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Inflation (mis)perceptions in the euro area*

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Abstract

There has been a growing interest on inflation perceptions in the euro area, in particular, following the euro cash changeover. It has been pointed out that a gap emerged between observed and perceived inflation since the introduction of the euro notes and coins. Such a statement relies on the fact that inflation perceptions, measured by the well-known balance statistic from the European Commission's consumer survey, hiked after January 2002 and remained high thereafter, as opposed to the observed inflation, which has remained fairly stable. In this paper, we discuss the issue of inflation perceptions measurement, by comparing the balance statistic with an alternative refined measure, which is computed using the probability method. We argue that the balance statistic should be used carefully, as it can induce to misleading conclusions. In fact, we provide, for both euro area and country level, evidence showing that, using the proposed alternative measure, the breakdown in the relationship between observed and perceived inflation did not occur at the time of the euro cash changeover.

Keywords: Inflation perceptions; probability method; balance statistic; euro area cash changeover; cointegration breakdown.

JEL classification: C16, C42, E31.

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1 Introduction

In the last few decades, the increasing interest of economists in agents' perceptions and expectations, in a context of improving data collection and statistical techniques, is associated with a surge in business and consumer surveys. Within the euro area, as well as in several other countries, various business and consumer surveys are conducted on a monthly basis.

The business and consumer surveys inquire firms and consumers directly about their assessment of present and future short-term movements in a number of variables. Since the answers only refer to the agents' opinion on the direction of change of a specific variable, the information gathered from these surveys is naturally of a qualitative nature. However, in order to use this information in economic models and econometric analysis, a great amount of effort has been put into converting qualitative information into quantitative data, so as to be comparable with the benchmark quantitative variables associated with each question.

Although several different variables have been investigated throughout the years (see, for example, Smith and McAleer (1995) or Driver and Urga (2004)), from all the questions of the surveys the ones that have received more attention are those related with prices (see, among others, Carlson and Parkin (1975), Berk (1999), or Thomas Jr. (1999)). One example of a survey with questions on price developments is the European Commission's (EC) consumer survey, which inquires 23000 consumers in the euro area about their perceptions and expectations of price developments (see European Commission (2007)).

In order to quantify the qualitative data some methods have been put forward (see Nardo (2003) for a survey). One of these methods is the Carlson and Parkin (1975) (CP hereafter) probabilistic method. This method assumes that each consumer answers the questionnaire according to a subjective probability density function associated with the variable under question. This allows one to interpret the share of respondents that provide a specific answer as a portion of the area under the aggregate probability density function. The CP method applied to the price questions is commonly found in the literature (see, for example, Forsells and Kenny (2002), Łiziak (2003) or Mestre (2007)). Although the initial formulae of CP method only tackled the three possible answers case, Batchelor and Orr (1988) and Berk (1999) adapted the CP method to take into

account a richer set of survey responses, in which it is possible to choose between five alternative answers, as is the case of the EC consumer survey.

Unlike most of the work done so far on this subject, which focus mainly on the inflation expectations, in this paper we exploit the information of the question on inflation perceptions. Considering the qualitative data from the EC consumer survey and using the CP method generalised for the five possible answers case, the aim of this paper is to provide a measure of perceived inflation, which could be directly comparable with the observed inflation. This is applied to the euro area as a whole, as well as to several euro area member countries, for a sample period covering the last twenty years.

In fact, perceived inflation does not have to be equal to observed inflation. As Berk (1999) points out, individual agents may not be able to perceive accurately the aggregate rate of inflation, due to the signal extraction problem (see Lucas (1972, 1976)). Furthermore, assessing inflation perceptions may shed some light on the recent debate on the impact of the euro on inflation perceptions, which has been gathering momentum ever since the introduction of the euro banknotes and coins in January 2002. According to Eurostat (2003) the most significant impact of the euro changeover in the euro-zone observed inflation rate took place between December 2001 and January 2002 and is estimated to be within the range of 0.09 to 0.28 percentage points. In sharp contrast with all the available quantitative estimates, which point to a moderate impact on inflation, perceived inflation, as measured by the balance statistic, increased strongly and stayed at a higher level, well above the observed inflation rate, ever since. Therefore, the stable relationship that apparently existed between these two variables, in both the euro area and individual countries, clearly broke down after the introduction of the euro notes and coins. Furthermore, the existence of this gap led, in some countries, to conjectures about the quality of official consumer price statistics (see ECB (2007)).

The balance statistic is the most commonly used summary statistic of inflation perceptions, calculated from the answers to the question on inflation perceptions of the EC consumer survey. Several authors argue that, albeit direct comparison between the balance statistic and the observed rate of inflation should not be done, it is possible to analyse their evolution through time by plotting the two series on the same graph but with different scales. However, the balance statistic has several caveats and using it as a proxy for inflation

perceptions can lead to misleading conclusions. This seems to be the case when assessing the impact of the euro cash changeover on inflation perceptions. Hence, in this paper an alternative refined measure of perceived inflation is put forward.

In order to address the issue of the relationship between perceived and observed inflation, we test for cointegration between observed inflation and the proposed alternative measure of perceived inflation, and whether there is a breakdown in this relationship, in January 2002, using the tests recently suggested by Andrews and Kim (2006). We show that this measure of perceived inflation is cointegrated with the observed inflation and that there is no evidence of a breakdown in the relationship, namely at the time of the euro cash changeover.

The remainder of the paper is organised as follows. In section 2, the measurement of inflation perceptions is addressed and the corresponding empirical results are presented. In section 3, the relationship between observed and perceived inflation is evaluated and we also test for a breakdown between reality and perceptions, motivated by the physical introduction of the euro. Finally, section 4 concludes.

