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# Core inflation rates: a comparison of methods based on west German data

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## Summary

This study compares different methods of calculating the core inflation rate, the latter being taken as the general price trend, i.e. the persistent component of measured inflation. This price trend is therefore assumed to be free of transitory price movements. This paper focuses on an empirical analysis of data taken from the consumer price index for (western) Germany. In addition, the different methods are examined critically from a theoretical perspective, focusing on two types of procedure: statistical methods and methods based on economic theory. The latter include a new procedure which is based on the P* approach. In order to assess the advantages and disadvantages of the various approaches, certain features of the core rates are tested, i.e. to establish whether they meet certain criteria, which would determine their suitability as indicators of the price trend.

The principal finding of the study is that core inflation rates – irrespective of the method chosen – are not always able to meet the requirements. The methods encounter particular difficulties with regard to avoiding bias in relation to measured inflation, these problems being aggravated when adjustments are made to account for the effects of taxation. The predictive quality with regard to measured inflation also frequently leaves a great deal to be desired. In particular, however, the methods are unable to distinguish adequately between transitory and permanent components of the inflation rate. Statistical core inflation rates perform relatively well, while core rates based on economic theory suffer, in particular, from a constant need for revision. Even so, the newly introduced P* method is convincing, at least in the latter category. Given the relatively poor overall outcome, it would appear advisable not to use core inflation rates as the sole monetary policy indicators; however, they are a useful complement to measured inflation. Moreover, rather than focusing on one method only, it would be better to combine several selected methods.

# Zusammenfassung

Die vorliegende Studie präsentiert einen Vergleich zwischen verschiedenen Methoden für die Kalkulation der Kerninflationsrate. Dabei wird die Kerninflation als der generelle Preistrend, d.h. die persistente Komponente der gemessenen Inflation, aufgefasst. Dieser soll somit frei von transitorischen Preisbewegungen sein. Im Mittelpunkt der Arbeit steht eine empirische Analyse von Daten für den Preisindex für die Lebenshaltung für (West-)Deutschland. Daneben werden die Methoden aus theoretischer Sicht kritisch beleuchtet. Zwei Verfahrensstränge stehen dabei im Vordergrund: Statistische Methoden und Methoden auf der Basis der ökonomischen Theorie. Im Rahmen der letzteren wird auch ein neues Verfahren vorgestellt, das auf dem P*-Ansatz beruht. Um Vor- und Nachteile der verschiedenen Ansätze einzuschätzen, werden die Kernraten auf einige ihrer Eigenschaften geprüft, d.h. darauf, ob sie gewisse Kriterien erfüllen, damit sie als Indikator für den Preistrend geeignet sind.

Als Hauptergebnis der Arbeit ist zu konstatieren, dass die Kerninflationsraten – unabhängig von der gewählten Methode – die an sie gestellten Anforderungen nicht immer erfüllen können. Die Methoden haben insbesondere bei der Mittelwerterhaltung Probleme, die sich bei Korrektur um Steuereffekte verschärfen. Auch die Prognosegüte im Hinblick auf die gemessene Inflation lässt häufig zu wünschen übrig. Insbesondere aber können sie nicht adäquat zwischen transitorischer und permanenter Komponente der Inflationsrate differenzieren. Relativ gut schneiden die statistischen Kerninflationsraten ab. Kernraten auf der Basis der ökonomischen Theorie leiden insbesondere unter einem ständigen Revisionsbedarf. Die neu vorgestellte P*-Methode kann dennoch zumindest in dieser Klasse überzeugen. Aufgrund des insgesamt relativ ungünstigen Resultats erscheint es ratsam, Kerninflationsraten nicht als alleinige geldpolitische Indikatoren zu verwenden; ihre Verwendung komplementär zur gemessenen Inflation ist aber sinnvoll. Zudem sollte man sich nicht auf eine Methode konzentrieren, sondern einige ausgewählte Methoden miteinander kombinieren.

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## I. Introduction

The analysis of price movements is of key importance for a central bank mandated to safeguard price stability. Generally, the focus is on inflation at the consumer level, which, in Germany, is usually measured by the change in the consumer price index (CPI). However, it is not easy to interpret inflation data as they are mostly very volatile. These short-run fluctuations are not related to the underlying inflationary pressure in the economy, and should not be allowed to deflect a forward-looking, medium-term-oriented monetary policy. Rather, monetary policy should focus on the general price trend, i.e. the persistent component of inflation. Accordingly, there is a general consensus on the need for a price indicator which is largely immune to “temporary shocks”. A variable of this kind could also be used (by the public) for an *ex post* assessment of monetary policy performance and would certainly simplify the task of explaining monetary policy measures.

“Core inflation” has become the established term for this measure. However, core inflation is not a variable that can be observed directly; it has to be estimated. This task is rendered more difficult, however, by the fact that while general notions about core inflation exist, there is no widely accepted theoretical definition. Eckstein (1981) considers core inflation to be the increase in prices which occurs when the economy is on its long-term growth path. Others take core inflation to be the “monetary” inflation which occurs as a result of growth of the money stock.[1] Studies which view core inflation in relation to developments on the demand side point in a similar direction.[2] This is underpinned by the normative concept that core inflation is that part of inflation which can be controlled by the central bank and for which the latter bears ultimate responsibility (e.g. Blinder, 1997). The complexity of the problem of core inflation is compounded, moreover, by the fact that despite (or because of) the lack of a theory, many calculation methods have been developed on the empirical side in recent years which attempt to use statistical or econometric procedures to isolate the price trend.[3]

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[*] I should like to convey my thanks to Christina Gerberding, Heinz Herrmann, Johannes Hoffmann, Stefan Kuhnert, Jürgen Reckwerth, Hans-Eggert Reimers, Rasmus Rüffer, Michael Scharnagl, Bernd Schnatz, Karl-Heinz Tödter, Hans-Georg Wels and those who took part in seminars at the Deutsche Bundesbank and the Turkish central bank for their valuable suggestions and comments. Special thanks go to Stephen Cecchetti and Gert Wehinger for making their programs available. Of course, any remaining errors are mine.

