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Dias, Francisco; Duarte, Cláudia; Rua, António

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Inflation expectations in the euro area: Are consumers rational?*

Francisco Dias
Banco de Portugal

Cláudia Duarte
Banco de Portugal

António Rua
Banco de Portugal

Abstract

In this paper, we propose a quantitative measure for inflation expectations based on consumer survey data. Thereafter, we proceed to testing the rationality assumption. This issue is of noteworthy interest in its own as it is commonly assumed in the theoretical modelling literature that the rational expectations hypothesis holds. This analysis is conducted for the euro area as a whole, as well as for several member countries, using a sample covering the last two decades. Moreover, we also assess if the conclusions hold when one focuses on the post-euro introduction period.

Keywords: Inflation expectations; consumer survey; probability method; rationality tests; common factors.

JEL classification: C16, C22, C43, E31.

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1 Introduction

The analysis of agents' expectations is of paramount importance. For instance, it is common practice to assume *a priori* that the rational expectations hypothesis holds in the theoretical modelling literature. Hence, the empirical assessment of the properties of expectations is a key issue. In particular, we focus on inflation expectations, discussing its quantification based on consumer survey data and testing the rationality assumption for the euro area as a whole, as well as for several member countries.

The study of the expectations formation process is particularly relevant for understanding how economic agents make decisions. In addition to its influence on the dynamics of economic behaviour, a formal analysis of expectations became crucial in the wake of Lucas's (1976a) critique. In particular, it is now widely accepted that monitoring the evolution of inflation expectations is of great importance. For example, inflation expectations are closely tracked by central banks, such as the European Central Bank (ECB), who are committed to a credible and price stability-oriented monetary policy.

Among the theories on expectations formation presented so far in the literature, the one that has received more attention is the rational expectations hypothesis (see Muth (1961)). This hypothesis relies on the assumption that expectations are, in their essence, similar to the informed predictions derived from the relevant economic theory. For relevant economic theory read conditional expectations from the 'true' structural economic model, whatever that may be. The rational expectations hypothesis has been subject to an ongoing debate, which partly owes its existence to the inherent difficulties associated with testing a variable that is not easily measurable.

The surge of qualitative opinion surveys, associated with the improvement of data collection and treatment techniques, fostered the use of quantification methods for measuring expectations. In particular, the probability method, developed by Carlson and Parkin (1975) (CP hereafter), is one of the most widely used for this purpose. This method assumes that each survey respondent answers the questionnaire based on a subjective probability density function associated with the variable under question. Therefore, the aggregate share of respondents that provide a certain answer to the question can be interpreted as a specific portion of the area under the aggregate probability density function.

In practice, the CP method has been frequently applied to price expectation questions. Initially, the original CP formulae were developed for surveys with three alternative answers (see Carlson and Parkin (1975), Smith and McAleer (1995) and Driver and Urga (2004)). Due to the subsequent existence of surveys in which there are five possible alternative answers, the CP method had to be extended in order to take into account the larger information set (see Batchelor and Orr (1988) and Berk (1999)). In this generalised version of the method it is assumed that the consumers' price expectations are conditioned by their perceptions of current and past inflation. This extended method has been applied, for example, by Forsells and Kenny (2002) and Mestre (2007) to the euro area and also by Łiziak (2003) to both Poland and the euro area.

The assessment of the rationality hypothesis is based on a set of four tests that has been suggested in the literature, namely tests for unbiasedness, lack of serial correlation, efficiency, and orthogonality (see Pesaran (1989)). The unbiasedness test tries to evaluate the existence of a systematic and/or persistent difference, *i.e.*, a bias between the observed and the expected inflation measures. Let the forecast errors be defined as the difference between actual inflation and inflation expectations. The lack of serial correlation test assesses whether forecast errors are serially correlated. Finally, both efficiency and orthogonality tests aim to evaluate the extent to which agents incorporate relevant information (past inflation values, in the case of the efficiency test, and data from a broader set of macroeconomic variables, for the orthogonality test) in their expectation formation process.

Some authors, for instance Grant and Thomas (1999) and Bakhashi and Yates (1998), focus on the unbiasedness test, while others also assess the efficiency and orthogonality (see Thomas Jr. (1999), Forsells and Kenny (2002) and Łiziak (2003)). Concerning the assessment of the lack of serial correlation, this test has progressively lost ground. Presently, the existence of serial correlation in the forecast errors is no longer considered inconsistent with rational expectations. In fact, due to overlapping forecast intervals and the difficulties that agents face in identifying the temporary or permanent nature of shocks affecting price developments, serial correlated forecast errors may subsist even in a context of rational expectations (see Grant and Thomas (1999)). Nevertheless, assessing serial correlation in forecast errors may still be relevant, since understanding the dynamics of forecast errors is essential for the proper testing of efficiency and orthogonality.

As we try to provide further insight on the measurement and on the nature of inflation expectations, the aim of this paper is twofold. First of all, we reassess the measurement and quantification of inflation expectations. In contrast with most of the literature on this topic, which focuses on the euro area and/or a single country, we consider a more comprehensive empirical application, covering data for the euro area as a whole as well as for eight member countries, namely Germany, France, Italy, Spain, Belgium, the Netherlands, Ireland and Portugal. Moreover, as we use the information for the question related to price expectations from the European Commission's (EC) consumer survey, we apply the extended version of the CP method for tackling the five alternative answers case. However, unlike most of the work published so far, we anchor the inflation expectations on a more refined measure of inflation perceptions, which is also based on the EC's consumer survey (see Dias *et al.* (2009)).

