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The Euro Through the Looking-Glass

Perceived Inflation Following the 2002 Currency Changeover

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Abstract: Following the Euro changeover in January 2002, consumers across the Euro Area perceived a sharp rise in inflation, in contrast to official figures. Several theories have been advanced to explain this apparent economic illusion, but they struggle to account for its striking scale and persistence. We offer an alternative account, based on the premise that the currency changeover increased consumers' perceptual error when assessing the value of monetary amounts. Under plausible assumptions, this would lead them to experience a loss of purchasing power. We confirm two empirical hypotheses in support of the theory: (1) the extent of overestimation of inflation was strongly associated with subjective difficulty using the Euro; (2) there was a simultaneous downward shift in expected inflation. Our results imply that currency changeovers are not simple matters of numerical conversion.

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“It’s a poor sort of memory that only works backwards”

Lewis Carroll, *Alice Through the Looking-Glass*

1. Introduction

In January 2002, consumers in 12 European nations began to conduct transactions using Euro notes and coins. In the months that followed, those same consumers perceived a very steep increase in inflation (Aucremanne, Collin and Dhyne, 2005; Fluch and Stix, 2007; Antonides, 2008; and others; see Ranyard et al., 2008 for review). Official figures, meanwhile, showed the rate of inflation to be stable and, historically speaking, relatively low. There is no agreed term for this apparently illusory perception that the Euro changeover was followed by a period of rapidly rising prices, which hereafter we refer to as the “perceived Euro price increase” (PEPI). The PEPI was not only large, but also persistent. Although decreasing from its peak, perceived inflation was still historically high in most Euro Area countries in late 2006. A large majority of Euro Area consumers, 92.3%, think that the introduction of the euro added to the increase in prices.¹ The aim of this paper is to propose a new theory of what caused the PEPI.

It can be tempting to dismiss the PEPI as a psychological quirk or emotional response to the abandonment of the old domestic currencies. This would probably be a mistake. Misperceptions of inflation may have both macroeconomic and microeconomic consequences. There is a strong and consistent relationship between perceived inflation and expected inflation (e.g. Carlson, 1977; Jonung, 1981), a concept of recognised macroeconomic importance. Furthermore, perceptions of and expectations for inflation may affect consumers’ purchasing patterns. There is evidence that the Euro changeover negatively affected eating out in German restaurants (Eife and Maier, 2007). Controlling for background characteristics, consumers who overestimated inflation in Ireland between 2002 and 2007 were also keener to curb household expenditure and less likely to

¹ Flash Eurobarometer 193, The Eurozone, Five years after the introduction of the Banknotes and Coins in the 12 Member States, September 2006.

be planning to buy a car (Duffy and Lunn, 2009). Thus, perceptions of inflation, including misperceptions, may have significant impacts on economic activity.

The net has been cast wide in the hunt for a convincing explanation of the PEPI. Theories have been based on: overweighting price increases of cheap or frequently purchased items; rational inattention to price increases; the influence of expectations on subsequent perceptions; the role of the media in forming expectations and perceptions; additional weighting of salient price increases; and anchoring of reference prices in the old currency (see Section 2 for references). We argue below that, while each of these approaches may help to explain the PEPI, its primary cause has yet to be identified.

We propose a new theory. Our account is based on the idea that consumers perceived the value of monetary amounts with a greater degree of perceptual error following the currency changeover and that they took this error into account when conducting transactions. Given these assumptions, consumers would have felt a genuine loss of purchasing power.

Section 2 describes in greater detail the various explanations proposed for the PEPI, together with an assessment of supporting evidence. Section 3 outlines the new theory and derives empirical hypotheses. Section 4 provides the associated tests. Section 5 concludes.

2. Theories of the PEPI

2.1 The Scale of Misperception

In order to evaluate potential explanations, it is important to appreciate fully the dramatic nature of the change in perceptions that occurred after January 2002. The only consistent time series relating to inflation perceptions in the Euro Area, covering both before and

after the changeover, is provided by the Joint Harmonised EU Programme of Business and Consumer Surveys. The Consumer Survey asks EU consumers about their perceptions and expectations regarding price changes. Each country's sample consists of approximately 1,000 to 1,500 consumers. We use the results of these surveys for 1997 – 2006. Luxembourg is the only country excluded, because data prior to 2002 are not available.² Question 5 asks how prices compare with 12 months ago and offers respondents the following categories of response: Lower (r_1), About the same (r_2), A little higher (r_3), Quite a bit higher (r_4), Very much higher (r_5), Don't know (r_6). We employ the “balance statistic”, which is the standard EU-wide method for summarising responses to this question. It is calculated as:

$$(r_1 + \frac{1}{2}r_2) - (\frac{1}{2}r_4 + r_5).$$

The raw data for individual countries reveal much variation in the level and month-on-month volatility of the balance statistic. Given nuances of language, different inflation histories and the qualitative nature of the question, such variation across countries is perhaps unsurprising. We standardise the perceived and recorded inflation (HICP) data-series for each country by transforming them into Z-scores based on the mean and standard deviation from January 1997 to December 2001, i.e. for the five-year period prior to the changeover. Figure 1 presents month-on-month means for 11 Euro Area countries (unweighted) following this standardisation.

The balance statistic for perceived inflation tracks the HICP remarkably well in the period up to December 2001 – a good example of a “wisdom of crowds” effect. The onset of the PEPI is perfectly synchronised with January 2002, when a steep increase in inflation perceptions began, such that over the following six months a gap of more than 2.5 standard deviations opened up – five times greater than the largest overestimation in the preceding five years. The PEPI was not only dramatic in scale, but also in persistence. The overestimation of price rises continued at the approximate level established in mid-2002 for almost two years, after which it began to abate. Yet by the end of 2006, five years after the Euro changeover, the disparity for the Euro Area as a whole was still over

² Data for Portugal are missing for the first eight months of 1997, so all analyses for Portugal use only data from September 1997 onwards.

half what it was at its peak, although Figure 1 in fact masks significant between country differences (to which we return).

The primary job of any theory of what caused the PEPI is, therefore, to account for its extraordinary size and longevity. Existing explanations can be grouped into two types. First, there are theories that do not assert that consumers misperceived price changes on individual items, only that they weighted price increases on certain types of item disproportionately relative to official inflation calculations. That is, overestimation was caused by a systematic bias in the way consumers aggregate accurate assessments of price changes. Second, there are theories based on an upward bias in the perception of individual price rises, leading to a misperception of overall inflation.

2.2 Aggregation Errors

One possible account of the PEPI holds that there was a real increase in the price of those goods that consumers give most weight when assessing overall inflation. Frequently purchased items, such as food, clothing or restaurant meals, may have a greater impact on perceptions and some evidence suggests that they were subject to genuine price increases around the time of the changeover (e.g. Del Giovane and Sabbatini, 2006; Fluch and Stix, 2007; Brachinger, 2008). Alternatively, Dziuda and Mastrobuoni (2009) argue that there were genuine price increases for lower priced goods, because the Euro changeover led to a decrease in price transparency as consumers had difficulty dealing with prices after the cash changeover. If perceptions are driven by frequently purchased items or cheap items, such differential price changes might have caused perceived and recorded inflation diverge.

