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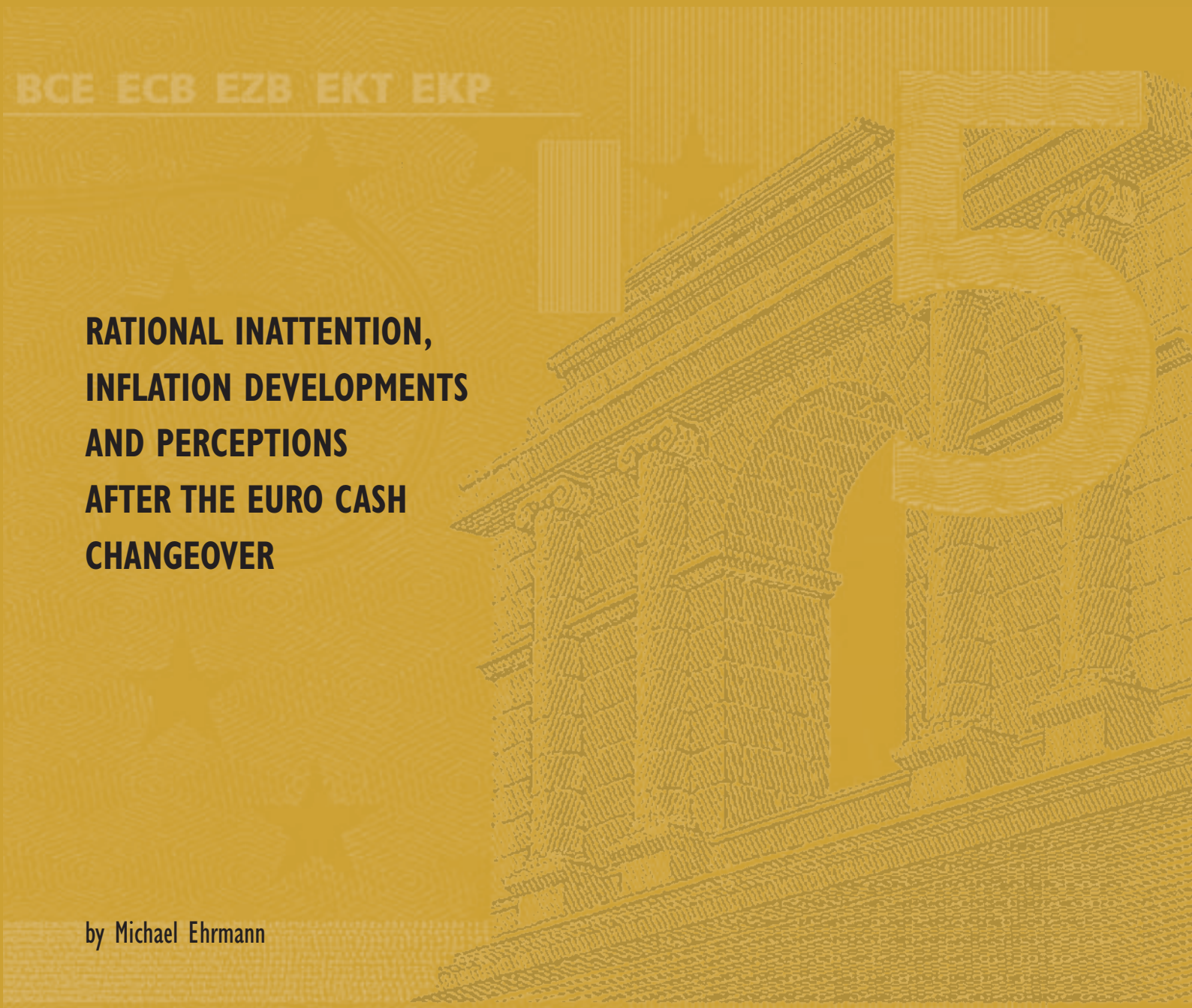

RATIONAL INATTENTION, INFLATION DEVELOPMENTS AND PERCEPTIONS AFTER THE EURO CASH CHANGEOVER

by Michael Ehrmann

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by Michael Ehrmann [2]

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Abstract

This paper uses the euro cash changeover to test theories of finite information-processing capacities on the side of consumers. It argues that the denomination of prices in a new currency has increased the information-processing requirements for consumers by more than for sellers, a wedge that can lead to price increases. The size of the wedge should depend on the complexity of the currency conversion rates. In line with this theory, the paper finds that the evolution of prices for food products around the cash changeover varied across countries, depending on the complexity of conversion rates. These changeover effects are found in particular for goods with prices below one euro sold in mid-priced stores. The paper also finds that cross-country differences in the mismatch of perceived and actual inflation in the aftermath of the cash changeover are linked to differences in the complexity of conversion rates.

JEL classification: D84, E31, E58, L11
Keywords: rational inattention, perceived inflation, euro cash changeover

Non-technical summary

The introduction of euro cash and coins on January 1st, 2002, has triggered a heated discussion about its effect on inflation in literally all countries of the euro area. There is a mismatch in the public perception that the changeover has led to general price increases, and the statistical evidence that such price increases have been concentrated in few sectors.

This paper attempts to analyse these issues in more detail. Unfortunately, simply looking at price developments around the time of the cash changeover is complicated by the fact that price increases could have been triggered by other concurrent factors, such as the bad weather conditions of the winter season 2001/2002, and the spreading of the mad cow and the foot and mouth diseases somewhat earlier. In the search for cash changeover effects, this paper therefore exploits an important feature of the event, namely that the changeover was taking place simultaneously in 12 countries, and that this was done using 11 different conversion rates. In particular, it tests whether price developments and their perceptions in the aftermath of the euro cash changeover are related to the complexity of the conversion rate.

Doing so, the paper furthermore sheds light on recently proposed models of information-processing constraints of economic agents. For each purchase, consumers need to acquire information about the true price of a good (including, e.g., information on the quantity and the quality of the good), to process this information in order to judge the price, and to come to a decision whether or not to purchase the good. As this information acquisition and processing is costly, there will be an optimal level of information that the consumer will obtain. The paper argues that the changeover has created an increase in required information processing on the side of consumers, which was not matched with an equally large increase on the side of sellers, a pattern that could lead to price increases.

The paper finds that the complexity of the conversion rate and inflation developments after the cash changeover are related for the food (and clothes) retail sector. In countries with the least complicated conversion rates, inflation in the aftermath of the cash changeover turned out to be relatively lower, whereas conversion rates that are larger than 100 (which imply that the prices in euro look considerably smaller than in the old national currency) led to relatively higher inflation rates. At the same time, the evidence is also consistent with the hypothesis that consumers decide to rely less on rules of thumb in the case of highly complicated conversion rates, as inflation turned out to be relatively lower in countries with the most complex conversion rates. Amongst food products, the differential patterns in inflation across countries are mainly observed for goods with prices below one euro. Furthermore, market structures come into play, as the patterns are found mainly for products sold in mid-priced stores as opposed to chain stores or supermarkets.

In the attempts to explain the mismatch in perceived and actual inflation in the aftermath of the cash changeover, it has been argued that price increases in frequently purchased items could have led to the impression of general price increases. As food items are probably the most frequently bought items, the paper analyses whether the same patterns that helped explaining food inflation across countries can also shed

light on cross-country differences in the mismatch between perceived and actual inflation. It finds evidence that the mismatch is indeed related to the complexity of conversion rates.

In order to gauge the importance of the findings from a *macroeconomic perspective*, it is important to highlight four points. First, the volatility of food prices around the cash changeover that was present for other reasons not only complicated the signal extraction problem for consumers, but also the identification problem in the econometric analysis, and could thus possibly affect the results. Second, the differences found in this paper are measured only relative to a group of small countries that had medium complex conversion rates (in particular Belgium, Greece and Luxembourg). Third, as the paper finds that cash changeover effects relate in particular to countries with medium complex conversion rates, it does not imply a general rule that with increasing levels of complexity changeover effects are more pronounced, which can limit the macroeconomic impact of the finding. Fourth, the patterns do not apply generally. Just like general price increases have been restricted to some sectors, the relationship between the complexity of conversion rates and price developments is confined to food and clothes retailing; and there, it applies only to low-priced goods sold in mid-priced stores, which might have a relatively small market share.

1. Introduction

On January 1st, 2002, the circulation of euro banknotes and coins was initiated in the 12 countries of the euro area. The new currency had already existed as a unit of account since 1999, the start of stage three of European Economic and Monetary Union (EMU), but it was only at the beginning of 2002 that banknotes and coins denominated in the national legacy currencies were replaced by euro cash. Accordingly, euro area consumers needed to adapt to a new currency for their cash purchases as of this date. This process did not have to be completed overnight – the national currency units generally lost their status as legal tender only in February 2002.[1] Furthermore, it was common practice (and in some countries legally required) to display prices in both currencies for some period, in order to facilitate the transition. Notwithstanding these facilitators, European consumers needed to become familiar with a new currency denomination within a relatively short period of time. This transition was complicated by the fact that the conversion rates were highly complex, contrary to most other currency changeovers. Most introductions of new banknotes and coins are intended to cut a number of zeros from highly inflated currencies.[2] Such a conversion makes the new prices look considerably smaller than prices in the old denomination, but it requires only a straightforward mathematical operation to reconvert prices posted in the new currency back into the familiar anchor currency. The euro cash changeover was different in that respect, as the conversion rates were set in order to find a common denomination for 11 different currencies, and as such could not necessarily be computationally easy.[3]

The cash changeover has triggered a heated discussion about its effect on inflation in literally all countries of the euro area. There is a general belief in the public that the changeover has increased prices dramatically (European Central Bank 2002b, p. 41). According to a survey by the European Commission in November 2002, 84% of euro area consumers thought that the conversion of prices to euro has been made to the detriment of consumers. Two years later, in November 2004, 95% of respondents answered that the introduction of the euro has favoured rising prices.[4]

On the other hand, there is very little statistical evidence that the introduction of the euro banknotes and coins has led to general price increases. Extensive studies of the National Statistical Institutes

[1] For details, see European Central Bank (2002a). Germany was the only country where the national currency (DM) lost its status as legal tender already on December 31st, 2001. However, in practice retailers generally accepted DM cash for their transactions for a considerable period of time.
[2] E.g., in France in 1958, Israel in 1985, Argentina in 1983, 1985 and 1992, and Romania and Turkey in 2005.
[3] There are probably few other examples of such complex changeover episodes like, for instance, the conversion to a decimal system in the United Kingdom and Ireland in 1971. Interestingly, nearly 35 years after this changeover, there is still a belief in the public that it has led to dramatic price increases, although this has not been confirmed statistically. See, e.g., a series of views expressed on this topic in a BBC website at http://news.bbc.co.uk/onthisday/hi/witness/february/15/newsid_2732000/2732345.stm. An earlier discussion of the effects on prices is provided in Moore (1973).
[4] European Commission (2002) and European Commission (2004), respectively.

and the National Central Banks based on the individual price observations that are used to construct consumer price indices have come to the conclusion that the overall effect has been limited. However, while the effect on the *overall* price level appears to be relatively moderate, prices in some sectors seem to have risen noticeably in all euro area countries. This is particularly evident in the service sector, where the above mentioned studies have singled out restaurants, cinemas, dry cleaning and hairdressers as cases with rather significant price increases (European Central Bank 2002b, p. 40). There is therefore an obvious mismatch in the public perception that the changeover has led to general price increases, and the statistical evidence that such price increases have been concentrated in few sectors.

This paper attempts to analyse these issues in more detail. Unfortunately, simply looking at price developments around the time of the cash changeover is complicated by the fact that price increases could have been triggered by other concurrent factors that are difficult to identify. As a matter of fact, prices for food products increased substantially around the changeover due to special events that had occurred just before, such as the bad weather conditions of the winter season 2001/2002, and the spreading of the mad cow and the foot and mouth diseases somewhat earlier. In the search for cash changeover effects, this paper therefore exploits an important feature of the event, namely that the changeover was taking place simultaneously in 12 countries, and that this was done using 11 different conversion rates. This adds a cross-sectional dimension that aids the identification problem at hand.

