to 0.05. Regarding the influence of inflation expectations on inflation, the results are less clear-cut. In some cases, for instance as regards Germany and the UK, we find that inflation expectations do not Granger-cause subsequently realized inflation rates. In other cases, we find evidence of two-way rather than one-way causation between the two variables. In particular, this is true for the Italian data.

For the sake of comparability with other studies, we also report the results of the corresponding VEC analysis for all of our measures of expectations (even though the null of at most one CE is rejected in most cases). Imposing one CE, we find that in general, the estimated values of the adjustment coefficient $\delta_{\pi e}$ are significant with the expected positive sign. However, in three out of twelve cases, the estimates are too close to zero or too imprecise to be significant. Furthermore, as regards the Italian consumers' expectations (when scaled with actual past inflation) and the Consensus Forecasts for the UK, the results of the VEC analysis are somewhat at odds with those of the VAR analysis. Turning to the feedback from expected inflation to actual inflation, we find little evidence that our measures of consumer expectations exert any significant influence on actual inflation. However, as far as the Consensus Forecasts are concerned, the estimates of $\delta_{\pi}$ are significant with the expected negative sign in three out of four cases, suggesting that there may be some adjustment of inflation towards inflation expectations as well as the other way around.

[29] See Doepke et al. (2005), p. 7f.

Overall, we find that with only two exceptions, our measures of inflation expectations are Granger-caused by actual inflation (but less frequently the other way around), suggesting that the expectations of the surveyed households and experts are forward-looking (rational) in the sense that they ultimately revert to their long-run "rational" values. With one or two exceptions, the results of the Granger-causality tests in the stationary VAR framework are confirmed by the results of the bi-variate VEC models.

### III.4. Inflation, expectations and output dynamics

For three out of the four countries considered here, our results are consistent with those of previous empirical studies which find that the process generating inflation is not strongly influenced by inflation expectations (the one possible exception being Italy).[30] However, this finding is not necessarily at odds with New Keynesian theories of price dynamics as is sometimes claimed in the literature. For one thing, it should be clear that the adjustment coefficient $\delta_\pi$ tests the influence of past expectations on current inflation, whereas, in the New Keynesian model of aggregate supply, inflation depends on current expectations of future inflation (as well as on a measure of the output gap). This proposition is different from the one examined so far, but again, we can use our survey measures of inflation expectations to test it directly.

Following Paloviita and Viren (2005), we use a simple VAR model of inflation, $\pi_t$, one-year-ahead inflation expectations, $E_t\pi_{t+4}$, and the output gap, $y_t$, to examine the issue. The model can be seen as nesting various variants of the Phillips curve. We proxy the output gaps by the HP-filtered time series of (log) GDP. As noted by Paloviita and Viren, one potential problem is the apparent non-stationarity of some of the time series concerned. However, according to the analysis conducted in the last section, most of our time series of inflation expectations and inflation are stationary within the sample period 1990Q4-2005Q3. Since our measure of economic activity is by construction stationary, too, we do not hesitate to conduct the analysis in terms of the levels of the three variables which enter the New Keynesian Phillips curve. Again, we restrict our attention to the results of simple Granger-causality tests. A full-fledged analysis of the dynamic interactions of the three variables, including the impulse responses and the variance decompositions, is left to future research.

[30] See, for instance, Forsells and Kenny (2002), p. 21, and Mehra (2002).

As a starting point, we estimate trivariate VARs with lag length 4 (consistent with the quarterly frequency of the data). We then check the residuals and, where necessary, include more lags to remove any remaining serial correlation. In some cases, we can reduce the lag length to 3 or even 2 lags (applying standard lag length criteria); in others, we have to increase it to 5 lags or to add lags 8 and 9 (see Table 8). In Table 8, we report the results of Granger Causality (Block Exogeneity Wald) Tests for each of the three endogenous variables across the three measures of expectations and the four countries considered here.[31] According to these tests, the output gap (HP-filter) is exogenous with respect to both inflation and inflation expectations in the majority of cases, notably in France, Italy and the UK (except for the VAR including the second measure of British consumers' expectations). However, as regards Germany, the joint hypothesis that inflation and inflation expectations do not Granger-cause the output gap is rejected across all measures of expectations.

Turning to the process governing expectations formation, the results of the Granger causality tests are quite mixed. Four out of our eight measures of consumers' expectations display a significant response to lagged values of the output gap or of inflation or to both of them, while the other four don't. In contrast, exogeneity of the Consensus Forecasts can only be rejected in one case, namely as regards the forecasts for Germany. Again, this may be interpreted as evidence against simple backward-looking models of expectations formation. But we still need to check the robustness of these results, for instance to different measures of the output gap.