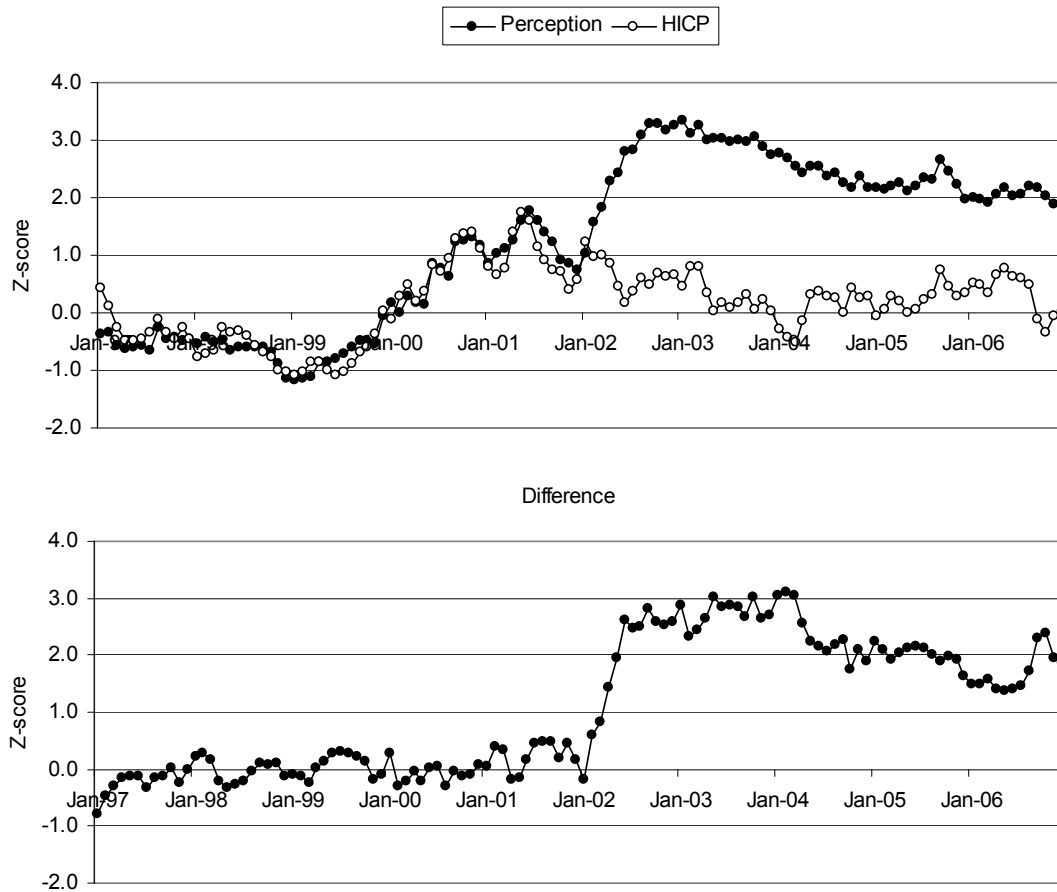
Although plausible, this account is hard to square with much empirical evidence. Firstly, econometric tests have produced at best mixed results. If the theory holds, inflation indices for frequent out-of-pocket expenditures (or similar subcategories) should have a very much greater influence than the HICP on inflation perceptions, which does not seem

to be the case (Ehrmann, 2006; Dohring and Mordonu, 2007). Structural breaks in the relationship between the inflation and perception time-series occur in 2002 (Vogel, Menz and Fritsche, 2009), suggesting the sudden impact of a separate influence. Furthermore, while Dziuda and Mastrobuoni (2010) confirm their hypothesis that the price of low-price items increased disproportionately across the Euro Area as a whole, the effect was not consistent across all countries, unlike the PEPI. Secondly, while the price of some frequently purchased goods, particularly food, did indeed rise disproportionately around the time of the Euro changeover (Ehrmann, 2006), the increase began in 2001. Yet the synchrony of the PEPI with January 2002 is clear and sharp (Figure 1). Lastly, similar relative price movements also occurred in European countries that opted not to join the Euro, yet no steep rise in inflation perceptions occurred.

A more sophisticated version of biased aggregation is due to Brachinger (2008), who develops an *Index of Perceived Inflation* (IPI). In addition to assuming that consumers overweight frequently purchased items, the IPI incorporates the assumption of loss aversion from Prospect Theory (Kahneman and Tversky, 1979). Thus, if the Euro changeover resulted in an unusually large number of price changes, loss averse consumers might give disproportionate weight to increases. Turning to empirical evidence, however, while a specific parameterisation of the IPI does display an increase for Germany in January 2002, it also results in much higher perceived inflation in 2001 (Hoffman, Leifer and Lorenz, 2006; Brachinger, 2008, Figure 4). Again, the problem is to explain an effect that is so large and precisely synchronous with January 2002.

In summary, although consumers may not aggregate price changes as official measures of inflation do, the empirical evidence does not indicate that aggregation biases were the main cause of the PEPI.

Figure 1: Perceived inflation and the HICP for the Euro Area, 1997 – 2006



2.3 Misperception of Individual Price Increases

An alternative proposition is that the introduction of Euro notes and coins resulted in an upward bias in the perception of individual price changes. Evidence certainly suggests that consumers found it hard to adjust to using the Euro. Ranyard (2007) provides evidence that consumers made pricing and other errors in Ireland following the changeover, while Hofmann, Kircher and Kamleitner (2007) found that the majority of a sample in Austria in 2004 failed to convert Euro amounts into Austrian schilling correctly. Ehrmann (2006) argues that such calculation errors would result from “rational inattention”, because rational consumers would devote less time and effort to making accurate price comparisons following the changeover, with variation across countries being produced by the differing cognitive demands of the conversion rate.

Yet the problem for such a theory is to explain why calculation errors were directional. Why would consumers have been much more inclined to conclude, erroneously, that a price had gone up rather than down? One possibility is that expectations influenced perceptions (Traut-Mattausch et al., 2004, 2007; Greitemeyer et al., 2005). Findings from social psychology suggests that people are more likely to perceive what they expect to perceive. If consumers expected price rises to accompany the Euro changeover, they may then have erroneously perceived them. Traut-Mattausch et al. (2004) provide experimental evidence showing that German subjects who compared prices between restaurant menus, priced first in Deutschmarks and then in Euros, perceived price increases that were not there. In a similar experiment, Greitemeyer et al. (2005) obtained even higher estimates of price increases from subjects in whom expectations of higher prices had been induced. Traut-Mattausch et al. (2007) further postulate a mechanism by which expectations influence perceptions: when consumers convert reference prices from the old currency into the new currency, they spot and correct mistakes when the calculation does not match expectations, but fail to do so when it does.

