Defining Price Stability

SUMMARY

In 1998, the European Central Bank provided a quantitative definition of its price-stability objective as an annual rate of increase in the Harmonized Index of Consumer Prices (HICP) of below 2.0 percent. This paper takes a measurement perspective in evaluating the ECB's quest for price stability during the first years of monetary union. We start by considering what the HICP is designed to measure and how accurate is it in terms of its stated objective, and then ask whether there is any sense in which a 2.0-percent "limit" on HICP inflation can be said to be too low from a measurement perspective. We conclude that the conceptual underpinnings of the HICP remain sufficiently vague that it is difficult to compare with other indexes or come to any hard conclusions about its accuracy. However, it is possible that the HICP is susceptible to the biases that are known to affect other measures of inflation at the consumer or household level, and if forced to quantify potential bias, a point estimate of 1.0 percent strikes us as reasonable. Bias of this magnitude, in conjunction with the inherent noisiness of the headline number and the well-known aversion of central bankers to deflation, argues for a modest upward redefinition of the rate of HICP inflation consistent with price stability.

- Stephen G. Cecchetti and Mark A. Wynne

Inflation Measurement and the ECB's Pursuit of Price Stability: A First Assessment

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"*For all these conceptual uncertainties and measurement problems, a specific numerical inflation target would represent an unhelpful and false precision. Rather, price stability is best thought of as an environment in which inflation is so low and stable over time that it does not materially enter into the decisions of households and firms.*"

Alan Greenspan, "Transparency in Monetary Policy," remarks to the Federal Reserve Bank of St. Louis Economic Policy Conference, October 11, 2001

"The ECB's Governing Council was of the view that the quality of the HICP made it feasible to set a precise definition of price stability as part of its monetary policy strategy."

Otmar Issing, "The Relevance of Reliable Statistical Systems for Monetary Policy Making in the Euro Area", speech to CEPR/ECB Workshop on Issues in the Measurement of Price Indices, November 16, 2001.

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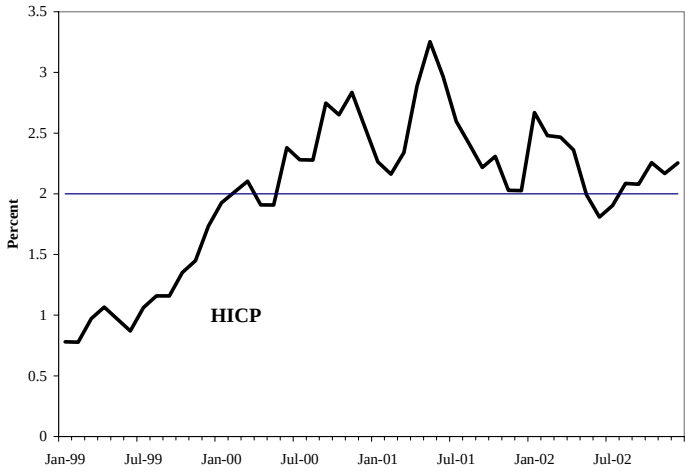
1. INTRODUCTION

Article 105 of the Treaty Establishing the European Community mandates that the primary objective of the European System of Central Banks shall be to maintain price stability. In October 1998 the Governing Council of the ECB adopted its "stability-oriented monetary policy strategy." Included was a quantitative definition of price stability as "…a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the euro area of below 2%…to be maintained over the medium term." Since the beginning of monetary union in 1999, through December 2002, inflation has been at or above this self-imposed limit of 2 percent in no fewer than 30 of 48 months, as Figure 1 shows.

Unlike the ECB, the Federal Reserve has consistently shied away from offering a

Figure 1
HICP inflation in the euro area since launch of EMU



Source: Eurostat/Haver Analytics

quantitative definition of price stability. Rather, throughout his tenure, Chairman Alan Greenspan has defined price stability qualitatively as prevailing when inflation ceases to be a factor in the decisions of households and businesses, as our opening quote indicates. Of course, Alan Greenspan is not the first Fed chairman to prefer a qualitative rather than a quantitative definition of price stability. In 1983, Greenspan's predecessor, Paul Volcker argued that "…A workable definition of …"price stability" would …be a situation in which expectations of generally rising (or falling) prices over a considerable period are not a pervasive influence on economic and financial behavior…"[price] stability" would imply

that decisionmaking should be able to proceed on the basis that "real" and "nominal" values are substantially the same over the planning horizon – and that planning horizons should be suitably long." Among the reasons Chairman Greenspan has given for not advancing a precise quantitative definition are the difficulties associated with inflation measurement in a dynamic economy About a month after Chairman Greenspan's defence of the Fed's reluctance to provide a quantitative definition of price stability in the US, ECB Board member Otmar Issing confidently asserted that the ECB does not share the Federal Reserve's concerns about price index accuracy.

In the recently completed assessment of its policy strategy, the Governing Council reaffirmed its view that the HICP is sufficiently accurate that it can safely be used to quantify ECB's Treaty mandate of price stability. Are they right? Is the quality of inflation statistics available to the Governing Council sufficient for them to be used as they are? And is the zero to two percent range appropriate?

This is the backdrop for our review of various aspects of the performance of the ECB during the first years of the European Monetary Union (EMU). The creation of the HICP in time for an assessment of the convergence criteria prior to the launch of EMU was a remarkable achievement. And when it came to quantifying what is meant by price stability in the euro area there was no viable alternative to the HICP. With that said, however, we think it is necessary and possible to do better. We will pose and attempt to answer three questions. First, what is the HICP, and what is it designed to measure? Answering this question in the context of a discussion of monetary policy leads us to ask: What does price stability mean for monetary policymakers? We argue that the welfare basis for the price-stability objective of the ECB (and other central banks) creates a compelling case for policymakers to focus on a cost-of-living index, as this provides the clearest measure of the impact of inflation on households. While it is relatively uncontroversial that the final objective of a central bank should be defined in terms of a headline measure of inflation such as the cost-of-living-based consumer price index, few would argue that central bankers should respond to every monthly uptick or downtick in the monthly measure. This leads us to our second question: Is it possible to construct a measure of core inflation based on the HICP that does better than the traditional measures that are reported each month as part of the regular monthly release of the HICP. Core inflation plays a prominent role in the deliberations of most central banks. The idea is that monetary policy should be concerned with the medium-term (i.e. several-year) trend in inflation, not the month-to-month or quarter-to-quarter ups and downs. In fact, policymakers who react to high-frequency price fluctuations are likely to add volatility rather than stabilize it. We will examine various measures of core inflation based on the HICP and confirm what has already been found in many countries, namely that traditional measures of core inflation are of limited value, and that non-traditional measures deserve greater prominence. And third, we will take on the difficult issue of the definition of price stability. Given recent trends in central banking practice, and the ECB's Treaty mandate to maintain

price stability, everyone expected the ECB to put forward a quantitative definition of price stability. And given the paucity of other comprehensive inflation measures for the euro area and the lags in the publication of the GDP-based price measures, it was not at all surprising that the definition was in terms of the HICP. However, the ECB has been criticized for setting its inflation "target" too low, and for not making it symmetric. We will argue that the 2 percent limit on HICP inflation may be too low for a ceiling, and that the ECB's definition of the rate of HICP inflation consistent with price stability should be revised upward. Measurement bias alone is not sufficient reason for an upward revision. Our point estimate of bias is in fact below the current 2.0 percent limit. However, there is considerable uncertainty associated with this point estimate. This uncertainty, combined with the aversion of most central bankers to deflation and the inherent noisiness of month-to-month inflation, is central to our argument for a higher target and range. Our rough calculations suggest 1¼ to 2½ percent HICP inflation as a better definition of price stability. We view this as an operational minimum. Concerns about the zero nominal interest rate bound – that there will be times when further interest rate reduction are desirable but impossible – would raise this range even further.

2. THE HARMONIZED INDEX OF CONSUMER PRICES

From the launch of EMU in January 1999 through December 2002, the HICP rose by just over 9 percent. Over the same period, inflation in the U.S. has been roughly the same: the Consumer Price Index for All Urban Consumers (CPI-U) went up 10.1 percent from the beginning of 1999 to the end of 2002. It would seem that inflation performance in the U.S. was comparable to that in the euro area, and it may have been. But comparisons are not so simple, because the CPI-U and the HICP differ in their conceptual frameworks. The CPI-U is an approximation to a cost-of-living index and its construction in grounded in welfare economics. The HICP is unequivocally not a cost of living index, but it is less clear what it is. These conceptual differences give rise to many important differences in practical implementation, the most important of which has to do with the treatment of owner-occupied housing. In the CPI-U, owner-occupied housing services are priced on a rental equivalence basis, and have a weight (relative importance as of December 2001) of about 20 percent. The HICP does not (at present) include the services of owner-occupied housing in its domain of definition. There are also important differences in terms of coverage. The U.S. CPI measures of the inflation experiences of urban households only (about 85 percent of all households) while the HICP is supposed to measure the inflation experiences of all households resident in the economic territory of the member states.

2.1. The Conceptual Framework

The HICP has its origin in the Treaty imperative that for the purposes of assessing convergence prior to EMU, inflation "…shall be measured by means of the consumer price index on a comparable basis, taking into account differences in national definitions." (See Article 1 of the Protocol on the convergence criteria). Given the pressure of time in the run-up to EMU, the only viable option was to use the common components of national CPIs to produce a measure of inflation at the consumer level that was comparable across countries. The conceptual justification has been provided as something of an afterthought.