Finally, turning to the inflation process itself, our results suggest that the output gap (or rather the measure of the output gap used here) Granger-causes inflation in Germany and Italy whereas it does not exert a similar influence on inflation in France and the UK (when expectations are measured by the EC survey data). Regarding the influence of inflation expectations on inflation, the evidence is again rather mixed. In Italy, each of the measures of inflation expectations considered here exert a significant influence on inflation. By contrast, inflation in Germany and the UK does not seem to depend on any of our measures of inflation expectations, which may be interpreted as evidence against the New Keynesian model of inflation. Note, however, that the VARs considered here do not fully capture the forward-looking nature of the New-Keynesian Phillips curve since they model inflation as depending on the lags of the expectations variable rather than on its contemporaneous

[31] The full set of estimation results are available from the author on request.

value. Furthermore, the overlapping nature of the inflation variable (which measures inflation over the past *four* quarters) inevitably leads to highly significant coefficients of the first three lags of inflation which may well soak up some of influence of inflation expectations and the output gap. To shed more light on this issue, it would be useful to re-estimate the model at an annual frequency.

## IV. Conclusions

In this paper, we compare the properties of two sets of survey expectations which are drawn from the European Commission's consumer survey and from the expert surveys conducted by Consensus Economics. Our analysis yields the following results:

- The quantification of the qualitative data from the consumer survey requires the choice of a scaling variable that captures respondents' perceptions of past inflation. Throughout this paper, we use actual past inflation as well as a measure of perceived past inflation calculated from the answers to Question 5 of the survey as scaling variables. When comparing the resulting expectations series, we find that the RMSEs of the alternative expectations measures are fairly similar for Germany and France, whereas the expectations series scaled with perceived past inflation perform much better than those based on actual past inflation for both Italy and the UK.
- When comparing the predictive power of the two sets of survey expectations, we find that for three of the four countries in our sample (Germany, Italy and the UK), the expert forecasts are substantially more precise than the household expectations. Furthermore, the Consensus Forecasts for Germany, Italy and the UK manage to outperform the naive extrapolative forecast by considerable margins.
- When turning to the issue of rationality, we find that most of our survey measures of inflation expectations pass the test of unbiasedness. Furthermore, most of them are efficient with respect to the information contained in past forecast errors (thereby providing evidence of weak-form efficiency). However, with one exception, none of the forecast errors is completely orthogonal to all of the information variables considered here.
- When analysing the interaction of expected and actual inflation in a VAR framework, we find that most of our measures of expectations are Granger-caused by subsequently realized inflation rates (but less frequently the other way around), suggesting that the surveyed households and experts are forward-looking in the sense that their expectations ultimately revert towards the fully "rational" values.

- Finally, to shed more light on both expectations formation and on the inflation process, we estimate simple trivariate VARs of inflation, one-year-ahead inflation expectations and output. Interestingly, we find that while some of our measures of inflation expectations depend on lagged values of the output gap and/or of inflation, others don't. In particular, for three out of four countries, the expert expectations collected by Consensus Economics are exogenous with respect to both lagged output and inflation. Again, this may be interpreted as evidence against simple backward-looking models of expectations formation.

Overall, our results suggest that expectations are neither fully rational (in the sense of Muth) nor completely backward-looking. Both dimensions of expectations formation have important monetary policy implications. On the one hand, backward-looking elements in the formation of expectations introduce additional lags into the transmission mechanism which reinforce the need for monetary policy makers to adopt a forward-looking approach. On the other hand, if expectations are at least partly forward-looking, the efficacy of monetary policy depends on the ability of the central bank to stabilize private sector expectations. A clear definition of the ultimate objective and the announcement of a comprehensible and transparent monetary policy strategy play a key role in this context.