Secondly, after obtaining a quantified measure of expected inflation, we proceed on testing whether the agents' inflation expectations are rational or not. To shed some light on this issue, we consider the unbiasedness, efficiency and orthogonality tests, and we also check for the serial correlation of forecast errors. While adopting the conventional testing framework for the unbiasedness and efficiency tests (see, for example, Forsells and Kenny (2002) and Łiziak (2003)), we extend the orthogonality test framework to those cases in which agents live in an information-rich environment. In such a context, we resort to the diffusion index model of Stock and Watson (1998). The basic underlying idea of the diffusion index model is to summarise large amounts of information in a handful of variables, which retain the major features of the original dataset.

Furthermore, in order to provide an additional insight into the potential effects of the introduction of the euro on the nature of inflation expectations, the above-mentioned tests are applied not only to the whole sample but also to the post-euro introduction period, i.e., January 1999 onwards.

The paper is organised as follows. In section 2, the quantification of inflation expectations is discussed while in section 3, the framework for the rationality tests is described. In section 4, the empirical results for the euro area and several member countries are presented. Finally, section 5 concludes.

2 Inflation expectations

The existence of regular and readily available economic surveys, such as the EC consumer survey, prompted the use of qualitative data for measuring expectations. Nevertheless, even though the surveys inquire consumers directly on their assessment of future developments in prices, the answers only refer to the agents' opinion on the direction of changes, not to precise figures. Therefore, the data gathered are of qualitative nature. Thus, in order to use it as a proxy for inflation expectations, qualitative information has to be converted into quantitative data, so as to be comparable with the benchmark quantitative variable, the observed inflation series.

Amongst all the methods presented in the literature to convert qualitative data into quantitative variables, we use the CP method to quantify the qualitative information on inflation expectations from the EC consumer survey. Though formal comparisons of the different quantification methods encompass several difficulties, there is some evidence in favour of the method proposed by Carlson and Parkin. In a simulation context, the results in terms of measurement errors suggest that the CP method performs well in terms of fitting the generated data (see Nardo (2003)).

The key assumption of the CP method is that each consumer, at each moment in time, responds to the questionnaire according to a subjective probability density function associated with the variable of interest. It follows that the aggregate proportion of respondents that provide a particular answer can be interpreted as a specific area under an aggregate probability density function. Initially, the CP methodology was developed for surveys that encompassed only three possible answers. Within this framework, consumers would report no change in expected inflation if their expectations fell within an interval centred at zero, with fixed boundaries. By the same token, if their expectations were higher (lower) than the right (left) boundary of that interval, they would report a rise (fall) in expected inflation.

Currently, numerous surveys, including the EC consumer survey, present five alternative answers instead of three. In particular, referring to the question on the evaluation of future price developments, the corresponding possible answers are the following (see European Commission (2007)):

By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will...

1) increase more rapidly
2) increase at the same rate
3) increase at a slower rate
4) stay about the same
5) fall
6) don't know

In other words, consumers are asked if the year-on-year expected inflation rate will be: 1) above their current inflation perceptions; 2) the same as the perceived inflation; 3) below the perceived inflation; 4) nil or 5) negative[1].

To take into account this richer set of answers, the initial formulae of the CP method were extended (see Batchelor and Orr (1988) and Berk (1999)). The extension of this method implicitly allowed for time-varying boundaries for the indifference intervals. Furthermore, the exact wording of the question and the five alternative answers reveals the existence of two reference values for the assessment of the evolution of expected inflation: zero and the perceived inflation. Therefore, the quantification of inflation expectations, through the extended CP methodology, necessarily reflects the different allocation of the answers, the assumed distribution, as well as the perceived inflation rate. So, the calculation of the expected inflation measure requires *i*) the choice of the distribution for inflation expectations across the population, and *ii*) the quantification of inflation perceptions.

Concerning the distribution for inflation expectations, the Normal distribution is the most frequently used. Such a choice is based on the Central Limit Theorem. Consider inflation expectations, at time t, for the N consumers surveyed, as random variables. If one assumes that these variables are independently distributed, with subjective probability density functions with finite first and second moments, then relying on the Central Limit Theorem, the distribution of the sum of these variables, for the N individuals, is asymptotically Normal. Despite not being a consensual choice, the Normal distribution hypothesis has been very popular, probably because of its analytical simplicity, and has proved to be robust to comparative analysis. For example, in contrast with

[1] As stressed by Mestre (2007), the "don't know" answer is not very informative. Thus, the proportion of respondents that fall in this category are reallocated proportionally to the other response categories (see, for instance, Forsells and Kenny (2002)).

those who criticise the symmetric shape of the distribution (see, for example, Carlson (1975) and Batchelor (1981)), Balcombe (1996) and Berk (1999) do not find empirical evidence in favour of using asymmetric distributions. Furthermore, the latter and Löffler (1999) conclude that assuming normality does not affect the results significantly.