Starting from the observation that "…there is no operational definition of 'inflation' ", Eurostat (2001) states "…the HICP…[is]…a Laspeyres-type price index that is based *on the prices of goods and services available for purchase in the economic territory of the Member State for the purpose of directly satisfying consumer needs*." (p. 19, emphasis in original.) The HICP covers household final monetary consumption expenditure as defined by the European System of Accounts (ESA 95). Household final monetary consumption is defined as the component of consumption expenditure incurred by households regardless of nationality or residence status, in monetary transactions, on the economic territory of the Member State, on goods and services that are used for the direct satisfaction of individual needs or wants, and in one or both of the two time periods being compared. (Eurostat, 2001, pp. 19-20) The HICP is intended as a "pure" price index, meaning that "…it is only changes in prices that are reflected in the measure between the current and base or reference period. *The HICP is not a cost of living index*." (p. 19, emphasis in original)

Instead, as Astin (1999) explains, the intent is for the HICP to track the cost of actual monetary transactions. This means that no imputed prices, such as those for the services of owner-occupied housing, should be used in the HICP. The same reasoning is used to exclude the cost of borrowing money, on the grounds that it is neither a good nor a service.

The HICP was first published in March 1997, with the release of the figures for January 1997. The raw price data are collected by national statistical institutes, compiled into national HICPs and then forwarded to Eurostat, which publishes the overall HICP for the EU and the euro area (the Monetary Union Index of Consumer Prices, MUICP), as well as *about* 129 individual price series at various levels of aggregation. We say about because exact numbers are hard to come by. To see the problem, we can look at the 3-digit level. The individual series titled "Telephone and telefax equipment" and "Telephone and telefax services" are reported, along with the combined series called "Telephone and telefax equipment and services". In principle all countries are supposed to report the separate series, but in practice some only report the combined series.

While the basket of goods priced for the HICP is the same across all EU countries, the individual prices are not aggregated using a common set of expenditure weights. Rather prices in each country are weighted according to expenditure patterns in that country. Thus,

in 2000, for example, the expenditure division Food and Non-alcoholic beverages had a weight of 24.4 percent in the HICP for Spain, but only 12.1 percent in the UK. Each country is supposed to ensure that the weights used to aggregate the individual prices are sufficiently up to date to ensure comparability. Many countries (accounting for a bit less than two-thirds of the euro area HICP) update the item weights each year or plan to start doing so soon. The HICPs for each country are aggregated into an overall index for the EU (the EICP) and the euro area (the MUICP) using country weights derived from the share of each country's household final monetary consumption in the relevant total. The EICP and MUICP are annual chain indexes, with weights updated each year. Thus the weights for 2003 are the based on national accounts data on household final monetary consumption expenditure for 2001 updated to December 2002 prices.

2.2. Evaluating the HICP

A number of authors have already critiqued the HICP's conceptual basis, or lack of one. Prominent among them are Diewert (2003) and Wynne and Rodriguez (2002). As they point out, the framework is not very well developed (certainly nowhere near as well developed and understood as the theory of the cost-of-living index), and what conceptual basis exists suffers from a number of internal inconsistencies. One of particular note is the manner in which quality adjustment is treated. To determine when quality adjustment is called for, Eurostat notes that "Quality change occurs whenever …a change in [product] specification has resulted in a significant difference in utility to the consumer between a new variety or model of a good or service and a good or service previously selected for pricing in the HICP for which it is substituted." (Eurostat, 2001, 69, emphasis added) It is difficult to make sense of this statement except in the context of the theory of the cost-of-living index, which Eurostat claims the HICP explicitly is not.

It is equally difficult to understand the claim that the HICP includes no imputations. If taken literally, then as Diewert (2002) points out, the index should ignore new goods and services. This would apply to both new goods and new varieties of existing goods. The appropriate treatment of new goods in the cost of living framework is to estimate a virtual price for the earlier period when the good was not available, and use this virtual price to compute the index. In the case of new varieties of existing goods, some form of quality adjustment will typically be needed, which will again entail the imputation of prices to characteristics of goods.

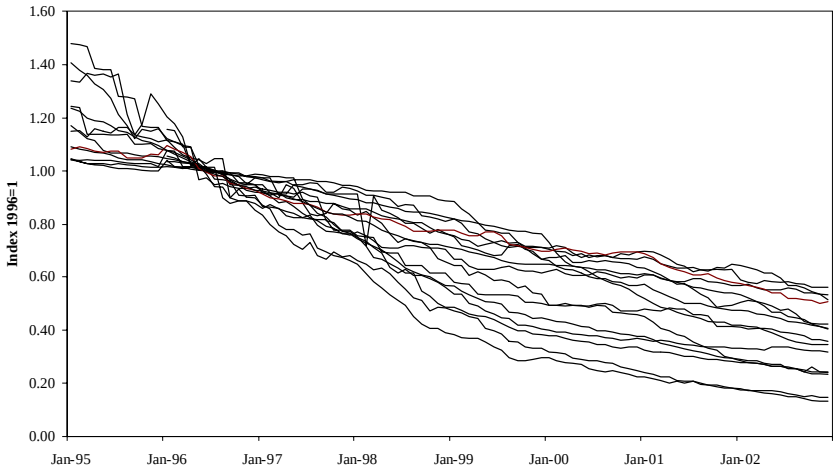
The lack of a solid conceptual foundation makes evaluation of the HICP itself nearly impossible. For example, how could we possibly figure out the extent of measurement error in the HICP without a clear notion of what we should be trying to measure? Error relative to what? Maybe the HICP suffers from the generic measurement problems that attend consumer price indices – substitution bias, bias due to the failure to correct for quality change properly,

and so on – but who knows? Without a theoretical ideal, it is simply impossible to do the sort of evaluation that has been done for the U.S. CPI. And indeed, Eurostat (2001, p. 36) asserts that it is inappropriate to criticize the HICP from the cost-of-living perspective. This means that most if not all of the biases that are known to affect fixed-weight Laspeyres-type measures of inflation, such as substitution bias, quality bias and new goods bias may have no meaning in the context of the HICP.

These problems notwithstanding, measurement error is of serious concern to central bankers. Achieving true price stability means knowing the accuracy of the available price indices. For the Governing Council of the ECB, this means having some sense of the size of the bias in the HICP. But as our previous logic suggests, we find it difficult to evaluate the likely extent of such a bias. An equally severe obstacle to any attempt to assess the accuracy of the HICP is limited amount of publicly-available information on the data collection and adjustment practices of the individual national statistical offices, and how well they implement the ideal HICP.

Finally, there is suggestive evidence that the HICP may be failing even to harmonize price measurement across the EU. Of all the components of the HICP, the category "09.1.3 – Information processing equipment" is the one most likely to include similar if not identical products in every country, and also one most likely to be susceptible to serious quality adjustment problems. Commission Regulation 1749/1999 defines this category as including personal computers and monitors, printers, software and miscellaneous accessories accompanying them, calculators, typewriters, word processors and telefax and telephone answering facilities provided by personal computers. Figure 2 plots the recent behaviour of this component of the HICP for each country, deflated by the relevant national HICP.

Figure 2
Relative price of information processing equipment in EU countries



Source: Eurostat/Haver Analytics.

The extraordinary range of estimates shown in this figure suggests that the HICP may be failing to achieve its most basic objective. The evidence is only suggestive: it could well be that the different inflation experiences reflect nothing more than national differences in the composition of spending on information processing equipment. However, absent evidence to the contrary, we are inclined to interpret the figure as illustrating significant differences in quality adjustment procedures in the decentralized compilation of the HICP. Hoffman (1998) documents comparable problems in the German CPI, which is also decentralized.

2.3. Bias

With these observations as background what can we say about the accuracy of the HICP? Are there any grounds for believing that measurement error might be so significant that 2 percent inflation as measured by the HICP would constitute true price stability? Or is the HICP so accurate that true price stability would require no increase in the HICP? There is a strong presumption on the part of many economists that substitution in response to relative price changes, improvements in quality, and the introduction of new goods of necessity impart an upward bias to conventional measures of consumer price inflation. However, some recent research has cast doubt on some of these priors, and there is no alternative to a detailed examination of the construction of the HICP to determine whether bias exists. [See in particular the papers by Silver and Heravi (2002), and Hobijn (2001, 2002).]

Box 1: Sources of bias in measures of consumer price inflation

Measures of consumer price inflation that are rooted in the theory of the cost-of-living index may deviate systematically from an ideal measure for a variety of reasons. Loosely speaking such bias can arise because of the manner in which raw data are collected, the way they are combined into the final index, or the technique used to adjust them for changes in quality.

A typical consumer price index is intended to measure the inflation experience of a hypothetical average or representative consumer. To construct the index, the government statistical agency has to figure out what consumers buy and where they buy it. These are done with various expenditure surveys, and mistakes give rise to bias.

The first difficulty is that consumers buying patterns change all the time, while surveys are infrequent. And in particular, as some goods become relatively more expensive and others relatively less expensive, consumers will tend to shift their expenditure patterns away from the goods that have become more expensive and towards those that have become less expensive. The willingness to make such substitutions lessens the impact of price changes on consumers' standards of living, and to the extent that statisticians fail to take such substitution possibilities into account, the overall measure of consumer price inflation they compile will be subject to substitution bias. Different price indices are more or less subject to substitution bias. Measures like the HICP and the U.S. CPI that are based on expenditure weights that change infrequently are particularly susceptible to this problem, and are known to overstate inflation as a direct result.

Failing to account for changes in where consumers shop gives rise to something called outlet-substitution bias. If consumers have typically made the bulk of their food purchases at small neighbourhood bakeries and butcher shops, but a liberalization of the retailing industry suddenly causes a dramatic increase in the attractiveness of supermarkets that charge lower prices, a failure on the part of the statisticians to take this into account in deciding where to gather price information may again impart an upward bias to the consumer price index.