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**Figure 1: Actual inflation and perceived inflation according to EC Consumer Survey**

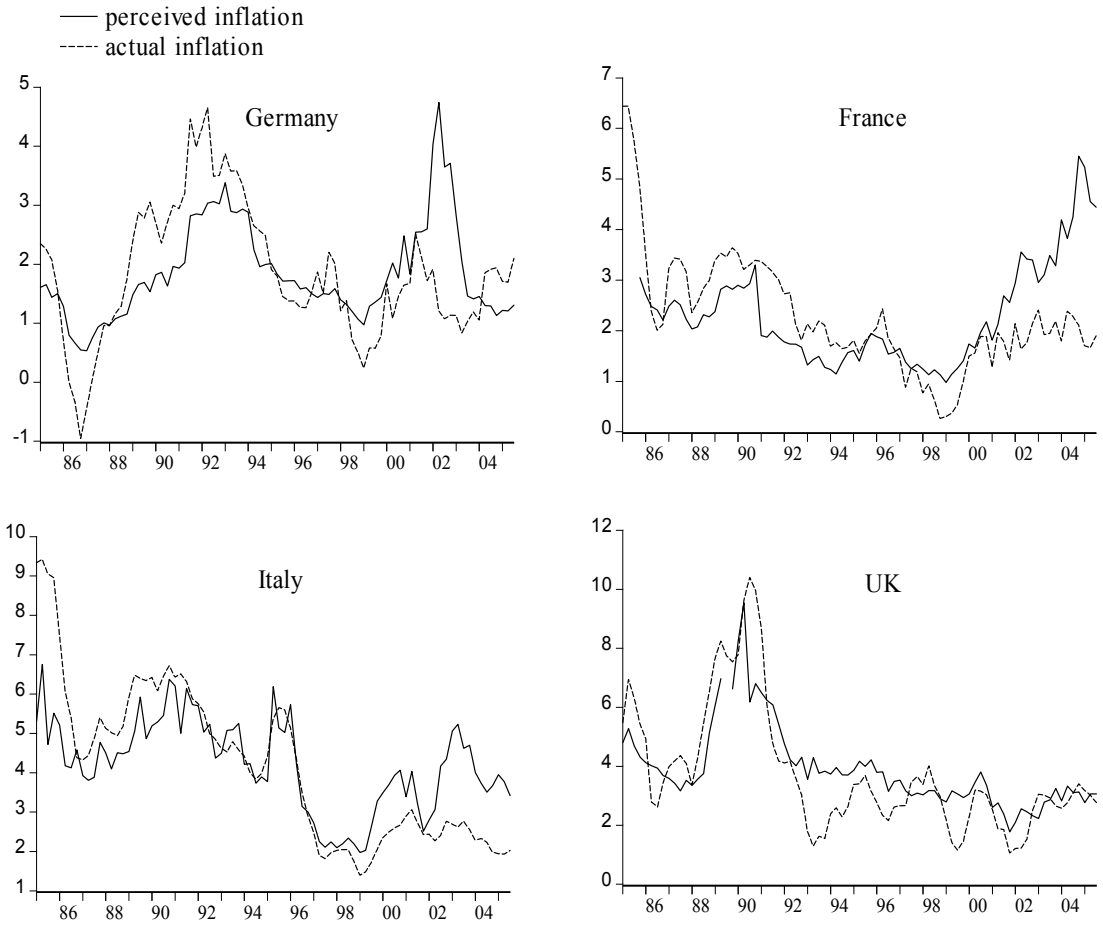