[1] For example, Bryan/Cecchetti (1994).

[2] See the study by Quah/Vahey (1995).

[3] Comprehensive surveys are given in Roger (1998) and Wynne (1999).

Against this background, the aim of this paper is to compare different methods used to calculate core inflation rates. As all approaches – irrespective of their point of departure and the procedure adopted – ultimately set out to identify transitory price movements and to extract them from the measured rate of inflation, this study is concerned with this aspect only. Core inflation is accordingly taken to be the price trend, i.e. the persistent element of measured inflation. The focus of the study is an empirical analysis of data for (western) Germany. In addition, several methods are examined critically from a theoretical perspective. Attention is paid to two types of procedures to which a certain prominence can be attributed: statistical methods and methods based on economic theory. The latter include a new procedure based on the P* approach. In order to evaluate the advantages and disadvantages of the various approaches, the core rates are examined descriptively and their features are tested to determine whether they meet certain criteria, which form a basis for determining their suitability as indicators of the price trend. Owing to the lack of a theoretical basis, the assessment criteria cannot be derived consistently. Rather, they are determined in an *ad hoc* manner. This kind of procedure implies that it is not possible to weight the criteria; they all have virtually the same weighting. Hence the analysis carried out here does not aim or claim to determine the "best" method. Rather, its aim is to enhance the understanding of core inflation rates, to present the range of the estimates and to heighten readers' awareness of the various methods.

The study is structured as follows. In Section II the transitory movements are "classified" and desirable properties of a core inflation rate defined. Section III describes the concept behind the estimation methods, the calculation procedure and the advantages and disadvantages of each approach. Core rates for western Germany for the period from 1981 to 1998 are presented in Section IV and compared on the basis of the criteria set out in Section II. Section V concludes.

## II. Transitory price movements and desired properties of core inflation rates

Although transitory movements in measured inflation vary, they are classified in the following. To arrive at this classification, their impact both on the inflation rate and on the price level is analysed. One "category" of transitory price movements stems from seasonal fluctuations, i.e. price movements which occur regularly in the course of a year and which have no permanent effect on the price level. These transitory fluctuations do not pose a problem in that they can be eliminated at the outset by a seasonal adjustment procedure. However, it should be noted that seasonal adjustment represents a kind of filter. The methods of calculating core inflation are then a second filter, which operates independently of the seasonal adjustment procedure. It is therefore better to carry out seasonal adjustment and to eliminate other temporary shocks in a single step. Seasonal price fluctuations may also be excluded, however, by observing annual rates of change.

By contrast, irregular price movements, which may also persist for a longer period of time, pose a far greater problem in terms of price analysis. A classic example is provided by fluctuations in the price of fresh foodstuffs caused by unusual weather conditions. Over the longer term, they should have no effect on the development of the rate of inflation, as it tends to be reversed after a certain time, thereby cancelling out its impact. Neither has it, therefore, any long-run impact on the price level. In principle, oil price shocks and other sudden shifts in the terms of trade have similar effects. In such cases, however, it generally takes longer for the price level to revert to its former trend.[4]

Permanent changes in prices also pose difficulties for price analysis insofar as the change is made discretely and substantially affects private household budgets. Examples are increases in administered prices such as public transport fares or postage. These are usually introduced at irregular intervals and are often relatively large. They lead to a shift in the price level, which in turn produces a temporary increase in the rate of inflation. When month-on-month rates are considered, the shock is felt once only in the first month, while year-on-year rates continue to be affected for a period of twelve months. If no further price surges occur, the inflation rate subsequently reverts to its former level but the price level does not.

This is also the case for increases in indirect taxes. They basically lead to a permanent rise in the price level but *per se* have only a temporary influence on the rate of inflation. Even so, a distinction should be made between special indirect excise duties, such as the tax on tobacco, and a general excise duty (VAT). The former affect only a few items in the basket of goods and their increase can be classified, as in the aforementioned examples, as a "relative price shock". By contrast, a change in the VAT rate affects a wide range of goods and services in the basket and can be considered as a general price level shock.

Whether a shock will turn out to be transitory or not, however, cannot be ascertained from its genesis alone. The reaction of monetary policy is also of importance. In particular, it depends on whether and to what extent the central bank accommodates first-round effects while forestalling second-round effects. If second-round effects are validated, even a development that is transitory in nature may have permanent effects.

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[4] A chart showing these shocks is given in Deutsche Bundesbank (2000).

For the analysis of the various calculation methods, we take the following approach. We test whether calculation using a particular method produces a rate of inflation, which contains the persistent elements while largely excluding transitory components. We supplement this basic procedure by adding criteria, which, from the point of view of a central bank using core measures in its decision-making process, appear desirable and plausible. But we dispense with normative criteria, such as the claim by Bryan/Cecchetti (1994) that the core rate should be closely related with monetary growth.