2 Inflation perceptions

2.1 Measurement

From amongst the methods that have been put forward to convert qualitative data into quantitative variables, we use the CP method to quantify the qualitative information on inflation perceptions from the EC consumer survey. Even though formal comparisons of the different methods are not always possible, there is some evidence in favour of using the method proposed by Carlson and Parkin (1975). In a simulation context, the results in terms of measurement errors and their systematic nature for different quantification methods suggest that the CP method has a good performance in terms of fitting the generated data (see Nardo (2003) for a discussion).

The CP method assumes that each consumer, at each moment in time, answers the questionnaire according to a subjective probability density function associated with the variable under question. This assumption allows one to interpret the proportion of respondents that provide a particular answer as

a specific part of the area under the aggregate probability density function. In this case, the question considered is about inflation perceptions at time t. The initial formulae of CP methodology was developed for surveys with only three possible answers. Within such a framework, consumers would report a no change answer in the rate of perceived inflation if their perceptions fell within an interval centred on zero with fixed boundaries. Else, if their perceptions were higher (lower) than the right (left) boundary of the interval, they would report a rise (fall) in the rate of perceived inflation.

One of the key assumptions of CP method concerns the choice of the distribution of perceived inflation across the population. Initially, and in most subsequent empirical applications, the choice was the Normal distribution. This choice can be justified based on statistical theory relying on the Central Limit Theorem. If one assumes that inflation perceptions, at time t, for the N consumers surveyed are random variables, independent and identically distributed, with subjective probability density functions with finite first and second moments, then, according to the Central Limit Theorem, the distribution of the sum of these variables is assimptotically Normal. The possibility of using this method is based on the cross-sectional dimension of the survey at each moment in time.

Nevertheless, the choice of the Normal distribution has been subjected to some criticism. For example, Carlson (1975) and Batchelor (1981) stress the fact that considering a symmetric distribution may be a strong assumption. However, adding to the analytical convenience of assuming a Normal distribution, there is also empirical evidence in favour of the use of this distribution. Balcombe (1996) and Berk (1999) have not found empirical evidence in favour of using asymmetric distributions. Moreover, the latter as well as Löffler (1999) conclude that results are similar with or without the normality assumption[1].

To take into account a richer set of surveys' answers, in which it is possible to choose between five alternative choices, the initial formulae of the CP method were extended (see Batchelor and Orr (1988) and Berk (1999)). One example of these surveys is the EC consumer survey. In particular, the question and the corresponding possible answers, regarding the evaluation of current price

[1] In our empirical analysis, we also allowed for a distribution other than Normal, such as the Uniform distribution (see, for example, Liziak (2003)) but the results did not change much. The results are available from the authors upon request.

developments, 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

In other words, consumers are asked if year-on-year inflation rate is: 1) above its moderate level; 2) at its moderate level; 3) below its moderate level; 4) nil or 5) negative.

The extension of the CP method also implicitly allowed for time-varying boundaries of the indifference intervals. Moreover, due to the way the question is posed, now, in addition to the zero inflation, there is another reference value for the evaluation of the evolution of perceived inflation, which is the moderate inflation rate. Thus, any measure for perceived inflation should not only reflect the different allocation of answers but also be a function of this moderate inflation rate.

Denote P_{it} as the proportion of answers falling in the i^{th} response category at time t.[2] The fractions of responses can be regarded as the maximum likelihood estimates of the areas under the perceptions' distribution delimited by the relevant tresholds (see Batchelor and Orr (1988)) (see Figure 1). Let F be the cumulative Normal standard distribution function and define the tresholds (Z_{it}) as

$$Z_{1t} = F_t^{-1}(1 - P_{1t}) \quad (1)$$

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

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

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

[2]Note that, as stressed by Mestre (2007), the "don't know" answer is not very informative. Hence, it has been a current practice to reallocate proportionally the corresponding fraction to the other response categories (see, for example, Forsells and Kenny (2002)).

As shown by Batchelor and Orr (1988) and Berk (1999), the perceived inflation rate, π_t^p, can be written as[3]

$$\pi_t^p = \frac{-Z_{3t} - Z_{4t}}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}} \pi_t^m \tag{5}$$

where π_t^m is the moderate inflation rate. From (5) one can see that the moderate inflation rate performs a scaling role with respect to the perceived inflation rate. Batchelor and Orr (1988) argue that the moderate inflation rate reflects the individual's best guess of the permanent or trend rate of inflation. Hence, a possible proxy for the moderate inflation rate could be obtained by using a filtering procedure that allows one to extract the trend component of the inflation rate. Such filtering could be attained through the use, for example, of the Hodrick and Prescott (1997) filter. The HP filter is a well-known and standard filtering procedure which provides a smooth trend component (see, for example, King and Rebelo (1993) for a discussion).

2.2 Perceived inflation in the euro area

Using the above-mentioned measure, we compute the perceived inflation rate for the euro area as a whole and for several individual countries, namely Germany, France, Italy, Spain, Belgium, Netherlands, Ireland, Portugal and Greece[4]. Survey data is available on a monthly frequency, while the sample period, which differs slightly across countries, covers almost the last twenty years, up to December 2006. Data on inflation, measured by the consumer price index year-on-year rate of change, are from the OECD Main Economic Indicators database[5] (see table 1).

Regarding the computation of the moderate inflation rate, the HP smoothing parameter is set to 14400, a standard value when working with monthly data, and as usual, the end of sample problem of HP filter is tackled by extracting

[3] See the Appendix for details.

[4] Finland, Austria and Luxembourg are not included because series, for these countries, are available for a limited time span.