The paper furthermore sheds light on recently proposed models of information-processing constraints of economic agents. For each purchase, consumers need to acquire information about the true price of a good (including, e.g., information on the quantity and the quality of the good), to process this information in order to judge the price, and to come to a decision whether or not to purchase the good. As this information acquisition and processing is costly, there will be an optimal level of information that the consumer will obtain. The paper argues that the changeover has created an increase in required information processing on the side of consumers, as they need to (at least initially) convert prices posted in the new currency back into their familiar anchor currency in order to be able to assess the price of a product. Consumers are therefore faced with the possibility to either convert prices accurately, which is costly if the conversion is complex, or to use a simple rule of thumb, which comes at the cost of making conversion mistakes. Importantly, this increase in required information processing is not matched with an equally large increase on the side of sellers, for mainly three reasons. First, whereas each price setter needs to convert prices for the products only once, consumers need to do so for each individual purchase. Second, when converting prices, the vendor knows the exact price that has to be converted, whereas consumers needed to remember the benchmark prices from their earlier purchases, creating an additional wedge due to one-sided

uncertainty. Third, the cash changeover is likely to have changed relative prices of many products, for instance due to upward- and downward rounding of different prices, thus complicating the task of evaluating the price of a product. As a consequence, information-processing requirements increased disproportionately strongly for consumers – a wedge that might lead to rising prices if consumers face information processing constraints.

For each conversion rate, there is an approximation or a rule of thumb that can lead to a reasonable conversion of prices. However, these are complex to different degrees themselves. It should be expected that there is some range of complexity, where agents use the rules of thumb. In this range, the wedge between sellers' and consumers' information processing requirements becomes larger, the more complex these rules are. Beyond a certain level of complexity, the benefits of using the rule of thumb are relatively small, such that it will be optimal for consumers to rely less the use of rules of thumb, and instead use a different technology to convert prices, such as taking a pocket calculator to the shop.

The paper finds that the complexity of the conversion rate and inflation developments after the cash changeover are related for the food (and clothes) retail sector. In countries with the least complicated conversion rates, inflation in the aftermath of the cash changeover turned out to be relatively lower, whereas conversion rates that are larger than 100 (which imply that the prices in euro look considerably smaller than in the old national currency) led to relatively higher inflation rates. The evidence in the paper is also consistent with the hypothesis that consumers decide to rely less on rules of thumb in the case of highly complicated conversion rates, as inflation turned out to be relatively lower in countries with the most complex conversion rates. Amongst food products, the differential patterns in inflation across countries are mainly observed for goods with prices below one euro. Furthermore, market structures come into play, as the patterns are found mainly for products sold in mid-priced stores as opposed to chain stores or supermarkets.

To find these effects particularly for the food retail sector matches well with theories of rational inattention. Whereas other goods and particularly services are most often bought in single or few items, food products are normally purchased in large numbers, which makes it relatively more costly to convert the price of each individual item. Furthermore, food products are on average relatively cheap, which reduces the benefits of properly reconverting prices to the familiar anchor. This is in line with the effects being particularly strong for low-priced items. Furthermore, food prices are known to have been rather volatile and increasing strongly around the cash changeover due to unrelated factors like bad weather conditions or the spreading mad cow and foot and mouth diseases. The volatility of food prices at this time furthermore increased information processing

costs for consumers, who needed to assess the effects of these developments on the appropriate benchmark price.

In the attempts to explain the mismatch in perceived and actual inflation in the aftermath of the cash changeover, it has been argued that price increases in frequently purchased items could have led to the impression of general price increases (Brachinger, 2005; Del Giovane and Sabbatini, 2005). As food items are probably the most frequently bought items, the paper analyses whether the same patterns that helped explaining food inflation across countries can also shed light on cross-country differences in the mismatch between perceived and actual inflation. It finds evidence that the mismatch is indeed related to the complexity of conversion rates. Countries where consumers were rationally more inattentive show a lower mismatch initially (and thus a lower complaint rate about price increases). As it is in those countries that food prices increase significantly more, however, the mismatch is closing relatively less quickly over time.

In order to gauge the importance of the findings from a *macroeconomic perspective*, it is important to highlight four points. First, the volatility of food prices around the cash changeover that was present for other reasons not only complicated the signal extraction problem for consumers, but also the identification problem in the econometric analysis, and could thus possibly affect the results. Second, the differences found in this paper are measured only relative to a group of small countries that had medium complex conversion rates (in particular Belgium, Greece and Luxembourg). Third, as the paper finds that cash changeover effects relate in particular to countries with medium complex conversion rates, it does not imply a general rule that with increasing levels of complexity changeover effects are more pronounced, which can limit the macroeconomic impact of the finding. Fourth, the patterns do not apply generally. Just like general price increases have been restricted to some sectors, the relationship between the complexity of conversion rates and price developments is confined to food and clothes retailing; and there, it applies only to low-priced goods sold in mid-priced stores, which might have a relatively small market share.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature on the euro cash changeover and on theories of rational inattention. Section 3 exposits the hypothesis how the cash changeover relates to theories of rational inattention. In Section 4, we explain how the conversion rates have been classified for the econometric analyses, and provide information on the other data used in this paper. Section 5 shows how inflation and its perception have evolved with the cash changeover. In Section 6, the relationship between the complexity of conversion rates and overall inflation and its sectoral breakdown are analysed, and further details on the food retail sector and on the mismatch between perceived and actual inflation are presented. Section 7 concludes.

2. Related literature

2.1 The euro cash changeover

Accompanying the cash changeover, National Statistical Institutes and National Central Banks of the euro area conducted several analyses on how prices were effectively converted into euro. The main focus of these analyses related to the effect of attractive prices. Aucremanne and Cornille (2001) conducted an *ex-ante* simulation how the need to find new attractive prices in the new denomination could affect consumer price inflation in Belgium, and predicted effects in the order of 0.5 to 0.7%. The main message stemming from the *ex-post* studies confirms these predictions, finding that there has likely been some rounding effects due to the need to find new attractive prices, but that the consequences for overall inflation were rather contained (0.6% for the Netherlands, 0.2% for France). At the same time, several contributions point out that there have been noticeable price increases in some sectors, particularly the service sector, where restaurants, cinemas, dry cleaning and hairdressers have been found to exhibit unusual price increases.[5] Note that all these contributions are focusing on individual countries, such that no cross-country comparison is available.

A second set of papers has focused on the effect of the changeover on restaurant prices, one of the sectors where noticeable price increases have occurred around the cash changeover. Deutsche Bundesbank (2004) identifies price increases in excess of those predicted by the development of the relevant cost factors. Adriani et al. (2003) argue that the changeover constituted a co-ordination device for the restaurant sector to shift to a high-price equilibrium, and provide some evidence for their hypothesis based on data from the Michelin Red Guide. This explanation is opposed, however, by Hobijn et al. (2004), who show that a model of menu costs with firms deciding on the optimal timing for adoption of the euro in a state-dependent fashion can explain the observed price patterns in the absence of any jump to a new high-price equilibrium. The predictions of the model are that price increases, which are normally staggered, will concentrate around the introduction of the euro, and that price increases prior to the changeover will be based on a shorter optimization horizon, such that expected increases in marginal costs after the changeover will not be reflected in price changes beforehand. A calibration of this model generates an increase in inflation which closely matches the one observed in the data. This hypothesis is also supported by Gaiotti and Lippi (2005), who find that price increases in the aftermath of the changeover are consistent with a menu-cost model: in a panel of 2500 Italian restaurants, they find that the rise in the price of a restaurant meal in 2002 is mainly due to a larger fraction of restaurants revising their prices than to a larger size of the individual price increases.

[5] See, e.g., Folkertsma et al. (2002) for the Netherlands, Banque de France (2002) for France, Santos et al. (2002) for Portugal or Deutsche Bundesbank (2002a, 2002b) for Germany.

A third set of papers tests for the existence of money illusion using data on charity donations around the cash changeover. Kooreman et al. (2004) show that nominal donations to charity in the Netherlands before the changeover increased approximately with the rate of inflation. In 2002, these donations jumped by 11%. They take this as suggestive evidence for money illusion, since applying a rule of thumb of 2 to the Dutch conversion rate of 2.20371 implies underestimating euro prices by around 10%. In a similar vein, Cannon and Cipriani (2005) find that the introduction of the euro banknotes and coins led to an unusual real increase in donations to church collections in Italy and Ireland. An interesting test for price level effects is conducted in Angelini and Lippi (2005). These authors use data on cash withdrawals from ATM in Italy, yet find no evidence that the officially recorded price level deviates from the one implied by the cash withdrawals.

Finally, there is a strand of psychological literature which mainly studies how consumers develop their intuitions for prices in euro. The main message from this literature, which is generally based on experimental evidence, is that such a process takes a considerable amount of time. Marques and Dehaene (2004) report that by June 2002, price estimates in euros have not yet become as accurate as those in the national currencies. Generally, prices expressed in euros tended to be overestimated in experiments (e.g., Traut-Mattausch et al. 2004). Fischer et al. (2002, p.43) similarly find that after eight months, the euro still constituted a "'veil' that complicates an appropriate perception of real prices."

In sum, several aspects of the changeover have been studied at national levels; however, for a more complete picture, an analysis of cross-country differences is warranted. Such a step will be attempted in this paper.

2.2 Rational inattention

A large number of papers has recently dealt with issues of bounded rationality, in order to explain various features of macroeconomic data that are difficult to reconcile with fully rational agents, such as the presence of sticky prices and, related to this, the existence of real effects induced by nominal disturbances. Some contributions have argued that economic agents might face constraints in their capability to process information. On the side of *price setters*, this feature has been shown to lead to large and highly persistent real effects of nominal disturbances (Woodford 2002, Adam 2005). Reis (2004) models inattentive producers who rationally choose to be inattentive to news and to update their information only sporadically. The predictions from this model fit US inflation remarkably well. Empirical evidence on the importance of information-gathering and decision-making costs on the side of price setters has been provided by Zbaracki et al. (2004). Using data from a large US industrial manufacturer, the authors show that these costs amount to nearly 20% of the firm's net margin.

On the side of *consumers*, Sims (2003) suggests that information-processing constraints might create temporary market power for sellers. Consumers need to acquire price information, process it, possibly compare it with other information, and decide upon this information, each of which comes at a cost. Reis (2005) formalises these ideas in a theoretical model, where consumers decide against continuously updating their information and re-computing their optimal consumption plans. His model predicts that aggregate consumption adjusts slowly to shocks as news disperses only slowly throughout the population. Although close in spirit to the ideas tested in this paper, the model in Reis (2005) would predict that consumers instantaneously adjust their consumption behaviour in response to the cash changeover, since it was an anticipated event, and the currency conversion rates were well known to most consumers.

This paper is therefore closer to models assuming that a customer faces costs of assessing the true price of a product (e.g. because its quality cannot be judged immediately). In such models, consumers need to acquire the necessary information about the true price of a good, process it in order to judge the price, and come to a decision whether or not to purchase the good. As this information acquisition and processing is costly, there will be an optimal level of information that the consumer will obtain. Evidence in this direction is provided, e.g., by Ameriks et al. (2004). They model "absent-minded" consumers who only have a vague notion of what they spend on various consumption items, and find, based on a consumer survey, that there is indeed a large degree of uncertainty of consumers about their own consumption expenditures. An interesting test of the existence of rational inattention of consumers is provided in Levy et al. (2005a). These authors develop a model that explicitly incorporates costs and benefits of information processing into the consumers' maximisation problem. They argue that consumers might want to rationally ignore small price changes if the costs of detecting the changes exceed the benefits. Using scanner data from a US supermarket chain, the paper estimates an inattention span in a range of up to about 15 to 30 US cents, or 3 to 10 percent of a product's price. Another implication of rational inattention is tested and supported in Levy et al. (2005b): if customers are rationally inattentive to rightmost digits in prices, 9-ending pricing can be an equilibrium outcome. Finally, a related model has been developed by Mastrobuoni (2004) for the context of the cash changeover, positing that low-priced goods will have larger price increases after the cash changeover. This hypothesis is tested in country-by-country regressions, each including 45 sectors. The paper finds evidence for such effects only for three countries, namely France, Italy and Spain. This lack of results could be due to a rather arbitrary choice of sectors (out of 93 sectoral inflation series, only a subset could be used because of missing explanatory data), or likewise because the paper cannot disentangle other, contemporaneous, effects from those induced by the cash changeover.

3. The euro cash changeover and rational inattention

The current paper aims to contribute and to combine both strands of the literature. It argues that the cash changeover provides a natural testing ground for theories of rational inattention on the consumer's side. The changeover has created an increase in required information processing on the side of consumers, as they needed to (at least until they were acquainted with the new denominations - which, as mentioned above, has been a slow process) convert prices posted in the new currency back into their familiar anchor currency in order to be able to assess the price of a product. Consumers are therefore faced with the possibility to either convert prices accurately, which is costly if the conversion is complex, or to use a simple rule of thumb, which comes at the cost of making conversion mistakes. Importantly, this increase in required information processing is not matched with an equally large increase on the side of sellers, for mainly three reasons. First, whereas each price setter needs to convert prices for the products only once, consumers need to do so for each individual purchase. Second, when converting prices, the vendor knows the exact price that has to be converted, whereas consumers needed to remember the benchmark prices from their earlier purchases, creating an additional wedge due to one-sided uncertainty. Third, the cash changeover is likely to have changed relative prices of many products, for instance due to upward- and downward rounding of different prices, thus complicating the task of evaluating the price of a product. As a consequence, information-processing requirements increased disproportionately strongly for consumers – a wedge that might have led to increasing prices if consumers face information processing constraints, up to a point where the cost-benefit trade-off equalises for consumers.