So, considering the Normal standard distribution, denote P_{it} as the proportion of the answers falling in the i^{th} category at time t, and F as the cumulative Normal distribution function. The relevant thresholds of the intervals are the maximum likelihood estimates that can be obtained from the fractions of responses (see Batchelor and Orr (1988)) (Figure 1). Hence, the thresholds Z_{it} can be defined as

$$Z_{1t} = F_t^{-1}(1 - P_{1t}) \quad (1)$$
$$Z_{2t} = F_t^{-1}(1 - P_{1t} - P_{2t}) \quad (2)$$
$$Z_{3t} = F_t^{-1}(1 - P_{1t} - P_{2t} - P_{3t}) \quad (3)$$
$$Z_{4t} = F_t^{-1}(P_{5t}) \quad (4)$$

Following Batchelor and Orr (1988) and Berk (1999), the expected inflation rate, π_t^e, can be written as:

$$\pi_t^e = \frac{-Z_{3t} - Z_{4t}}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}} \pi_t^p \quad (5)$$

where π_t^p is the perceived inflation rate, which plays a scaling role for the expected inflation rate.

For the perceived inflation rate, several alternatives have been considered in the literature. One immediate and naïve proxy for this variable is the contemporaneous observed inflation rate (Łiziak (2003)), or the one-period lagged inflation, to take into account publication lags (Mestre (2007)). However, it may be a strong assumption to consider that agents perceive current or past inflation rates perfectly, in particular due to the signal extraction problem ((see Lucas (1972, 1976b)).

Alternatively, survey information can also be used to obtain a measure for inflation perceptions. One can consider the question regarding the evaluation of current price developments. In particular, the question and the corresponding possible answers are the following (see European Commission (2007)):

How do you think that consumer prices have developed over the last 12 months? They have...

1) risen a lot
2) risen moderately
3) risen slightly
4) stayed about the same
5) fallen
6) don't know

Berk (1999) suggests grouping the proportion of responses associated with the five possible answers into only three proportions, and then applying the traditional CP method to obtain a measure of inflation perceptions (see also Mestre (2007)). This approach, though avoiding the discussion about how to anchor the perceived inflation, does not fully take into account the detailed information provided by the survey. In this context, Batchelor and Orr (1988), argued for a measure of π_t^p based on the five alternative answers to the question on inflation perceptions, which is anchored to a moderate inflation rate. Following Batchelor and Orr (1988), Dias *et al.* (2009) presented a measure of perceived inflation that exploits all the information available in the question above, which will be adopted in this paper[2].

3 Rationality

The concept of rational expectations was introduced by Muth (1961) and is based on the assumption that expectations are, in their essence, similar to the informed predictions derived from relevant economic theory. The predictions should exploit, as much as possible, all available information in the dataset. Furthermore, relevant economic theory should encompass the underlying structural economic model.

In practice, for assessing the validity of the rational expectations hypothesis a set of tests has been proposed in the literature, namely tests for unbiasedness, lack of serial correlation, efficiency and orthogonality (see Pesaran (1989)). Unbiased expectations assume that rational agents do not commit systematic and

[2]Nevertheless, the overall results are qualitatively similar when the observed inflation rate is used as a proxy for the perceived inflation rate.

persistent errors when forecasting inflation. This means that rational agents may over or under predict inflation at some moments in time, but that does not take place over a long time span. Considering the following model for observed inflation

$$\pi_t = \alpha + \beta \pi_t^e + u_t \tag{6}$$

where, π_t is the observed inflation rate, then a formal test for unbiasedness can be carried out by jointly testing $\alpha = 0$ and $\beta = 1$. The rejection of this hypothesis suggests the existence of bias in inflation expectations. For instance, if $\alpha \neq 0$ then the expected inflation would not be fully capturing the systematic component of observed inflation, giving rise to a persistent difference in the averages of the two series.

In a non-stationary context, the rational expectations hypothesis implies that the observed and the expected inflation rates move together, so that there is no persistent divergence between the two variables (see Grant and Thomas (1999)). In this case, the unbiasedness restriction requires the existence of cointegration between the observed and the expected inflation and that the cointegrating vector $[\alpha\ \beta]$ is equal to [0 1]. If one rejects the hypothesis of $[\alpha\ \beta] = [0\ 1]$, then the data suggest that expectations are biased.

Regarding efficiency and orthogonality, both tests are concerned with the use of information by agents to forecast inflation: in the first case, with the use of past inflation rates, while, in the second, with the use of a wider set of information. The terminology of the tests is not consensual among the different authors. For example, Forsells and Kenny (2002) use weak- and strong-efficiency to designate the efficiency and orthogonality tests, respectively. As commonly defined in the literature, testing weak-efficiency (or efficiency) consists in assessing the statistical significance of past observed inflation values in a regression with the forecast error as dependent variable. If the coefficient in this regression associated with past inflation is significant, then lagged observed inflation can be helpful to improve inflation forecast accuracy. In the regression, we also allowed for past forecast errors to avoid serial correlation.