[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 almost unchanged.

the inflation rate trend using observations beyond the end of 2006[6]. Figure 2 presents the observed inflation rate and the resulting measure of inflation perceptions. In general, the perceived inflation rate follows closely the observed inflation rate. This is quite clear for all countries with the exception of France and, to a lesser extent, Spain. This may reflect the lack of harmonisation in the surveys for these countries and, therefore, the results for France and Spain should be interpreted with more caution (see Gerberding (2001)).

Additionally, we also plot in Figure 2 the balance statistic for each country, which is the measure usually used to present survey results and is computed as a weighted average

$$b = -P_5 - \frac{1}{2}P_4 + 0P_3 + \frac{1}{2}P_2 + P_1 \tag{6}$$

with *ad hoc* weights given to each answer. The balance statistic is a popular summary measure as it is quite straightforward to compute and is released each month by the European Commission. The balance statistic for the inflation perceptions' question, apart from the scale, has been widely used as a proxy for perceived inflation (see ECB (2003, 2005, 2007) or Dörring and Mordonu (2007), among others). However, we shall now argue that the balance statistic for such question is not always a proper measure of perceived inflation. Following Mestre (2007), the rationale behind the balance statistic can be presented as follows. Considering Z_t as a continuous random variable, the expected value of Z_t is given by $\int_{-\infty}^{+\infty} Z\phi(Z)dZ$ where $\phi(Z)$ is the probability density function. If one assumes that Z_t is a discrete random variable that takes on only five different values $(1, \frac{1}{2}, 0, -\frac{1}{2}, -1)$ then we get

$$-1\int_{-\infty}^{Z_4}\phi(Z)dZ - \frac{1}{2}\int_{Z_4}^{Z_3}\phi(Z)dZ + 0\int_{Z_3}^{Z_2}\phi(Z)dZ + \frac{1}{2}\int_{Z_2}^{Z_1}\phi(Z)dZ + 1\int_{Z_1}^{+\infty}\phi(Z)dZ \tag{7}$$

Since $P_5 = \int_{-\infty}^{Z_4}\phi(Z)dZ$, $P_4 = \int_{Z_4}^{Z_3}\phi(Z)dZ$, $P_3 = \int_{Z_3}^{Z_2}\phi(Z)dZ$, $P_2 = \int_{Z_2}^{Z_1}\phi(Z)dZ$ and $P_1 = \int_{Z_1}^{+\infty}\phi(Z)dZ$, we end up with b. Note that the limits of integration do not need to be known, which results in a simplification of the calculations. Despite being simpler, the underlying structure of the balance

[6] We also assessed how sensitive are the results to the filter chosen and the results end up being similar.

statistic can be too restrictive, in the sense that Z_t is assumed to be a discrete random variable, with its values being fixed arbitrarily. Instead, in a more general case, one can consider Z_t as being a continuous random variable and with data-dependent limits of integration, as is the case of the perceived inflation measure presented in the previous section. In addition, the balance statistic ignores the level of the variable of interest. This statistic combines the information of the survey with a fixed set of weights, chosen *ad hoc*. Since, as stressed earlier, the EC consumer survey only inquires about the direction of change of perceived inflation, and not about its level, the level of the balance statistic is determined by the weights, while its variation reflects the survey-based information. Hence, the balance statistic cannot be used directly as a proxy for the level of perceived inflation rate. Furthermore, we will show that, in the general case, the balance statistic, even for the change of the perceived inflation rate, is an inadequate measure.

Let us disentangle the measure of perceived inflation presented in equation (5). The perceived inflation rate has two components: (i) a component that reflects only survey information, $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$ and (ii) π_t^m, the moderate inflation rate. The first component provides a measure of the slack of perceived inflation versus the moderate inflation measure that is present in the second component. By differencing equation (5) one can assess the role played by each component on the evolution of the perceived inflation rate

$$d\pi_t^p = d\left(\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}\right)\times\pi_t^m + \left(\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}\right)\times d\pi_t^m \quad (8)$$

From (8) one can see that, in the general case, the changes in perceived inflation, $d\pi_t^p$, depends both on the evolution of the component directly associated with the survey results and on the changes in the moderate inflation rate. Hence, survey information is not enough to capture the evolution of perceived inflation. In the special case of a constant moderate inflation rate, i.e, $d\pi_t^m = 0$, one obtains $d\pi_t^p = d\left(\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}\right)\times\pi_t^m$, that is, the changes in perceived inflation reflect, proportionally, only the changes in the component that reflects survey results, as does the balance statistic.

Does this means that the balance statistic is useless after all? To shed some light on this, as an illustrative example, we plot for the euro area the balance statistic and $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$, that is, the component of the perceived inflation

that reflects only survey results (see Figure 3). Interestingly, and apart the scale, both measures present a quite similar behaviour[7]. For some intuition on this results, imagine, for example, that, at some moment in time, P_1 increases while P_2 decreases by the same amount, with all the other proportions of responses unchanged. As in the balance statistic a bigger weight is attached to P_1 than to P_2, the balance statistic will increase, equation (6). Regarding $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$, when P_1 increases and P_2 decreases by the same amount, Z_1 is smaller while all other Z_i remain unchanged and in this case, $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$ increases. A similar reasoning can be applied to the other cases.