For each conversion rate, there is an approximation or a rule of thumb that can lead to a reasonable conversion of prices. However, these are complex to different degrees themselves. It should be expected that there is some range of complexity, where agents use the rules of thumb. In this range, the wedge between sellers' and consumers' information processing requirements becomes larger, the more complex these rules are. Beyond a certain level of complexity, the benefits of using the rule of thumb are relatively small, such that it will be optimal for consumers to rely less the use of rules of thumb, and instead use a different technology to convert prices, such as taking a pocket calculator to the shop. As a matter of fact, special pocket calculators that converted a given sum to or from euros by pressing one button were sold or often distributed freely in several countries of the euro area. Unfortunately, however, no information on the actual frequency of their use is available to the author. This hypothesis is consistent with the elaboration likelihood model, which has been frequently applied in research on consumer behaviour. It predicts that consumers process information accurately when they have the ability and the motivation to do so, whereas they might resort to using heuristics otherwise (Tversky and Kahneman 1974; Lien 2001).

Although the paper will test for changeover related effects in all sectors, food retailing seems to be particularly apt for such testing, for three reasons. First, contrary to many other goods and particularly services, food products are normally purchased in a large number, which makes it relatively more costly to convert the piece of each individual item. The importance of this issue is underlined by the fact that the multi-item nature of food shopping determines pricing strategies already in normal times. For instance, it has been shown that that shops often compete fiercely on the price of few products that most shoppers now the price of (so-called known value items), and make profits through higher mark-ups on other items.[6] Second, food products are on average relatively cheap, which reduces the benefits of properly reconverting prices to the familiar anchor. Third, food prices have been rather volatile and subject to substantial adverse shocks around the cash changeover due to unrelated factors like bad weather conditions or the spreading mad cow and the foot and mouth diseases. Price increases that are well understood because of cost increases can be easily justified by the seller, and are more likely to be accepted by the consumer (Rotemberg 2005; Fabiani et al. 2005). The exact extent to which costs have increased for the retailer cannot be known to the consumer, who faces the complicated task of estimating the appropriate price that would result from the cost increases.

4. The data

4.1 Euro conversion rates

The second column of Table 1 reports the official euro conversion rates of the various national currencies. The rates are expressed such that one euro equals the number of national currency units displayed in the table. As argued in the introduction, it is obvious that these rates were by no means simple – although it is also clear that there are large differences in the degree of complexity. In the following, we will try to establish some way of summarising the complexity of these rates. A few points deserve mentioning at this point. First, although the euro area consists of 12 countries, there are only 11 conversion rates, since Belgium and Luxembourg had already established a monetary union before. Second, 10 of these 11 rates are larger than one. The exception is the Irish rate, which is below one at a value of 0.787564. This difference is important for the empirical tests, as Ireland is the only country where prices look larger after the conversion to euro. This will require a special treatment of Ireland in the econometric analysis. Third, there are a number of countries with conversion rates larger than 100 (or even 1000, as in the case of Italy). In these countries, prices denominated in euro appear much smaller than the familiar prices in the national currencies. Since research on consumer behaviour has shown that there is a tendency to underestimate a price when it is converted to a stronger currency (Raghubir and Srivastava 2002), we will control whether this has affected the inflationary developments in the aftermath of the cash changeover.

[6] Classical known value items are milk, bread or bananas. See Walsh and Whelan (1999), or Guardian (2005).

Whereas the special case of Ireland and the special treatment of conversion rates larger than 100 are easily justifiable, the remainder of the classification of conversion rates is entirely judgemental. We will therefore test whether the results obtained with a benchmark classification are sensitive to alternative classifications. Table 1 reports the various characteristics of the conversion rates that have been used in the classifications, and lists the respective outcomes.

To explain the classification pattern adopted, let's look at the case of Germany. With a conversion rate of 1.95583, Germans could apply a rather simple rule of thumb to convert prices in euro back to the familiar prices in DM: multiplying the displayed prices by 2 will lead to an overestimation of DM prices by 2.26% (see columns 4 to 6 in Table 1). With this simple rule of thumb, German consumers made relatively small mistakes, and they erred on the conservative side, as they overestimated prices. We will consider this an example of a simple conversion rate. A similar reasoning applies to the cases of Italy and Portugal. In Italy, doubling the displayed prices, and adding three zeros (an effect for which we control separately, as mentioned above), will lead to an overestimation of prices by 3%. In Portugal, again a simple rule of thumb of 2 (plus adding two zeros) gave a reasonably good approximation of the escudo prices. Although Portuguese consumers underestimated prices, the mistake was very small at 0.24%. These three conversion rates will thus form the group of simple rates in the subsequent analysis.

At an increasing level of complexity, we have ordered the Belgian and Luxembourgian rate of 40.3399. With a rule of thumb of 4, and the addition of a zero, prices will be underestimated, albeit only slightly at less than one percent. In the benchmark classification, we will also add the Greek conversion rate to the medium complexity level. Using the *inverse* of the conversion rate, Greek consumers could use the rule of thumb that 3 euros are roughly equal to 1000 drachmas. With this rule, all prices need to be *divided* by three, and with the addition of 3 zeros, prices will be estimated reasonably close with a mistake of 2.23%. However, as dividing is possibly a more complex mathematical operation than multiplication, we will test whether the results are sensitive to this classification by reclassifying the Greek rate as complex – which it undoubtedly is when using the *non-inverted* rate of 340.75.

All remaining rates are classified as complex in the benchmark classification scheme. In Finland and Spain, consumers could achieve reasonable estimates of prices by multiplying or dividing prices by six (and adding three zeros in Spain, as 6 euros are roughly equal to 1000 pesetas). As these operations are relatively complex, but seem more straightforward than those required for the remaining countries, these two countries are re-classified into the medium complex group for a robustness test.

For France, there is no obvious rule of thumb that can be derived from either the conversion rate or its inverse. A multiplication by 6 would have strongly underestimated prices, whereas a multiplication by 7 substantially overestimates prices, namely by 6.7%. In a similar vein, the Austrian conversion rate is extremely complex, as prices needed to be divided by 7 or multiplied by 14, both extremely complex mathematical operations. For the Netherlands, the only way to arrive at a reasonable judgement is by multiplying prices by 2, divide the result by 10, and add this new result to the earlier intermediate result. Irish consumers needed to divide prices by four and then multiply the result by five.

This last group of countries, Austria, France, the Netherlands and Ireland, is classified as complex in all classification schemes considered in this paper. Beyond the robustness test where Finland and Spain are re-categorised into the medium complex group, we employ also a third classification that categorises all those rates as complex that revert to the inverse of the rates (and thus to divisions rather than multiplications) in order to yield manageable rules of thumb. In this last classification, Germany, Italy and Portugal remain in the simple category, Belgium, Finland and Luxembourg in the medium one, whereas Austria, France, Greece, the Netherlands and Spain are classified as complex cases. Table 1 provides an overview of the various factors considered in this classification exercise, and of the three different schemes adopted.

One additional issue that will be factored into the subsequent analysis is whether a country had a legal requirement for dual display of prices around the cash changeover, as was the case in Austria, Greece and Portugal. Dual display of prices allows for an easier comparison of prices in the two denominations, and as such reduces the information processing costs for consumers. It is important to know that dual display of prices has been a widespread behaviour in most countries of the euro area, often based on *voluntary* agreements between retailers and national governments. However, as it is very difficult to quantify the extent to which the dual display was indeed practised in the various countries, we will only analyse whether there is an effect of a *legal requirement* (assuming that this has been effective in making *all* retailers display their prices in both currencies). Again, this is a rather conservative testing strategy. If a legal requirement is not found to have contained price increases, it could be that dual display of prices as such has had an effect, but that it is not possible to trace it empirically as this has been such a widespread practice also in most other countries of the euro area.

4.2 HICP inflation rates

The focus of the econometric analysis will be to test whether the complexity of conversion rates (as defined above) has had an influence on the evolution of prices in the various countries. For these tests, sectoral inflation rates will be computed. The underlying data has been provided by Eurostat.

It consists of consumer price index data at the 3-digit COICOP level (covering on average 82 sectoral price indices per country). These data are available at a national level, and are used to compile a comparable consumer price index, the "Harmonised Index of Consumer Prices" (HICP). All data are monthly, and not seasonally adjusted. From the original price level data, we construct a variety of annualised inflation series for different horizons around the cash changeover, namely

December 2001 to January 2002
January 2001 to January 2002
July 2001 to July 2002
October 2001 to April 2002
March 2001 to March 2002
December 2001 to December 2002

The analysis of different horizons around the cash changeover is important for various reasons. First, it could be imagined that prices rose around the cash changeover, but that they returned to lower levels again quickly in the face of falling demand. Short-term effects might therefore be different from longer-term effects. Second, as mentioned in the introduction, the cash changeover was accompanied by a period of dual display of prices in both euro and the national predecessor currencies for a couple of months. In general, such dual display was widespread until at least the end of February 2002. Again, this might imply that the effects at shorter horizons differ from those in the longer term. Third, in several countries, such as France, Germany and Greece, retailers and the government signed voluntary agreements to keep prices stable around the cash changeover (although with different degrees of participation and commitment across these countries). In France and Germany, these agreements were in place until June 2002, such that it can be important to consider a period that extends beyond the end of such agreements. Finally, it is also important to allow for the fact that price setting behaviour has already changed in the uprun to the changeover. Accordingly, inflation rates that extend further back than December 2001 might be interesting to analyse, too.

For the purposes of this paper, it is important to analyse exclusively prices that are market-determined. The price index data provided by Eurostat contains a variety of sectors where prices are to a large extent administered by local, regional or central governments. Unfortunately, there is no general definition of administered prices that could be used to identify sectors that need excluding from the econometric analysis. Instead, following earlier examples (ECB 2003 or Lünnemann and Mathä 2005), the price indices for health, transport services, postal services and education were dropped.

In a similar vein, it is crucial not to mistake price increases that arose due to changes in taxes around the euro cash changeover for changeover-induced price developments. Based on an analysis of the Annual Reports of all euro area National Central Banks for the years 2001, 2002 and 2003, we have therefore assembled a list of all tax changes that could potentially fall into the period

around the cash changeover. Whenever such a tax change occurred during the period of analysis, we excluded the corresponding sectoral inflation rates for the respective country in the analysis. The relevant tax changes comprise:

An increase in the maximum price of certain types of bread in Belgium, July 2001

The abolition of radio and TV license fees in Belgium in April and October 2002

An increase in French tobacco taxes, January 2002

Increased taxes on tobacco, energy and insurance products in Germany, January 2002

An increase in municipal taxes and levies in the Netherlands, January 2002

Increased taxes on tobacco, alcohol and hydrocarbon products in Spain, January 2002

A VAT increase from 17% to 19% in Portugal, June 2002

The VAT increase in Portugal constitutes are rather problematic case for the analysis in this paper. As it could potentially have affected the entire set of sectoral inflation rates, we decided to perform all tests for periods that include June 2002 twice, once including, once excluding all Portuguese data. Fortunately, all results presented below are robust to this treatment.

4.3 Price level data

This paper will also test whether potential conversion effects depend on characteristics of a product's price itself, such as the price level, or the competitiveness of the market in which it is sold. For this purpose, price *level* data is required, as aggregated *indices*, even at the sectoral level, will not be able to shed light on these issues. The paper will therefore furthermore analyse price level data as provided by the Economist Intelligence Unit (EIU).[7] In its "worldwide cost of living survey", the EIU collects actual price levels for a large number of goods and services in 19 cities of the euro area. From the full set of data available, this paper will consider only prices for food products, beverages and clothes. The database covers 92 food products, 20 beverages and 32 clothing goods. For example, prices are collected for 1kg of white bread, 500g butter, 375g cornflakes, 1l of orange juice, women's cardigan sweaters, etc. For most products, EIU City Data reports two prices – one collected in supermarkets or chain stores, another in mid-priced stores. This allows for a convenient distinction of outlets according to market structure – we will assume that mid-priced stores have some monopoly power and face less competition than supermarkets or chain stores, which allows them to charge higher prices to their customers.[8] Comparability across countries is ensured in the sense that only outlets where standard products of internationally comparable quality are available for normal sale are sampled. Finally, by choosing only data

[7] These data have been used extensively in literature on purchasing power parity (e.g., Engel and Rogers 2004).