**Figure 2: Expected inflation according to EC Consumer Survey**

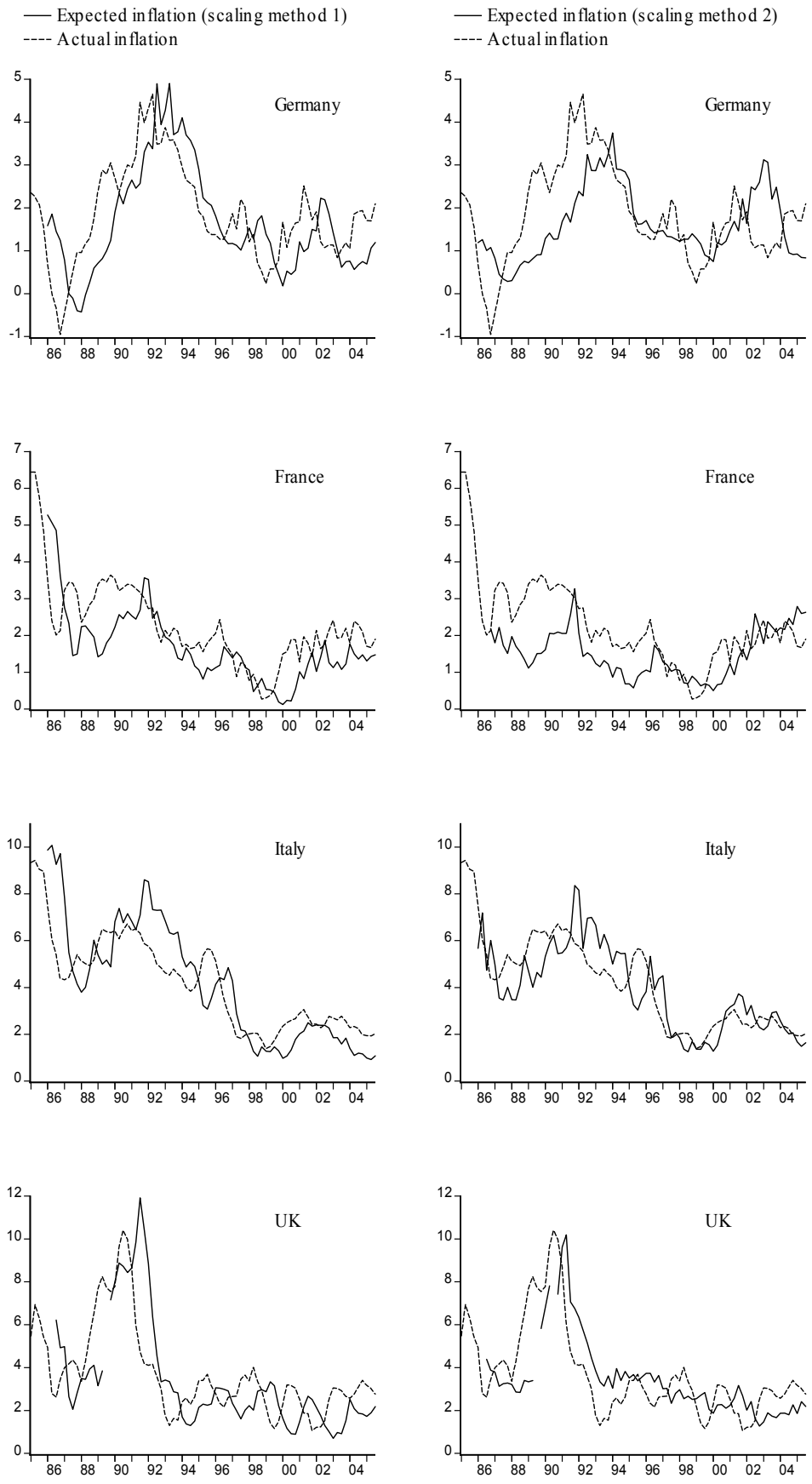
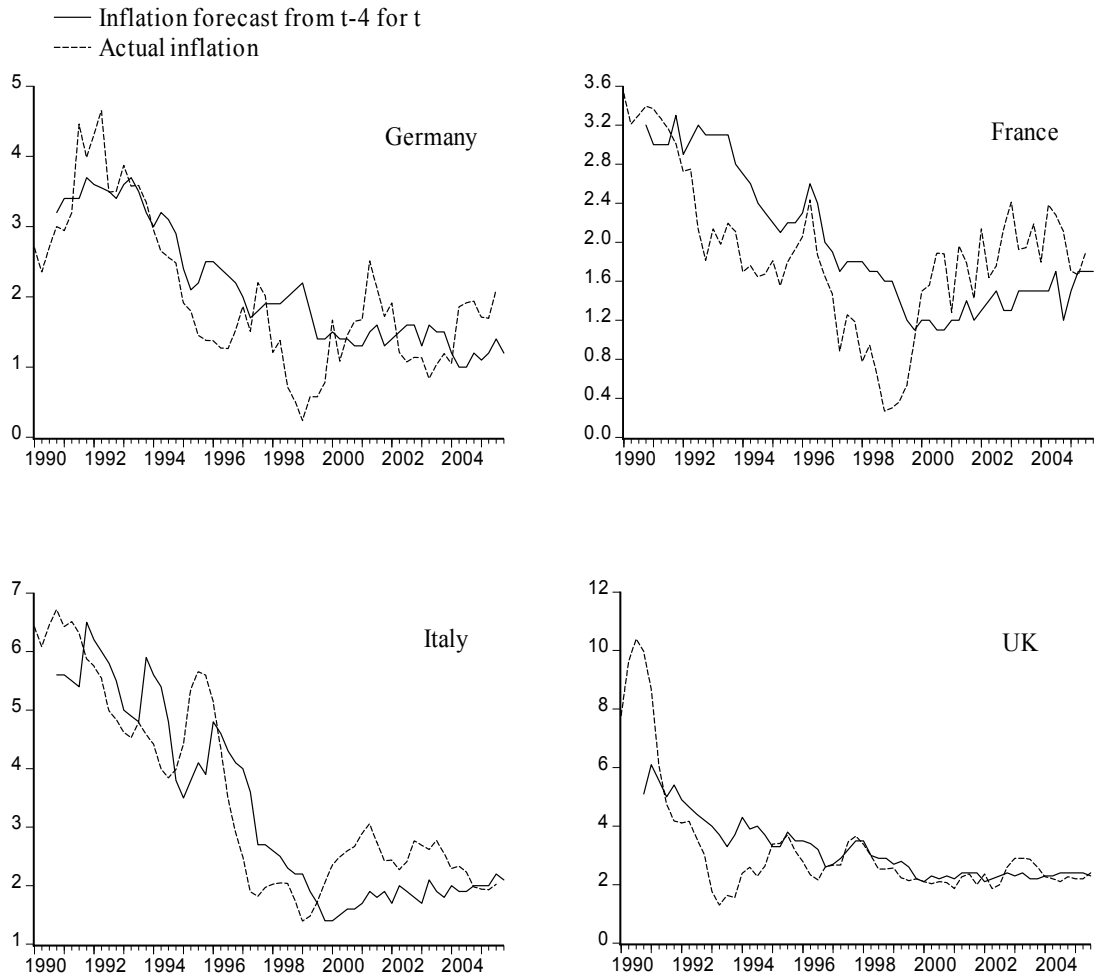