So, in practice, despite a less flexible use of survey results, the balance statistic conveys roughly the same information as the component that reflects only survey information of the perceived inflation measure, when a more general approach is allowed. If this is true, how far are we from getting a perceived inflation measure through the balance statistic? An obvious caveat of the balance statistic is the fact that its scale is meaningless so, it cannot replace $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$ in equation (5). Hence, the balance statistic cannot be used directly to obtain the level of perceived inflation rate. Concerning the changes in the perceived inflation rate, as seen from equation (8) survey information is also not enough to provide a proper quantification of this variable. However, in a context of stable moderate inflation rate ($d\pi_t^m = 0$), as the changes in the perceived inflation rate are proportional to the component that only reflects survey results, and, since the balance statistic and $\frac{-Z_{3t}-Z_{4t}}{Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t}}$ evolve similarly, the balance statistic could be used as a proxy for the evolution of perceived inflation. Therefore, the standard procedure of plotting the observed inflation rate and the balance statistic, allowing for different scales, to assess the evolution of inflation perceptions is acceptable only in a context of a relatively stable inflation environment, since in this case the trend inflation rate would be almost constant. For example, by plotting the observed and perceived inflation rate and the balance statistic over the last six years, for the euro area (see Figure 4), a period in which the inflation has been relatively stable, one can see that the balance statistic and the proposed perceived inflation measure are very similar.

[7] The same evidence is found for all countries considered.

3 The euro cash changeover

3.1 Overview

In the last few years, there has been a growing debate on the divergent evolution of observed inflation and the balance statistic, which is the most commonly used indicator for perceived inflation (see, for example, ECB (2007)). Despite the fact that observed inflation did not change significantly, the balance statistic increased substantially after the physical introduction of the euro banknotes and coins, clearly deviating from the observed measure of inflation. The resulting gap between the two measures peaked somewhere at the beginning of 2003, across countries, and has been somewhat persistent since then (see Figure 2).

Since the information on the directional change of inflation perceptions, provided by the balance statistic, seems to be at odds with the evolution of the observed inflation, several arguments have been put forward to explain this fact. Since the breakdown in the relationship between the observed inflation and the balance statistic occurred at the same time as the euro cash changeover, several analysis have tried to understand if the physical introduction of the euro could be held responsible for that gap.

In the emerging literature on this subject (see, amongst others, ECB (2003, 2005, 2007), Aucremanne, Collin and Stragier (2007) and Dörring and Mordonu (2007)) the role of the euro cash changeover as the trigger for this gap has been presented in different ways. For example, it has been claimed that the euro cash changeover, and the extensive media coverage associated with it, may have drawn more attention to price increases, inducing an overreaction in inflation perception. Moreover, the rises in consumer prices that actually took place in the wake of the changeover appear to have been concentrated on the most frequently purchased goods, and that may have had a very significant effect on the inflation perceptions. It has also been argued that a large number of European consumers still convert prices from euro to their former national currency, anchoring the relative prices to the pre-changeover levels.

As discussed earlier, the balance statistic cannot be used to assess the evolution of perceived inflation over a sample period in which observed inflation is not stationary. Hence, this invalidates the use of the balance statistic to test the impact of euro cash changeover on inflation perceptions when the whole sample is considered, since in most countries it encompasses a pronounced disinflation

period. In fact, the misuse of the balance statistic led wrongly to the conclusion that there is a divergence between observed inflation and perceived inflation, which could be associated with the introduction of the euro in January 2002. Furthermore, some of the explanations put forward may be based on circumstantial evidence since, for example, some of the price increases that occurred at the time of the euro cash changeover, especially in frequently purchased goods, are not directly related with this event, in particular the increase in energy prices (related with the price of oil in international markets) and in unprocessed food prices (closely associated with the weather and harvest conditions) (see Eurostat (2003)).

In the next section, we proceed into formal testing whether a break occurred in the relationship between observed and perceived inflation, after the introduction of the euro notes and coins, resorting to an adequate measure of the latter variable for the whole sample.

3.2 The impact on inflation perceptions

In this section, we provide an addtional insight into the impact of the euro area cash changeover on inflation perceptions by testing whether there is a breakdown in the relationship between observed and perceived inflation. As opposed to what is perceptable when using the balance statistic (which is valid only under certain circumstances), from Figure 2 one can immediately suspect that such a breakdown does not seem to withstand when a proper measure of perceived inflation for the whole sample period is used. Nevertheless, a more formal test is also presented.

Naturally, to assess if there is a break in that relationship, one has to assume the existence of a stable relationship up to the potential breakpoint. In particular, in the presence of integrated time series this means that there should be cointegration in that sample period. Hence, in first place we test for unit roots, resorting to the well-konwn Augmented Dickey-Fuller test. We conclude that both observed and perceived inflation are I(1) for all countries considered (see Table 1). The next step is to test for cointegration between observed and perceived inflation up to December 2001, that is, up to the moment immediately before the potential break point. Considering the Johansen trace statistic, we conclude in favour of the existence of a cointegrating vector for all countries (at a 5 per cent significance level, except for France, Belgium and Ireland

where we consider a 1 per cent significance level) (see Table 2). This evidence is also supported by the Engle and Granger cointegration test. Moreover, we also compute the cointegrating vector recursively to assess the stability of the relationship and we do not find evidence of parameter instability.

As a stable cointegration relationship has been found up to the moment of the euro cash changeover, we proceed into testing for a cointegration breakdown. For this analysis, we use the test recently proposed by Andrews and Kim (2006) (see, for example, Carstensen (2006) for an application). In contrast with other tests suggested in the literature, the tests developed by these authors are suitable for the case considered here, since the post-breakdown period is relatively short. The general underlying idea of these tests is that, if there is a break, the pre- and post-break point parameters of the cointegration relationship will be different. Moreover, by assuming a stable relationship during the whole sample period, the errors associated with the post-break point observations would be large. Hence, the suggested cointegration breakdown tests are generalizations of the well-known Chow stability test. Based on simulation results for size and power, Andrews and Kim recommend the P test statistic[8]. Taking as the break point the timing of the euro cash changeover, we obtained the results presented in Table 3. We find no evidence of a cointegration breakdown for the euro area as a whole, as well as for individual countries, at the time of the euro cash changeover. Hence, using the proposed measure for inflation perceptions, for the whole sample, we find no support for the idea that a gap, motivated by the euro cash changeover, has emerged between observed and perceived inflation.