*Unbiasedness*

The core inflation rate should have the same mean as headline inflation over the period under review. Such unbiasedness has been called for, *inter alia*, by Roger (1997, 1998)[5] and is based on the following considerations. If the average core rate diverges markedly from measured inflation over a longer period, this is a sign that not only transitory shocks, but also part of the trend have been filtered out. This may give wrong signals with regard to the trend and might provide incorrect information in terms of monetary policy. Moreover, the discrepancy may lead to the public not accepting the core inflation rate. However, a rigorous application of this criterion creates difficulties if adjustments for the effect of indirect taxes (or other mainly one-sided shocks) are made when calculating core inflation.

*Low volatility*

If transitory movements are filtered out of the inflation rate, the ensuing trend inflation should show far smaller fluctuations than measured inflation. If not, it may be doubted whether irregular fluctuations have actually been eliminated from the time series. The suitability of such a method would be questionable.

*Robustness*

In the literature calls are frequently made for the core inflation rate to display robustness with respect to a change in the observation period. Wynne (1999) gives economic policy reasons for this. If core inflation is used as a measure for the purpose of communicating with the public, frequent revisions of earlier core inflation data can lead to credibility problems. Moreover, in this case statements about the current trend are subject to great uncertainty, limiting the suitability of the core measure as an indicator for monetary policy.

*Independence between core inflation and shocks*

The component that is filtered out of measured inflation, i.e. the shock, should not contain any information about the future core rate. While core inflation rates should not reflect the temporary effects of price shocks, they should mirror the persistent effects resulting from

5 See also Marques/Neves/Sarmento (2000).

that shock (Roger, 1997, and Mio/Higo, 1999). These persistent effects may arise, for example, in relation to backward-looking inflation expectations and resulting second-round effects. Such effects have an impact on the inflation trend. If the excluded components contain information about the (future) core rate, permanent and temporary effects have been confused and the exclusion results in a loss of information.

*Improved forecast of future headline inflation*

According to Blinder (1997), a key selection criterion for a core inflation rate is its information content with regard to future measured inflation.[6] Long and variable time lags in the monetary transmission process forces monetary policy to be forward-looking. However, only the persistent component of the current inflation rate is likely to contain information about future inflation. The core rate, reflecting the persistent component, therefore ought to incorporate all available information about future measured inflation. Hence it should be more suitable than the current headline inflation for forecasting future headline inflation.

*Link between core rates and inflation expectations*

Irrespective of the concept and method, core inflation rates are generally viewed in the literature as being associated with inflation expectations.[7] It is assumed that inflation expectations tend to be related to the price trend rather than to short-term fluctuations. Core inflation rates should therefore display a stronger link with inflation expectations than measured inflation does.[8]

*Timeliness*

As far as possible, the core inflation rate should be available at the same time as new data on headline inflation are published. If it only becomes available much later, it is of little use for interpreting current price developments. Timeliness is also important if core inflation is used to explain monetary policy measures to the public.

*Understandable by the public*

In order to promote widespread acceptance of the core rate, the calculation methods should be comprehensible to the public. This does not necessarily mean that all the technical details will be fully understood. Rather, it should be possible to communicate the general concept of the calculation method to the public (Roger, 1998).

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[6] See also Johnson (1999). Bryan/Cecchetti (1994) already tested this feature, although they gave no reason for choosing the criterion.

[7] See, for example, Roger (1998).

[8] Such a test, however, cannot be equated with the question of the rationality of inflation expectations; rather, inflation expectations are assumed to be rational.

## III. Alternative approaches to calculating core inflation rates

In order to compare methods, the plurality of available methods makes it necessary to be selective. In the following, we focus on two approaches, which are relatively prominent both in the literature on core inflation and in the praxis of price analysis, namely statistical methods and methods based on economic theory. We do not analyse methods based on time series approaches. These approaches are frequently subject to a severe end-point problem, which significantly limits their usefulness for calculating core inflation.[9] Much the same applies to the dynamic factor index proposed by Bryan/Cecchetti (1993).

### 1. Statistical methods

Statistical methods[10] rely on the construction of typical price indices and focus on disaggregated price data. An aggregated price index such as the German CPI represents an arithmetic mean of the price relatives of the goods and services in the basket of goods, weighted according to their expenditure shares in the base period (Laspeyres Index). The rate of inflation is thus a weighted average of rates of change in the individual prices, with the weights being extrapolated on the basis of relative price movements. If the price of a particular item displays marked fluctuations, these carry over to the aggregated rate of inflation, albeit in a weaker form. Statistical methods calculate a core rate by reducing the impact (the weight) of components displaying exceptional price fluctuations. The focus is, accordingly, on relative price movements.

### 1.1 Complete exclusion of volatile components

In the most popular method for calculating core rates, certain components are completely and systematically excluded from the overall index.[11] In general, this is rationalised by the fact that these goods are very likely to be affected by transitory (supply-side) shocks and that their price is correspondingly volatile. The implicit assumption is that the price development of these components contains no information on the price trend (i.e. their "inflation signal" is zero). Hence their weight in the basket of goods is permanently set at zero. Examples of volatile components are seasonal food and energy, the price of which is

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[9] See Roger (1998) and Wynne (1999).