The theory that expectations of price increases biased perceptions can be subjected to a straightforward empirical test. Expected inflation should have risen prior to the Euro changeover by a magnitude consistent with the subsequent increase in perceptions. Expected inflation was indeed unusually high in Finland in 2001 (Koskimäki, 2005). We compare the perceptions and expectations time-series for the Euro Area and for 11 countries in Section 4.

Why would consumers expect the Euro changeover to push prices up? Ranyard et al. (2005) found that some Irish consumers expected firms to try to hide price increases, or to round prices up rather than down. There is also some evidence that media reporting after the changeover contributed to perceptions of rising prices (Soroka, 2006; Lamla and Lein, 2010). These influences are plausible, but if they constitute primary causes of the PEPI, why did the effect also persist over at least five years, long after the initial price changes and associated media interest?

The persistence of the PEPI seems to be more in keeping with evidence regarding how consumers compare prices. There is a body evidence to suggest that consumers employ reference prices stored in memory, be they single values or price ranges (see Mazumdar, Raj and Sinha, 2005, for review). Reference prices may be formed through experience over a number of years. One possibility, then, is that for many items consumers failed to update reference prices from the old currency into Euro, resulting in ongoing inflation perceptions being biased upwards by comparison with prices in 2001, rather than twelve months previously (Brachinger, 2008).

Table 1 shows that a large proportion of Euro Area consumers were still regularly converting prices into their old currency even in 2008, especially for exceptional rather than day-to-day purchases. Thus, unless consumers continued to update references prices in the old currency even after it was no longer in use, pre-Euro reference prices might have continued to influence perceptions of changing prices. Stix, 2009, using data from a 2004 survey suggests that a factor behind the persistence in Austria seems to be the use by a large fraction of the population of legacy currency prices when making price comparisons. Furthermore, there is evidence that consumers' recollections of some pre-Euro prices are subject to a downward bias, with recalled prices dating back to well before the changeover (Cestari, Del Giovane and Rossi-Arnaud, 2006).

Table 1: Extent of price conversion into the old currency in 2008. Responses across Euro Area to survey question: *When purchasing, do you count mentally...?*

	Exceptional purchases*	Day-to-day shopping
	%	%
Most often in euro	34.4	61.2
Most often in national currency	40.3	21.1
As often in euro as in national currency	25.3	17.6
	100.0	100.0

* For example the purchase of a house or a car

Source: Flash Eurobarometer 251, September 2008

2.4 Summary of Previous Theories

A number of plausible theories of the PEPI have been advanced, based on biases in consumers' aggregation of price changes and misperceptions of individual price changes. The former theories, however, do not appear to account for the precise timing of the PEPI, which is perfectly synchronised with the introduction of notes and coins in January 2002. The most promising of the latter theories concerns the possibility that consumers expected price rises following the Euro changeover, biasing their subsequent perceptions. There is some supporting experimental evidence for this theory, but it struggles to account for the persistence of the PEPI, which seems more in keeping with a failure to update reference prices from the old currency.

Looking across the available theory and evidence, the suspicion arises that the primary cause of the PEPI may not have been identified. We therefore offer a possible alternative.

3. A Theory Based on Perceptual Error

3.1 *The Psychophysics of Exchange*

Standard (Hicksian) consumer theory focuses not on the *process* of exchange, but on the *desirability* of exchange. Its aim is to define the consumer bundle that maximises utility, rather than to address the process by which opportunities to gain utility are identified and taken advantage of. Accurate perceptions of relative prices and value (or utility) are assumed and present no impediment to the prosecution of exchanges.³ Whatever one's preferences, however, the process of exchange is likely to be constrained not only by budgets, but also by the accuracy of human perceptions of value. This applies to perceptions of both the value of monetary amounts and the value of items on offer. In

³ Throughout this paper we use 'value' rather than 'utility' when addressing the question of what goods and services are worth to individuals. We use 'perceived value' to refer to an agent's assessment of what a given item is worth to them. We do not use 'utility' in this context because we are considering the nature of the mental representation of what things are worth and do not wish to imply that it is represented as an ordered set of preferences.

order to determine that a gain from trade can be made via an exchange, an economic agent must be able to discriminate a positive difference in value between what is gained and what is given up, i.e. the agent must compare two mental representations of value and form another perception of the likely transaction surplus. Our theory emphasises that this process of discrimination will depend on the degree of error associated with perceptions of value.

Little is known about how accurately humans perceive value, although much is known about perceptual systems and the process of perceptual discrimination generally. The relevant psychophysical evidence is discussed in detail in Lunn and Lunn (2009), which advances a computational theory (c.f. Marr, 1982) of simple economic exchanges, designed to explain gaps between willingness-to-accept and willingness-to-pay. Briefly, psychophysicists use forced-choice discrimination experiments to measure the precision, or degree of stochastic error, in our internal representations of the world around us. Even when subjects are asked to discriminate between two stimuli differing according to a perceptual primitive such as size or weight, and where the subject is in a controlled environment and is given task-specific practice, a difference of at least 5 – 10 % (the “Weber fraction” or “threshold”) is required for subjects to discriminate between two stimuli reliably. For more complex perceptions, discrimination thresholds are considerably higher, implying a higher degree of perceptual error. Experiments also show that when more than one perception must be combined to make an overall judgement, subjects are able to weight their judgements according to the different degrees of error associated with each perception, e.g. when information from vision and touch is combined into an overall assessment of shape (Ernst and Banks, 2002).

Considered in this context, the values of goods and services are complex perceptions. They require not only consideration of perceptual primitives such as size, weight and colour etc., but also perception of higher order properties such as fashionability, taste or durability, or even properties like promptness, courtesy and skill. It is therefore likely that human perception of the value of goods and services is subject to substantial error. What

about perceptions of the value of monetary amounts? There is some evidence that, when using a familiar currency, the accuracy of consumers' perceptions of the value of monetary amounts may be similar to that for perceptual primitives such as size. For example, estimates of Weber fractions for discriminating between pay rises are of the order of 5 – 7 % (Mitra, Gupta and Jenkins, 1997).⁴

We use this knowledge of the mechanisms of perceptual discrimination to generate three psychophysical assumptions. First, agents perceive value with substantial stochastic error. Second, the perceptual error associated with the value of monetary amounts increased following the Euro changeover. Expressed intuitively, consumers had a good feel for what five marks, five francs, five gilder etc. was worth, but following the changeover, they were less sure what five Euro was worth. Third, agents can estimate the extent of their own perceptual error and take it into account when deciding whether to exchange. While these assumptions are primarily motivated by psychophysical evidence unconnected with exchange behaviour, this last assumption is also supported by direct evidence that subjects are influenced by uncertainty of valuation when setting willingness-to-pay and willingness-to-accept in exchange experiments (Horowitz and McConnell, 2002).