For strong-efficiency (or orthogonality), a similar testing framework is considered but, in this case, the purpose is to check if a broader information set is orthogonal to the forecast errors. Considering the following equation,

$$e_t = \mu + \psi\Omega_{t-12} + u_t \quad (7)$$

where $e_t = \pi_t - \pi_t^e$ and Ω_{t-12} denotes the information set available at the time expectations are formed. Forecast errors are orthogonal to the economic variables considered relevant for predicting inflation if $\psi = 0$. Rational agents are supposed to use all relevant information for which the marginal benefit of gathering and utilizing the information exceeds its marginal cost. Since nowadays, due to data dissemination progress, agents have access to a wider information set at a progressively lower cost, the relevant information set can encompass an extremely large number of variables. As noted by Forsells and Kenny (2002), including so many variables in a multivariate equation can lead to multicollinearity and/or overfitting, in addition to the potential scarcity of degrees of freedom. To avoid these econometric difficulties, these authors suggested transforming this one-step multivariate approach into a several-step univariate one, in which each independent variable is considered one at a time. However, this testing strategy still has some caveats. First of all, the true multivariate nature of the test is lost, as the relevance of each variable for explaining the forecast errors is tested individually. Furthermore, data publication lags are not taken into account.

Recognising these limitations, Łiziak (2003) tried to extend this testing procedure in order to take on board publication lags and more than one independent variable at a time. This author considered groups of variables, with between two and six variables each, and built regressions of the forecast errors on each group individually. Moreover, publication lags were also accounted for, by only including, at each moment in time, the variables that the agents actually knew at the time the survey took place. Since forecast errors exhibit autocorrelation, a lagged forecast error term was also included as an additional independent variable.

The strong-efficiency test herein proposed differs from the ones mentioned above, as we try to take into account large information sets. Following the seminal work of Stock and Watson (1998), we rely on the common factors extracted from the original dataset. The key role of the common factors is to summarise large amounts of information in a few variables, which capture the main features of the original data. In fact, the idea behind the factor model is that variables have two components: the common component, which can be captured by a small number of variables, the common factors, and the idiosyncratic component, which reflects variable-specific features. Hence, the purpose of using common factors is to reduce the dimension of data, by pooling the most significant information from the initial series while excluding their idiosyncratic component. Let X_t be a N-dimensional multiple time series of variables, observed for $t = 1, \ldots, T$. Assume the following static factor representation for X_t data generating process:

$$X_t = \Lambda F_t + e_t \quad (t = 1, \cdots, T) \tag{8}$$

where F_t is a $(r \times 1)$ vector of non-observable factors, Λ is a $(N \times r)$ matrix of (unknown) loadings and e_t is a N-dimensional vector of the idiosyncratic components. When both $N \to \infty$ and $T \to \infty$, Stock and Watson (1998, 2002), Bai and Ng (2002), Bai (2003) and Amengual and Watson (2007) have shown that, under slightly different sets of assumptions regarding the data generating processes of the factors and the idiosyncratic components, the first k principal components span the factor space. Hence, it is possible to overcome the problem of the dimension of the information set at hand by reducing the number of regressors in a parsimonious way, without neglecting a significant amount of information. Intuitively, common factors can be seen as capturing the underlying economic driving forces, which agents intrinsically sense based on news, individual experience and so on.

As in Łiziak (2003), we also control for lagged forecast error terms and take into account data publication lags, by shifting the relative position of the series, so that at each moment in time the independent variables considered reflect the information available to the agents at the time of the survey (see, for example, Altissimo *et al.* (2007) and Rünstler *et al.* (2009)). For this purpose, consider the following model

$$e_t = \mu + \sum_{i=1}^{p} \rho_i e_{t-i} + \sum_{j=1}^{k} \psi_j F_{j,t-12} + u_t \tag{9}$$

where p is the number of autoregressive terms included in order to cope with autocorrelation, F_j refers to the j^{th} common factor extracted from the broad information set and k denotes the number of common factors considered in the regression. We rely on the criteria proposed by Bai and Ng (2002) to determine the number of factors to be included in the model. Hence, agents' inflation expectations are orthogonal to the information set considered or, in other words, agents are strongly efficient, if the hypothesis $\psi_1 = ... = \psi_k = 0$ is not rejected.

4 Empirical results

Using the methodology described in section 2, we computed the expected inflation rate for the euro area as a whole and for several individual countries, namely Germany, France, Italy, Spain, Belgium, the Netherlands, Ireland and Portugal[3]. The survey data, provided by the European Commission, is available on a monthly basis, and the sample period, which differs slightly across countries, covers almost the last twenty years, up to December 2006[4]. Data for inflation, as measured by the year-on-year rate of change of the consumer price index, are from the OECD Main Economic Indicators database[5]. The resulting measure for inflation expectations is presented in Figure 2.

Concerning bias, we find no evidence in favour of unbiasedness. Our results are in line with those obtained by Berk (1999), Łiziak (2003) and Mestre (2007). Based on the ADF unit root test, we conclude that observed and expected inflation are integrated of order one. Although Johansen test results point to the existence of cointegration between the observed and the expected inflation (see Table 1), we clearly reject the hypothesis of a cointegrating vector $[\alpha \ \beta]$ being equal to $[0 \ 1]$ for all countries (see Table 2)[6]. This picture does not change significantly if we restrict our sample to the post-euro introduction period, that is since January 1999, in which only Spain and Portugal show some signs of unbiasedness. Nevertheless, when we only test the condition of $\beta = 1$, we conclude that, in general, this hypothesis is not rejected, both for the full

[3] The other member countries of the euro area as of 1999, namely Finland, Austria and Luxembourg, are not included because the corresponding series for these countries are only available for a shorter time span.