The problems posed by changes in the quality of the goods and services included in the consumer price index, and the arrival of new goods in the consumer marketplace pose the greatest challenges for statisticians in accurately measuring the cost of living. Quality bias arises when statisticians fail to take into account improvements in the quality of a good or service included in the consumer price index. For example, suppose that all cinemas introduce elaborate new sound systems that enhance the overall movie-going experience, and raise ticket prices at the same time. If consumers willingly pay the higher ticket prices because they value the greater sound quality, but statisticians simply record the higher ticket prices without account for the changed quality, then inflation will be overstated.

Finally, new goods bias arises when the statisticians fail to recognize the introduction of new goods or services on which consumers spend a significant fraction of their income. The

distinction between genuinely new goods and new varieties of existing goods is not always clear cut, although few would dispute that mobile phones or DVDs are genuinely new goods, while more durable shoes or clothing, say, are simply better varieties of existing goods. Failing to recognize the introduction of new goods that are subsequently purchased by most consumers may impart an upward bias to a consumer price index because such goods typically experience rapid price declines following their introduction. Under the rules governing the construction of the HICP, new goods or services are supposed to be introduced into the index when they account for one tenth of one percent of consumer spending.

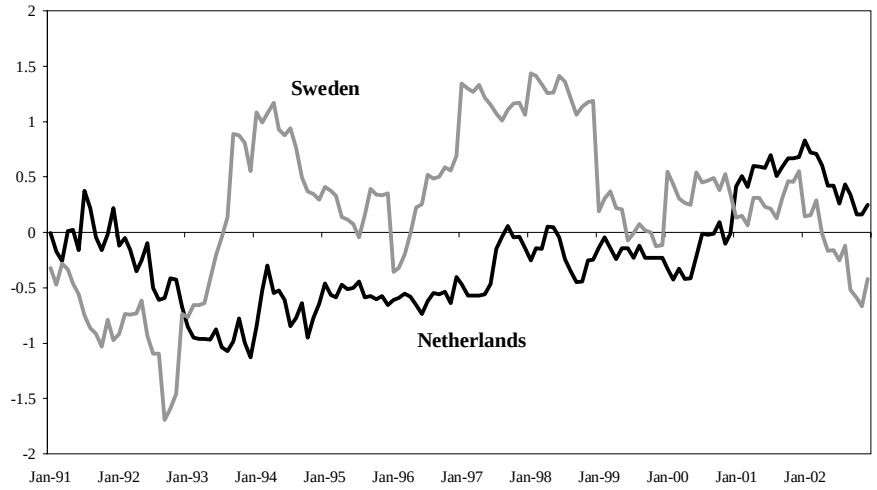
Wynne and Palenzuela (2002) provide a comprehensive review the current state of knowledge on the accuracy of the HICP, and argue that there is very little scientific basis for a point (or even an interval) estimate of a positive bias in the HICP. But let's deny ourselves the luxury of such fence sitting, and ask if forced to produce a number for the potential bias, what would it be? Lebow and Rudd (2003) is the most up to date and comprehensive review of the accuracy of the CPI-U, and they estimate that it overstates the rate of increase in the cost of living by about 0.9 percent a year, with a range from 0.3 to 1.4 percentage points. By comparison, the Boskin Commission (Boskin et. al. 1996) estimated that the CPI-U overstated inflation by about 1.1 percent a year, with a range of 0.8 to 1.6. There have been no comparable studies of the accuracy of the HICP, and only a handful of studies of the accuracy of national CPIs in the EU. The best of the existing studies of the accuracy of measures of consumer price inflation in the EU, Hoffman (1998), estimated that the German CPI overstated inflation by about 0.75 percent a year. So for the sake of discussion, a point estimate of an upward bias of 1.0 percent would be consistent with such evidence as exists.

And this point estimate is likely to be very imprecise. The comprehensive studies for the U.S. suggest that the standard error on those estimates is roughly 0.4.[1] Our view is that this is a floor for any estimate of the uncertainty in the bias of a euro-area cost-of-living index. The evidence on information technology prices alone suggests the possibility of significantly higher uncertainty. Our conservative estimate is that the point estimate of 1 percent has a standard deviation of ½ of one percentage point. We will come back to these figures in our evaluation of the Governing Council's definition of price stability.

[1] This estimate comes from Lebow and Rudd's (2003) and is based on the information summarized in their Table 1. This table reports, variously, 80 percent and 90 percent confidence intervals for estimates of the bias. If 0.3 percent is the lower limit of an 80 percent confidence interval, then with a point (mean) estimate of 0.9 percent the standard deviation must be (0.9-0.3)/1.45 = 0.41. If instead we take the range to be a 90 percent confidence interval, the standard deviation is (0.9 – 0.3)/1.65 = 0.36. Applying the same calculus to the Boskin Commission yields comparable estimates.

2.4. Does It Make Any Difference?

Figure 3
Difference between HICP and CPI (COL) inflation



Source: Eurostat/OECD/Haver Analytics

Should policymakers care about any of this? Would it make any difference if they were to shift attention away from the HICP and toward a cost-of-living index? Would such a move have had any impact at all on policy actions? We can address this issue by comparing alternative inflation measures. Both the Netherlands and Sweden use the theory of the cost-of-living index as the conceptual framework for their national CPIs, which they continue to produce alongside their national HICPs. Figure 3 shows the difference between inflation at the consumer level as measured by the HICP and the cost-of-living based CPI for each of these countries over the past decade (that is, HICP inflation minus CPI inflation). As Figure 3 shows, HICP inflation exceeded CPI inflation in the Netherlands for most of 2001 and 2002; a similar situation prevailed in Sweden for most of 1997 and 1998. Other things being equal, a monetary policy that was based on developments in the HICP would have been too tight (from a welfare point of view) in both instances. The reason for the discrepancy between the two measures of inflation has to do with the treatment of owner-occupied housing. As we noted in our discussion of the HICP above, the "no imputations" rule means that the cost of owner-occupied housing is not included in the HICP. It is included in the CPI, however. Indeed, if we compare the behaviour of prices in the expenditure class "Housing, water, electricity and fuels" which is computed for both the HICP and the CPI for

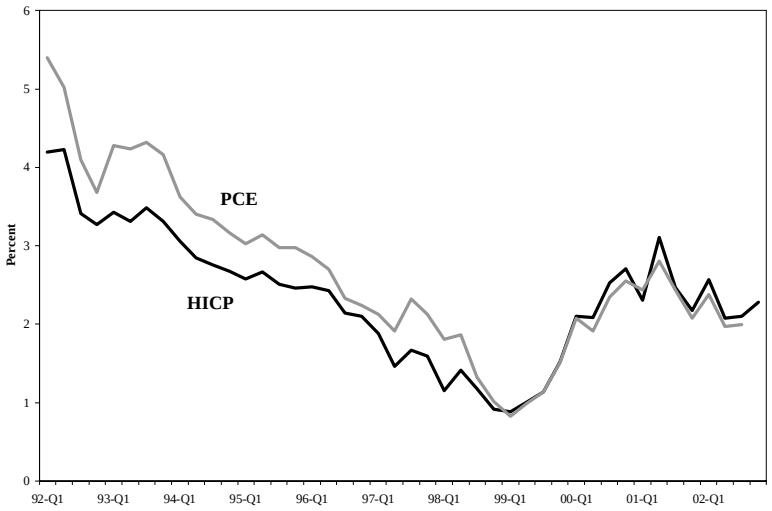
Sweden, we find essentially the same pattern of discrepancies as shown in the Figure above. That is, the prices of "Housing, …" as measured by the CPI were falling from 1997 through 2000, whereas the HICP showed the same prices as rising for most of this period. The difference between "Housing…." Prices as measured by the HICP and the CPI amounted to 3.0 to 5.0 percentage points in the early part of this period, and averaged 1.7 percentage points over the period as a whole (that is, the HICP for "Housing, …" rose at an average annual rate that was 1.7 percent greater than the increase in the CPI.)

While the two measures of inflation at the consumer level can diverge for periods of a year or longer, they do tend to track each other over long periods of time (formal statistical tests confirm that they are cointegrated). From January 1991 through December 2002, the mean inflation rate at the consumer level in the Netherlands as measured by the HICP was 2.5 percent, versus 2.7 percent as measured by the cost of living based CPI. For Sweden the comparable figures are 2.6 percent HICP inflation and 2.3 percent CPI inflation. HICP inflation is somewhat more volatile than CPI inflation in the Netherlands (standard deviation of 1.2 as opposed to 0.8 percent) while the opposite is the case in Sweden (standard deviation of HICP inflation of 2.3 percent, versus 2.6 percent for the CPI).

The deflator for personal consumption expenditure (PCE) is a comparable proxy for a cost-of-living index for both the European Union (EU) and the euro area. The PCE deflator is a measure of consumer price inflation computed as part of the national accounts, and so is available for all EU countries. Figure 4 plots both the HICP and a personal consumption expenditure deflator (PCE) for the euro area over the past ten years.[2] The PCE is an approximation to a cost-of-living index that differs from the HICP in a number of ways, the treatment of housing being the primary one. As is standard for cost-of-living measures, the PCE attempts to measure the cost of all consumption, including especially the cost of housing to homeowners. The cost of homeownership is computed by assuming that owners rent their own houses from themselves, and then going to the rental information to estimate the rental that they would have to pay to do it. In the U.S. this is referred to as "owner's equivalent rent," and it makes up 20 percent of the consumer price index. Since housing is such large component of consumption spending, including it can have an important impact on estimates of inflation.