3.2 Potential Impact of Currency Changeover on Exchange

We now consider the effects of these three assumptions on the process of exchange. Figure 2 presents a schematic account of a simple exchange incorporating significant perceptual error, in line with our first assumption. The agent employs a continuous internal representation of value (horizontal axis) to compare their perception of an

⁴ It is important to note here that the fact that monetary amounts can be represented as precise numerical values does not imply that their value can be perceived without error. While forced-choice discrimination between two monetary amounts can be performed with perfect accuracy, by simply choosing the larger or smaller number, the comparison of the value of a monetary amount with the value of an item requires conversion of each perception into a common mental representation. There is evidence that the brain processes rewards using a sort of “internal currency” (e.g. Montague and Berns, 2002). In doing so, the mapping from monetary values into the internal currency will be subject to a degree of error, or noise, which will limit the precision of subsequent discriminations using the internal currency.

amount of money, P , with their perception of an item, A . Perceptual error is reflected in the variability of the probability density functions that form the representations. The agent can base the decision of whether to buy on both the expected values and the variabilities of their perceptions. We assume for now that perceptual errors are normally distributed. This assumption is well supported by psychophysical evidence for many types of stimuli, but is not essential to the logic of our theory.

Suppose that, in exchange for A , the agent is just willing to pay money in the old currency that they perceive to be worth P_c . Prior to the introduction of the Euro, the agent's perceptions were (Figure 2, top)

$$A \sim N(\mu_a, \sigma_a^2) \quad \text{and} \quad P_c \sim N(\mu_p, \sigma_c^2).$$

Assuming no covariance between the perceptual errors, the agent was willing to trade to realise an expected surplus (Figure 2, bottom) of

$$E(\text{surplus}) = A - P_c \sim N(\mu_a - \mu_p, \sigma_a^2 + \sigma_c^2).$$

Following the introduction of the Euro, our second psychophysical assumption implies that the internal representation of the equivalent monetary amount changed from P_c to P_e . It is possible the changeover might also have produced a systematic bias in the perception of value, especially where consumers used an approximate rule of thumb for making the conversion (e.g. €1 → 2 DM), but here we consider the case where the expected value remained unchanged:⁵

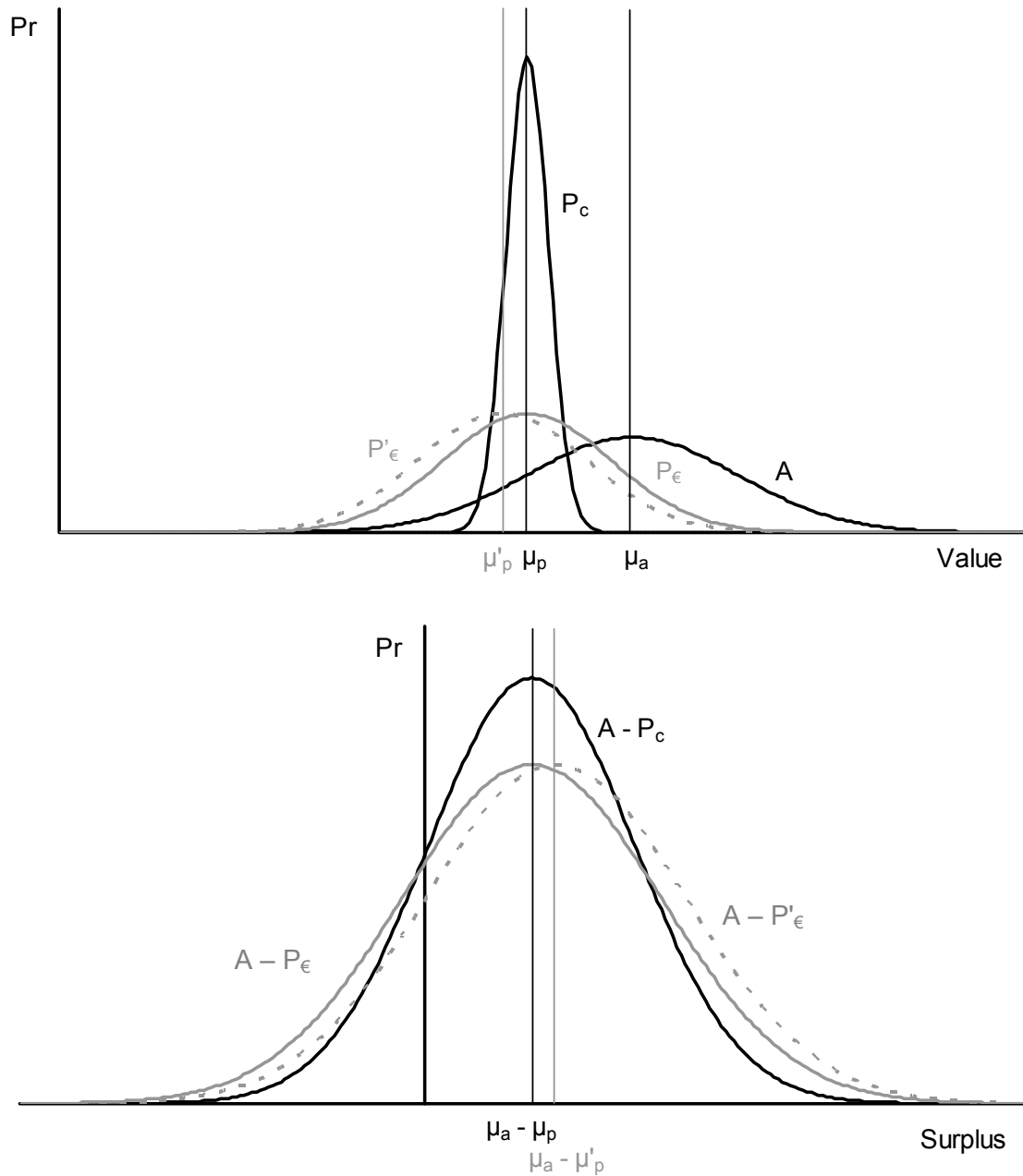
$$P_e \sim N(\mu_p, \sigma_e^2), \quad \text{where} \quad \sigma_e^2 > \sigma_c^2.$$

The impact on the perceived surplus from the transaction is:

$$E(\text{surplus}) = A - P_e \sim N(\mu_a - \mu_p, \sigma_a^2 + \sigma_e^2), \quad \text{where} \quad \sigma_a^2 + \sigma_e^2 > \sigma_a^2 + \sigma_c^2.$$

⁵ The exact conversion rate was €1=1.95583 DM. Using a rule of thumb of €1=2DM overestimates euro prices by 2.26%. For other countries, similar rules of thumb produce biases ranging from -2.23% to 6.71%. For a discussion of this aspect of the changeover see Ehrmann (2006).

Figure 2: Schematic account of the impact of increased perceptual error following the Euro changeover. In the old currency, a consumer was willing to pay a monetary amount of perceived value P_c to obtain an item of perceived value A (top). The changeover increased the perceptual error surrounding monetary amounts [$\text{Var}(P'_{\epsilon}) > \text{Var}(P_{\epsilon})$]. The expected surplus (bottom) was unchanged, yet increased variability in the surplus may make the consumer unwilling to pay the amount of perceived value P_{ϵ} and willing only to pay the amount of perceived value P'_{ϵ} instead. This loss of purchasing power is akin to inflation.