[8] A caveat in using outlet type as a proxy for market structure is that mid-priced stores might face similar competition than supermarkets, but can charge higher prices as they offer e.g., convenience and flexibility.

collected in the capitals of each country, the sample is restricted to one observation per country/outlet-type/product combination, as in the case of the national inflation rates discussed in the preceding section.

4.4 Perceived inflation

Finally, this paper will make use of consumer survey data constructed by the European Commission. Each month, the Commission asks around 21,000 consumers in the euro area whether they think that consumer prices, over the last twelve moths, have i) risen a lot, ii) risen moderately, iii) risen slightly, iv) stayed about the same, v) fallen, or whether they vi) don't know. The answers to this question are then aggregated up to a balance statistic, indicating the share of consumers thinking that inflation has increased relative to those stating that inflation has decreased or remained unchanged. [9] This proxy for consumers' perceived inflation is available at a national level. As will be seen below, this measure of perceived inflation, appropriately rescaled, has been tracking actual consumer price inflation extremely well until January 2002, indicating the reliability of these data.

5. The effect of the euro cash changeover on inflation and inflation perceptions

5.1 Effects on inflation

Even though it has been argued that the cash changeover has not had an effect on overall inflation, it is clear that this is not the case for all subsectors. As mentioned in the introduction, unusual price increases have been observed in a few sectors around January 2002. One way to visualise this effect is to look at the distribution of sectoral inflation rates measured from December to January. Figure 1 plots this distribution for two countries: the Netherlands, a country where the effect on overall inflation has been estimated to be above average,[10] and for the United Kingdom, which does not participate in monetary union and as such did not have a cash changeover in January 2002. In each chart, the distribution is plotted for the years 1998, 1999 and 2000 (dashed lines) and for 2002 (solid line). What is apparent is not so much a shift in the mean of inflation overall in the Netherlands, but rather a striking increase in the skewness of this distribution in 2002 – a development which is entirely absent in the United Kingdom.[11] This chart points to the possibility that there have been unusual price increases in some sectors, which might, however, have insufficient weight in the overall basket to move the mean of overall inflation substantially. However, looking at the skewness of sectoral distributions of all European Union countries, Table 2 shows that the

[9] The statistic is defined as the difference of the (weighted) proportion of respondents stating that consumer prices have risen and those stating that prices have fallen or stayed about the same. The weighting takes into account the relative share of consumers who opted for the different answers on each side. For more details, see http://europa.eu.int/comm/economy_finance/indicators/businessandconsumersurveys_en.htm.

[10] See the references in the introduction.

[11] Note that in both countries, the distribution spans a large space, which has to do with the fact that annualised monthly rates can become very large, particularly when calculated for seasonal months like December and January.

developments are rather heterogeneous across euro area countries. In the first column, the table reports the average skewness in the years 1998, 1999 and 2000 (for 3-digit COICOP December to January inflation rates). The second column reports the skewness in January 2002, the month of the cash changeover. Finally, the third column calculates the difference between the two. In several countries of the euro area, a strong increase in skewness is observed – which is largely, but not entirely absent in the control group of the non-euro area European Union countries. In several countries, skewness (which is normally negative) has turned positive in 2002, and has reached extraordinary levels (for example in France and the Netherlands). Looking at the (unweighted) average for the euro area and the three non-euro area countries, it turns out that the increase in skewness is considerably larger in the euro area (even though this is an aggregate of many more countries, which should smoothen such changes), and turns positive for the euro area, but not for the three non-euro area countries. However, at the same time, in four of the twelve euro area countries, skewness decreases, and in another four, the increase is less pronounced than for example in Sweden. This points to a need to analyse the developments considering differences across countries, such as the complexity of the conversion rates, as will be done in section 5.

5.2 Perceived inflation

As mentioned in the introduction, the cash changeover has had a striking effect on inflation perceptions of European consumers. Figure 2 plots the time series of the European Commission's measure of perceived inflation against a properly rescaled series of HICP inflation[12] for 11 of the 12 euro area countries (data for Luxembourg are available as of January 2002 only, such that it is not possible to rescale the series to match inflation for the time prior to the cash changeover), a euro area aggregate, and the three non-euro area European Union countries that serve as benchmark. The time of the changeover, January 2002, is shown by a vertical line in each chart. Several results are noteworthy. First, perceived and actual inflation track each other extremely well in the period until December 2001. Second, following the changeover, there has been a clear mismatch between the two series. In all countries of the euro area, perceived inflation is considerably higher than actual inflation. Third, such a mismatch is clearly absent from the three countries in the control group. Finally, this mismatch has been closed in only a few countries until the end of 2004 (a fact which has recently been discussed also in ECB 2005).

The synchronicity between the cash changeover and the beginning mismatch of the two series strongly suggests that figure 2 portrays an effect of the cash changeover. Again, however, it is worth

[12] This has been achieved by regressing perceived inflation on actual inflation and a constant, $\pi_t^{perc} = \alpha + \beta\pi_t^{act} + \varepsilon_t$, for the time until December 2001. The chart plots π_t^{perc} and $\hat{\pi}_t^{rescaled} = \hat{\alpha} + \hat{\beta}\pi_t^{act}$, i.e. measured perceived inflation and rescaled actual inflation, with the rescaling after 2002 based on the estimated parameters prior to 2002.

noting that there is a large heterogeneity across countries. Even though inflation perceptions increased beyond actual developments in *all* countries of the euro area (a factor that cannot be explained by cross-country analyses like the one attempted in this paper), the size of the gap and the speed with which it has (or not) been closing clearly differs across countries and calls for an explanation which is varying across countries. Section 6.4 will get at this issue.

6. The complexity of conversion rates, inflation and inflation perceptions

6.1 Effects on all sectoral inflation rates

In this section, we will analyse whether the evolution of prices around the cash changeover in the various countries can be related to the complexity of conversion rates. In a first step, we will test whether such an effect is discernible in the cross-section of *all* sectoral inflation rates. One issue that needs to be addressed, however, is whether such a regression should be performed in order to explain inflation, or alternatively the *change* in inflation. For such a decision it is helpful to know that HICP inflation in the euro area in 2001 stood at 2.3% - precisely the same level of inflation that was observed also in 2002. Furthermore, it is well documented that the position of countries' inflation rates relative to the euro area mean is extremely persistent.[13] Also during the year 2002, most countries have remained in their relative position, implying that the unchanged mean for the euro area does not mask significant cross-country heterogeneity in the evolution of inflation in 2002. Unchanged positions relative to the mean imply, however, that a model in inflation levels needs to take account of country-fixed effects. As the explanatory variables vary only across countries, it is not possible to enter both simultaneously, such that an alternative model, e.g. in first differences, is required. Against this background, we will subsequently search for changeover effects in the *change* of inflation[14] – with the average level of inflation unchanged, it seems more promising to understand whether in such a stable environment, some *changes* in sectoral inflation rates are related to the complexity of conversion rates.[15]

Even though the aim of this paper is to see whether inflation has changed in response to cash-changeover effects, it is helpful to control for the developments in other potential determinants of inflation. The literature on New Keynesian Phillips Curves generally relates inflation to the output gap; open economy versions include furthermore the change in effective exchange rates (see, e.g., Angeloni and Ehrmann 2004). For the regressions, first differences of these variables have therefore

[13] See, e.g., Angeloni and Ehrmann (2004).

[14] For instance, in the case of annual July-July inflation rates, this change would be expressed as the difference between the annual inflation rate in July 2002 and the annual inflation rate in July 2001.

[15] Performing the regressions for inflation *levels* suggests similar effects of the complexity of conversion rates. However, these effects could partially be spurious in that they do not disappear when estimated for time periods that have not been affected by the cash changeover, like inflation rates for July 2001-July 2000. Results are robust to an intermediate assumption, namely that inflation follows an autoregressive process (see Table 6).

been used as controls, along with the variables of interest for this paper. [16]

The regression model is therefore as follows:

$$\Delta\pi_{s,c} = \alpha_s + \alpha_{IE} D_{IE} + \beta_{SR} D_{SR} + \beta_{CR} D_{CR} + \beta_{00} D_{00} + \beta_{DD} D_{DD} + \beta_{OG} \Delta OG_c + \beta_{ER} \Delta^2 ER_c + \varepsilon_{s,c} \qquad (1)$$

where *s* denotes a sector, *c* a country, π an inflation rate and Δ the first difference operator. Sectoral inflation rates are explained by sector-fixed effects (α_s), a dummy variable that is equal to one for all Irish inflation rates (D_{IE}), controlling for the fact that the Irish conversion rate is the only one below one, a set of dummy variables that are equal to one for countries with simple conversion rates (*SR*), complex conversion rates (*CR*), with rates yielding euro prices that are smaller than one hundredth of the prices denominated in the national currency (*00*), and finally for countries with legal requirements for dual display of prices (*DD*). Furthermore, the model controls for changes in the output gap (*OG*) and in the appreciation of effective exchange rates (*ER*). The significance of all estimators is judged on the basis of hetoroskedasticity-robust standard errors.

The hypotheses are that the change in inflation is relatively lower for simple conversion rates and countries with a dual display of prices ($\beta_{SR} < 0$, $\beta_{DD} < 0$), whereas it should be relatively higher for conversion rates larger than 100 ($\beta_{00} > 0$).[17] The expected sign for complex conversion rates (β_{CR}) is not entirely clear, as predicted by the elaboration likelihood model. If consumers use simple rules of thumb, it should be positive – if they perceive the potential mistakes made with these rules as too large and accurately convert prices, the sign of β_{CR} should be negative.

Table 3 shows the results for the full set of sectoral inflation rates, calculated over various horizons. Not unexpectedly, there is basically no evidence that the complexity of conversion rates has had a significant effect on the entire subset of sectoral inflation rates. For the July-July inflation rates reported in row (5), it seems that a legal requirement to display prices in euro and in the national currency has helped to subdue inflation by one percentage point. Overall, however, the results in this subsection show that for the overall distribution of inflation rates, there is very little explanatory power for the variables of interest.

[16] Results of these variables are not shown for brevity. The results are robust to excluding these controls.

[17] In general, the countries with conversion rates larger than 100 have also experienced relatively larger inflation rates historically. History-dependence in consumer behaviour could have two effects. Either, consumers become *less* attentive to price increases (which is what theories of rational inattention would predict). In this case, the effect should go in the same direction as hypothesised above. Alternatively, consumers might have become used to larger (relative) price movements, and have learned to become *more* attentive. In this case, the effects would partly offset each other. Finding a positive coefficient β_{00} would then be even stronger evidence for the theories of rational inattention.

6.2 Slicing the distribution

As shown in figure 1 above, changeover effects might not have led to shifts in the support or the mean of the distribution of sectoral inflation rates, but could have affected its skewness. This section will therefore separately analyse various parts of the distribution, in three different ways. First, each national distribution will be sliced into various percentile groups. The inflation rates contained in each group will then be pooled across countries, and the regressions of the previous section will be repeated. This way, it is possible to understand whether the complexity of conversion rates has exerted effects on certain parts of the distribution in an agnostic approach, i.e. without imposing that this should be the case in certain sectors or for other predetermined characteristics. The second way is to use only inflation rates that have increased by more than certain threshold levels, where two dimensions will be considered – first, a geographical one: inflation developments in excess of those observed in other parts of the European Union; second, a time perspective: inflation developments in excess of those observed historically. For the first of these, a sectoral subindex is earmarked for the regression if it is are larger than twice the average unweighted increase observed for the three non-euro area European Union countries Denmark, Sweden and the United Kingdom. For the second approach, for each country and sector, the average inflation over the years 1995-2001 will be calculated, and each sector that shows inflationary developments in excess of twice its own, national historical pattern, is earmarked to enter the regression.

The third way to slice the distribution will be to look at sectoral aggregates. This will allow seeing whether effects are detectable for certain sectors. The three approaches are complementary. Whereas the latter will allow an easy economic interpretation, as the effects can be ascribed to specific sectors, the former two can be useful to detect changeover effects that are shaping the distribution in a certain fashion (e.g., can the largest increases in inflation in each country be explained through changeover effects), but that are independent of sectors. Such effects can be expected if the competitiveness of sectors differs across countries.