[2] A variant of the personal consumption expenditure (PCE) index is the Federal Open Market Committee's current preferred measure of inflation. Committee members, and especially Chairman Greenspan, believe it to be the most accurate cost-of-living index currently produced in the U.S. The Eurostat version of the PCE is somewhat different from its American cousin. The primary difference is in the weighting. The U.S. variant is a chain-type index, while the PCE is an implicit deflator. The chain-type index is designed to minimize substitution bias that tends to make fixed-weight indices like the CPI overstate inflation. By contrast, deflators ignore the welfare impact of substituting from high to low price items, and so systematically underestimate inflation.

Figure 4
Comparing HICP and PCE (COL) inflation in the euro area



Source: Eurostat/Haver Analytics; European Central Bank

Looking at the details in Figure 4, we see that the HICP and the PCE deflator move nearly in lock step, especially since the inception of monetary union. The average difference is 0.28 percentage points (standard deviation 0.34) for the entire 1992 to 2002 period. Since 1999, the difference has been much smaller, averaging 0.08 percentage points with a standard deviation of 0.10. The two series – the HICP and the PCE proxy for the cost-of-living index – move together and since 1992 the HICP has been on average 0.17 percentages points lower (standard deviation 0.19). All of this evidence together suggests that over the past decade, the HICP has tended to underestimate, but move closely with, changes in a cost-of-living index. This is not too surprising, given what we know about the rate of change in the price of owner-occupied housing in most EU countries since 1990. The deflators of imputed rentals for housing in almost all EU countries have tended to rise faster than the PCE deflators for most of the period since 1990. And since the PCE deflator can be thought of as (essentially) a weighted average of HICP inflation and the rate of change of the cost of owner-occupied housing, it should not be too surprising that the HICP might have had a tendency to understate the rate of increase in a cost-of-living type measure of inflation over the past decade.

2.5. Evaluating the HICP as a measure of monetary inflation

Putting aside the issue of the measuring the cost of living, we can explore the extent to which the HICP is measuring what its architects say it is trying to measure. Recall for our earlier discussion, that at the same time that they deny the HICP is a cost-of-living index, Eurostat officials state that the HICP is a "pure" price index reflecting changes in the nominal cost of monetary consumption. We interpret these statements as saying that their goal is to construct an accurate index of monetary inflation. Understanding what this is and how to measure it means moving away from the utility-based framework that is the conceptual basis for cost-of-living indices. Instead of starting with households, consumers and utility maximization, our approach to the measurement of monetary inflation takes as its point of departure the idea that the observed changes in the prices of individual goods and services can be thought of as the sum of a general (monetary) inflation component and a good- or service-specific (relative-price) component. This way of thinking about inflation measurement can be traced back to the earliest literature on inflation measurement. Writing in the nineteenth century, at a time when most countries were on the gold standard, William Stanley Jevons (1865) was interested in detecting the component of price changes that was "…due to a change on the part of gold." Reasoning that any change in the central bank's holdings of gold must affect all prices in equal proportion, he proposed taking a simple geometric mean of all price to identify this monetary component of price changes. That is, monetary inflation is the component of price changes that is uncorrelated with relative price changes contemporaneously. Bryan and Cecchetti (1993) and Cecchetti (1996) further elaborated this purely statistical view of inflation measurement, and argued for the computation of monetary inflation as the common element in a broad cross-section of prices using a "dynamic factor index" (DFI). (See Box 2 for a detailed description.) When applied to the components of the HICP, the DFI can be interpreted as a measure of monetary inflation at the household level, and a check on the accuracy of the HICP as a "pure" price index.

To understand the difference between a cost-of-living index and an index such as the DFI, consider an example in which we have divided consumption into two categories, food and shelter. A cost-of-living index based on expenditure patterns would give food a weight of 0.3 and shelter a weight of 0.7 in the construction of the aggregate price index. A dynamic factor index concentrates on finding the weights that cause the relative price changes of the two categories to cancel out. Because the relative price changes are the inverse of one another, that means giving them equal weight – instead of 30/70, the weights would be 50/50. Because there are only two goods, this is extremely special. Adding more goods and dynamics changes immediately drives us away from equal weighting to weights that depend on the variance of a series and its persistence – the less noisy and more persistent inflation is

in a given component, the higher the weight will be. These are the things that make any given series more informative about the piece that is common among them all.

Importantly the DFI weights are based on statistical information content, not on expenditure or GDP shares. While this may seem disturbing at first, it really shouldn't be. After all, statistical analysis is about using the most informative data points to answer a well-posed question. The DFI asks what the common element is in all prices – the part conceptually analogous to pure monetary inflation – and then uses the data in the best way possible to estimate it. Since this has nothing to do with the cost of living, it is not surprising that it is unrelated to household expenditure patterns. Furthermore, because it gives higher weight to inflation in commodities (or countries) that is more persistent the DFI is consistent with the ideas that have been suggested recently in work by both Benigno and Lopez-Salido (2001) and Mankiw and Reis (2002) who suggest that monetary policy should target an inflation index that gives more weight to prices based on how sticky they are.

Using this as a basis, we can evaluate the HICP as a measure of monetary inflation at the household level – its stated measurement objective. Table 1 reports the weights that come out of the DFI computation. The latter are constructed from the individual HICPs of the 12 countries in the monetary union – the "MU12" – including Greece throughout the sample. Looking first at the table, we see that the re-weighting is fairly drastic. The combined weights on Germany, France and Italy fall from 0.70 to 0.24 for the headline HICP, while the weight on Luxembourg goes from roughly zero to 0.10.

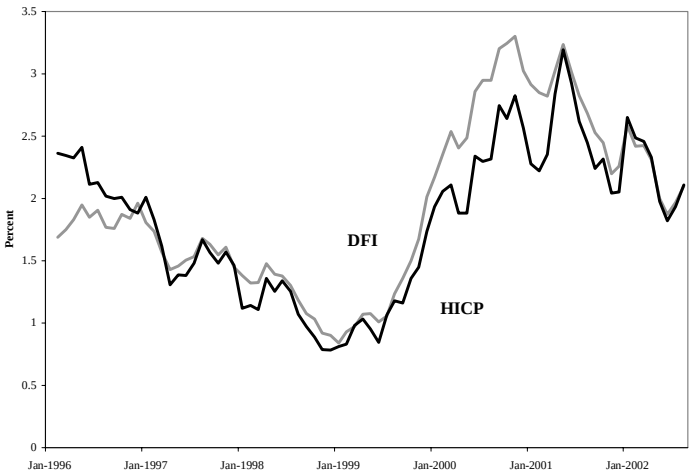
Table 1: Comparison of Weights in the HICP and the Dynamic Factor Index

	HICP Weights	DFI Weights
Austria	0.03	0.18
Belgium	0.03	0.15
Finland	0.02	0.11
France	0.20	0.10
Germany	0.31	0.09
Greece	0.02	0.02
Ireland	0.01	0.05
Italy	0.19	0.05
Luxembourg	0.00	0.10
Netherlands	0.05	0.04
Portugal	0.02	0.04
Spain	0.10	0.08

Source: Eurostat/Haver Analytics and authors' calculations. Values are for headline HICP and DFI computing using headline HICP. The DFI weights are the average over the entire sample.

Figure 5 plots the headline HICP together with the dynamic factor index constructed from the individual euro-area country HICPs. After seeing the numbers in Table 1 the figure is less startling that one might have expected. The HICP and DFI have a correlation of 0.92 – high enough that it's hardly worth doing the work to construct the DFI. Since the inception of monetary union, the HICP has been below the DFI by roughly 0.2 percentage points. And the standard deviation of the difference between the two series is 0.27. We note that substituting the official national CPIs for the Eurostat published HICPs changes almost nothing – the HICP is below the CPI-based DFI by 0.2 percentage points on average, with a standard deviation of 0.21, again since January 1999. We will return to this in our assessment of the Governing Council's use of a zero to 2 percent range.

Figure 5
Dynamic Factor Index and HICP



Source: Authors calculations; Eurostat/Have Analytics.

Box 2: The Dynamic Factor Index

The problem of inflation measurement is one of the oldest in economics. Most of us learn about index numbers and are trained to think about inflation measurement from a cost-of-living perspective. However, an alternative statistical approach takes as its point of departure the following decomposition of the change in the price of some good or service, π_{it}, today as having a common (monetary) component, π_t, and an idiosyncratic (good-specific or relative-price) component, x_{it}. Formally,

$$\pi_{it} = \pi_t + x_{it},$$

where *i* indexes the set of prices and *t* is time. The problem of inflation measurement is to figure out the value of π_t from the individual π_{it}. To do this, Bryan and Cecchetti (1993)

proposed a radically different approach to the problem of inflation measurement. Specifically, they assume that the common (monetary) component of price change is generated by a time series as follows:

$$\psi(L)\pi_t = \delta + \xi_t \ .$$

Furthermore, they assume that the idiosyncratic (relative-price) component is generated by the time-series model

$$\theta_i(L)x_{it} = \eta_{it} \ .$$

In these expressions, $\psi(L)$ and $q_i(L)$ are vectors of lag polynomials, and ξ_t and η_t are i.i.d. random variables. Throughout, it is assumed that both the common element, π_t, and the idiosyncratic components, x_{it} can be modelled as AR(2) processes.

The main identifying assumption of the model is that the common component and the idiosyncratic components are mutually uncorrelated at all leads and lags. This is achieved by assuming that $\Theta(L) = [\theta_i(L)]$ is diagonal and that all the error terms in the model are mutually uncorrelated. This is consistent with the notion that the common component captures all of the (monetary-policy induced) co-movement in the individual price series, leaving x_{it} to reflect only idiosyncratic (relative price) movements. To set the scale of π_t, the variance of ξ_t is normalized to one. Assuming that the η_t's, and the x_{it}'s, are independent of each other is done from analytical convenience. The "true" relative price shocks can be any linear combination of these.