[10] The approaches have been derived from the "stochastic theory of index numbers", which perceives the rate of change in the price of a particular good as being composed of a general price trend common to all goods and a relative price component which is interpreted as "white noise". The relative price changes are seen as being caused by mainly supply-side factors and are not considered of relevance for monetary policy. See Wynne (1999) and the literature listed there.

[11] Many central banks (e.g. USA, Japan, Canada, Australia, New Zealand) regularly use such core rates in price analysis. This is also true of most EU central banks and the ECB.

determined by world market conditions. Administered prices are also often excluded. The exclusion generally takes place at a relatively high level of aggregation (i.e. for groups of goods and services) and is decided once and for all. The exclusion criterion is generally the historical price variability of the components compared with a given volatility limit.[12]

The exclusion method has the advantage of being easy to handle and to understand. Moreover, the core rates are calculated on the basis of a pre-defined rule, which may result in enhanced transparency (Álvarez/Matea, 1999, and Roger, 1998). However, numerous criticisms can be levelled against this calculation method.[13]

- The method is arbitrary, as the definition of an "acceptable" volatility limit and therefore the exclusion of certain components is subjective.
- The method is inflexible with regard to future shocks. High volatility in the past does not necessarily mean that the price of the component will fluctuate markedly in the future. Rather, the remaining components may also be affected by transitory shocks.
- The permanent exclusion of a particular component has the effect of excluding both its volatile element and its trend from the overall index. If that trend diverges markedly from the trend of measured inflation, the resulting core rate might be biased.
- From an empirical point of view, the exclusion of volatile components does not necessarily cause the remaining aggregate to evolve smoother; this is dependent on the structure of the covariance matrix (Issing, 1999).

## 1.2 Weighting according to relative price variability

In these methods, the weights are likewise determined in relation to the strength of the "inflation signal". It is assumed that a component's signal for the general price trend will decrease as its relative price variability increases. Accordingly, in calculating the core rate lower importance is assigned to volatile components, while components that fluctuate less are given a greater weight. In contrast to the exclusion method, in this method all components in the basket of goods are retained.

Two different approaches based on this idea have been proposed in the literature. In the approach developed by the Bank of Canada a second weight is used in addition to the initial basket weight – the reciprocal of the historical standard deviation of the relative price changes.[14] By contrast, Dow (1994) and Diewert (1995) proposed to totally dispense with the expenditure weights. As a substitute, the components should be weighted solely in

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[12] Wynne (1999) defines this limit as an "unacceptably high level of volatility".
[13] See, for example, Roger (1998).
[14] See Laflèche (1997) and Johnson (1999).

line with their inflation signal, which is defined as the reciprocal of the historical variance of relative prices.[15] As a result, very volatile components are “penalised” much more than in the Bank of Canada approach.

Both approaches have the advantage of ensuring that no information that might contain important indications of the price trend is lost when calculating the core rate. Decisions about whether and which components are to be excluded thus cease to be taken on an *ad hoc* basis, and there is no need to determine once and for all for which components the inflation signal tends towards zero. Rather, time-variable weights taking account of possible changes in volatility over time may be admitted. However, the following disadvantages should be mentioned:

- In both methods the issue of unbiasedness is theoretically not determined.
- The time horizon for calculating the weights is chosen subjectively. If a short period is chosen, structural changes in relative prices are taken into account; however, possible exceptional developments in this period may heavily influence the weight of a component. By contrast, calculating the weights over the entire observation period is likely to prove less sensitive to outliers; however, the inclusion of new data can lead to a *ex post* revision of the weights and thus of the core rate.

In disregarding expenditure weights, the Dow/Diewert approach is problematic as the calculation of the core rate departs distinctly from the general concept of CPI statistics.[16] Moreover, it is based on the assumption that the prices of the individual goods represent a sample drawn from an unknown population. However, the way in which the CPI data are collected does not necessarily comply with this idea.[17] Finally, the underlying assumption that the inflation rates of the individual components are normally distributed cannot always be taken for granted.

### 1.3 Trimmed means

Considering the calculation of core inflation on the basis of disaggregated price data as a purely technical estimation problem, the features of the cross-sectional distribution of price changes have to be taken into account. Empirical studies show that the price changes are

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[15] Wynne (1997) applies this method to the CPI for the United States and Wynne (1999) recommends it as an alternative to other approaches for the euro area.

[16] Keynes, Edgeworth and others have already debated the issue of whether individual price changes should be weighted according to their economic or statistical importance. Diewert (1995) provides a good summary of this debate. Wynne (1999) points out the problems that this poses in connection with core inflation.

[17] See Diewert (1995) and Ball/Mankiw (1999).

not normally distributed in many countries.[18] The cross-sectional distribution tends to be skewed and leptokurtic, which is also the case for German data (see Annex A).

If the statistically recorded prices are perceived as a sample, assuming normal distribution, the weighted mean (weighted by expenditure shares) of the distribution, i.e. headline inflation, is the maximum likelihood estimator.[19] It has the BLUE feature and is efficient. However, the weighted mean is not robust to possible deviations from normal distribution; in particular, it is very sensitive to outliers. In this case, estimators which give a smaller or no weight to outliers (known as limited influence estimators) are preferable as they are relatively efficient irrespective of the form of distribution. They are thus better able to capture the central tendency, in this case the general price trend.