4 Conclusions

The measurement of inflation perceptions has gained a lot of attention in the last few years, in the euro area. This renewed interest stems from the fact that apparently the euro cash changeover in January 2002 had a substantial impact on inflation perceptions. Using the well-known balance statistic, released by the European Commission, as a proxy for perceived inflation, a gap between observed and perceived inflation emerged after the introduction of the euro notes and coins. To try to explain the existence of a break in the relationship between

[8] The other test statistic proposed by Andrews and Kim (2006) is denoted by R. We also computed the R test statistic and the results are qualitatively the same.

observed and perceived inflation several explanations have been suggested, and even the credibility of consumer price measures was put at stake.

However, we show that one should be very careful when drawing conclusions from the simple balance statistic, which is only an adequate measure of the evolution of perceived inflation under special circumstances. To circumvent the limitations of the balance statistic, in this paper, we propose a more refined measure of perceived inflation, which was computed for the euro area as a whole, as well as for individual member countries. This measure is based on the probabilistic method and exploits the information from the question on inflation perceptions of the European Commission's consumer survey. As it overcomes the caveats of the balance statistic, the proposed measure of perceived inflation allows one to obtain a valid inference on the impact of the euro cash changeover. In sharp contrast with previous works, which rely on the balance statistic, we find no evidence of a break between observed and perceived inflation after the euro cash changeover, both in the euro area and in individual countries.

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Appendix

Let π_t^p be the perceived inflation rate, at time t. Let Z_t be

$$Z_t = \frac{\pi_t^p - E\left[\pi_t^p\right]}{\sigma_t}$$

the standardised perceived inflation rate. If one assumes that the perceived inflation rate has a Normal distribution then Z_t will have a standard Normal distribution.

Considering the five probability areas derived from the answers to the survey one can define

P_{1t}, the proportion of consumers surveyed at time t that believe that prices have risen a lot in the last 12 months, i.e., the inflation rate is above its moderate level;

P_{2t}, the proportion of consumers surveyed at time t that believe that prices have risen moderately in the last 12 months, i.e., the inflation rate is at its moderate level;

P_{3t}, the proportion of consumers surveyed at time t that believe that prices have risen slightly in the last 12 months, i.e., the inflation rate is below its moderate level;

P_{4t}, the proportion of consumers surveyed at time t that believe that prices have stayed about the same in the last 12 months, i.e., the inflation rate is nil;

P_{5t}, the proportion of consumers surveyed at time t that believe that prices have fallen in the last 12 months, i.e., the inflation rate is negative.

Using the inverse of the cumulative Normal standard distribution function it is possible to get the following four values of the Z variable

$$\begin{aligned} Z_{1t} &= F_t^{-1}(1 - P_{1t}) \\ Z_{2t} &= F_t^{-1}(1 - P_{1t} - P_{2t}) \\ Z_{3t} &= F_t^{-1}(1 - P_{1t} - P_{2t} - P_{3t}) \\ Z_{4t} &= F_t^{-1}(P_{5t}). \end{aligned}$$

Assuming that consumers report that their perceived inflation is at its moderate level if $\pi_t^m - \delta_t \leq \pi_t^p \leq \pi_t^m + \delta_t$ (where π_t^m is the moderate inflation rate) and is nil if $-\varepsilon_t \leq \pi_t^p \leq \varepsilon_t$ (see Figure 1) we get

$$
\begin{aligned}
Z_{1t} &= \frac{\pi_t^m + \delta_t - E\left[\pi_t^p\right]}{\sigma_t} \\
Z_{2t} &= \frac{\pi_t^m - \delta_t - E\left[\pi_t^p\right]}{\sigma_t} \\
Z_{3t} &= \frac{\varepsilon_t - E\left[\pi_t^p\right]}{\sigma_t} \\
Z_{4t} &= \frac{-\varepsilon_t - E\left[\pi_t^p\right]}{\sigma_t}.
\end{aligned}
$$

It is possible to solve this system for $E\left[\pi_t^p\right]$, σ_t, δ_t and ε_t, all scaled with respect to the moderate rate of inflation (π_t^m),

$$
\begin{aligned}
E\left[\pi_t^p\right] &= -\frac{Z_{3t} + Z_{4t}}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}}\pi_t^m \\
\sigma_t &= \frac{2}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}}\pi_t^m \\
\delta_t &= \frac{Z_{1t} - Z_{2t}}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}}\pi_t^m \\
\varepsilon_t &= \frac{Z_{3t} - Z_{4t}}{Z_{1t} + Z_{2t} - Z_{3t} - Z_{4t}}\pi_t^m.
\end{aligned}
$$

Table 1: Unit root tests (ADF)

	Sample period	Observed inflation		Perceived inflation	
		t-statistic	p-value	t-statistic	p-value
Euro area	Jan 1991 - Dec 2006	-2.52	0.11	-2.10	0.27
Germany	Jan 1985 - Dec 2006	-1.74	0.47	-2.81	0.06
France	Jan 1985 - Dec 2006	-1.89	0.38	-1.78	0.45
Italy	Jan 1985 - Dec 2006	-1.32	0.72	-2.19	0.23
Spain	Jun 1986 - Dec 2006	-1.24	0.76	-1.75	0.47
Belgium	Jan 1985 - Dec 2006	-2.40	0.15	-2.76	0.07
Netherlands	Jan 1985 - Dec 2006	-2.37	0.16	-2.82	0.06
Ireland	Jan 1985 - Dec 2006	-2.64	0.09	-2.21	0.22
Portugal	Jun 1986 - Dec 2006	-1.29	0.74	-0.87	0.89
Greece	Jan 1985 - Dec 2006	-1.82	0.43	-0.81	0.90