The parameters of the model are then estimated via maximum likelihood using the Kalman filter. As a by-product, the Kalman filter recursively constructs minimum mean square error estimates of the unobserved components π_t and x_{it} given observations of π_{it}. The common index, the DFI, can be written as a linear component of current and past values of the observed series

$$\hat{\pi}_t = \sum \hat{w}_i(L)\pi_{it} \ .$$

The weights are reported in Table 1 and the estimated index is plotted in Figure 5.

An index of this sort can be computed using virtually any set of prices. For example, Bryan, Cecchetti and O'Sullivan (2002) examine the implications of including stocks, bonds and real estate, along with the price of goods and services, to derive a comprehensive measure of monetary inflation (as opposed to a measure of monetary inflation at the household level, which is the measurement objective of the HICP). And the range of prices used to compute the DFI could be further broadened to include in addition to asset prices the prices of intermediate goods and wages, along the lines suggested by Irving Fisher (1920).

3. CORE INFLATION MEASURES DERIVED FROM THE HICP

Putting conceptual issues to one side, policymakers still face important questions in choosing a measure of inflation on which to focus in their policy deliberations. Most people

agree that headline inflation is not a good choice, as it is often distorted by transitory relative price changes unrelated to the medium-run objectives of central bankers. Instead, the response is to focus on core inflation measures. With that in mind, we examine whether the information in the HICP can be combined in a different way that would provide the ECB with a better measure of core inflation.

Among possible candidates for core inflation measures, the traditional exclusion or "Ex. Food & Energy"-type are typically given greatest prominence. These measures attempt to reduce noise by eliminating certain classes of price changes that are (implicitly) deemed to contain no information about inflation trends. But there is a potential tradeoff. While simple to compute and easy to explain, exclusion-style core measures throw out lots of information, some of which might be useful. It need not always be the case that food and energy prices never contain about underlying inflation developments. And it need not be the case that all of the included components are always informative.

Examples are easy to come by. For instance, in the aftermath of the September 11 terrorist attacks on the United States, the insurance payments arising from these events caused a huge decline in the price of insurance in the PCE deflator leading analysts to supplement traditional core PCE with one that excluded insurance as well as food and energy. Likewise, the October 2002 Producer Price Index showed a surprisingly large 1.1-percent increase month over month, largely due to the elimination of various discounts introduced by automakers to sustain sales in the wake of September 11. The reaction was to compute a measure of core PPI inflation excluding the price of new cars. To eliminate distortions caused by regular changes in cigarette taxes, some analysts produce a "smoke-less" core U.S. CPI. And the list goes on and on.

The point that excluded components of traditional core measures are not necessarily the least informative comes out clearly in Table 2, where we report the mean and standard deviation of 12-month inflation in the 45 major components of the HICP computed over the period from 1996:1 to 2002:8.[3] The shaded items are the ones removed from the "All Items Excluding Energy, Food, Alcohol and Tobacco" measure of core inflation computed and reported each month by Eurostat. We have sorted the table by the standard deviation of price changes at this lower frequency. These range from 0.57 (Spirits) to 7.40 (Liquid fuels). Importantly, the shaded categories are not all at the top of the table, and that some of the unshaded items have very high standard deviations. Oils and Fats; Coffee, Tea and Cocoa; Postal Services; and Telephone and Telefax Equipment and Services are high volatility

[3] Note that the level of detail reported in Table 2 is not the maximum level of detail reported in the HICP. We consolidated some of the four-digit class levels to ensure maximum comparability across countries.

components that are *included* in the traditional core measures. And there is little justification for excluding the beer or spirits categories.[4]

[4] At the one-month horizon, the single most volatile price series is that for Package Holidays (COICOP/HICP code 09.6), with a standard deviation of 58.40! Our consolidation of various four-digit classes conceals some remarkable variation in individual prices series.

Table 2: Volatility of 12-Month Changes in Components of Euro Area HICP			
	Weight	Mean	Std. Dev.
Fuels and Lubricants	40.1	3.26	7.40
Oils and Fats	6.1	0.80	5.23
Coffee, Tea and Cocoa	5.5	-0.95	5.20
Vegetables incl. Potatoes & Tubers	15.8	2.33	4.94
Electricity, Gas and other Fuels	49.7	2.49	4.61
Fruit	11.7	3.09	3.84
Meat	42.5	1.98	2.80
Telephone/Telefax Equipment and Services	20.9	-2.49	2.35
Postal Services	2.4	1.91	2.00
Milk, Cheese and Eggs	22.5	1.52	1.86
Fish	12.0	3.50	1.47
Health	31.9	2.80	1.21
Tobacco	22.8	3.95	1.20
Water Supply and Misc. Services	26.7	3.24	1.14
Services for Maintenance/Repair of Dwellings	9.6	1.91	1.08
Footwear, including Repairs	15.7	1.79	1.03
Wine	8.2	1.95	1.00
Bread and Cereals	26.9	1.61	0.93
New and Used Automobiles	44.6	1.06	0.93
Clothing	64.7	1.02	0.92
Repair of Household Appliances	1.1	3.03	0.92
Rent for Housing	63.0	2.18	0.90
Nondurable Household Goods	9.9	1.28	0.90
Food Products, n.e.c.	3.9	1.34	0.89
Household Textiles	6.9	1.39	0.85
Transport: Spare Parts & Accessories	9.7	0.31	0.85
Accommodation Services	15.2	3.45	0.83
Mineral Water, Soft Drinks & Juices	9.5	1.10	0.81
Motor Cycles and Bicycles	8.6	1.18	0.81
Miscellaneous Goods and Services	69.8	1.92	0.78
Catering	70.1	2.49	0.75
Transport: Maintenance and Repairs	24.7	2.76	0.74
Transport Services	21.8	2.67	0.73
Beer	6.9	0.97	0.67
Sugar, Jam, Honey, Syrups, Chocolate	10.4	1.37	0.63
Products for Maintenance/Repair of Dwellings	8.7	1.92	0.62
Domestic & Home Care Services	8.3	3.05	0.61
Spirits	3.8	0.90	0.57
Recreation and Culture	96.9	1.06	0.55
Education	8.8	2.72	0.55
Glassware/Tableware/Household Utensils	5.8	1.68	0.50
Furniture/Furnishing/Carpet/Repair	33.2	1.46	0.47
Major Household Appliance/Small Elect Appliances	10.8	-0.49	0.39
Tools and Equip for House & Garden	5.1	0.68	0.37
Other Services for Personal Transportation Equip.	11.3	1.81	0.34

Source: Eurostat/Haver Analytics; Authors' calculations. Sample period: 1995:1 through 2002:8. Mean and standard deviation are for the 12-month changes. Weights are for 2000 and are from Eurostat (2001).

Exercises like this emphasize the *ad hoc* nature of traditional core measures of inflation. The weighted median and trimmed mean measures of core inflation proposed by Bryan and Pike (1993) and Bryan and Cecchetti (1994) (and explained in more detail in the Appendix Box) seek to bring some discipline to the process. The idea behind these alternatives is to discard each month only those prices deemed to have the least information about underlying inflation developments. Some months this may mean discarding food prices; other months it may mean discarding energy or apparel prices, and in yet other months it may mean discarding the prices of goods that have recently been subjected to large indirect tax increases.[5] Not only that, but measures like the weighted median and trimmed mean have some very desirable statistical properties.[6]

Table 3
Comparing Measures of Core Inflation, Euro-area level and individual countries

	Headline HICP	Ex Energy, Food, Alcohol& Tobacco	Optimal trim*	Weighted Median
Euro-Area*	0.35	0.38	0.21	0.30
Austria	0.42	0.37	0.33	0.41
Belgium	0.60	0.60	0.43	0.64
Finland	0.48	0.36	0.33	0.58
France	0.41	0.57	0.24	0.24
Germany	0.52	0.48	0.34	0.57
Greece	0.61	0.99	1.20	1.40
Ireland	0.71	0.77	0.38	0.57
Italy	0.48	0.42	0.42	0.95
Luxembourg	0.80	0.60	0.59	0.74
Netherlands	0.64	0.76	0.60	1.33
Portugal	0.61	0.45	0.33	0.63
Spain	0.52	0.43	0.27	0.29

*The euro-area figures are constructed using data that includes all 12 members of the monetary union as of 2002. The table reports the root mean square errors (RMSE) for various measures of core inflation defined as the deviation of the measures from a measure of trend inflation. Trend inflation is measured as a HP filter of monthly HICP inflation with smoothing parameter 14,400. Optimal trim for each country is the trim that minimizes the RMSE. Computations cover the period 1996 to 2002 using the 12-month change in the index

Source: Eurostat/Haver Analytics; Authors' calculations.