**Figure 3: Consensus Forecasts of Inflation**



## Table 2: Comparison of RMSEs of alternative scaling procedures

Estimation period: 1986Q1 – 2005Q3 (79 obs)

| Price expectations according to | Germany | France | Italy | UK |
|---|---|---|---|---|
| | Root mean square forecast error | | | |
| EC Consumer Survey (1) | 1.01 | 0.98 | 1.53 | 1.97 |
| EC Consumer Survey (2) | 1.09 | 0.96 | 1.17 | 1.55 |

## Table 4: Comparison of predictive power

Estimation period: 1990Q4 to 2005Q3 (60 obs)

| Price expectations according to | Germany | France | Italy | UK |
|---|---|---|---|---|
| | Mean absolute forecast error | | | |
| EC Consumer Survey (1) | 0.74 | 0.58 | 1.01 | 1.42 |
| EC Consumer Survey (2) | 0.78 | 0.61 | 0.84 | 1.14 |
| Consensus Forecasts | 0.57 | 0.59 | 0.74 | 0.65 |
| | Root mean square forecast error | | | |
| EC Consumer Survey (1) | 0.85 | 0.70 | 1.25 | 1.92 |
| EC Consumer Survey (2) | 1.01 | 0.73 | 1.11 | 1.34 |
| Consensus Forecasts | 0.69 | 0.68 | 0.86 | 1.07 |
| | Theil's inequality coefficient[1)] | | | |
| EC Consumer Survey (1) | 0.94 | 1.11 | 1.16 | 0.98 |
| EC Consumer Survey (2) | 1.11 | 1.15 | 1.03 | 0.68 |
| Consensus Forecasts | 0.76 | 1.07 | 0.79 | 0.61 |

1) Forecast error of the survey data relative to the naive extrapolative forecast ($E_t\pi_{t+4}=\pi_{t-1}$). Values smaller than unity imply that the forecasts of the surveyed households and experts outperform the naive extrapolative forecast.

## Table 5: Are the forecast errors unbiased?

Estimated equation: $\pi_t - E^s_{t-4}\pi_t = c_0 + \varepsilon_t$

Estimation method: OLS, Newey-West correction of standard errors

| $H_0$: $c_0=0$ (p-values) | *Germany* | *France* | *Italy* | *UK* |
|---|---|---|---|---|
| EC Consumer Survey (1) | 0.38 ($c_0$=0.17) | 0.01 ($c_0$=0.43***) | 0.50 ($c_0$=-0.20) | 0.62 ($c_0$=0.19) |
| EC Consumer Survey (2) | 0.33 ($c_0$=0.21) | 0.00 ($c_0$=0.57***) | 0.85 ($c_0$=0.04) | 0.80 ($c_0$=0.08) |
| Consensus Forecasts | 0.28 ($c_0$=-0.17) | 0.30 ($c_0$=-0.17) | 0.59 ($c_0$=0.11) | 0.19 ($c_0$=-0.28) |

Sample periods: EC Survey 1986Q1-2005Q3; Consensus Forecasts 1990Q4-2005Q3.
***(**/*) denotes significance at the 1%(5%/10%) level.