Robust estimators in the class of limited influence estimators are the so-called trimmed means proposed, for example, by Bryan/Pike (1991) and Bryan/Cecchetti (1994) for determining core rates. The calculation of a trimmed mean involves, first, ranking changes in the prices of the CPI components at a given point in time according to size together with their associated weights. Second, a certain percentage is excluded from each tail of the ordered distribution. Finally, the weighted average of the remaining components is determined (using readjusted weights, so that the sum of the weights adds up to 1). Special cases are the (weighted) mean, where neither tail of the distribution is trimmed, and the weighted median, where almost 50% is trimmed from both tails of the distribution.

In the aforementioned approaches, the weight of a single component is dependent on its (relative) movement over a period of time, while the trimmed mean focuses on a specific point in time. Depending on a component's location in the distribution at that point in time, it is either given a zero weight (i.e. it is trimmed) or, as a result of the readjustment, a higher weight compared to the initial basket weight. The method has no memory, as no account is taken of how the component behaved in the past. The trimming of a component is purely data-determined and is not systematic but varies over time.

In the context of trimming, one indeterminate issue is the extent of the trimming. Various methods of determining the optimal percentage share in the case of symmetric trimming are proposed in the literature:

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[18] See, for example, for the United States Bryan/Cecchetti (1999), for Japan Shiratsuka (1997), for the United Kingdom Bakhshi/Yates (1999), for Canada Johnson (1999), for New Zealand Roger (1995), for Australia Kearns (1998), for Spain Alvarez/Matea (1999) and for Belgium and the euro area Aucremanne (2000). The "menu cost" model presented by Ball/Mankiw (1995) proposes a theoretical explanation for the non-normal distribution. Balke/Wynne (2000) show that the distribution can also be the outcome of asymmetric shocks. Bryan/Cecchetti (1999) see this as a problem related to small samples.

[19] See Judge et al. (1985), Cecchetti (1997) and Roger (1997).

1. Hogg (1967) and Koenker/Bassett (1978) examine, on the basis of Monte Carlo simulations, the efficiency of various trim parameters as a function of the kurtosis. If the kurtosis is between 2 and 4, it is advisable to take the mean (i.e. no trimming), for kurtosis between 4 and 5.5 the 25% trimmed mean and if the kurtosis is greater than 5.5 the median.
2. Bryan/Cecchetti (1994) propose selecting the trim parameter for which the ensuing rate shows the smallest (empirical) variance.
3. Bryan/Cecchetti/Wiggins (1997) use a benchmark procedure. They define a reference variable and compare the trimmed mean with it. The optimal trim parameter is determined, for example, in such a way as to minimise the root mean square error (RMSE) of the x%-trimmed mean compared with this reference variable. As the reference variable, they suggest a centred moving average of the inflation rate over a longer period (between 12 and 60 months). Kearns (1998) uses the HP filter as an alternative for determining the trend. Benchmarking implies that the "true" core rate is known but cannot be observed in real time owing to the lags caused by centring (or the end-point problem related to the HP filter). By minimising the RMSE, an optimal approximation of the trend inflation might be achieved. The problem with benchmarking, however, is that one core rate is tested against another core rate with unknown properties (Marques/Neves/Sarmento, 2000).

There are further disadvantages:

- Unbiasedness is not ensured. It depends on the skewness of the distribution. By definition, a symmetric trim leads at the limit to the median. The median coincides with the mean only in a symmetric distribution; in the case of a skewed distribution the moments diverge permanently. In order to overcome this problem, Kearns (1998) and Roger (1997) suggest using asymmetric trims.
- The approaches to determining the optimal trim are not immune to the fact that the distribution, and therefore the optimal trim, changes when new data are included.
- The optimal parameter varies according to the selection criterion applied.
- Trimmed components have no impact on the core rate, while the impact of the remaining components increases. This dichotomy is unsatisfactory given the degrees of freedom available when selecting the trim parameter (Bakhshi/Yates, 1999).
- Owing to the non-linearity of the trimmed means, the question of intertemporal disaggregation is non-trivial (Roger, 1998).

Importantly, one problem shared by all statistical methods is their inability to filter out the impact of a VAT rate change affecting most of the goods in the basket as they focus solely on relative price movements. Furthermore, they all fail to address the issue of the level of aggregation, although the resulting core rates are not transitive for different levels of aggregation. Hence all these methods are subject to many degrees of freedom.

## 2. Methods based on economic theory

While economic theory plays a minor role in statistical methods, it is explicitly included in the following category of methods by taking account of theoretical long-run relationships between macroeconomic variables.

### 2.1 Structural VAR approaches

In the method developed by Quah/Vahey (1995), the basic assumption is that there is no long-run trade-off between output and inflation. Within the framework of a bivariate structural VAR (SVAR), it is assumed that inflation and output are driven by two types of shock.[20] In view of the aim of isolating a core inflation rate that reflects monetary factors, a distinction is made between the shocks on the basis of their effects on output, i.e. between those shocks which (in the medium to long run) have no impact on output and those which are associated with persistent output effects. Assuming a long-run vertical Phillips curve, core inflation is defined as the component of measured inflation that has no long-run effect on output. Consequently, it is the first-category shocks that determine the core inflation rate. The second-category shocks, which are clearly distinguished from those in the first category (they are orthogonal), have no long-run effect on core inflation but do have a long-run effect on output. Their impact on headline inflation is estimated unrestrictedly. They are normally equated with supply shocks (oil price shocks, etc.), while the first-category shocks are associated with demand shocks.[21]

From the perspective of monetary policy, it basically makes sense to use such a core rate as it can be interpreted as a monetary variable. The approach also has the advantage of being rather agnostic as few restrictions are applied. Moreover, identification is based on the long term as covered by theory. The method has its own problems, however, and the concept allows for discretion in the way it is implemented.