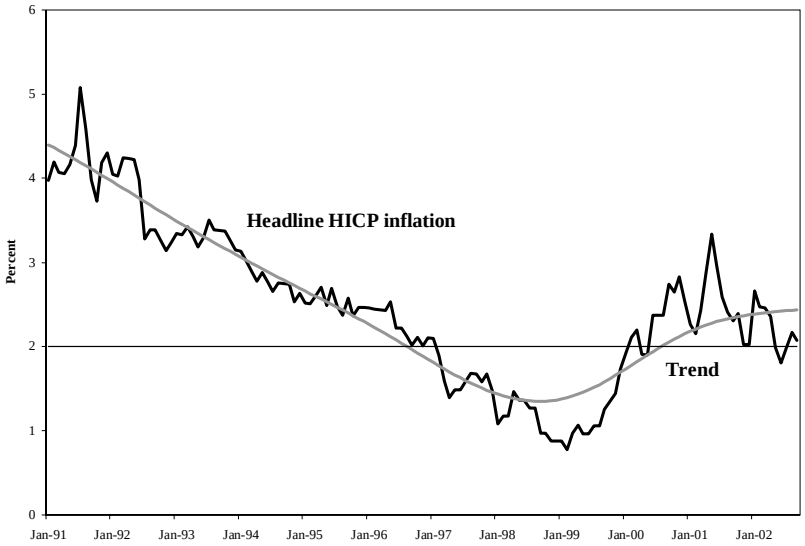
[5]This approach to core inflation measurement has been explored at the level of individual EU member states by Álvarez and Matea (1998, 1999) for Spain, Aucremanne (2000) for Belgium, Bakhshi and Yates (1999) for the UK, le Bihan and Sédillot (2000, 2002) for Germany, and Meyler (1999) for Ireland. Vega and Wynne (2001) compute these measures for the euro area and show that the desirable characteristics they exhibit at the level of individual member states appears to hold at the euro area level as well.

[6] Bryan, Cecchetti and Wiggins (1997) show how these measures are more robust measures of the mean of a distribution that has fat tails. Since price change distributions often have excess kurtosis, this improves the quality of the estimates. Vega and Wynne (2001) document the presence of excess kurtosis in the HICP.

Looking at the ability of the measures to track trend inflation provides further evidence that either the trimmed mean or median measures of core outperform the traditional measures. It is clear that central banks rely on measures of core inflation to provide them with some sense of where trend inflation is headed. Thus it makes sense to evaluate measures of core in terms of their ability to track trend inflation. Here we are immediately confronted with the problem of the short time span for which the HICP has been around, and the even shorter time span since the creation of EMU. Nevertheless, the results are worth reporting as they buttress what has been found in many other countries over longer time periods. Table 3 reports the root mean square errors (RMSEs) of various measures of core inflation, defined in terms of their deviations form a measure of trend inflation. And the results are not sensitive to our choice of how to compute the trend. (Figure 6 plots headline HICP inflation and our measure of the trend.) The smaller the RMSE, the closer the core measure is to the trend.

Several points are worth noting. First, for the vast majority of individual countries, as well as for the euro area composite, headline HICP is a better measure of the trend than the conventional core. For the euro area, the RMSE for the HICP excluding energy, food, alcohol and tobacco is higher than the one for the HICP itself. Alternative exclusion measures, such as the HICP excluding seasonal food or unprocessed food or energy, have the same property. To put it bluntly, these measures are worse than doing nothing.

Figure 6
Headline HICP and trend inflation



Source: Eurostat/Haver Analytics; Authors' calculations.

The same cannot be said of the trimmed mean and weighted median, which are nearly always better than the headline HICP at tracking the trend for the euro-area. The weighted median HICP is roughly 15 percent better at tracking the trend than the HICP itself, while the optimal trimmed mean is 40 percent better.

The estimates in Table 3 are important in helping us to understand how to construct an inflation range for policymakers. If we assume that the inflation objective is the medium-term trend, then the numbers in the table give us an estimate of the variation in any specific measure of inflation about that trend and we can use them to compute ranges within which variation can be tolerated. Speaking in probabilistic terms, policymakers can construct an interval within which the probability is 70, 80 or 90 percent that the trend inflation remains on target – and the higher the probability, the bigger the range. So, for example, if the traditional core measure were in a range of 0.35 percentage points above or below the target, one would conclude that there is a 70 percent chance that inflation is still at the target. To be 90 percent sure, the range would have to be plus or minus roughly 0.6 percentage points. With the weighted median, the equivalent numbers are plus or minus 0.30 percent and plus or minus 0.5 percent. We will use this in our discussion of the current zero to two percent range laid out in the ECB's monetary policy strategy, to which we now turn.

4. DEFINING PRICE STABILITY

We now have amassed a fair amount of information about the HICP. In Section 2 we concluded that, while the HICP may not have a solid theoretical grounding, it does track cost-of-living indices that do. But these consumption-based price measures have well-known biases that the HICP probably shares. Even when evaluated on its own terms, as a measure of monetary inflation, we find evidence of bias in the HICP. We then proceeded to examine alternative measures of inflation based on the data in the HICP and reported two basic findings in Section 3. First, the headline HICP is a noisy measure of the medium-term trend that is the focus of the ECB's policy strategy. Second, non-traditional measures of core inflation perform much better than traditional measures in tracking trend inflation.

Our final task is to bring these findings together in order to evaluate the ECB's definition of price stability. Do the data support the use of a zero to two percent range for the HICP as the objective for monetary policy in the euro area? We address this question in two steps. First we compute an estimate of the central point of a range – what might be considered a "point inflation target." And second, we use the information we have collected to construct an interval about this target that represents a range within which measured inflation can fluctuate without concern that the target is being compromised.

4.1. An Inflation Target

Calculating a point inflation target is a necessarily speculative activity. We base our estimate on the following principles that, in our view, summarize the consensus of central bankers. In a perfect world, the monetary policy would work to achieve price stability. That is, policymakers' objective would be zero inflation, properly measured. Furthermore, this zero inflation objective should be defined in terms of a welfare-based measure of inflation, such as a cost-of-living index. Since published consumer price indices contain bias relative to the cost-of-living ideal, the quantitative definition of the price stability objective should reflect this bias. That is, a finding of positive bias in the index used to define price stability would argue for defining price stability at some positive measured rate of inflation rather than zero. Likewise a finding of negative bias would argue for defining price stability at some negative measured rate of inflation. In section 2 above, we argued that while there is at present very little scientific evidence to support a claim that the HICP routinely overstates or understate the true rate of inflation, it is nevertheless reasonable to conjecture that the HICP shares the same biases as have been found in the US CPI, and likely of the same order of magnitude. First, we conjecture that measures of the cost of living in the EU are upward biased by about 1.0 percent per annum. This is marginally higher than the 0.9 percent bias found by Lebow and Rudd (2003) in the US CPI, but lower than the 1.1 percent bias estimate

of the Boskin Commission. A point estimate of 1.0 percent bias in EU cost of living indexes thus strikes us as a reasonable guess.

This estimate is subject to some degree of uncertainty. Lebow and Rudd (2003) present a range from 0.3 to 1.4 percent, while the Boskin Commission presented a range from 0.8 to 1.6 percent. A more useful measure of the uncertainty associated with these point estimates is given by the standard deviation of the estimate. Above we noted that the standard deviation of the estimates for the US tend to be around 0.3 to 0.35, but that the greater uncertainty about the accuracy of cost-of-living indexes in the EU warrants a higher figure. We conjecture that an estimate of a 1.0 percent bias in European cost of living indexes should be viewed as very imprecise, and that a standard deviation of 0.5 percent associated with the bias estimate is reasonable. These are the figures reported on the first row of Table 4 below.

Since the HICP is not a cost-of-living index we need to make an adjustment. While at the level of individual EU countries (specifically, the Netherlands and Sweden) cost-of-living based CPIs and the HICP tended to track each other over long periods of time, the same did not appear to be true at the EU level. In Figure 4 we noted that the HICP tends to increase at a rate below that of a proxy for a cost of living index at the EU level by about 0.28 percentage points, and that the standard deviation of the difference was 0.34 percent. We rounded these figures to 0.25 and 0.33 in the second row of Table 4. Thus our point estimate of bias in the HICP is the sum of our guess of the bias in EU cost-of-living indexes (1.0 percent) and the bias in the HICP as a measure of the cost of living (-0.25 percent), that is, 0.75 percent. Coincidentally, this is exactly equal to Hoffman's 1998 estimate of the bias in the German CPI.

Table 4: Bias and Precision of Various Inflation Measures

	Bias Estimate	Precision as Measured by Standard Deviation
Euro-Area Cost-of-Living Indices as a measure of Inflation	1.0	0.50
HICP as a Measure of Cost-of-Living	–0.25	0.33
Headline HICP as a Measure of the HICP medium-term trend	0.0	0.35

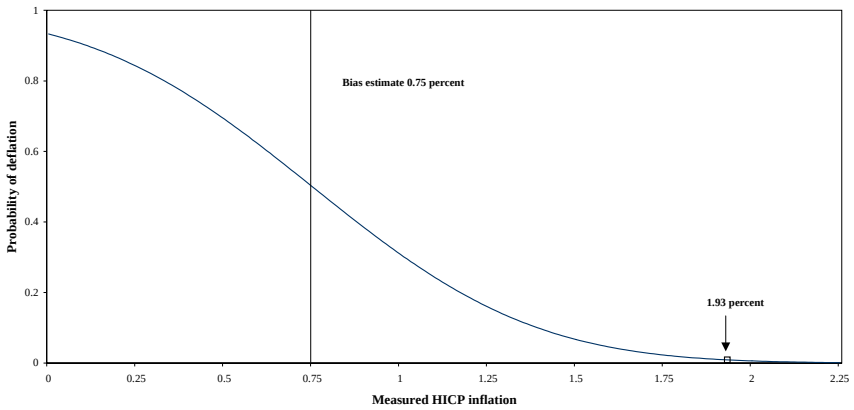
An estimate of the bias provides a baseline for any central bank's inflation objective. But it is only a start. The simple calculation that focuses solely on the level of the bias ignores a number of considerations that often enter into central banker's deliberations. These include uncertainty in the measurement of the bias itself as well as the desire to ensure that policy does not come up against the zero nominal interest rate floor. From a measurement perspective, we presume that policymakers will take uncertainty into account.