Thus, the introduction of the Euro changed the nature of transactions for agents able to take account of both expectation and variability of the perceived surplus – our third assumption.

A risk-averse agent who was just willing to pay the monetary amount perceived as P_c , may have become unwilling to pay the equivalent Euro amount perceived as P'_e . Yet risk aversion is only one possible rationale for altering the willingness to pay. A second potential rationale is loss aversion. Given sufficient perceptual error surrounding the value of the item, the currency change increased the probability of making a loss. A third rationale is offered by the computational theory of exchange offered by Lunn and Lunn (2009), who show that an optimising agent will reduce willingness-to-pay and increase willingness-to-accept in response to increased error in perceived value, given the plausible assumption of a positive correlation between the extent of perceptual error and price dispersion in the market. For the present purposes, however, it is immaterial which rationale drives behaviour. Our conjecture is only that the increased perceptual error surrounding monetary amounts reduced the likelihood of exchanges at prices equivalent to those in the old currency.

Returning to Figure 2, the agent may now only be willing to pay the amount perceived as worth P'_e . Thus, in terms of consumers' willingness to make purchases in the new currency, the Euro lost value relative to the currency it replaced. Note that the change represents a genuine loss of purchasing power. In the case of a risk- or loss-averse consumer, a greater share of income is being paid to combat risk or loss, reducing the expected value of goods and services consumed.⁶ Thus, we add the final assumption that consumers translate this loss of purchasing power as increased inflation. Evidence in support of this assumption comes from studies showing that consumers incorporate changes in income into their assessments of inflation (e.g. Gamble, 2006). Given this, the consumer will perceive a price rise equivalent to:

$$P_c - P'_e.$$

⁶ The loss of purchasing power for a consumer behaving according to the computational theory of exchange (Lunn and Lunn, 2009) is harder to explain outside the context of a formal model, but similarly would consist of reduced trade.

3.3 Derivation of Empirical Hypotheses

Our theory implies that when consumers started using the Euro, they began to experience decreased purchasing power. It is hard to be explicit regarding how long it would take for these experiences to generate a perception of economy-wide inflation, and hence for the PEPI to emerge fully, but we find a relatively sharp increase spanning six-to-nine months (see Figure 1) intuitively reasonable. This time period would be required for consumers to experience exchanges involving a range of item categories, rather than just frequently purchased items. Similarly, while it is hard to be explicit about the persistence of the PEPI, the pattern of behaviour revealed by Table 1 suggests that a comparison process akin to that in Figure 2 could have persisted as long as reference prices were held in the old currency and the value of Euro amounts was perceived with greater error. Consumers' ongoing desire to use of the old currency is suggestive that both of these premises hold.

However, it is preferable to look for an original empirical hypothesis linking perceptual error to the extent of the PEPI over time. We therefore searched for a variable to proxy for perceptual error in valuation of amounts expressed in Euro. After considering various options, we decided that the following question from the Eurobarometer surveys was most suitable:

It's X years since we have been using the euro instead of (nat. currency). Today would you say the euro continues to cause you a lot of difficulty, some difficulty or no difficulty at all?

Of course, consumers' difficulties when using the Euro might not consist only of problems assessing value. They could also include recognising notes and coins, handling them, managing personal finances and so on. Nevertheless, the primary force of this question relates to consumers' ease of making purchases in Euro, which people would be sure to consider this when answering such a question. Our first empirical hypothesis is therefore that the strength of the PEPI across countries and time will be related to

consumers' subjective difficulty using the Euro. We test this using orthodox econometric techniques for estimating panel data.

What do the other theories of the PEPI predict? Aggregation based theories assume accurate perception of prices changes and thus predict no clear relationship between ease of operating in the currency and the PEPI. The theory that expectations drove perceptions also makes little in the way of a concrete prediction, unless we consider the elaborated version of Traut-Mattausch et al. (2007), which posits that expectations resulted in an unwillingness to correct mistakes. If the level of self-expressed difficulty in using the Euro is related to the likelihood of making conversion errors, then it could be argued that there should be a correlation between difficulty using the new currency and the PEPI. However, we simultaneously control for inflation expectations.

Our second empirical hypothesis surrounds expectations of future inflation and is linked to the first. If there is a relationship between subjective difficulty using the Euro and the size of the PEPI, then this implies that consumers were aware of their own shortcomings in using the new currency. Thus, to the extent that they expected to learn to use it better, our theory implies that consumers should have expected their purchasing power to increase again. Our second hypothesis is thus that January 2002 should have seen the emergence of a *downward* influence on expectations of future inflation, resulting in a break in the previous relationship between perceptions of current inflation and expectations of future inflation. This hypothesis is distinctive and therefore empirically appealing. Although the extent of the hypothesised downward shift in expectations is hard to predict, because it would have depended on how fast consumers expected to learn, it should have also been synchronous with the rise in perceptions.

What do other theories of the PEPI imply about the relationship between perceptions and expectations? Theories based on biased aggregation of price increases would predict that the relationship should continue as before, or at least they provide no reason to suggest otherwise. The theory that prior expectations pushed up perceptions makes a more

concrete prediction: the rise in perceptions should have been foreshadowed by a rise in expectations that was at least approaching the same order of magnitude. Thus, the different theories produce contrasting and easily testable empirical hypotheses regarding the relationship between perceptions and expectations. A final point to note here is that both types of theories rest on consumers making *unwitting* errors, so it is hard to see how they could have taken the errors into account when forming expectations. In contrast, we hypothesise that consumers knew that their own difficulty valuing the currency was reducing their purchasing power and so could take account of learning when forming expectations.

4. Empirical Analysis

4.1 Data

The subjective “difficulty” variable is available from a series of “Flash” Eurobarometer surveys assessing attitudes to the new currency, which the EU conducted following currency changeover. Responses across the Euro Area are available for nine dates, five in 2002 (January, March, May, September, November), November 2003, November 2004, October 2005 and September 2006. We convert the responses into a balance statistic in similar fashion to the balance statistic for perceptions.⁷ We employ this data alongside the EU Consumer Survey data on perceived and expected inflation, and recorded inflation (HICP) taken from official figures.