Table 2: Cointegration tests

	Johansen trace test				Engle-Granger test	
	r_0	N	λ_{trace} value	p-value	t-statistic	p-value
Euro area	0	2	17.73	0.02	-3.83	0.02
	1	2	3.84	0.05		
Germany	0	2	16.58	0.03	-3.63	0.02
	1	2	0.71	0.40		
France	0	2	26.58	0.00	-4.38	0.00
	1	2	4.43	0.04		
Italy	0	2	18.35	0.02	-3.49	0.04
	1	2	2.97	0.09		
Spain	0	2	28.02	0.00	-5.46	0.00
	1	2	3.61	0.06		
Belgium	0	2	29.80	0.00	-4.01	0.01
	1	2	5.31	0.02		
Netherlands	0	2	20.69	0.01	-3.49	0.04
	1	2	0.00	0.97		
Ireland	0	2	33.87	0.00	-3.52	0.03
	1	2	6.04	0.01		
Portugal	0	2	19.60	0.01	-4.65	0.00
	1	2	0.78	0.38		
Greece	0	2	15.86	0.04	-3.19	0.08
	1	2	0.40	0.53		

Note: 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. In the Engle and Granger test, under H_0 there is no cointegration.

Table 3: Cointegration breakdown test
P statistic

	p-value
Euro area	0.11
Germany	0.44
France	0.96
Italy	0.44
Spain	0.10
Belgium	0.82
Netherlands	0.07
Ireland	0.22
Portugal	0.67
Greece	0.65

Note: Under H_0 there is no cointegration breakdown. Only the p-values are reported, because the critical values change from case to case so that the test statistics themselves are difficult to interpret.