Recent events have made policymakers extremely "deflation averse." For more than a decade now, the Japanese economy has been mired in a deflationary recession. There is a significant body of opinion that Japan's problems are due in no small part to the failure of the Bank of Japan to prevent deflation taking hold. Persistent, broadly based price declines left borrowers without the revenue to repay debts, causing a deterioration in lender balance sheets and eventually paralyzing the banking system. The Japanese experience has convinced many central bakers that deflation may pose greater risks than inflation, and seems to have made many of them more tolerant of small amounts of inflation than they are of small amounts of deflation. This has immediate implications for how to integrate uncertainty in to the construction of the inflation target. In fact, for a given level of deflation aversion, the bigger the uncertainty about the bias, the higher the target should be set.

Analytically, this implies a calculation in which we first choose the policymakers tolerance for the possibility that the inflation target actually implies steady deflation. We take this to be a fairly small number – 2½ percent, or 1 in 40. With a 2½ percent tolerance, we need to shift our target measured inflation (0.75 percent based on our best guesses about the extent of bias in the HICP) up by an increment equal to 1.96 times the standard deviation of the estimated bias, 1.96 being the ordinate that cuts off 2½ percent of the tail of a standard normal distribution. For the HICP there are two sources of uncertainty, namely that associated with the estimated bias in EU cost-of-living indexes (which we put at 0.5 percent), and that associated with the estimated bias in the HICP as a cost-of-living index (which we put at 0.33 percent). Assuming that these two sources of uncertainty are independent, gives us a standard deviation of 0.60 percentage points (that's the square root of $(0.5)^2 + (0.33)^2$). Multiplying this by 1.96 we have an adjustment of 1.18 percentage points. Adding this increment to the point bias estimate of 0.75 yields 1.93 percent. Our interpretation of this is that when reported HICP is rising at a rate of 1.93 percent, there is less than a 2½ percent probability that prices properly measured are actually falling.

Figure 7 plots the relationship between measured HICP on the horizontal axis and the probability that there is deflation on the vertical axis. For any tolerance, you can read off the value for the point inflation target. Increasing the willingness to accept deflation reduces the point target, while reducing the tolerance for deflation increases it. For example, accepting a 10 percent probability that prices are actually falling would imply a target of 1.52 percent, while a probability of 1 percent implies a target of 2.15 percent. Changes in both the point estimate and precision of the bias change the figure. An increase in the point estimate shifts the entire picture to the right, while a decline in precision twists the curved line counter-clockwise raising the section to the right of the vertical line.

Figure 7
Probability of deflation in true price level as function of measured HICP inflation



Source: Authors' calculations.

4.2. A Target Range

The second step is to figure out the size of the target range. The ECB's monetary policy strategy states explicitly that their inflation objective is "over the medium term." This brings us to the information in Section 3 where we computed the precision of the various HICP-based measures of inflation. Again, we can make a statistical statement. Assume that policymakers would like there to be only a high probability, say 90 percent, that a reading on the 12-month change in the headline HICP is not different from the target. Given this, we can compute a range around the target. Using the 90 percent tolerance for error, we take plus or minus 1.64 times the HICP's precision estimate of 0.35. This gives us a band of plus or minus 0.58 percentage points. If the target were 1.93 percent (as implied by a 2½-percent tolerance for the possibility that it implies deflation) then the range is 1.35 to 2.51.

There are two ways to reduce the size of this range. The first would be to increase the tolerance for imprecise measurement, thereby reducing the multiple on the RMSE. A move to 70 percent reduces the target band to plus or minus 0.35. The other way to reduce the target range is to take advantage of core inflation measures. Since they have less short-term volatility, their RMSEs are smaller. If for example, the ECB were to set its objective in terms of the weighted-median HICP, since its RMSE is 0.30, then the 90-percent band need only be from 1.44 to 2.42 percent.

While extremely speculative, these calculations suggest that a zero to 2 percent range is too low. Rounding our preference estimates, we suggest that it would be much more prudent for the ECB to adopt a target range of 1¼ to 2½ percent for 12-month changes in the HICP. Concerns about the zero nominal interest rate constraint as well as the potential benefits that might come from small positive inflation would push the upper end of this range closer to 3 percent. An increased tolerance for short-term deviations of headline inflation from the medium-run trend might result in an increase in the size of the band.

The implications of shifting to a definition of price stability where HICP inflation of 2 percent is closer to the midpoint than the top of the range are immediately apparent. In particular, looking back over the recent history we see that from June 2000 to April 2002 the 12-month change in the headline HICP consistently exceeded 2 percent. This created significant challenges for the ECB, as the upper limits of its inflation target range was breached during a period when the world economy was slowing significantly. The primacy of the price-stability objective meant that there was little latitude to reduce interest rates in an effort to spur short-term growth. After all, the Governing Council had to ensure that inflation did not remain levels that were deemed intolerably high. A shift to a range up to 2½ percent would have meant that there inflation exceeded the limit only intermittently during the Fall 2000 and the Spring 2001, breeching 3 percent in only one month, May 2001. It is our view that a shift to a higher, and more reasonable, target range would increase flexibility in a manner that is potentially very productive.

5. CONCLUSIONS

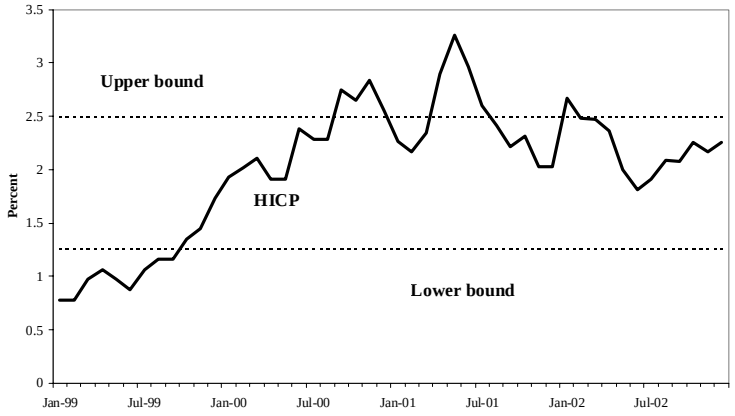
We have reviewed the primary measure of inflation used by the ECB to guide its policy deliberations, and tied the issue of inflation measurement to the important question of operationalising the ECB's mandate for price stability. The ECB has no meaningful alternative to the HICP for tracking inflation developments in the euro area. However, the HICP is poorly understood outside the community of statisticians involved in its production. While all measures of inflation at the consumer level seem to move together over long periods of time, there appear to be significant short-term discrepancies between cost-of-living based CPIs and the HICP. These discrepancies have potentially important implications for monetary policy, and make it essential that the HICP be put on a firmer theoretical footing. This could be achieved either by adopting the cost-of-living index as the measurement objective for the HICP, or by articulating an alternative internally consistent theory of the HICP. This would then allow a more meaningful assessment of the scope for measurement error, with all that this would imply for the ECB's definition for price stability.

For now, we think it is reasonable to conjecture for the sake of argument that the HICP shares the biases that have been found in the U.S. CPI, and ask what biases of comparable magnitude might imply for the definition of price stability. We have shown that the presence

of bias, in conjunction with the inherent noise in the HICP and central banker's aversion to deflation, suggests that the ECB's definition of price stability as prevailing at 2% may be too low. Our calculations imply that the ECB might want to recast its definition of price stability as a range from 1¼ to 2½ percent. Figure 8 shows what inflation performance since the launch of EMU would have looked like relative to this alternative definition.

On 8 May 2003 the ECB announced the results of its evaluation of the original monetary policy strategy that had been in place since October 1998. At that time, the Governing

Figure 8
HICP inflation relative to alternative definition of price stability



Source: Authors' calculations; Eurostat/Haver Analytics.

Council confirmed the definition of price stability as "below 2 percent … to be maintained over the medium term." Simultaneously they agreed that in pursuit of this objective, they would aim to maintain HICP inflation at "close to 2 percent over the medium term." One interpretation of this is that the ECB has moved from a 2 percent ceiling to a symmetric 2 percent target. This is entirely consistent with the target range that we propose.

Finally, we have shown that conventional measures of core inflation derived from the HICP are worse than doing nothing. This complements what has been found for many other countries, and further reinforces our belief that there is an important role for non-traditional measures of core inflation such as the trimmed mean and weighted median in the formulation and communication of monetary policy in the euro area.

Appendix:

Using the Trimmed Mean and Weighted Median to Estimate Core Inflation

The trimmed mean measure of core inflation pioneered by Bryan and Cecchetti (1993) and Bryan, Cecchetti and Wiggins (1997) differs substantially from the standard exclusion-style measures. Instead of eliminating the same components of the price index every month, their procedure removes the components of the index that have the highest and lowest inflation each month.

We begin with a bit of notation. Each month we have observations on the components that are used to construct the price index. For the HICP at the 4-digit level, these are listed in Table 2 in the text. Denote the inflation in component *i* in month *t* π_{it}. The headline HICP is constructed as the weighted average of these π_{it}'s, where the weights are based on expenditure patterns. Letting w_i denote the weight on component *i*, we can write the headline index as $HICP_t = \sum_i w_i \pi_{it}$. (For simplicity we ignore the fact that the HICP is actually constructed as a fixed-weight index in levels, and so taking the weighted average of the component inflation requires using time-varying weights. We do this in the application.)

Exclusion measures, such as the HICP excluding food, energy, alcohol and tobacco, simply set the weights on the excluded goods to zero and rescale the weights on what's left.