- The assumption of a long-run vertical Phillips curve implies that, in the long term, inflation is neutral in its impact on the real economy (i.e. the price level is superneutral). This does not necessarily correspond to the conventional view of the effects of inflation, according to which even a fully anticipated rate of inflation can generate permanent real

[20] It is assumed that both measures have a stochastic trend but are not cointegrated. The system is therefore formulated using the rate of change in inflation and output growth.

[21] For a technical description of the approach, see Quah/Vahey (1995) and Blanchard/Quah (1989).

costs. Instead, Wynne (1999) recommends that estimation of the SVAR should be based on the assumption of long-run neutrality of the price level.[22] This is, for example, already taken into account in the analyses of Aucremanne/Wouters (1999), Bjørnland (1997), Blix (1995) and Gartner/Wehinger (1998). This kind of approach is equivalent to a standard model of aggregate demand and aggregate supply. In this model demand shocks are output-neutral in the long run since there is a long-run vertical supply curve.

- The assumption of only two structural innovations is restrictive and involves the risk of mis-specification. In VAR models with a low dimension the identified shocks have to be interpreted as the aggregate of a number of "underlying" shocks (Faust/Leeper, 1997). Even Quah/Vahey (1995) point out that identical treatment of all shocks which have a long-run effect on output (non-core shocks such as oil price, labour supply and productivity shocks) can be problematic. Moreover, the concept of a single core shock is based on the assumption that there is a uniform core inflation process in the economy, covering all sectors and regions, and that this is determined by monetary policy alone. One way of making these assumptions less stringent is to estimate a VAR with a higher dimension including, for example, the short-term interest rate (Dewachter/Lustig, 1997, Gartner/Wehinger, 1998), the money stock (Blix, 1995) or oil prices/import prices (Bjørnland, 1997, Claus, 1997).[23] The results for the core rate depend, however, on the additional variables included in the model, which are left to the discretion of the user.

The approach has further drawbacks:

- The choice of the variable that proxies output is problematic.[24] In order to calculate a core inflation rate that has the same frequency as measured inflation, it is useful to take industrial production as the output variable. However, its cyclical development is not always representative of the economy as a whole. Moreover, industrial production data is often subject to major revisions. While the calculation of GDP on a monthly basis is possible, it entails, however, time lags of several months.
- The choice of the lag length in the VAR has an effect on the development of the core rate (Blix, 1995). The smaller the number of lags, the more closely the core rate follows measured inflation.
- The core rate varies – for a given set of variables – in line with the estimation period. The inclusion of new observations and therefore the re-estimation of the VAR can lead to a revision of the core rate over the entire estimation period.

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[22] This means that inflation (and not its rate of change) is treated as a stationary variable.

[23] In a VAR with a higher dimension there is a possibility of cointegration relationships between the variables, which should not be neglected. Blix (1995) takes this into account by analysing common trends.

[24] Fase/Folkertsma (1996) also discuss the question of which variable should be used for inflation and opt for a simple arithmetical average of the individual inflation rates.

- Interpreting the deviations between measured and core inflation is difficult and may be impossible to convey to the public (Roger, 1998).

## 2.2 The P* approach

Over the long run, inflation is unquestionably a monetary phenomenon. It is therefore appropriate to take monetary developments explicitly into account when calculating a core rate. While Blix (1995) includes the cointegration relationship between the money stock, prices and output in a VAR model[25] in the calculation of the core rate, in this study we adopt a different approach to modelling the relationship between the money stock and prices – the P* approach. To date it has been largely neglected in the discussion of core inflation rates.[26]

The P* model for inflation was developed by Hallman/Porter/Small (1989) and is based on the quantity theory. In this model, the equilibrium price level P* is defined by the money stock M per unit of real potential output Y*, multiplied by the long-run equilibrium value of velocity V*. In logarithmic terms, this is expressed as:

(2.2.1) $p^* = m - y^* + v^*$.

In the long run the price level converges to its equilibrium value. However, the adjustment generally takes a long time, with the result that the long run price level P* (i.e. its rate of change) cannot be taken as a core inflation rate that has rather a medium-term perspective. Hence the dynamic adjustment processes must be taken into account when calculating the core rate.[27] The price gap, i.e. the relative difference between the equilibrium price level and the current price level, is used as a determinant of short-term price developments. The price gap is defined as:

(2.2.2) $p^* - p = (y - y^*) + (v^* - v)$,

and comprises the output gap and the liquidity gap.

The price dynamic is determined by:[28]

(2.2.3) $\Pi_t = \Pi_t^e + \beta \Delta X_t + \gamma \left( p_{t-1}^* - p_{t-1} \right) + \varepsilon_t$,

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[25] However, he assumes a stationary velocity, which is questionable for many countries including Germany.

[26] Johnson (1999) links the concept of P* to core inflation rates but does not explore it empirically.

[27] I am grateful to Karl-Heinz Tödter for pointing this out.