Figure 1 - Inflation perceptions distribution

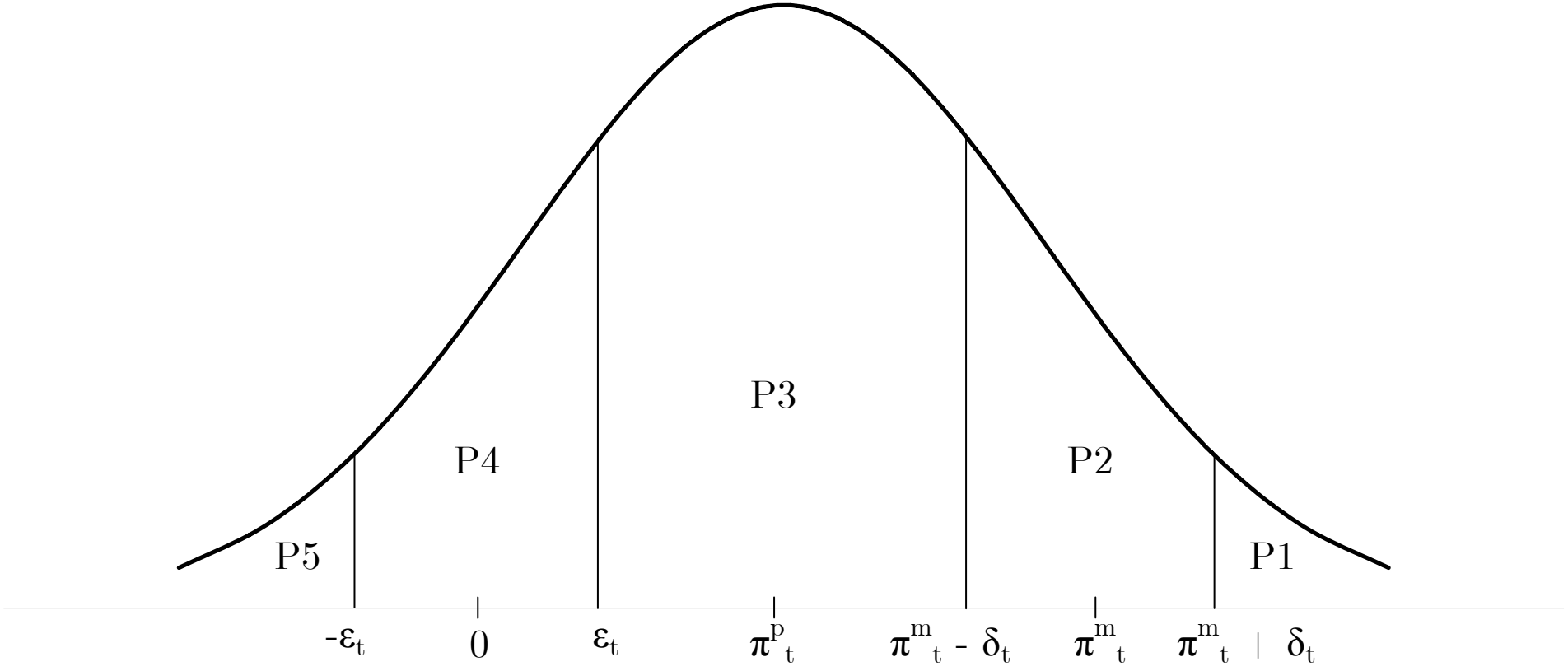


Figure 2 - Observed inflation, perceived inflation and balance statistic

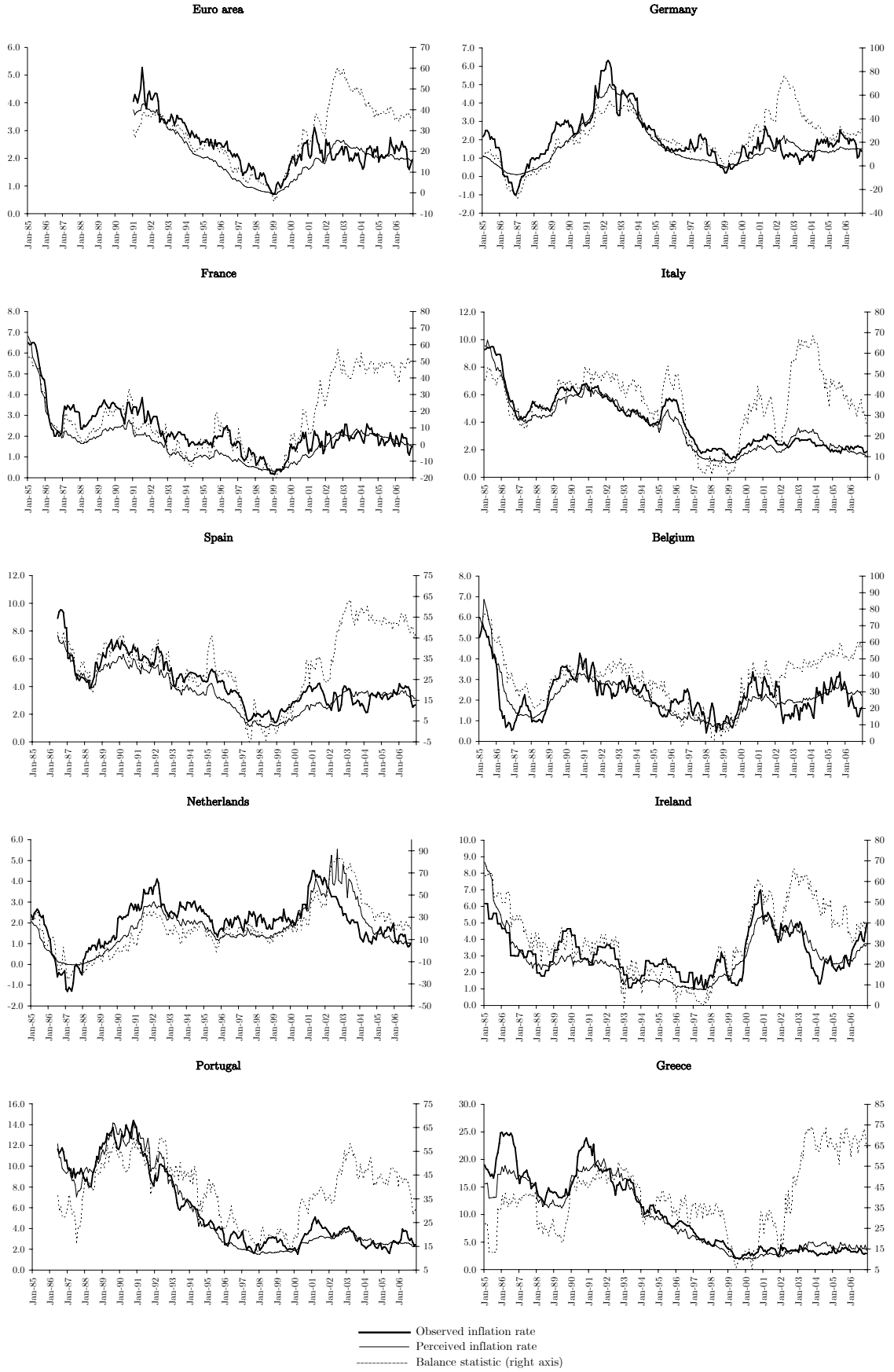


Figure 3 - Balance statistic and $(-Z_{3t}-Z_{4t})/(Z_{1t}+Z_{2t}-Z_{3t}-Z_{4t})$ for the euro area