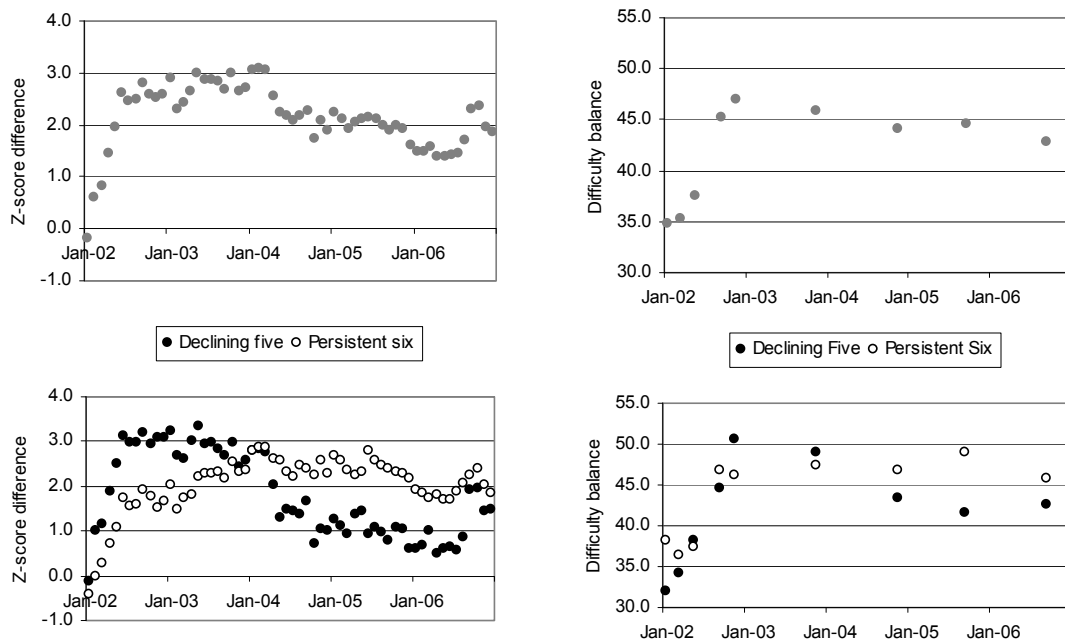
4.2 Subjective Difficulty Using the Euro and Perceived Inflation

The top panels of Figure 3 compare the progress of the PEPI over time with that of consumers’ subjective difficulty using the Euro. The pattern is strikingly similar. A steep rise during 2002, followed by a gradual decline. In the bottom panels of Figure 3, we

⁷ For the period January 2002 – September 2002, the question had four possible responses: a lot of difficulty (r1), some difficulty (r2), a bit of difficulty (r3) or no difficulty at all (r4). From November 2002 – November 2006, response r3 was removed. To cope with this change, we calculate the balance statistic as $[(r_1 + \frac{1}{2}r_2) - \frac{1}{2}r_4]$ throughout, adding 50 to make the statistic positive.

repeat the analysis with the countries divided into two groups, based on a comparison of the PEPI for the period January 2002 – June 2004 and July 2004 to December 2006. In Austria, Belgium, Germany, the Netherlands and Spain (the “declining five”), the PEPI was significantly reduced in the later period, while for the other six countries (the “persistent six”) the PEPI was as large in the second period as it was in the first.⁸ Again, the series are very similar, consisting of a steep initial rise for the declining five countries following by a slower fall, and a shallower rise followed by a levelling off among the persistent six. The similarity of the pattern between the PEPI and consumers’ self-expressed difficulty using the Euro is consistent with our theory.

Figure 3: The PEPI (left) and self-expressed difficulty using the Euro (right), 2002 - 2006. Top panels are the mean (unweighted) for 11 Euro Area countries. Bottom panels provide separate series for the five countries with declining PEPI and six countries with persistent PEPI.



⁸ The one nation which is hard to classify is Italy, where there was a very marginal decline. Repeating the analysis with Italy in the declining group makes no discernable difference to the results.

The univariate analysis of Figure 3 suggests a strong association between the dramatic increase in perceptions of inflation and consumers' difficulty using the Euro. To test this further, while controlling for the level of inflation itself and for inflation expectations, we explored a variety of panel data estimation methods, using the Z-score difference between perceived inflation and the HICP as the dependent variable. This is our preferred measure of the PEPI, because it captures the extent of the gap between perception and reality relative to recent history. To test whether unusually high expected inflation drove higher perceived inflation, we included the standardised Z-score difference between expected inflation and perceived inflation twelve months previously.⁹ Because we had sparse data on subjective difficulty using the Euro, we employed a linear interpolation at the country level, to allow estimation on month-by-month data.¹⁰ The subjective difficulty variable for each country enters the model as the increase in the balance statistic from the level of January 2002.

Initial investigations using a standard panel model with country fixed effects revealed unsatisfactory serial correlation in the residuals. Given that the dependent variable and two of three independent variables were constructed from balance statistics based on categorical survey questions, conducted in countries with different languages and inflation histories, this is perhaps unsurprising. The strength of the associations between these categorical variables would be likely to be subject to random effects. Hence, we employed a model with random effects for each covariate and sequentially tested the restriction that the coefficient was the same for each country. The tests rejected this restriction in each case.

The first column of Table 2 presents a random effects model for the ten-month period from January to November 2002. The coefficients reveal that the size of the PEPI was

⁹ It is important that this variable is expressed as the difference between expectations and perceptions, firstly because we are interested in the potential role of unusually high inflation expectations, but secondly because the two variables are highly correlated. Simply entering the expectations balance statistic as a variable therefore confounds the level of expectations with the level of perceptions one year previously, which might reasonably be expected to be related to current perceptions, regardless of expectations.

¹⁰ Other forms of interpolation were also tried, but the results are not sensitive to the method of interpolation.

reduced in countries with higher recorded inflation following the changeover, as might be expected. With respect to expectations, although the coefficient is positive, we find no significant effect of expectations in 2001 on the size of the PEPI in 2002. On the other hand, the variable for subjective difficulty using the Euro is highly significant, confirming the suggestion of the univariate analysis.

Table 2: Random effects panel regression of Z-score difference between perceived and recorded inflation.

	(1) <i>Jan. 2002–Nov. 2002</i>		(2) <i>Jan. 2002–Sep. 2006</i>	
	β (s.e.)	$p > z $	β (s.e.)	$p > z $
HICP	-0.963 (0.210)	0.000	-0.957 (0.356)	0.007
Expected Inflation (t - 12 months)	0.151 (0.217)	0.486		
Difficulty Using the Euro	0.073 (0.015)	0.000	0.069 (0.026)	0.008
Intercept	3.685 (0.445)	0.000	3.732 (1.179)	0.002
<i>Random effects parameters</i>				
s.d. (HICP)	0.458 (0.117)		1.161 (0.268)	
s.d. (Expected Inflation)	0.595 (0.240)			
s.d. (Difficulty)	0.036 (0.017)		0.082 (0.023)	
s.d. (Residual)	0.473 (0.040)		0.652 (0.019)	
Log restricted-likelihood	-113.721		-690.213	
No. Obs.	110		616	

Ideally, we wanted to run the same panel regression from 2002 to 2006. However, the diagnostics of such a model are poor, because it turns out that there is a structural break in the relationship between expected inflation and perceived inflation either side of 2002 (see next section). Thus, the second column of Table 2 presents a model for the full time period with expected inflation excluded. Again, the level of recorded inflation and