[28] See Hallman/Porter/Small (1989) and Tödter/Reimers (1994).

where $\Pi$ is the rate of inflation, $\Pi^e$ inflation expectations and $\varepsilon$ an iid shock. Vector X permits the inclusion of factors which have a short-term impact on price movements, such as oil price developments or changes in indirect taxation.

To operationalise this, an assumption must be made about the formation of inflation expectations. In the following a return-to-normality model is assumed (Reckwerth, 1997), where inflation expectations always return to a level that is considered normal. This normal level is proxied by the central bank's inflation target $\Pi^z$:

(2.2.4) $\Pi_t^e = \alpha \Pi_{t-1} + (1-\alpha)\Pi_t^z$.

Inserting this into (2.2.3), we obtain:

(2.2.5) $\Pi_t = \alpha \Pi_{t-1} + (1-\alpha)\Pi_t^z + \beta \Delta X_t + \gamma\left(p_{t-1}^* - p_{t-1}\right) + \varepsilon_t$.

In effect, the interaction of the short-run dynamics with the long-run equilibrium takes the form of an error correction model, which implies that, at the end of all adjustment processes, the inflation rate converges to the central bank's inflation target. In the long run the core inflation rate coincides with the central bank's inflation target. Looking at the medium term, a core rate $\Pi^*$ can be computed from equation (2.2.5), which includes only inflation expectations and the price gap. By contrast, the temporary effects are set at zero (i.e. $\beta = 0$ and $\varepsilon = 0$):

(2.2.6) $\Pi_t^* = \alpha \Pi_{t-1} + (1-\alpha)\Pi_t^z + \gamma\left(p_{t-1}^* - p_{t-1}\right)$.

Depending on the magnitude of parameter $\alpha$, the core inflation rate moves more or less closely in line with the inflation rate of the previous period, i.e. it takes account of the inertia of price movements. At the same time it is anchored to the central bank's inflation target and to the previous path of monetary growth. In addition, core inflation is consistently derived from monetary theory.

The practical implementation of the concept gives rise to problems, especially if the P* core inflation rate needs to be available on a monthly basis. These relate, in particular, to the availability of potential output on a monthly basis and the estimation of a long-run equilibrium value of velocity using a money-demand function based on monthly data. However, these difficulties can be overcome relatively easily. Nevertheless, the method does have some disadvantages:

- If short-run factors are included in the estimation of the dynamic price equation and these are set at zero when estimating trend inflation, there is no guarantee of unbiasedness.
- Extending the estimation period to include new information may necessitate a revision of the historical values for core inflation.

- The selection of factors, which affect price developments in the short run, has an impact on the developments of the core rate.

# IV. Core inflation rates for western Germany from 1981 to 1998

## 1. Price data

All core measures are derived from data for the west German CPI. By concentrating on west German data, the numerous special factors influencing price development in eastern Germany are excluded. All rates of change are based on logarithmic values.

The analysis is limited to the period from 1981 to 1998, as consistent disaggregated price data are available for that period only. The period includes three base years (1980, 1985 and 1991) with different weighting structures, which are taken into account when core inflation rates are calculated. The disaggregation is mainly geared to the 1983 version of the "Systematik der Einnahmen und Ausgaben der privaten Haushalte" (classification of consumer income and expenditure, SEA) which forms the basis for the weighting scheme.[29] The trimmed means, the weighted median and the inflation rates weighted according to relative price variability are calculated using 55 components, which are almost identical with the two-digits of the SEA.[30] By contrast, the exclusion method is based on a relatively high level of aggregation with six components (seasonal and non-seasonal food, energy, non-energy industrial goods, rents and other services).

With regard to the calculation of the rate of inflation, this study takes a dual-track approach, analysing both month-on-month changes and year-on-year changes. A focus on month-on-month figures is not advisable, as they are highly volatile. Rather, some studies (e.g. Bryan/Cecchetti, 1994) recommend an *ex ante* smoothing of the inflation rates, as obtained by looking at somewhat longer horizons. However, there is a trade-off between the rates of change over a longer time horizon and the information content of high-frequency data. The main disadvantage of longer-term rates is that they reflect not only current but also past developments. The base effect in the case of year-on-year rates implies that one-off, significant shifts in the price level for specific components affect the rate of inflation over the entire year. After trimming, this may mean that these components are excluded for a longer period, possibly even an entire year (Crawford/Fillion/Laflèche,

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[29] Previously, classification was based on the 1963 list of consumer goods. Since the transition to the 1995 basket of goods in February 1999 the price index has been derived from the international Classification of Individual Consumption by Purpose (COICOP). Neither have the same coverage as the SEA.

[30] The components and their weight in the 1991 basket of goods are shown in Table 2, p. 23.

1998). Moreover, turning-points are recognised too late (Shiratsuka, 1997). In the context of SVAR approaches, using annual rates also leads to MA processes, which are difficult to handle. Analysing core inflation rates calculated over different horizons also makes it possible to detect whether the outcome for individual methods differs with regard to intertemporal disaggregation. However, to facilitate an empirical comparison of the core rates, only annual rates are used below. Where core rates are calculated on the basis of month-on-month rates, they are compounded to annual rates.

## 2. Definition of different rates of inflation and how they are calculated

For the purpose of comparing methods, the following inflation rates are used:

**CPI** Measured inflation based on the CPI for western Germany (1991=100), as published by the Federal Statistical Office.