## Table 6: Are the forecast errors orthogonal to selected information variables?

Estimation equation: $\eta_t = c_0 + \beta \cdot \Omega_{t-5} + \varepsilon_t \quad with\ \eta_t = \pi_t - E^s_{t-4}\pi_t$

Estimation method: OLS, Newey-West correction of standard errors

| *$H_0$: $\beta$=0; p-values* | *Germany* | *France* | *Italy* | *UK* |
|---|---|---|---|---|
| *EC consumer survey (1)* | | | | |
| $\Omega_{t-5} = \eta_{t-5}$ | 0.91 | 0.36 | 0.75 | 0.85 |
| $\Omega_{t-5} = \pi_{t-5}$ | 0.00*** | 0.01** | 0.00*** | 0.00*** |
| $\Omega_{t-5} = i_{t-5}$ | 0.04** | 0.24 | 0.00*** | 0.01*** |
| $\Omega_{t-5} = (\eta_{t-5}, \eta_{t-9}, \pi_{t-5}, \pi_{t-9}, i_{t-5}, i_{t-9})$ | 0.00*** | 0.42 | 0.00*** | 0.00*** |
| *EC consumer survey (2)* | | | | |
| $\Omega_{t-5} = \eta_{t-5}$ | 0.05* | 0.00*** | 0.96 | 0.13 |
| $\Omega_{t-5} = \pi_{t-5}$ | 0.78 | 0.12 | 0.26 | 0.05* |
| $\Omega_{t-5} = i_{t-5}$ | 0.24 | 0.00*** | 0.58 | 0.14 |
| $\Omega_{t-5} = (\eta_{t-5}, \eta_{t-9}, \pi_{t-5}, \pi_{t-9}, i_{t-5}, i_{t-9})$ | 0.00*** | 0.00*** | 0.07* | 0.00*** |
| *Consensus Forecasts* | | | | |
| $\Omega_{t-5} = \eta_{t-5}$ | 0.95 | 0.01*** | 0.80 | 0.44 |
| $\Omega_{t-5} = \pi_{t-5}$ | 0.59 | 0.55 | 0.08* | 0.69 |
| $\Omega_{t-5} = i_{t-5}$ | 0.61 | 0.06* | 0.01** | 0.90 |
| $\Omega_{t-5} = (\eta_{t-5}, \eta_{t-9}, \pi_{t-5}, \pi_{t-9}, i_{t-5}, i_{t-9})$ | 0.00*** | 0.00*** | 0.00*** | 0.00*** |

Sample periods: EC Survey 1986Q1-2005Q3; Consensus Forecasts 1990Q4-2005Q3. ***(**/*) denotes significance at the 1%(5%/10%) level.

**Table 7: Survey forecasts und subsequently realized inflation rates ($E_{t-4}\pi_t$, $\pi_t$)**

| | ***Germany*** | | |
|---|---|---|---|
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| ***VAR analysis:*** | | | |
| - lag length | 4 lags | 5 lags | 4 lags |
| - no of CE(s):[1] $H_0$: *none* | p=0.00 (***) | p=0.007 (***) | p=0.008 (***) |
| $H_0$: *at most 1* | p=0.010 (**) | p=0.009 (***) | p=0.045 (**) |
| - Granger Causality (p-values): | | | |
| $E_{t-4}\pi_t$ does not Granger-cause $\pi_t$ | 0.55 | 0.80 | 0.61 |
| $\pi_t$ does not Granger-cause $E_{t-4}\pi_t$ | 0.00 | 0.00 | 0.056 |
| ***VEC analysis:*** | | | |
| - lag length | 3 lags | 4 lags | 3 lags |
| - adjustment coefficients | | | |
| $\delta_\pi$ | -0.12 | -0.11 | -0.24*** |
| $\delta_{\pi e}$ | 0.61*** | 0.15** | 0.11** |
| - Granger Causality (p-values): | | | |
| $a_{21}=0$ | 0.89 | 0.65 | 0.59 |
| $a_{12}=0$ | 0.00 | 0.10 | 0.38 |
| | ***France*** | | |
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| ***VAR analysis:*** | | | |
| - lag length | 5 lags | 4 lags | 4 lags |
| - no of CE(s):[1] $H_0$: *none* | p=0.000 (***) | p=0.33 | p=0.009 (***) |
| $H_0$: *at most 1* | p=0.014 (**) | p=0.57 | p=0.035 (**) |
| - Granger Causality (p-values): | | | |
| $E_{t-4}\pi_t$ does not Granger-cause $\pi_t$ | 0.014 | (0.06) | 0.46 |
| $\pi_t$ does not Granger-cause $E_{t-4}\pi_t$ | 0.000 | (0.13) | 0.04 |
| ***VEC analysis:*** | | | |
| - lag length | 4 lags | (3 lags) | 3 lags |
| - adjustment coefficients | | | |
| $\delta_\pi$ | 0.03 | (-0.15*) | -0.07 |
| $\delta_{\pi e}$ | 0.65*** | (0.05) | 0.12*** |
| - Granger Causality (p-values) : | | | |
| $a_{21}=0$ | 0.009 | (0.046) | 0.34 |
| $a_{12}=0$ | 0.00 | (0.17) | 0.42 |