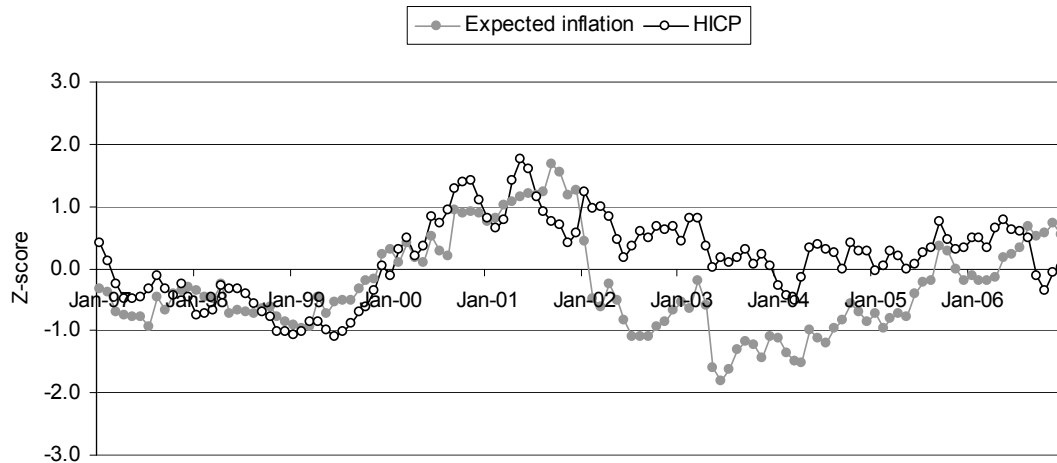
subjective difficulty using the Euro are highly significant. Note that for both models, the random effects parameters reveal that the standard deviation of the coefficient for subjective difficulty is such that the effect is strongly positive across all countries. Applying the same logic to the standard deviation of the coefficient for expected inflation suggests that the relationship varied very considerably across countries. Hence, there may have been some countries where the impact of expectations was markedly stronger, despite the fact that we found it to be non-significant across the Euro Area as a whole.

It could be argued that perceiving high inflation might itself cause people to experience difficulty using the Euro, i.e. that causation runs in the opposite direction, from the perception of inflation to subjective difficulty using the new currency. We do not find this argument convincing, because the question in the Eurobarometer seems to us to relate to difficulties experienced in everyday use of the new currency, but it cannot be ruled out. Other potential mechanisms could doubtless be proposed to account for this strong relationship.

4.3 The Impact on Expected Inflation

Figure 4 presents Z-scores for the expected inflation balance statistic and the HICP for the Euro Area in identical fashion to Figure 1 for inflation perceptions. Both series are standardised as before, according to the mean and standard deviation between January 1997 and December 2001.

Figure 4: Expected inflation and HICP inflation for the Euro Area, 1997 – 2006



The hypothesis of sudden downward pressure on expected inflation following the Euro changeover is confirmed. As is the case for perceived inflation, the standardised balance statistic for expected inflation tracked the HICP closely prior to January 2002. There was then an abrupt decline in expected inflation which, while not quite as dramatic as the increase in perceived inflation, was nevertheless substantial and exactly coincident with January 2002. Thus, there were sudden breaks in the relationships between all three variables (perceived inflation, expected inflation and recorded inflation) and it seems extremely unlikely that the phenomena depicted in Figures 1 and 4 are unconnected. Noteworthy, too, is that the fall in inflation expectations was persistent. As late as early 2006, expected inflation remained historically low.

Figure 4 is difficult to reconcile with the theory that the PEPI was caused by expectations influencing subsequent perceptions. Inflation expectations were not unusually high during 2001. There is some suggestion of an increase during the final four months, but expectations fell in October and November 2001. At no point was the gap between the two series more than one standard deviation, yet by the middle of 2002 perceptions were more than 2.5 standard deviations higher (Figure 1). Furthermore, given that expected inflation fell sharply in the first half of 2002, the expectations theory implies that perceptions should have begun to fall rapidly thereafter, which they did not.

We present separate analyses for all 11 countries in Appendix A. Every one experienced a substantial fall in inflation expectations following the Euro changeover. While it is difficult to see how this pattern could emerge if perceptions were being driven by expectations, it is notable that in two countries, Finland and Belgium, expectations in 2001 did reach the sort of historically high levels that would be required to explain the jump in perceptions that followed. It may be, therefore, that inflation expectations contributed to the PEPI to some extent in these two countries, which would be consistent with the large standard deviation on the expected inflation coefficient in the first column of Table 2. However, even in Belgium and Finland the changeover was followed by a sharp fall in expected inflation, which was not matched by a similar fall in perceptions, implying a break in the relationship between the two.

5. Discussion

The theory that the PEPI was caused by stochastic error in the perceived value of monetary amounts expressed Euro was supported by the results of two empirical tests. First, assuming that self-expressed difficulty using the Euro is linked to people's ability to value Euro amounts, we hypothesised a positive relationship between self-expressed difficulty and the PEPI across time and countries. This hypothesis was confirmed in a random effects panel model that controlled for the level of inflation and prior expectations of inflation. Second, consumers could reasonably expect to become more accurate in their assessments of what amounts in Euro were worth over time and, hence, see their purchasing power bounce back. Empirically, expected inflation fell across 11 Euro Area following the changeover.

While these findings are encouraging from the perspective of our theory, there are doubtless other possible interpretations of them. The changed relationship between perceptions and expectations would be consistent with any theory of the PEPI based on a perceptual or cognitive problem that consumers could reasonably expect to overcome. Similarly, such a theory might also imply a strong relationship between subjective

difficulty using the new currency and the perception of higher inflation. The mechanism we propose may thus be only one of a class of theories with the potential to fit the evidence supplied in Section 4.

We find it difficult to reconcile this evidence with previous theories of the PEPI. Theories based on biases in the way consumers aggregated otherwise accurately perceived price rises, which in any case do not appear to match the temporal pattern of the PEPI (see Section 2), appear unable to explain the similarly dramatic change in inflation expectations. Secondly, while the theory that perceptions were influenced by prior expectations can potentially account for the link between subjective difficulty using the currency and the PEPI, it is difficult to see how it can account for the fact that the very steep rise in perceptions of inflation was not foreshadowed by a similar increase in inflation expectations for 9 out of the 11 Euro Area countries, or for the failure of the fall in expectations in 2002 to be followed by a similar fall in perceptions.

The expectations driven theory does have supporting evidence from experimental studies showing that consumers perceive non-existent price rises in simple comparisons of restaurant menus priced in Deutschmarks and Euros (Traut-Mattausch et al., 2004; Greitemeyer et al., 2005). However, our theory based on uncertainty of value might predict similar results, since it is founded on the idea that consumers perceive less purchasing power in individual transactions. We hope it may be possible to devise an experiment that could explicitly distinguish between the two theories.

Our theory has implications regarding the ultimate effects of the switch to the common currency. The PEPI may have had a dampening effect on consumption. Given that the period following the changeover coincided with a period of historically low interest rates and credit expansion, this may not have had significant macroeconomic consequences. Nevertheless, for any country seeking to join the Euro in future, or for countries seeking other currency switches, the potential for dampening consumption may be important. More straightforwardly, whatever turns out to have been behind the PEPI, the

phenomenon strongly suggests that currency changeovers are not simple matters of numerical conversion.