[4] For the euro area, the sample starts in January 1992. For Spain and Portugal, it starts in June 1987. For the remaining countries, the sample starts in January 1986.

[5] In particular, for the euro area, the data refers to HICP, while for individual countries we consider CPI, because a longer time span is available. Nevertheless, if one considers HICP instead of CPI for the common sample period, the results remain virtually unchanged.

[6] The results do not change qualitatively if, instead of the Johansen cointegration test, we consider the single equation test of Engle-Granger. We also computed the cointegrating vector recursively to assess the stability of the relationship and we do not find evidence of parameter instability.

and post-euro introduction samples. So, in spite of some evidence in favour of $\beta = 1$, apparently, agents' expectations have, on average, systematically underestimated inflation, as the estimates obtained for α (whether or not imposing the restriction of $\beta = 1$) are, in general, positive[7].

Since agents may, at times, be unable to distinguish correctly between temporary and permanent shocks, it may not be surprising if they make repeated one-sided forecast errors, as they can mistakenly interpret permanent shocks as being of a temporary nature. This fact can help to explain why forecast errors show signs of autocorrelation for lags greater than 12 months[8]. However, this cannot explain entirely the fact that agents systematically underestimate average inflation, throughout the sample period, as the test results suggest and as is apparent in Figure 2, where expected inflation is, most of the time, below observed inflation. One possible reason is that, in the context of a steady disinflation process, during the late 80's and the 90's, and of the ECB's commitment to price stability, agents have a motive to, on average, anchor their expectations to a low inflation level, even if lower than the one actually observed.

In the context of cointegration between observed and expected inflation, one can also assess if expectations adjust to prices, prices adjust to expectations or both. In Table 3 we present the results of the tests to the dynamic adjustment of observed and expected inflation. According to these results, it seems that, in general, expected inflation adjusts towards observed inflation in the long run. Moreover, the reverse relationship does not seem to be significant, as the observed inflation is, in most cases, strongly exogenous. This finding is common to the euro area, in line with Forsells and Kenny (2002), and all the individual countries analysed, except for Ireland[9].

As the unbiasedness test suggests that agents have, in general, biased inflation expectations, the hypothesis of rational expectations is immediately ruled out, regardless the results of the efficiency and orthogonality tests. Nevertheless, even though agents incur in a systematic expectation error, Paquet (1992) argues that, in these cases, the existence of cointegration between the observed

[7]Even though the observed and expected inflation seem to have different means, since the hypothesis of $\beta = 1$ is, in general, not rejected, the forecast errors series turn out to be stationary, as confirmed by the ADF test.

[8]As for lags up to 12 months, the existence of autocorrelation can be related with overlapping forecast errors (see, for example, Forsells and Kenny (2002)).

[9]Furthermore, these results hold both in the full and post-euro introduction samples.

and expected inflation could also be interpreted as some sort of rationality, a so-called weak-form of rationality.

Concerning the weak-efficiency test (see Table 4), we find that for the sample period as a whole, one cannot reject weak-efficiency for the euro area, France, Italy and Spain (see also Forsells and Kenny (2002) for the euro area and Thomas Jr. (1999) for the US, among others). Hence, for Germany, Belgium, Netherlands and to a lesser extent Ireland and Portugal, we find no evidence in favour of weak-efficiency (for example, Łiziak (2003) also found similar results for Poland). When one considers the post-euro introduction sample, the results remain qualitatively unchanged with two exceptions, namely Germany and Ireland, which also present evidence of weak-efficiency.

Regarding strong-efficiency, in order to implement the above-mentioned test strategy, we had to collect large datasets for each country, from which the common factors were extracted. The information set was drawn from a common source, the OECD Main Economic Indicators, which covers a wide range of economic variables, including both quantitative and qualitative data, as well as real and nominal variables. In particular, we only considered the series released on a monthly frequency and available for the same sample period as the consumer survey[10]. All data are seasonally adjusted (with a few exceptions, such as interest or exchange rates) and, as usual, prior to factor extraction all data were transformed to be stationary. To determine the number of factors k to be included in the regression, we relied on the $IC1$ and $IC2$ criteria proposed by Bai and Ng (2002). The $IC1$ and $IC2$ criteria deliver the same result for the number of factors, for all countries except for the euro area (in this case we considered the number of factors determined by $IC1$, as it encompassed the other alternative). The test results suggest that there is evidence in favour of strong-efficiency only for the euro area, France and Spain (see Table 4). For the remaining countries, in line with the findings in Thomas Jr. (1999) for the US, strong efficiency is rejected. Focusing only on the post-euro introduction sample period, the same evidence holds with two exceptions, namely Italy and Ireland, which also show signs of strong-efficiency[11].

[10]The number of series considered differs slightly across countries and is, on average, around 50 series. A detailed list of the series is available from the authors upon request.

[11]One should also mention that, concerning both weak and strong efficiency, no evidence of a break in the parameter estimates was found at the time of the introduction of the euro.