1) Unrestricted Cointegration Rank Test (Trace). 2) Results of the restricted model in parentheses. When the restriction is not rejected, we only report results of the restricted model.
Sample period: 1990Q4-2005Q3.

**Table 7 contnd: Italy and UK**

| | ***Italy*** | | |
|---|---|---|---|
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| ***VAR analysis:*** | | | |
| - lag length | 8 lags | 4 lags | 7 lags |
| - no of CE(s):[1] $H_0$: *none* | p=0.00 (***) | p=0.01 (**) | p=0.000 (***) |
| $H_0$: *at most 1* | p=0.02 (**) | p=0.12 | p=0.012 (**) |
| - Granger Causality (p-values) : | | | |
| $E_{t-4}\pi_t$ does not Granger-cause $\pi_t$ | 0.00 | 0.03 | 0.00 |
| $\pi_t$ does not Granger-cause $E_{t-4}\pi_t$ | 0.00 | 0.00 | 0.00 |
| ***VEC analysis:*** | | | |
| - lag length | 7 lags | 3 lags | 6 lags |
| - adjustment coefficients | | | |
| $\delta_\pi$ | 0.00 | -0.10* | -0.19** |
| $\delta_{\pi e}$ | 0.10* | 0.25** | 0.44*** |
| - Granger Causality (p-values): | | | |
| $a_{21}=0$ | 0.22 | 0.55 | 0.00 |
| $a_{12}=0$ | 0.00 | 0.0995 | 0.31 |
| | ***UK*** | | |
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| ***VAR analysis:*** | | | |
| - lag length | 5 lags | 2 lags | 6 lags |
| - no of CE(s):[1] $H_0$: *none* | p=0.00 (***) | p=0.00 (***) | p=0.002 (***) |
| $H_0$: *at most 1* | p=0.00 (***) | p=0.00 (***) | p=0.012 (**) |
| - Granger Causality (p-values): | | | |
| $E_{t-4}\pi_t$ does not Granger-cause $\pi_t$ | 0.61 | 0.95 | 0.28 |
| $\pi_t$ does not Granger-cause $E_{t-4}\pi_t$ | 0.00 | 0.14 | 0.00 |
| ***VEC analysis :*** | | | |
| - lag length | 4 lags | 1 lag | 5 lags |
| - adjustment coefficients | | | |
| $\delta_\pi$ | -0.03 | -0.10 | -0.17** |
| $\delta_{\pi e}$ | 0.59*** | 0.17*** | 0.07 |
| - Granger Causality (p-values) : | | | |
| $a_{21}=0$ | 0.09 | 0.84 | 0.24 |
| $a_{12}=0$ | 0.00 | 0.51 | 0.00 |

1) Unrestricted Cointegration Rank Test (Trace). 2) Results of the restricted model in parentheses. When the restriction is not rejected, we only report results of the restricted model. 3) Trend assumption: no deterministic trend.
Sample period 1990Q4-2005Q3.