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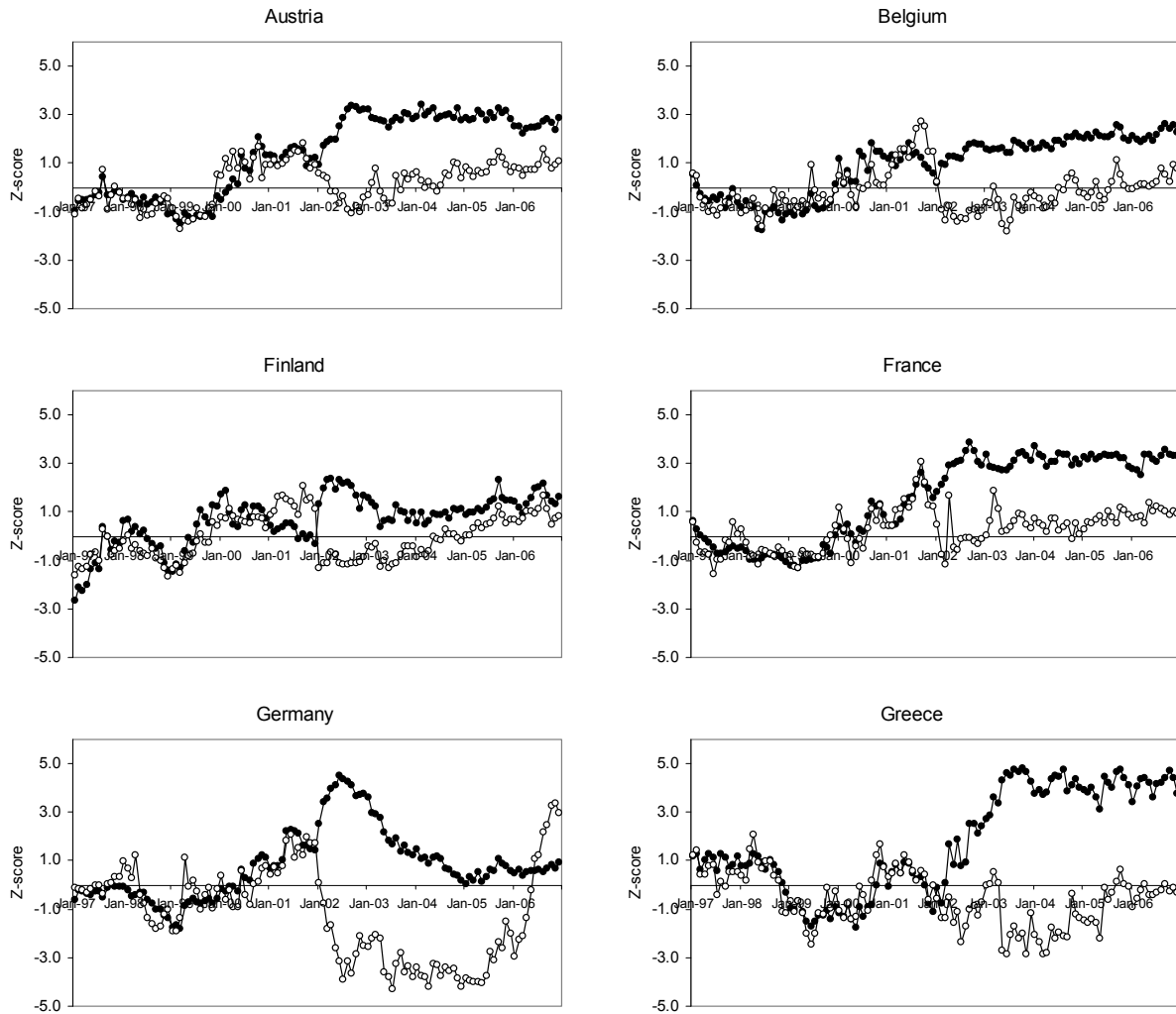
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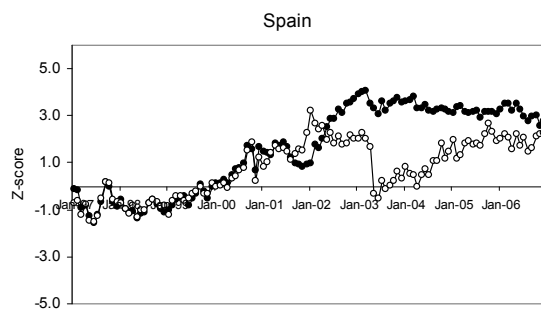
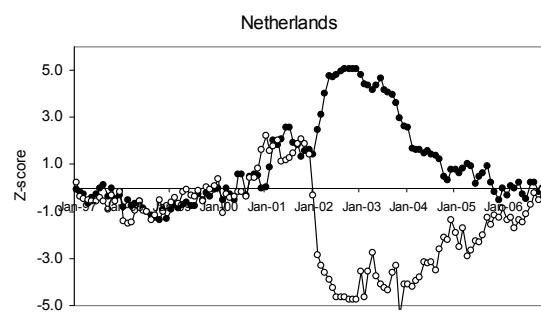
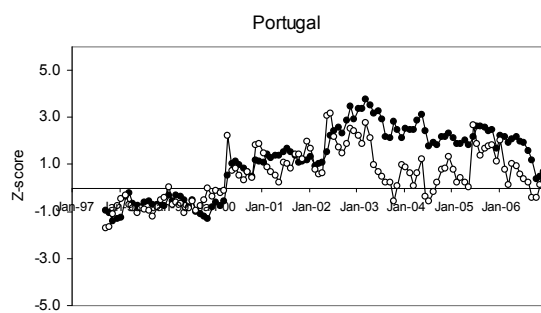
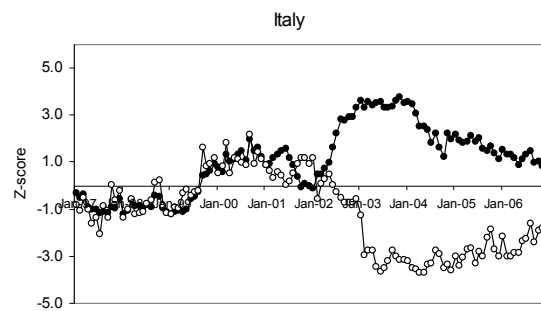
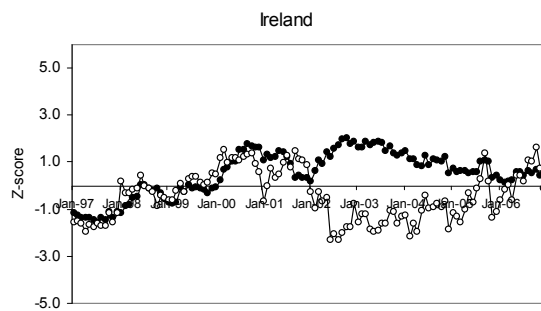
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Appendix

Inflation perceptions (solid circles) and inflation expectations (open circles) for 11 Euro Area countries (excluding Luxembourg) for the period 1997 – 2006. Z-scores are standardised using the mean and standard deviation of each series from January 1997 – December 2001.



Appendix cont...



Year	Number	Title / Author(s) ESRI Authors/Co-authors <i>Italicised</i>
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