Hence, no country satisfies the whole set of conditions necessary to comply with the rational expectations hypothesis. This evidence holds not only for the full sample but also for the post-euro introduction period (except for Spain in the latter case).

5 Conclusions

The purpose of this paper is to contribute to the debate on whether inflation expectations are rational or not. This issue is of particular relevance from a policy point of view, for example, to central banks, such as the ECB. Moreover, it has been a common practice in economic modelling to assume that the rational expectations hypothesis applies.

In the first place, inflation expectations measurement is reviewed and a quantification of such expectations is provided. Resorting to the rich consumer survey data released on a monthly basis by the European Commission, we rely on the well-known generalised version of Carlson and Parkin method. Thereafter, we proceed on testing the rationality hypothesis, which involves tests of unbiasedness, weak- and strong-efficiency. In the latter test, we extend the testing framework, so as to take on board large information sets resorting to the diffusion index model of Stock and Watson.

The empirical application is undertaken for the euro area and for several member countries, using a sample that covers the last two decades as well as the post-euro introduction period. We find no evidence in favour of unbiasedeness, as agents' expectations, on average, systematically underestimate inflation. The results do not change qualitatively if the sample is restricted to the post-euro introduction period, case in which only Spain and Portugal show some signs of unbiasedness. Concerning efficiency, based on the full sample period, we find evidence of strong-efficiency for the euro area, France and Spain, of weak-efficiency for Italy and no efficiency for Belgium, Netherlands, Ireland and Portugal. When one considers only the post-euro introduction period, the differences are that Italy and Ireland also show signs of strong-efficiency while Germany of weak-efficiency. Overall, the assumption of rationality does not seem to hold empirically for consumer inflation expectations in the euro area.

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Figure 1 - Inflation expectations distribution