Note that only estimates for July-July inflation will be shown in this section. This definition allows changes in price setting for 6 months prior and 6 months after the cash changeover, and extends beyond all voluntary agreements between retailers and governments to freeze prices.

Table 4 reports the results of the first two approaches. In line with the hypotheses, inflation rates in countries with simple conversion rates have increased by less than in countries with medium complex conversion rates for various parts of the distribution. Although this is not the case for rates in between the 25th percentile and the median, it holds for the entire distribution beyond the median. This effect becomes particularly sizeable in the upper end of the distribution: the change in the

inflation rate is lower by more than 8% for rates beyond the 87.5th percentile. In line with the hypotheses expressed above, there is also some evidence that conversion rates larger than 100 have led to larger changes in inflation, although only for an intermediate range of inflation rates. A legal requirement for dual display of prices seems to have contributed to lower inflation, albeit only in the range between the 25th percentile and the median of the distribution. All significant coefficients related to the effect of complex conversion rates have a *negative* sign. This suggests that in those countries, inflation was changing by less than in countries with medium complex conversion rates, and customers relied less on simple rules of thumb. As mentioned above, special pocket calculators that performed conversions to and from euros by pressing one button had been on offer in the euro area at the time – possibly, their use was more widespread in these countries, thus leading to lower changes in inflation.

A similar picture emerges when looking at the geographic and historical comparison in rows (6) and (7) of table 4, i.e. at those sectors where increases in inflation are large relative to the developments in Denmark, Sweden and the United Kingdom or relative to what has historically been observed for a given sector in a given country. These increases in inflation are smaller in countries with simple conversion rates, larger in those where the conversion rate has been larger than 100, and (although not statistically significant), smaller in countries with more complex conversion rates. The sign of the dual display of prices-dummy is also as expected, although significant only for the geographical comparison.

Moving on to table 5, we can see the results obtained for the various sectoral inflation rates. Although point estimates are generally negative for the dummies of simple and complex conversion rates as well as for the dummy indicating a dual display requirement, and mostly positive for the dummy for conversion rates beyond 100, statistical significance is found only for the food, beverages and clothes sector, and within this sector, particularly for the subcategories food and beverages. Again, the differences are sizable: inflation increased by 4% in countries with conversion rates beyond 100 relative to the benchmark – and it increased 3-4% less in countries with simple rates.

Table 6 provides several robustness tests for the results regarding food, beverages and clothes retailing. To facilitate the comparison, row (1) repeats the results of the benchmark model. Rows (2) and (3) present results if an equivalent model is estimated for the years 2001 and 2003, i.e. the year prior to and after the changeover. As the estimates refer to July-July inflation rates, these results relate to inflation from July 2000 to July 2001 and from July 2002 to July 2003, periods which should be pure of changeover effects. The parameters of interest lose significance, and often furthermore change sign. This is comforting, as it shows that the benchmark results seem to be

uniquely related to the period of the cash changeover. The second robustness test, reported in row (4), repeats the regression of the benchmark model, but excludes the entire set of Portuguese inflation rates. As mentioned above, these are likely affected by the increase in VAT when measured over the period July 2001 to July 2002. However, it is reassuring to see that all the results go through even when dropping all Portuguese observations.

Rows (5) to (7) provide another robustness test, namely whether a model of inflation *levels* rather than first differences in inflation would yield different results. Estimating this model for the year 2002, one arrives at the same conclusions as with the benchmark model. However, estimates in levels for the years 2001 and 2003 show that some of these effects can also be found in other periods. For example, in all three years, inflation rates in countries with conversion rates beyond 100 are significantly larger than in the benchmark countries. This is not surprising. The countries for which this dummy is equal to one are Greece, Italy, Portugal and Spain, all of which are known to have entered monetary union at a price level below the euro area average. Accordingly, they are in a convergence process and have experienced above-average inflation for every single year since the start of stage three of EMU in 1999 (Angeloni and Ehrmann, 2004). Based on these results, it becomes apparent that estimating the model in first differences of inflation rates is preferable to a model in levels, as the former allows disentangling such convergence effects (which apply to the level of inflation, but not necessarily to its growth rates) from those of the cash changeover.

Rather than estimating the models in levels of first differences of inflation rates, an intermediate solution might be to assume that inflation follows an autoregressive process. This has been done in another robustness test as follows. In a first step, an autoregressive model of order 1 has been estimated for each sectoral inflation rate, over the time period 1995-2001. The estimated autoregressive coefficient has then been used to construct a predicted value for inflation in 2002. Finally, the difference between actual inflation and this predicted inflation has been used in the regressions.[18] The results are reported in rows (8) to (10) of table 6. Results are again very similar to those found in the benchmark model: the effects in the year 2002 have the same sign, and are similarly significant, whereas they tend to disappear or even change sign for the other years.

Finally, rows (11) and (12) show results based on the benchmark model, but with a variation in the classification of the complexity of conversion rates. As argued in section 3, the classification adopted in this paper is entirely judgemental, which makes it important to test whether results are sensitive to changes in the classification. None of the alternative schemes changes the results. In

[18] Whereas the benchmark model is estimated as $\pi_t - \pi_{t-1} = \beta X_t + \varepsilon_t$, this robustness test amounts to estimating $\pi_t - \rho\pi_{t-1} = \beta X_t + \varepsilon_t$, and as such relaxes the implicit assumption that $\rho = 1$.

sum, the results reported in this subsection suggest that for the food, beverages and clothing industry, and particularly for food and beverages, there have been changeover effects that are related to the complexity of conversion rates. An immediate question that arises is whether there is any peculiar feature of this sector that could have fostered changeover-induced price effects. The subsequent section will therefore analyse this sector in more detail.

6.3 Food retailing

As argued in section 2, there are some important differences between food and beverages retailing and most other sectors portrayed in table 5, which makes it more likely that prices rose in the aftermath of the changeover. First, contrary to many other goods and particularly services, food products are normally purchased in a large number, which makes it relatively more costly to convert the piece of each individual item. Second, food products are on average relatively cheap, which reduces the benefits of accurately reconverting prices to the familiar anchor. Third, food prices have been rather volatile and subject to substantial adverse shocks around the cash changeover due to unrelated factors like bad weather conditions or the spreading mad cow and foot and mouth diseases. This is illustrated in figure 3, which shows the evolution of the indices for overall consumer prices (dashed line) and for food prices (solid line) in the countries of the euro area and the usual EU benchmark countries. All indices have been normalised to 100 in 2000. The vertical line denotes January 2002, i.e. the month of the cash changeover. It is clearly visible that food prices increased substantially more than the overall basket in the time *prior* to January 2002. Furthermore, this effect is not restricted to the euro area – it equally applies to Denmark, Sweden and the UK. In such an environment of very volatile food prices and large price increases (that are well understood and acceptable to customers), information processing requirements for consumers are extremely large, as they face the complex task of estimating the adequate benchmark price.

This section will investigate whether the effects found in table 5 are particularly related to low-priced items, and whether the same pattern can be found throughout the food retailing industry, or particularly for retailers with a certain amount of monopoly power. For the latter group, one could more easily imagine that an occasion like the cash changeover will lead to adjustments in price setting behaviour.[19]

For such an analysis, it is necessary to obtain price *level* data instead of the price index data used in the previous sections. Furthermore, the data should be available disaggregated for different outlet types. Both features are available with the data provided by the Economist Intelligence Unit (described in section 3.3), which will therefore be used in this section. Tables 7 to 9 present the

[19] It is known that price-setting behaviour differs across outlet types: super- and hypermarkets change prices significantly more often than mid-priced stores (Dhyne et al., 2005).

results obtained with all three different classification schemes for the complexity of conversion rates, as there are some minor differences for the three schemes. Rows (1) and (2) report the coefficients obtained for the entire set of prices for food, beverages and clothes (FBC) and for food, respectively, in order to compare the results with those obtained in the previous subsection. The overall pattern is similar to the one discussed above using the price indices in the sense that the parameters for β_{SR}, β_{CR} and β_{DD} are generally negative, and often significantly so. On the other hand, there are some differences, as the parameters for β_{00} are negative for classification scheme 2, which was not the case using the price index data. Overall, however, the similarity in results indicates that the EIU sample is reasonably representative and thus adequate for the questions at hand.

The second panels of Tables 7 to 9, rows (3) to (6), show how the effects differ according to outlet type, where two types are distinguished: supermarkets or chain stores and mid-priced stores. Two interesting differences emerge. First, the significance of the regressions in rows (1) and (2) results nearly entirely from the price-setting behaviour of mid-priced stores. Second, the differences in the size of coefficients are sizeable. To give an example, the change in inflation for food items sold in supermarkets in countries with simple conversion rates is 1.8% smaller compared to countries with medium complex rates. For food items sold in mid-priced stores, this difference is estimated to be 9.4%. This suggests that differences in market structures play a role; assuming that mid-priced stores have some degree of monopoly power, this seems to have aided them in setting different prices following the euro cash changeover.

The third panels of Tables 7 to 9 (rows (7) to (12)) analyse whether the price of a product is important for the incidence of changeover effects. All items have been split in three price categories according to their price level as recorded in 2002. As a matter of fact, there is clear evidence that the changeover effects have primarily been observed for lower-priced items – in the food sector particularly for goods below one euro, for clothes for products below 50 euro. Although there are some differences with respect to the significance of coefficients across the three classification schemes, the size of the coefficients is remarkable for all three of them. Inflation for food products priced below one euro has increased much less in countries with simple and complex conversion rates. The difference amounts to 12 to 20% between countries with simple and medium-complex rates, and to 6 to 16% when comparing countries with medium-complex and with complex rates. Similar orders of magnitude are observed for the relatively low-priced clothes. These differences become not only less significant, but furthermore much smaller with increasing prices of products.[20]

[20] Splitting the *entire* sample of products (i.e. including also observations in the database beyond food, beverages and clothes) according to the price level did not lead to significant results. Interestingly, this result is also in line with the importance of attractive prices for the changeover effects, as reported in Section 2.1. For low-priced items, moving from one attractive pricing point to the next implies larger inflation rates, as the difference between such attractive prices by definition constitutes a larger fraction of the price of the product. Unfortunately, the database used in this paper cannot be used to consider the impact of attractive pricing.

It is interesting to note that the category of products priced below one euro is heavily dominated by fruit and vegetables as well as dairy products. For example, 1kg of carrots, 1 lettuce, 1 kg of onions, 250g of canned peas or 150g of natural yogurt fall into this category. As mentioned above, it is well known that these food products had been subject to substantial price increases also due to other, non-changeover related factors like bad weather conditions or animal diseases. This environment of general price increases makes it more difficult for consumers to identify the appropriate benchmark price with which the euro price should be compared.

Another interesting result relates to the effect of a legal requirement for dual display of prices, which has lowered the increase of inflation for food products that are priced above 10 euro by a substantial amount, namely 12 to 15%.

6.4 Perceived inflation

As mentioned above, a puzzling feature of the cash changeover relates to the mismatch between actual and perceived inflation. In this last subsection, we will therefore investigate whether the factors that affected price developments as identified above can also, at least partially, explain this perception gap. Various explanations have been given as to why the perception gap arose in all countries of the euro area, such as the large number of price changes around the cash changeover (Del Giovane and Sabbatini 2005), or the large price increases in frequently purchased items (which were not necessarily due to the cash changeover; see e.g., ECB 2002b; Brachinger 2005). As food items certainly fall into this category, it is interesting to test whether differences in the complexity of conversion rates can shed light on the large cross-country differences in the size of the gap as well as in the speed with which the gap has been reduced over time.

For these purposes, a statistical measure of the gap is required. As perceived inflation is measured through a balance statistic, it covers a different scale (-100 to 100) than actual inflation. Accordingly, it is necessary to match the scale of the two series. The observations prior to the cash changeover are used to find the "typical" relationship between the two series, by regressing

$$\pi_t^{perc} = \alpha + \beta \pi_t^{act} + \varepsilon_t \qquad (2)$$

for each country. This relationship has then been used to rescale actual inflation into the range of perceived inflation, i.e. by calculating

$$\hat{\pi}_t^{rescaled} = \hat{\alpha} + \hat{\beta} \pi_t^{act} \qquad (3)$$

Having both series on a comparable scale, their mismatch can then be formulated as the difference between the two series, i.e.:

$$gap_t = \pi_t^{perc} - \hat{\pi}_t^{rescaled} \qquad (4)$$

In order to achieve a comparable measure across countries, the mismatch has been normalised by the standard deviation of perceived inflation observed in the country in the period until December 2001:

$$gap_t^* = \frac{gap_t}{\sigma(\pi_{-Dec01}^{perc})} \tag{5}$$

This measure can be calculated on a monthly basis for each country. In the econometric analyses, annual averages of the national gap measures have been calculated, thus yielding, e.g., for the year 2002:

$$g_{2002} = 1/12 \sum_{t=01/2002}^{12/2002} gap_t^* \tag{6}$$

Unfortunately, the non-availability of a measure of perceived inflation before January 2002 in Luxembourg does not allow calculating gap measures for this country. Dropping furthermore Ireland (because its conversion rate is below one) leaves only 10 observations for each year. The analysis is therefore based on an extremely small sample. In order to gain at least one degree of freedom, the regressions will contain only those variables that strictly relate to the properties of the conversion rate, and omit the dummy variable for a legal requirement of dual price display.
The regression results are reported in Table 10.