**Table 8: Inflation, inflation expectations and output**

| | ***Germany*** | | |
|---|---|---|---|
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| **VAR { $\pi_t$, $E_t\pi_{t+4}$, $y_t$}** | | | |
| - lag length | 3 lags | Lag 1-3, 8-9 | 3 lags |
| - Granger Causality (p-values) | | | |
| ***Dependent variable: $\pi_t$*** | | | |
| - excluded: $E_t\pi_{t+4}$ | 0.39 | 0.49 | 0.59 |
| - excluded: $y_t$ | 0.00 | 0.00 | 0.00 |
| - excluded: all | 0.00 | 0.00 | 0.00 |
| ***Dependent variable: $E_t\pi_{t+4}$*** | | | |
| - excluded: $\pi_t$ | 0.007 | 0.04 | 0.02 |
| - excluded: $y_t$ | 0.00 | 0.03 | 0.20 |
| - excluded: all | 0.00 | 0.00 | 0.03 |
| ***Dependent variable: $y_t$*** | | | |
| - excluded: $\pi_t$ | 0.19 | 0.00 | 0.00 |
| - excluded: $E_t\pi_{t+4}$ | 0.19 | 0.34 | 0.33 |
| - excluded: all | 0.00 | 0.007 | 0.00 |
| | ***France*** | | |
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| **VAR { $\pi_t$, $E_t\pi_{t+4}$, $y_t$}** | | | |
| - lag length | 5 lags | 5 lags | 5 lags |
| - Granger Causality (p-values) | | | |
| ***Dependent variable: $\pi_t$*** | | | |
| - excluded: $E_t\pi_{t+4}$ | 0.23 | 0.00 | 0.20 |
| - excluded: $y_t$ | 0.63 | 0.32 | 0.41 |
| - excluded: all | 0.38 | 0.01 | 0.36 |
| ***Dependent variable: $E_t\pi_{t+4}$*** | | | |
| - excluded: $\pi_t$ | 0.06 | 0.27 | 0.13 |
| - excluded: $y_t$ | 0.07 | 0.33 | 0.17 |
| - excluded: all | 0.05 | 0.18 | 0.099 |
| ***Dependent variable: $y_t$*** | | | |
| - excluded: $\pi_t$ | 0.52 | 0.82 | 0.87 |
| - excluded: $E_t\pi_{t+4}$ | 0.53 | 0.76 | 0.74 |
| - excluded: both | 0.82 | 0.93 | 0.93 |
| Sample period: 1990Q4 to 2005Q3. | | | |

**Table 8, contnd: Italy and UK**

| | ***Italy*** | | |
|---|---|---|---|
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| **VAR { $\pi_t$, $E_t\pi_{t+4}$, $y_t$}** | | | |
| - lag length | Lags 1-2, 8-9 | Lags 1-2, 8 | 2 lags |
| - Granger Causality (p-values) | | | |
| ***Dependent variable: $\pi_t$*** | | | |
| - excluded: $E_t\pi_{t+4}$ | 0.03 | 0.02 | 0.00 |
| - excluded: $y_t$ | 0.02 | 0.00 | 0.00 |
| - excluded: all | 0.00 | 0.00 | 0.00 |
| ***Dependent variable: $E_t\pi_{t+4}$*** | | | |
| - excluded: $\pi_t$ | 0.19 | 0.01 | 0.45 |
| - excluded: $y_t$ | 0.95 | 0.42 | 0.90 |
| - excluded: all | 0.38 | 0.046 | 0.60 |
| ***Dependent variable: $y_t$*** | | | |
| - excluded: $\pi_t$ | 0.72 | 0.85 | 0.24 |
| - excluded: $y_t$ | 0.54 | 0.58 | 0.33 |
| - excluded: all | 0.44 | 0.60 | 0.33 |
| | ***UK*** | | |
| | EC survey, method 1 | EC survey, method 2 | Consensus Forecasts |
| **VAR { $\pi_t$, $E_t\pi_{t+4}$, $y_t$}** | | | |
| - lag length | 4 lags | 2 lags | 5 lags |
| - Granger Causality (p-values) | | | |
| ***Dependent variable: $\pi_t$*** | | | |
| - excluded: $\pi_t$ | 0.16 | 0.11 | 0.18 |
| - excluded: $y_t$ | 0.40 | 0.48 | 0.002 |
| - excluded: all | 0.20 | 0.29 | 0.006 |
| ***Dependent variable: $E_t\pi_{t+4}$*** | | | |
| - excluded: $\pi_t$ | 0.00 | 0.27 | 0.22 |
| - excluded: $y_t$ | 0.10 | 0.04 | 0.22 |
| - excluded: all | 0.00 | 0.06 | 0.24 |
| ***Dependent variable: $y_t$*** | | | |
| - excluded: $\pi_t$ | 0.23 | 0.005 | 0.44 |
| - excluded: $y_t$ | 0.53 | 0.36 | 0.89 |
| - excluded: all | 0.22 | 0.008 | 0.48 |
| Sample period: 1990Q4 to 2005Q3. | | | |