Table 5

Inflation ordered from highest to lowest	Weight in HICP of the component with that inflation	Cumulative weight for all components with higher inflation
$\pi_{(12)t}$ maximum inflation	$w_{(12)}$	$w_{(12)}$
$\pi_{(11)t}$ - second highest inflation	$w_{(11)}$	$w_{(12)} + w_{(11)}$
$\pi_{(10)t}$ - third highest inflation	$w_{(10)}$	$w_{(12)} + w_{(11)} + w_{(10)}$
M	M	M
$\pi_{(1)t}$ - lowest inflation	$w_{(1)}$	$w_{(12)} + w_{(11)} + w_{(10)} + \ldots + w_{(1)}$

To compute the trimmed mean, and the weighted median, of the price changes each month, the first step is to take the components along with their weights and order them from highest to lowest. For the purposes of our example, let's assume that there are twelve components of the HICP, as there are at the 2-digit level. Also, let's use parentheses around the subscripts to denote the sorted inflation rates. That is, let $\pi_{(12)t}$ denote the highest individual inflation rate in month t, and $w_{(12)}$ the associated weight, and so on down to $\pi_{(1)t}$ and $w_{(1)}$ for the lowest inflation rates. The table nearby shows the sorted data. For the α-percent trimmed mean, cut off all components with cumulative weight less than $\alpha/100$ and

greater than (1-α/100), and average what's left (again using the weights).

An example helps demonstrate the point. In the table below, the weighted average inflation rate corresponding to the HICP is

Headline Inflation

= (0.05 x 5.0) + (0.20 x 4.5) + (0.10 x 4.0) + (0.01 x 3.5) + (0.24 x 3.0) + (0.02 x 2.5) + (0.10 x 2.0) + (0.02 x 1.5) + (0.15 x 1.0) + (0.02 x 0.5) + (0.03 x 0.0) + (0.01 x -0.5)

= 2.72

Table 6

Inflation ordered from highest to lowest	Weight in HICP of the component with that inflation	Cumulative weight for all components with higher inflation
5	0.05	0.05
4.5	0.20	0.25
4.0	0.10	0.35
3.5	0.01	0.36
3.0	0.24	0.60
2.5	0.03	0.63
2.0	0.10	0.73
1.5	0.02	0.75
1.0	0.15	0.90
0.5	0.02	0.92
0.0	0.03	0.95
-0.5	0.05	1.00

To compute the weighted median, simply scan down the 3rd column and note that it jumps from 0.36 to 0.60. This means that the median observation is 3.0 percent.

The trimmed mean can be a bit tricky. Say that we want the 5-percent trimmed mean. This means removing 5-percent of the weight from the top and bottom of the distribution of inflation and averaging what's left. Looking at the table, we see that this implies dropping 5 and –0.5, and averaging the rest. But when we compute this average, we need to be careful to rescale the weights, dividing by (1.0 – 2.0 x 0.05) = 0.9. So we compute

5% Trimmed Mean Inflation

= [(0.20 x 4.5) + (0.10 x 4.0) + (0.01 x 3.5) + (0.24 x 3.0) + (0.02 x 2.5) + (0.10 x 2.0)

+ (0.02 x 1.5) + (0.15 x 1.0) + (0.02 x 0.5) + (0.03 x 0)]/0.9
= 2.77

REFERENCES

Astin, John, 1999. "The European Union Harmonised Indices of Consumer Prices (HICP)" *Statistical Journal of the United Nations ECE*, 16, 123-135.

Aucremanne, Luc, 2000. "The use of robust estimators as indicators of core inflation." National Bank of Belgium Working Paper.

Álvarez, Luis J., and María de los Llanos Matea, 1998. "Measures of the inflation process." In José Luis Malo de Molina, José Viñals, and Fernando Gutiérrez (eds.) *Monetary Policy and Inflation in Spain*. New York: St. Martin's Press.

_____ and _____, 1999. "Underlying inflation measures in Spain." Banco de España – Servicio de Estudios Documento de Trabajo n.o 9911.

Bakhshi, H and Tony Yates, 1999. "To trim or not to trim? An application of a trimmed mean inflation indicator to the United Kingdom." Bank of England Working Paper Series Number 97.

Benigno, Pierpaolo and J. David López Salido, 2001 "Inflation persistence and optimal monetary policy in the euro area," unpublished manuscript, Department of Economics, New York University, October 2001.

Boskin, Michael J., Ellen R. Dulberger, Robert J. Gordon, Zvi Griliches, and Dale W. Jorgenson, 1996. *Toward a more accurate measure of the cost of living: Final report to the Senate Finance Committee from the Advisory Commission to Study the Consumer Price Index*. Washington DC: U.S. Government Printing Office.

Bryan, Michael F. and Christopher J. Pike, 1991. "Median price changes: An alternative approach to measuring current monetary inflation." Federal Reserve Bank of Cleveland *Economic Commentary*, December.

_____ and Stephen G. Cecchetti, 1993. "The Consumer Price Index as a measure of inflation." *Federal Reserve Bank of Cleveland Economic Review*, 29, Quarter 4, pp. 15-24.

_____ and _____, 1994. "Measuring core inflation." In N. Gregory Mankiw (ed.) *Monetary Policy*. Chicago: University of Chicago Press.

Bryan, Michael F., Stephen G. Cecchetti and Rodney L. Wiggins II, 1997. "Efficient inflation estimation," NBER. Working Paper No. 6183, September 1997.

Bryan, Michael F., Stephen G. Cecchetti and Roisín O'Sullivan, 2002. "Asset prices and inflation." NBER Working Paper No. 8700, January 2002.

Cecchetti, Stephen G., 1997. "Measuring short-run inflation for central bankers." *Federal Reserve Bank of St. Louis Review*, 79, 143-55.

Diewert, W. Erwin, 2003. "Harmonized indexes of consumer prices: Their conceptual foundations." Schweiz. Zeitschrift für Volkswirtschaft und Statistik, 138(4), 547-637.

European Central Bank, 2000. *Seasonal adjustment of monetary aggregates and Consumer Prices Indices (HICP) for the euro area*. Frankfurt am Main: European Central Bank.

_____, 2001a. "Measures of underlying inflation in the euro area." European Central Bank *Monthly Bulletin*, July, 49-59.

_____, 2001b. "Analysis of HICP developments based on seasonally adjusted data." European Central Bank *Monthly Bulletin*, January, 19-21.

_____, 2001c. *The Monetary Policy of the ECB*. Frankfurt am Main: European Central Bank.

Eurostat, 2001. *Compendium of HICP reference documents*, Luxembourg: Office for Official Publications of the European Communities.

Fisher, Irving, 1920. *The Purchasing Power of Money: Its Determination and Relation to Credit, Interest and Crises*. New and Revised Edition. New York: Macmillan.

Greenspan, Alan, 1994. Statement before the Subcommittee on Economic Growth and Credit Formulation of the Committee on Banking, Finance and Urban Affairs, U.S. House of Representatives, February 22.

Hobijn, Bart, 2001. "Is equipment price deflation a statistical artifact?" Federal Reserve Bank of New York Staff Report 139.

_____, 2002. "On both sides of the quality bias in price indexes." Federal Reserve Bank of New York Staff Report 157.

Hoffman, Johannes, 1998. "Problems of inflation measurement in Germany." Discussion Paper 1/98 Economic Research Group of the Deutsche Bundesbank.

Hogg, Robert V., 1967. "Some observations on robust estimation." *Journal of the American Statistical Association*, 1179-1186.

Howitt, Peter, 1997. "Commentary." *Federal Reserve Bank of St. Louis Review*, 79, 139-141.

Jevons, W. Stanley, 1865. "On the variation of prices and the value of the currency since 1782." *Journal of the Royal Statistical Society*, 28, 294-325.

Le Bihan, Hervé and Franck Sédillot, 2000. "Do core inflation measures help forecast inflation? Out-of-sample evidence from French data." *Economics Letters*, 69, 261-266.

_____ and _____, 2002. Implementing and interpreting indicators of core inflation: The case of France. *Empirical Economics*, 27, 473-497.

Lebow, David E., and Jeremy B. Rudd, 2003. "Measurement error in the Consumer Price Index: Where do we stand?" Journal of Economic Literature,.

Lequiller, François, 1997. "Does the French Consumer Price Index overstate inflation?" INSEE Direction des Études et Synthèses Économiques Document de travail G9714.

Mankiw, N. Gregory and Ricardo Reis, "What measure of inflation should a central bank Target?" unpublished manuscript, Department of Economics, Harvard University, September 2002.

Meyler, Aidan, 1999. "A statistical measure of core inflation." Central Bank of Ireland Technical Paper 2/RT/99.

National Research Council, 2002. *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes*. Panel on Conceptual, Measurement, and Other Statistical Issues in Developing Cost-of-Living Indexes, Charles L. Schultze and Christopher Mackie, Editors. Committee on National Statistics, Division of Behavioral and Social Sciences and Education. Washington DC: National Academy Press.

Silver, Mick and Saeed Heravi, 2002. "A failure in the measurement of inflation: Results from a hedonic and matched experiment using scanner data." European Central Bank Working Paper No. 144.

Volcker, Paul A., 1983. "We can survive prosperity" Speech at the Joint Meeting of the American Economic Association-American Finance Association, San Francisco, December 28.

Wynne, Mark A. and Diego Rodriguez Palenzuela, 2002. “Measurement error in the HICP: What do we know? What do we need to know?” European Central Bank Working Paper No. 131.

_____ and Juan Luis Vega, 2001. “An evaluation of some measures of core inflation for the euro area.” European Central Bank Working Paper No. 53.