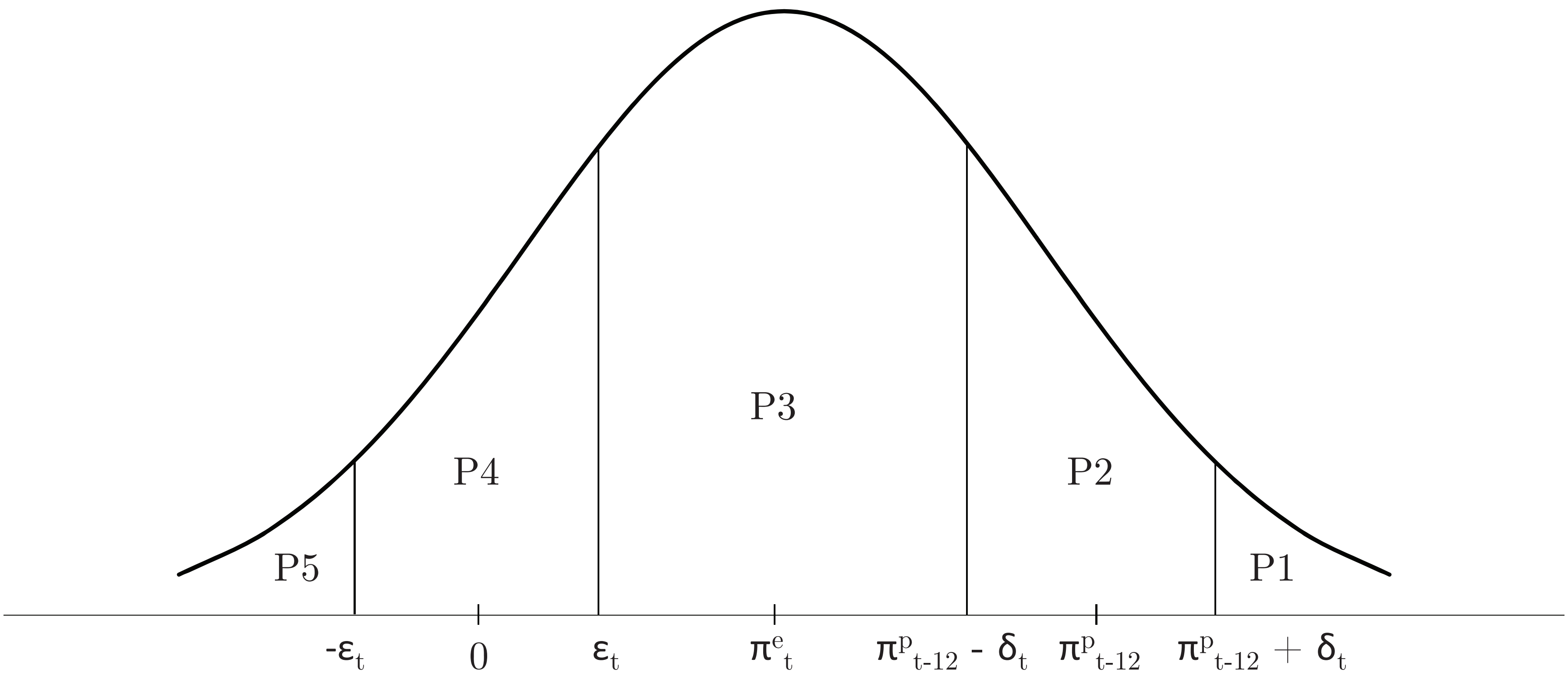

Figure 2 - Observed and expected inflation

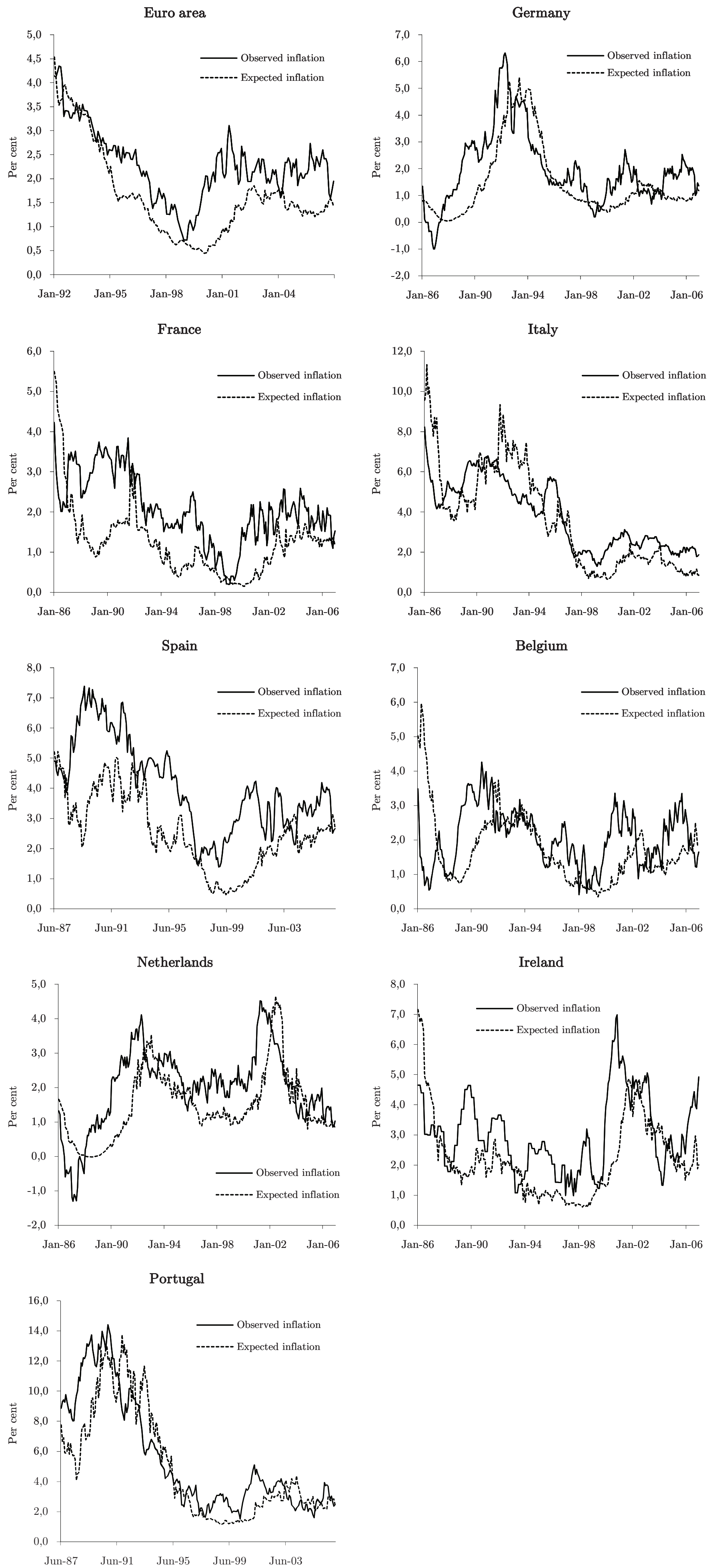

Table 1 - Cointegration tests

	Johansen trace test			
	r_0	N	λ_{trace} value	p-value
Euro area	0	2	26,79	0,00 **
	1	2	4,82	0,32
Germany	0	2	20,68	0,04 *
	1	2	6,83	0,14
France	0	2	38,71	0,00 **
	1	2	4,84	0,31
Italy	0	2	31,33	0,00 **
	1	2	2,86	0,62
Spain	0	2	22,14	0,03 *
	1	2	1,62	0,84
Belgium	0	2	54,75	0,00 **
	1	2	6,87	0,14
Netherlands	0	2	34,80	0,00 **
	1	2	8,20	0,08
Ireland	0	2	42,39	0,00 **
	1	2	4,16	0,40
Portugal	0	2	27,91	0,00 **
	1	2	2,82	0,62

Note: Consider the following test equation:

$$\Delta x_t = \Lambda x_{t-1} + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-i} + \varepsilon_t$$

where x_t is a vector. In our case, x_t includes observed and expected inflation. Let $\lambda_1 > \lambda_2 > ... > \lambda_N$ be the characteristic roots of Λ. In the Johansen trace test the hypotheses are formulated as follows: H_0 $r \leq r_0$ vs. H_1: $r \leq N$, where r denotes the number of cointegrating vectors and N is its maximum value, which in this case is 2. Moreover, the test statistic is the following:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{N} \ln(1 - \lambda_i)$$