Starting with the gap in 2002, all three parameters have the opposite sign to those found in the preceding regressions: in countries where the change in food inflation has been lower (i.e. in those with simple or complex conversion rates), the perception gap is larger – in countries where the change in food inflation has been higher, the perception gap is smaller. This result holds regardless of the classification scheme, although with different levels of significance. Given that the models are run on 10 observations, the findings do appear rather robust and significant, however, and particularly so for the benchmark scheme, where all parameters are significant at the 1% level. These findings are consistent with the theory of rational inattention. If, as has been argued, the large price increases in frequently purchased items (which were not necessarily due to the cash changeover), together with other factors like the large number of price changes, has led to the deviations of perceptions from measured inflation, we would expect this effect to be stronger in countries with simple conversion rates, where consumers are more likely to be aware of price increases, as they perform the conversion in a more accurate fashion. Accordingly, the perception gap can easily be larger. A similar reasoning applies to the other regressors. It therefore seems to be the case that those characteristics that led to relatively larger changes in inflation for food products have also been important in determining the increase in perceived inflation relative to actual inflation.

Moving on to explaining the gaps in later years, there is an interesting tendency of parameters to flip sign relative to 2002. It should be expected that in countries with relatively lower increases in inflation, the perception gap closes relatively more quickly. Indeed, this is what is found: the explanatory variables for the perception gap in 2004 generally have the opposite sign to those in 2002: in countries with simple conversion rates, the gap has closed more quickly – whereas in countries with rates beyond 100, the gap is still relatively large.

7. Conclusions

This paper has tested theories of finite information-processing capacities on the side of consumers using the occasion of the euro cash changeover on January 1st, 2002. The paper argues that this event has increased the required information processing for consumers, as they needed to reconvert prices displayed in euros to their old, familiar currency for each purchase. On the other hand, sellers faced a smaller increase in the required information processing. The changeover has been an anticipated event, conversion rates were well known, and at the time of converting prices sellers obviously knew the price of their products in the old currency. The number of conversions that needed to be performed was therefore substantially smaller for sellers than for consumers. Furthermore, sellers acted under perfect certainty about the old price, whereas consumers needed to remember prices in the old currency, thus adding uncertainty on the side of consumers. This problem is particularly severe in multi-item shopping, and for low-priced items, both being criteria that apply to food retailing. Finally, concurrent events like bad weather conditions and animal diseases had led to substantial price increases prior to and around the changeover, which made it even more difficult for consumers to estimate the appropriate benchmark price in the old currency. With limited information-processing capabilities on the side of consumers, this event generates an inattention span that will lead to price increases.

This paper has exploited the different degrees of complexity in the various euro conversion rates across countries to test these theories. The results suggest that price developments in the food (and clothes) retail sector have been related to the complexity of the conversion rate. In countries with the least complicated conversion rates, inflation in the aftermath of the cash changeover turned out to be relatively lower, whereas conversion rates that are larger than 100 (which imply that the prices in euro look considerably smaller than in the old national currency) led to relatively higher inflation rates. The paper also finds evidence for non-linearities, in the sense that inflation turned out to be relatively lower in countries with the most complex conversion rates, suggesting that consumers there relied less on simple rules of thumb. Amongst food products, the differential patterns in inflation across countries are mainly observed for goods with prices below one euro. Furthermore, market structures come into play, as the patterns are found mainly for products sold in mid-priced stores as opposed to chain stores or supermarkets. Finally, it is found that a legal requirement for

dual display of prices has helped to contain cash-changeover effects. All these findings are in line with hypotheses of rational inattention on the side of consumers.

The cash changeover has triggered a heated discussion about its effect on inflation in literally all countries of the euro area. There is a general belief in the public that the changeover has increased prices dramatically, whereas there is very little statistical evidence supporting this notion, which is restricted to few sectors. This mismatch between the public perception and actual inflation has been seen in all euro area countries, and has not yet been reversed in some of them. Explanations given included a prominence of price increases in frequently bought items in the formation of inflation perceptions. In line with this, this paper finds that the same variables explaining pricing patterns for the food sector can also shed light on the cross-country differences in this perception gap. Countries where consumers were rationally more inattentive show a lower mismatch initially (and thus a lower complaint rate about price increases). As it is in those countries that food prices increase significantly more, however, the mismatch is closing relatively less quickly over time.

How should these findings be evaluated from a *macroeconomic perspective*? It is important to remember that the effects identified here relate exclusively to developments that vary across countries. The paper can therefore not take a stand on the overall evolution of prices in the aftermath of the cash changeover. In line with this qualification, the paper has not identified effects for some sectors where price increases were felt most strongly, such as restaurants or services in general. Furthermore, four points are worth mentioning that have implications for the macroeconomic importance of the findings. First, the volatility of food prices around the cash changeover that was present for other reasons not only complicated the signal extraction problem for consumers, but also the identification problem in the econometric analysis, and could thus possibly affect the results. Second, the differences found in this paper are measured relative to a group of only small countries that had medium complex conversion rates (in particular Belgium, Greece and Luxembourg). Third, as the paper finds that cash changeover effects relate in particular to countries with medium complex conversion rates, it does not imply a general rule that with increasing levels of complexity changeover effects are more pronounced, which can limit the macroeconomic impact of the finding. Fourth, the patterns do not apply generally. Just like general price increases have been restricted to some sectors, the relationship between the complexity of conversion rates and price developments is confined to food and clothes retailing; and there, it applies only to low-priced goods sold in mid-priced stores, which might have a relatively small market share. These qualifications notwithstanding, the paper does not only find evidence for theories of rational inattention, it also entails some important policy conclusions. First, there has been a large number of tax increases around the cash changeover, an unfortunate coincidence that might have supported consumers' impression of euro-related price increases. Second, the paper

clearly shows that dual display of prices has had a dampening effect on the evolution of some prices, suggesting the importance of measures that simplify the information processing requirements for consumers.

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Table 1: The euro conversion rates and their classification for the econometric analysis

Country	Conversion rate		Rule of thumb				Classification of rates for econometric analysis				
	Official conversion rate	Inverse of conversion rate	Possible rule of thumb	Margin of error in %	Overesti-mates prices?	Mathematical operations required	Conversion rate < 1?	Conversion rate > 100?	Classifi-cation (1)	Classifi-cation (2)	Classifi-cation (3)
AT	13.7603	0.07267	7 euro ~100 schilling	3.68	Yes	divide by 7	No	No	Complex	Complex	Complex
BE	40.3399	0.02479	1 euro ~ 40 francs	-0.84	No	multiply by 4, multiply by 10	No	No	Medium	Medium	Medium
DE	1.95583	0.51129	1 euro ~ 2 DM	2.26	Yes	multiply by 2	No	No	Simple	Simple	Simple
FR	6.55957	0.15245	1 euro ~ 7 francs	6.71	Yes	multiply by 7	No	No	Complex	Complex	Complex
FI	5.94573	0.16819	1 euro ~ 6 markka	0.91	Yes	multiply by 6	No	No	Complex	Medium	Medium
GR	340.75	0.00293	3 euro ~ 1000 drachmas	-2.23	No	divide by three, multiply by 1000	No	Yes	Medium	Medium	Complex
IE	0.787564	1.26974	0.8 euro ~ 1 punt	1.58	Yes	divide by 4, multiply by 5	Yes	No	Complex	Complex	Complex
IT	1936.27	0.00052	1 euro ~ 2000 lire	3.29	Yes	multiply by 2, multiply by 1000	No	Yes	Simple	Simple	Simple
LU	40.3399	0.02479	1 euro ~ 40 francs	-0.84	No	multiply by 4, multiply by 10	No	No	Medium	Medium	Medium
NL	2.20371	0.45378	1 euro ~ 2.20 guilders	-0.17	No	multiply by 2, divide by 10, add the 2 numbers	No	No	Complex	Complex	Complex
PT	200.482	0.00499	1 euro ~ 200 escudos	-0.24	No	multiply by 2, multiply by 100	No	Yes	Simple	Simple	Simple
ES	166.386	0.00601	6 euro ~ 1000 pesetas	0.17	Yes	divide by 6, multiply by 1000	No	Yes	Complex	Medium	Complex

Table 2: Skewness of sectoral inflation rates, 1998-2000 versus 2002

Country	Average 1998-2000	2002	Difference
Austria	-0.38	2.90	3.28
Belgium	0.90	-1.48	-2.38
Germany	-1.40	-2.15	-0.75
Spain	-1.65	-0.79	0.86
Finland	-0.14	1.64	1.78
France	-1.45	3.45	4.90
Greece	-0.84	1.65	2.49
Ireland	-2.75	-1.61	1.14
Italy	2.82	0.12	-2.70
Luxembourg	-0.77	-1.34	-0.57
The Netherlands	-2.22	4.41	6.63
Portugal	-1.69	-0.67	1.02
Denmark	0.03	-1.17	-1.20
Sweden	-3.39	-1.42	1.96
United Kingdom	-1.41	-0.50	0.91
Euro Area	-0.80	0.51	1.31
Non-Euro Area	-1.59	-1.03	0.56

Note: Numbers denote the skewness of each country's distribution of annualised December-January inflation rates at the 3-digit COICOP level; frst column: average over 1998, 1999 and 2000; second column: 2002; third column: difference between the first and second column. Numbers for the euro area and the non-euro area aggregates are unweighted averages.

Table 3: The effect of conversion rate complexity on all sectoral inflation rates

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) December 01 - January 02	4.163	*7.530*	10.662 *	*5.719*	4.359	*5.965*	-2.295	*3.503*	821	0.320
(2) October 01 - April 02	-0.990	*0.961*	0.577	*0.934*	0.736	*0.728*	-0.129	*0.806*	807	0.293
(3) January 01 - January 02	0.336	*0.551*	0.150	*0.466*	-0.974 *	*0.569*	-0.182	*0.599*	811	0.412
(4) March 01 - March 02	-0.141	*0.490*	-0.154	*0.452*	-0.673	*0.540*	-0.053	*0.506*	802	0.316
(5) July 01 - July 02	-0.885	*0.652*	-0.908	*0.730*	0.665	*0.490*	-1.152 **	*0.493*	803	0.310
(6) December 01 - December 02	-0.435	*0.509*	-0.291	*0.506*	0.460	*0.432*	-0.100	*0.503*	808	0.581

Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR), conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) and legal requirements for dual display of prices (DD) on changes in sectoral inflation rates in all euro area countries, where the inflation rates are calculated over the horizons indicated in the left column. Conversion rate classification: simple rates in Germany, Italy and Portugal. Complex rates in Austria, Finland, France, Ireland, the Netherlands and Spain. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Table 4: The effect of conversion rate complexity on parts of the national distribution

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) < 25th percentile	1.779	*1.444*	0.462	*1.438*	-0.666	*1.245*	-0.678	*1.041*	197	0.573
(2) 25th - 50th percentile	0.568 ***	*0.170*	-0.132	*0.170*	-0.198	*0.172*	-0.461 ***	*0.155*	197	0.679
(3) 50th - 75th percentile	-0.378 **	*0.156*	-0.386 **	*0.152*	0.365 **	*0.156*	-0.194	*0.127*	197	0.556
(4) 75th - 87.5th percentile	-1.254 ***	*0.347*	-1.323 ***	*0.374*	0.185	*0.291*	-0.213	*0.260*	95	0.793
(5) > 87.5th percentile	-8.117 *	*4.152*	-5.573	*5.601*	2.691	*3.635*	-4.187	*2.781*	95	0.445
(6) > 2*average(DK,SW,UK)	-3.753 *	*1.955*	-2.720	*2.308*	1.451	*0.925*	-2.333 *	*1.341*	239	0.354
(7) > 2*average(1995-2001)	-3.388 **	*1.467*	-1.748	*1.716*	1.456 **	*0.719*	-1.280	*0.976*	297	0.351

Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR), conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) and legal requirements for dual display of prices (DD) on changes in sectoral inflation rates in all euro area countries, calculated over July 2001 to July 2002. Each national distribution is sliced according to its own percentiles, and the sectoral inflation rates within each group are then pooled across countries for the various regressions. Conversion rate classification: simple rates in Germany, Italy and Portugal. Complex rates in Austria, Finland, France, Ireland, the Netherlands and Spain. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Table 5: The effect of conversion rate complexity on sectoral inflation

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) Services	-1.931	*1.672*	-2.803	*1.952*	-0.355	*0.874*	-1.328	*1.140*	264	0.119
(2) Food, beverages & clothes	-4.037 **	*1.935*	-1.996	*2.239*	3.682 ***	*1.250*	-3.689 ***	*1.272*	202	0.345
(3) Food & beverages	-2.856 **	*1.182*	0.016	*1.216*	4.057 ***	*1.535*	-2.362 **	*1.041*	149	0.392
(4) Housing	0.885	*1.301*	0.166	*1.491*	-0.333	*0.582*	-0.004	*0.921*	209	0.457
(5) Transportation & communication	-1.138	*1.057*	-1.050	*1.065*	2.457	*1.588*	-2.106	*1.479*	80	0.241
(6) Recreation	-0.385	*0.711*	-1.377 *	*0.733*	-0.349	*0.891*	-0.497	*0.735*	208	0.214

Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR), conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) and legal requirements for dual display of prices (DD) on changes in sectoral inflation rates in all euro area countries, calculated over July 2001 to July 2002. Conversion rate classification: simple rates in Germany, Italy and Portugal. Complex rates in Austria, Finland, France, Ireland, the Netherlands and Spain. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Table 6: Robustness tests for the effect of conversion rate complexity on inflation in the food, beverages and clothes industry

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) Benchmark model	-4.037 **	*1.935*	-1.996	*2.239*	3.682 ***	*1.250*	-3.689 ***	*1.272*	202	0.345
(2) Benchmark model for 2001	0.340	*0.947*	0.712	*0.714*	0.603	*0.990*	-1.602	*1.189*	204	0.209
(3) Benchmark model for 2003	1.777	*1.594*	0.438	*1.550*	-1.438	*1.001*	2.461 **	*1.113*	202	0.199
(4) Benchmark model excluding Portugal	-3.333 *	*1.975*	-2.204	*2.248*	4.600 ***	*1.565*	-3.138 **	*1.316*	183	0.334
(5) Model for inflation levels, 2001	0.926	*0.920*	1.516	*1.080*	1.671 **	*0.663*	0.444	*0.681*	204	0.519
(6) Model for inflation levels, 2002	-3.255 **	*1.328*	-0.822	*1.331*	3.511 ***	*0.706*	-2.149 ***	*0.771*	202	0.335
(7) Model for inflation levels, 2003	-3.118 **	*1.253*	-0.334	*1.226*	3.890 **	*1.602*	-1.339	*1.651*	202	0.331
(8) Model with autoregressive inflation, 2001	20.037 **	*9.875*	21.793 *	*11.032*	1.878	*2.343*	0.078	*2.288*	204	0.229
(9) Model with autoregressive inflation, 2002	-6.462 *	*3.833*	-3.352	*3.891*	4.518 **	*1.909*	-3.666 ***	*1.393*	202	0.217
(10) Model with autoregressive inflation, 2003	3.646	*3.236*	3.828	*3.357*	1.248	*1.154*	-1.174	*1.261*	202	0.161
(11) Classification scheme 2	-3.620 ***	*1.171*	-3.566 *	*1.902*	1.070	*1.831*	-2.422 ***	*0.890*	202	0.361
(12) Classification scheme 3	-4.992 **	*2.118*	-2.982	*2.185*	3.025 **	*1.394*	-2.326 **	*0.986*	202	0.351

Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR), conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) and legal requirements for dual display of prices (DD) on changes in sectoral inflation rates for the food, beverage and clothes sector in all euro area countries. Benchmark model: as in table 5. Classification scheme 2: simple rates in Germany, Italy and Portugal. Complex rates in Austria, France, Ireland and the Netherlands. Classification scheme 3: simple rates in Germany, Italy and Portugal. Complex rates in Austria, France, Greece, Ireland, the Netherlands and Spain. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Table 7: The effect of conversion rate complexity on inflation in food, beverages & clothes retailing; EIU City Data, classification scheme 1

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) Food, beverages & clothes (FBC)	-4.147 **	*1.691*	-3.196 *	*1.902*	2.168	*1.618*	-2.247 *	*1.260*	1749	0.015
(2) Food	-5.640 **	*2.640*	-4.614	*3.017*	1.924	*2.459*	-3.745 **	*1.901*	977	0.019
(3) FBC in supermarkets	-2.679	*2.196*	-1.148	*2.455*	3.704 *	*2.169*	-1.564	*1.655*	1050	0.015
(4) FBC in mid-priced store	-5.511 **	*2.208*	-4.436 *	*2.492*	0.411	*2.062*	-2.388	*1.635*	875	0.023
(5) Food in supermarkets	-1.840	*4.015*	-1.136	*4.571*	4.414	*3.959*	-2.196	*2.932*	488	0.021
(6) Food in mid-priced store	-9.412 ***	*3.418*	-8.090 **	*3.911*	-0.508	*2.949*	-5.265 **	*2.422*	489	0.041
(7) Food, prices below 1 euro	-11.989	*7.249*	-6.191	*9.008*	10.510	*7.443*	-1.562	*5.499*	163	0.045
(8) Food, prices between 1 & 10 euro	-4.068	*3.000*	-2.762	*3.511*	1.634	*2.865*	-3.502	*2.199*	789	0.015
(9) Food, prices above 10 euro	-2.557	*5.825*	-7.410	*5.952*	0.470	*4.726*	-14.609 ***	*4.326*	188	0.109
(10) Clothes, prices below 50 euro	-11.056 *	*6.271*	-4.037	*6.114*	5.213	*4.143*	-3.542	*3.687*	101	0.052
(11) Clothes, prices between 50 & 300 euro	-8.044 ***	*2.883*	-2.863	*2.963*	4.802 *	*2.736*	-0.803	*2.190*	300	0.041
(12) Clothes, prices above 300 euro	-2.809	*5.502*	4.040	*6.663*	-9.198	*10.162*	-2.689	*5.566*	52	0.139

Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR), conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) and legal requirements for dual display of prices (DD) on changes in product price inflation for food, beverage & clothes retailing in all euro area countries. Data source: EIU City Data. Classification scheme 1: simple rates in Germany, Italy and Portugal. Complex rates in Austria, Finland, France, Ireland, the Netherlands and Spain. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Table 8: The effect of conversion rate complexity on inflation in food, beverages & clothes retailing; EIU City Data, classification scheme 2

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) Food, beverages & clothes (FBC)	-3.677 ***	*1.315*	-6.639 ***	*1.958*	-2.797	*2.075*	0.082	*1.250*	1749	0.018
(2) Food	-4.462 **	*1.963*	-7.896 ***	*2.912*	-4.077	*3.113*	-0.665	*1.797*	977	0.021
(3) FBC in supermarkets	-3.127 *	*1.740*	-4.877 *	*2.560*	0.030	*2.737*	-0.163	*1.667*	1050	0.016
(4) FBC in mid-priced store	-4.631 ***	*1.692*	-8.344 ***	*2.603*	-5.830 **	*2.718*	0.656	*1.623*	875	0.033
(5) Food in supermarkets	-2.192	*3.078*	-4.522	*4.330*	0.972	*4.733*	-0.846	*2.791*	488	0.022
(6) Food in mid-priced store	-6.686 ***	*2.451*	-11.263 ***	*3.897*	-9.073 **	*4.060*	-0.448	*2.281*	489	0.051
(7) Food, prices below 1 euro	-11.659 **	*5.234*	-16.403 **	*8.096*	-1.193	*8.276*	4.188	*5.033*	163	0.068
(8) Food, prices between 1 & 10 euro	-3.724 *	*2.204*	-6.465 *	*3.388*	-3.301	*3.565*	-1.112	*2.070*	789	0.017
(9) Food, prices above 10 euro	-0.048	*4.372*	-9.997 *	*5.791*	-7.118	*6.721*	-12.240 **	*4.876*	188	0.118
(10) Clothes, prices below 50 euro	-10.627 **	*4.608*	-13.255	*8.638*	-5.410	*8.226*	1.375	*4.524*	101	0.087
(11) Clothes, prices between 50 & 300 euro	-8.871 ***	*2.358*	-12.188 ***	*3.755*	-4.646	*3.914*	2.812	*2.384*	300	0.076
(12) Clothes, prices above 300 euro	-5.935	*6.660*	-2.018	*9.848*	-10.689	*12.053*	-3.039	*6.897*	52	0.135

Note: See table 7. Classification scheme 2: simple rates in Germany, Italy and Portugal. Complex rates in Austria, France, Ireland and the Netherlands.

Table 9: The effect of conversion rate complexity on inflation in food, beverages & clothes retailing; EIU City Data, classification scheme 3

	β_{SR}		β_{CR}		β_{00}		β_{DD}		Obs	R^2
(1) Food, beverages & clothes (FBC)	-4.889 **	*1.996*	-3.748 *	*2.185*	1.377	*1.717*	-0.369	*1.356*	1749	0.015
(2) Food	-6.000 *	*3.091*	-4.495	*3.299*	0.996	*2.602*	-1.296	*1.954*	977	0.018
(3) FBC in supermarkets	-3.406	*2.613*	-1.946	*2.838*	3.286	*2.279*	-0.724	*1.788*	1050	0.015
(4) FBC in mid-priced store	-6.598 **	*2.612*	-5.281 *	*2.913*	-0.706	*2.211*	0.239	*1.772*	875	0.023
(5) Food in supermarkets	-2.597	*4.692*	-1.966	*4.855*	4.003	*4.113*	-1.363	*2.999*	488	0.022
(6) Food in mid-priced store	-9.378 **	*4.027*	-7.039	*4.463*	-1.960	*3.218*	-1.196	*2.525*	489	0.036
(7) Food, prices below 1 euro	-19.953 **	*8.806*	-15.439 *	*9.234*	7.264	*7.742*	4.162	*5.397*	163	0.061
(8) Food, prices between 1 & 10 euro	-5.355	*3.500*	-4.114	*3.810*	0.688	*3.055*	-1.567	*2.266*	789	0.016
(9) Food, prices above 10 euro	0.231	*6.834*	-4.127	*6.579*	-0.494	*5.040*	-14.265 ***	*5.302*	188	0.102
(10) Clothes, prices below 50 euro	-15.917 **	*7.778*	-10.015	*9.031*	3.184	*4.662*	0.360	*4.148*	101	0.068
(11) Clothes, prices between 50 & 300 euro	-12.976 ***	*3.566*	-8.853 **	*4.097*	2.867	*2.914*	2.396	*2.477*	300	0.055
(12) Clothes, prices above 300 euro	-0.072	*8.410*	7.176	*10.289*	-7.775	*10.177*	-5.588	*7.196*	52	0.145