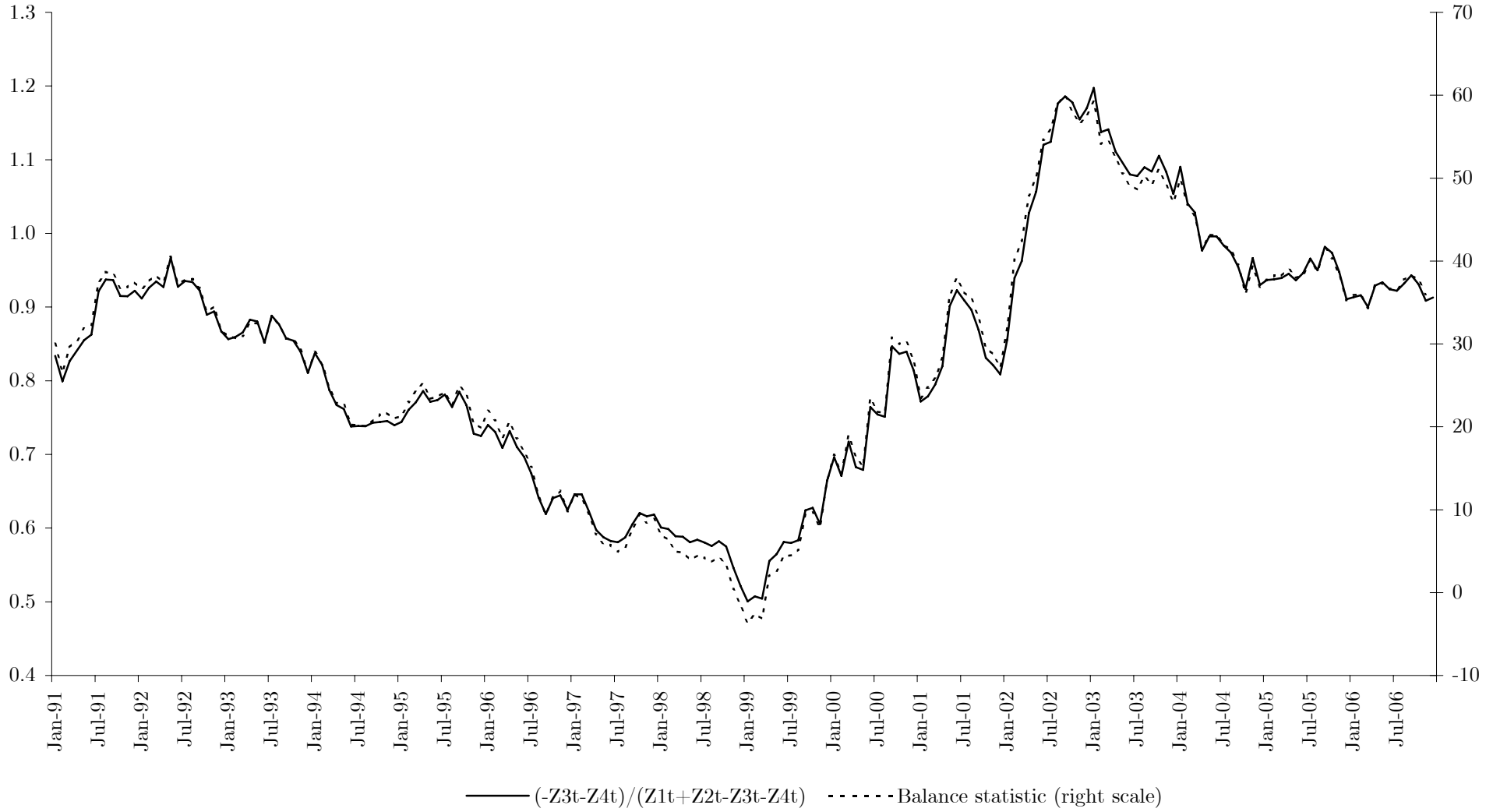
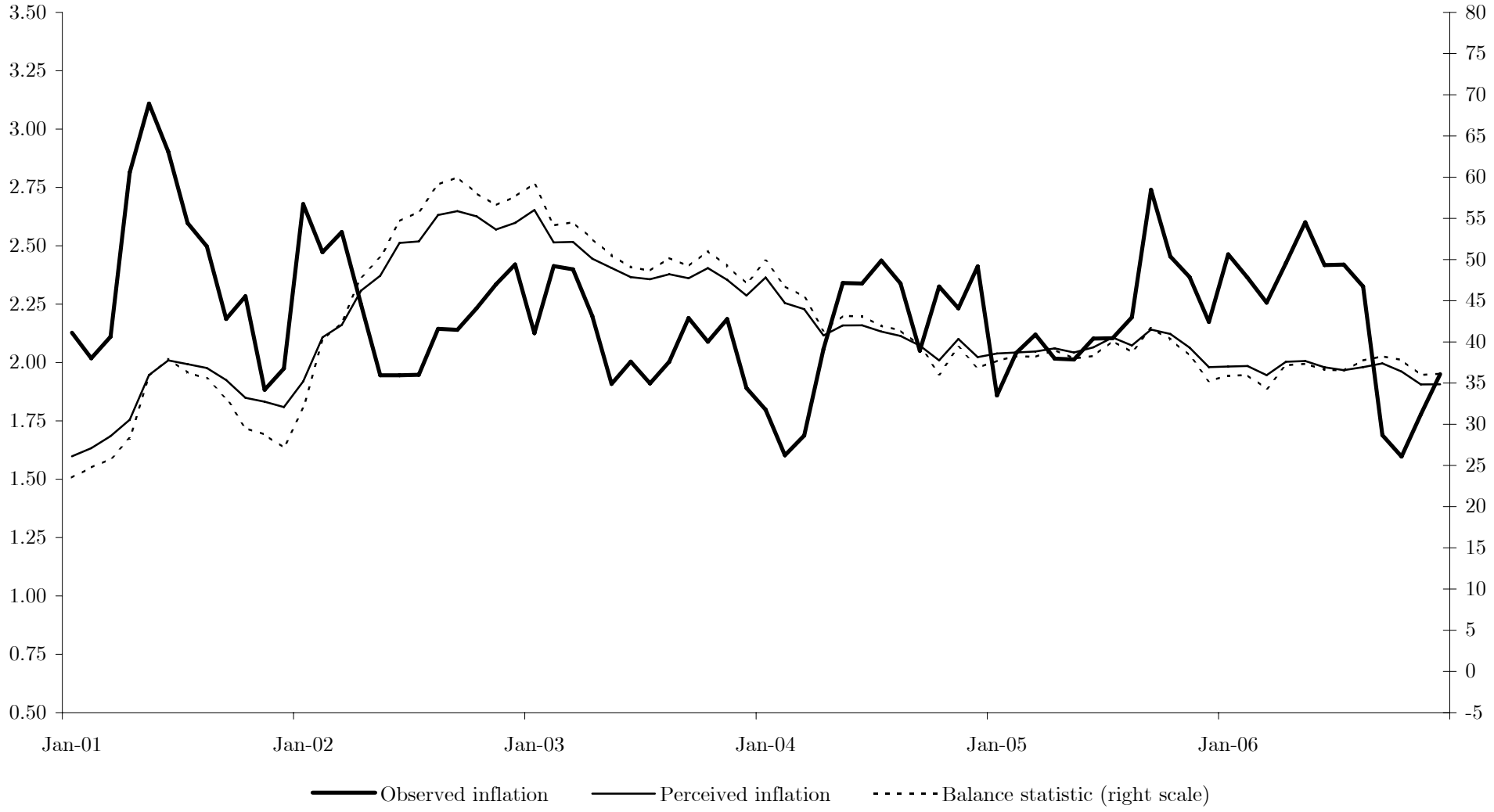


Figure 4 - Observed inflation, perceived inflation and balance statistic for the euro area



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