** denotes significance at a 1 per cent level and * at a 5 per cent level.

Table 2 - Bias of inflation expectations

	Full sample					Post-euro sample	
	Coefficient estimates			Coefficient tests (p-values)		Coefficient tests (p-values)	
	α and β free		α free and $\beta = 1$	H_0: $\alpha = 0$ and $\beta = 1$	H_0: $\beta = 1$	H_0: $\alpha = 0$ and β	H_0: $\beta = 1$
	α	β	α	H_1: $\alpha \neq 0$ or $\beta \neq 1$	H_1: $\beta \neq 1$	H_1: $\alpha \neq 0$ or $\beta \neq 1$	H_1: $\beta \neq 1$
Euro area	0.94 [0.12]	0.89 [0.08]	0.78 [0.06]	0.00 **	0.22	0.00 **	0.23
Germany	0.53 [0,20]	0.96 [0.11]	0.46 [0.12]	0.01 *	0.81	0.03 *	0.06
France	0.25 [0.32]	1.75 [0.23]	1.05 [0.13]	0.00 **	0.00 **	0.01 *	0.56
Italy	1.41 [0.29]	0.76 [0.07]	0.72 [0.25]	0.00 **	0.02 *	0.00 **	0.15
Spain	0.62 [0.57]	1.44 [0.21]	1.69 [0.23]	0.00 **	0.04 *	0.22	0.14
Belgium	0.93 [0,20]	0.80 [0.11]	0.61 [0,10]	0.00 **	0.18	0.02 *	0.35
Netherlands	-0.19 [0,30]	1.45 [0.17]	0.51 [0.13]	0.00 **	0.03 *	0.02 *	0.35
Ireland	1.10 [0.28]	0.96 [0.12]	1.02 [0.13]	0.00 **	0.76	0.04 *	0.73
Portugal	0.77 [0.54]	1.03 [0.09]	0.92 [0.31]	0.03 *	0.73	0.08	0.05

Note: The following model is considered: $\pi_t = \alpha + \beta\pi^e_t + u_t$

Results obtained through the Johansen approach. ** denotes significance at a 1 per cent level and * at a 5 per cent level. Standard deviations in brackets.

Table 3 - Dynamic adjustment test results

	π			π^e	
	Weak exogeneity $\gamma = 0$		Strong exogeneity $\gamma = \varphi_1 = \ldots = \varphi_n = 0$	Weak exogeneity $\lambda = 0$	
	Coefficients	p-values	p-values	Coefficients	p-values
Euro area	-0.035	0.49	0.48	-0.086	0.00 **
Germany	-0.014	0.73	0.18	-0.073	0.00 **
France	-0.042	0.09	0.26	-0.086	0.00 **
Italy	-0.002	0.86	0.51	-0.098	0.00 **
Spain	-0.022	0.32	0.12	-0.079	0.00 **
Belgium	-0.042	0.17	0.54	-0.114	0.00 **
Netherlands	-0.004	0.88	0.76	-0.119	0.00 **
Ireland	-0.088	0.00 **	-	-0.116	0.00 **
Portugal	0.003	0.86	0.00 **	-0.148	0.00 **

Note: For testing the exogeneity of π^e the model considered is:

$$\Delta\pi_t^e = \upsilon + \sum_{j=1}^{r} \delta_j \Delta\pi_{t-j}^e + \sum_{j=1}^{s} \theta_j \Delta\pi_{t-j} - \lambda(\pi_{t-1}^e - \pi_{t-1}) + \eta_t$$

Similarly, for π the model considered is:

$$\Delta\pi_t = \omega + \sum_{j=1}^{m} \psi_j \Delta\pi_{t-j} + \sum_{j=1}^{n} \varphi_j \Delta\pi_{t-j}^e - \gamma(\pi_{t-1} - \pi_{t-1}^e) + \varepsilon_t$$

P-values obtained through a single equation approach for the full sample. ** denotes significance at a 1 per cent level and * at a 5 per cent level.

Table 4 - Efficiency of inflation expectations

	Full sample		Post-euro sample	
	Weak	Strong	Weak	Strong
Euro area	0,226	0,460	0,964	0,112
Germany	0,009 **	0,000 **	0,076	0,003 **
France	0,179	0,063	0,081	0,053
Italy	0,080	0,033 *	0,052	0,502
Spain	0,533	0,103	0,422	0,672
Belgium	0,004 **	0,036 *	0,001 **	0,021 *
Netherlands	0,001 **	0,025 *	0,016 *	0,041 *
Ireland	0,024 *	0,038 *	0,066	0,102
Portugal	0,045 *	0,000 **	0,011 *	0,001 **

Note: The model considered for testing efficiency is the following:

$$e_t = \mu + \sum_{i=1}^{p} \rho_i e_{t-i} + \psi\, \Omega_{t-12} + u_t$$

where Ω_{t-12} refers to the past observed inflation at the time of expectations formation, in the case of weak efficiency, and to the set of common factors in the case of strong efficiency. The efficiency tests are carried out by assessing the significance of ψ. Each entry of the table corresponds to the p-value of the test statistic (the HACSE versions of the t or F statistic). Rejection of the null should be read as evidence of no efficiency. ** denotes significance at a 1 per cent level and * at a 5 per cent level.