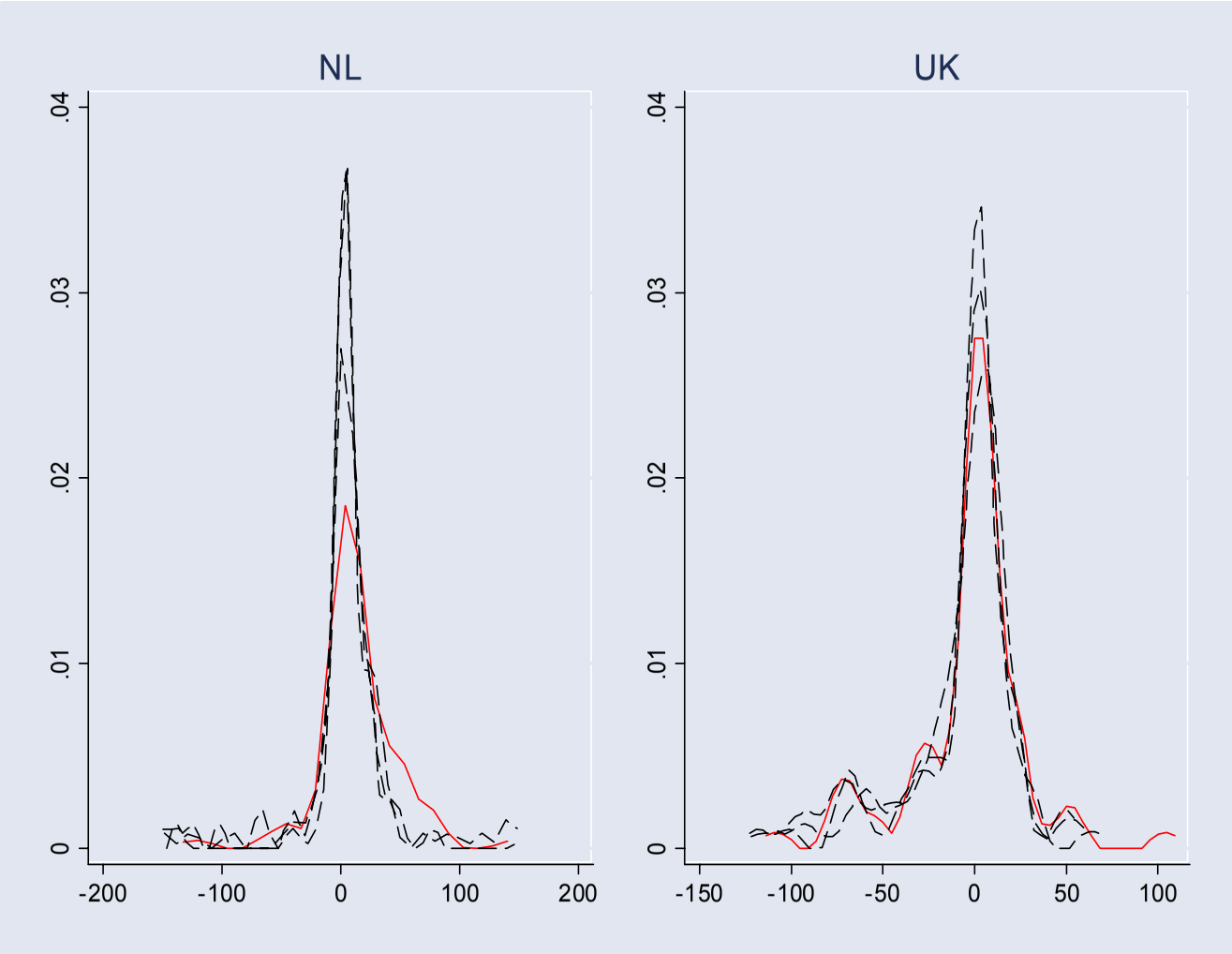
Note: see table 7 Classification scheme 3: simple rates in Germany, Italy and Portugal. Complex rates in Austria, France, Greece, Ireland, the Netherlands and Spain.

Table 10: The effect of conversion rate complexity on the inflation perception gap

	β_{SR}		β_{CR}		β_{00}		Obs	R^2
			Classification scheme 1					
g_{2002}	1.080 ***	*0.266*	1.171 ***	*0.228*	-1.183 ***	*0.188*	10	0.895
g_{2003}	0.225	*0.570*	1.285 **	*0.488*	0.621	*0.403*	10	0.713
g_{2004}	-1.545 **	*0.519*	0.039	*0.445*	1.501 ***	*0.367*	10	0.820
			Classification scheme 2					
g_{2002}	0.465	*0.498*	0.540	*0.467*	-0.753 *	*0.385*	10	0.538
g_{2003}	-0.728	*0.741*	0.156	*0.695*	1.003	*0.574*	10	0.386
g_{2004}	-1.631 **	*0.461*	-0.085	*0.432*	1.495 ***	*0.357*	10	0.821
			Classification scheme 3					
g_{2002}	0.337	*0.360*	0.788 *	*0.398*	-0.541	*0.360*	10	0.658
g_{2003}	-0.535	*0.486*	1.069 *	*0.537*	1.409 **	*0.486*	10	0.627
g_{2004}	-1.511 ***	*0.378*	0.243	*0.418*	1.612 ***	*0.378*	10	0.830

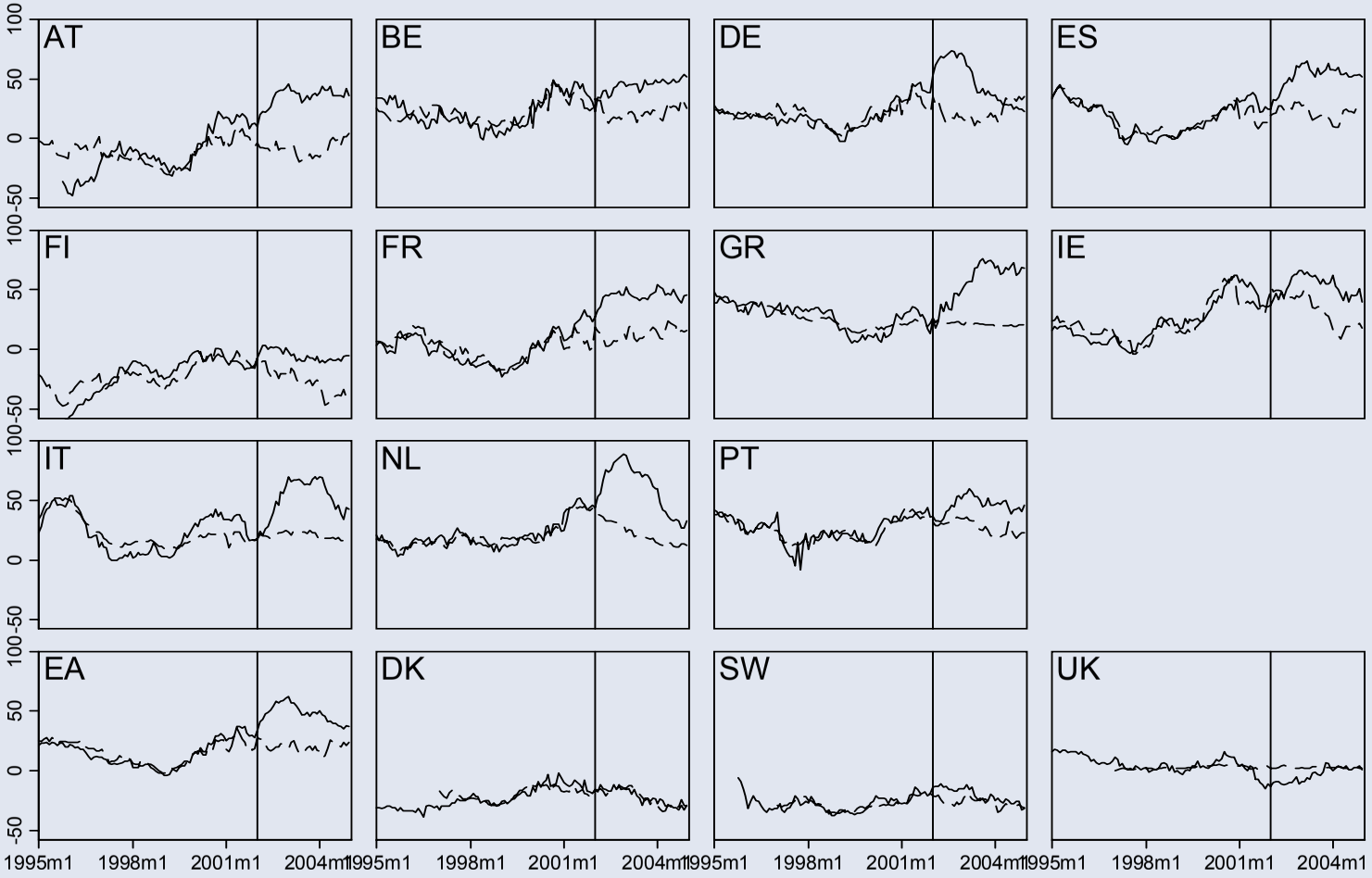
Note: This table shows the effect of simple conversion rates (SR), complex conversion rates (CR) and conversion rates that lead to euro prices being less than one hundredth their value in the national denomination (00) on annual inflation perception gaps in all euro area countries. Classification schemes: see notes to tables 7 to 9. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Numbers in italics are standard errors.

Figure 1: Distribution of sectoral inflation rates in the Netherlands and the United Kingdom



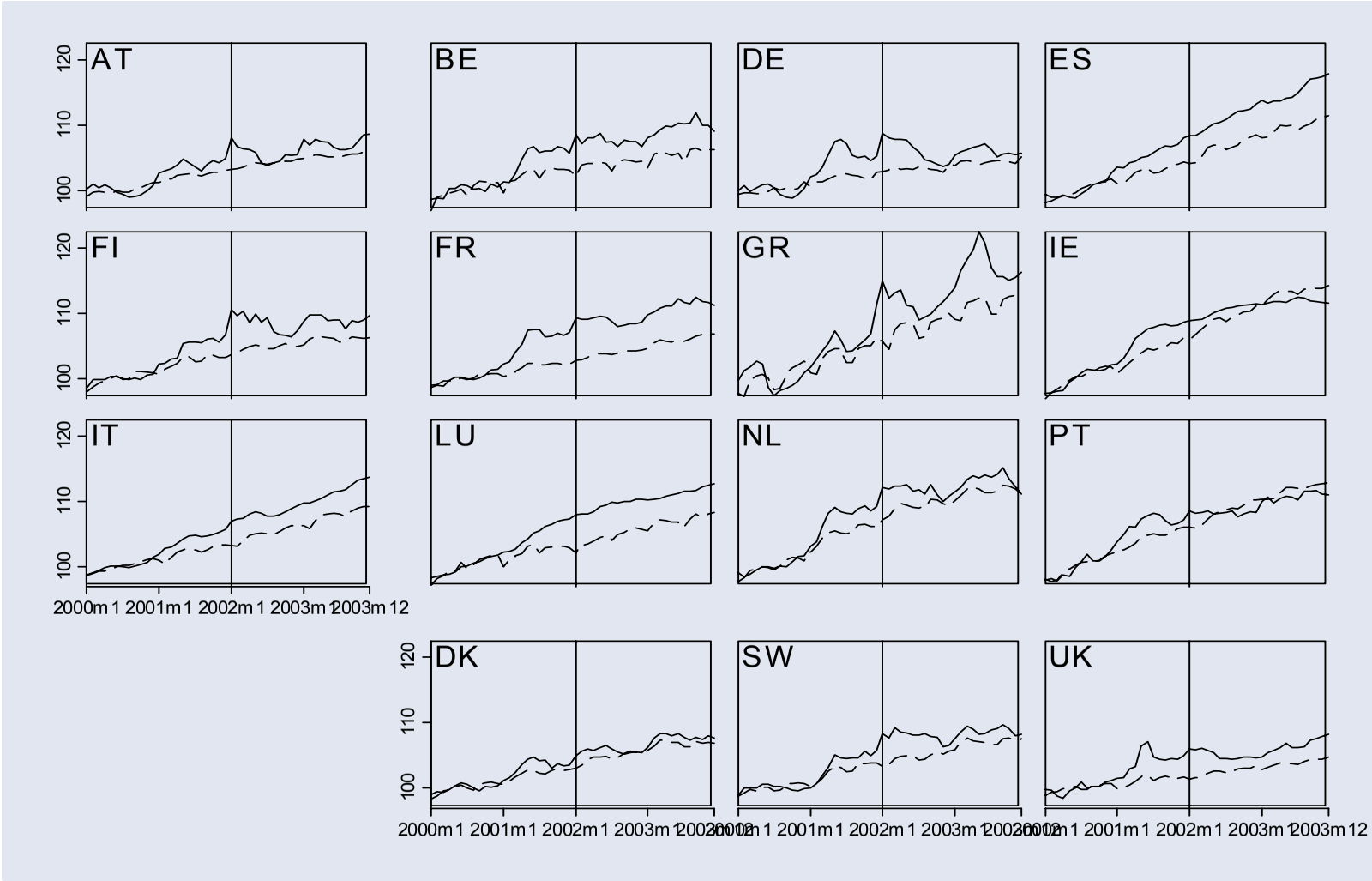
Note: The figure plots the distribution of inflation rates at the 3-digit COICOP level in the Netherlands and the United Kingdom. Inflation rates are annualised rates from December to January 1998, 1999 and 2000 (dashed lines) as well as 2002 (solid red line).

Figure 2: Actual and perceived inflation



Note: The figure plots the European Commission's measure of consumers' perceived inflation against a properly rescaled series of actual, national, HICP inflation. The vertical line shows January 2002, the month of the cash changeover. Luxembourg is missing, as there is no data on perceived inflation prior to January 2002. EA = euro area aggregate.

Figure 3: Indices of consumer prices and food prices



Note: The figure plots the consumer price index (dashed line) and the price index for food (solid line), 2001=100. The vertical line shows January 2002, the month of the cash changeover.

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