**CPIEX** CPI excluding seasonal food (fish, fruit, vegetables) and energy.

**VAR1** The core rate based on month-on-month rates using the approach adopted by the Bank of Canada, in which the initial basket weights are adjusted by the reciprocal of the historical standard deviation of the relative price change using the entire period under review when calculating the standard deviations. The results based on year-on-year rates scarcely differ from those based on month-on-month rates. Therefore, these are not analysed separately.

**VAR2** The core rate based on month-on-month rates using the Dow/Diewert approach, in which the components are weighted exclusively with the historical variance over the entire period. Here too, the series scarcely differ whether month-on-month or year-on-year changes are used.

**TRIM1** The 20% trimmed mean of the cross-sectional distribution of month-on-month rates (55 components). The trim parameter has been selected on the basis of the method proposed by Bryan/Cecchetti/Wiggins (1997), i.e. by minimising the RMSE with respect to the 36-month moving average of measured inflation. If minimum variance is used as the selection criterion, the 27% trimmed mean is optimal. Both rates follow a virtually identical course.

**TRIM2** The 20% trimmed mean of the cross-sectional distribution of annual rates. In order to enable a comparison to be made between the time horizons for calculating the rate of inflation, the same trim parameter has been chosen as for the month-on-month rates. If the 36-month moving average (based on year-on-year rates) is taken as the benchmark, the optimal trim is 6%. Applying the criterion of “minimal variance”, a trim parameter of 39% is optimal. This demonstrates that both the choice of time horizon for calculating rates and the selection criterion can lead to substantially different results.

**MED1** The weighted median of the cross-sectional distribution of disaggregated month-on-month rates.

**MED2** The weighted median of the cross-sectional distribution of year-on-year rates.

**SVAR1** The core rate based on a bivariate SVAR for west German industrial production and the CPI (using first differences). Unit root tests confirm the stationarity of the rate of inflation and of output growth; analyses following the Johansen procedure indicate no cointegration relationship between the price level and the level of industrial production. The model is estimated with eight lags for the period from 1979:1 to 1998:12; this lag length ensures serially uncorrelated and homoscedastic residuals. The system includes a constant and seasonal dummies. The core rate captures the resulting demand shocks only.

**SVAR2** The core rate based on a trivariate SVAR for the nominal oil price (world market price) in Deutsche Mark, west German industrial production and the CPI (using first differences). The oil price changes are stationary; the levels of the three variables are not cointegrated. Changes in VAT and mineral oil tax are included as additional exogenous variables.[31] For reasons of comparison, this model has been also estimated using eight lags, constants and seasonal dummies for the period from 1979:1 to 1998:12. For calculating the core inflation rate, only demand shocks are used; oil price shocks, other supply shocks and the impact of tax changes are not taken into account in the calculation.

**P*** The core rate based on a dynamic equation for the CPI. The estimation uses first differences for the period from 1979:1 to 1998:12. It includes the price gap, which is estimated on the basis of a money demand equation using the monetary aggregate M3 and west German potential output.[32] Further determinants are the price norm published by the Bundesbank[33] and several lags of the endogenous variable. To enable comparison with the core rate SVAR2, the nominal oil price and time series for changes in VAT and mineral oil tax are additionally included. The core rate is derived from the fitted values of this equation, disregarding the oil price and tax effects (for the results see Annex B).

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[31] See Reckwerth (1997) for their construction.

[32] We used the estimation for potential output that was used in deriving the monetary targets. See Deutsche Bundesbank (1995).

[33] Reckwerth (1997) contains an overview.

## 3. General features of core inflation rates

The movements in various core inflation rates (year-on-year rates) over the period from 1981 to 1998 are depicted in Charts 1-6. At first glance, many of the core rates appear to evolve largely similar as the CPI but showing fewer fluctuations. However, many core rates still display sudden changes of direction and a zigzag course; only VAR2 (Dow/Diewert method) and P* are very smooth. Comparing TRIM1 and TRIM2 (Chart 3) and MED1 and MED2 (Chart 4), it is obvious that the issue of intertemporal aggregation is empirically significant. The two core rates calculated on the basis of month-on-month changes, TRIM1 and MED1, are considerably different from the rates with the same trim that are calculated on the basis of year-on-year rates, TRIM2 and MED2.

Most core rates move relatively synchronously (see also the lower triangle in Table 1). The correlation between statistical core rates is generally very high (between 0.94 and 0.99). The correlation between the core rates of the first group (CPIEX to MED2) and those based on economic theory (SVAR1, SVAR2 and P*) is considerably smaller in some cases and does not reach a value of 0.9 even within the second group. P* shows the smallest correlation vis-à-vis all other core rates. This is particularly evident when looking at the correlation between the first differences of year-on-year rates (the shaded triangle in Table 1), which captures the short-run co-movements. In general, the directions taken by the core rates at a given point in time differ clearly. The assessment of whether and in which direction the general price trend is changing thus depends to a considerable extent on the method selected.

The question of whether the current trend value is higher or lower than headline inflation likewise depends on the approach adopted, as only in a few cases do all core inflation rates convey the same picture. To illustrate this, Chart 7 shows the highest and lowest core inflation rates at each point in time alongside measured inflation (CPI). The core rates cover a broad range which encompasses the CPI in nearly 80% of the observations. Headline inflation only diverges noticeably from all core rates in phases of exceptional shocks (oil price shock at the start of the period under review and exchange rate and oil price shock in 1986/1987).

**Chart 1: CPI and CPIEX**

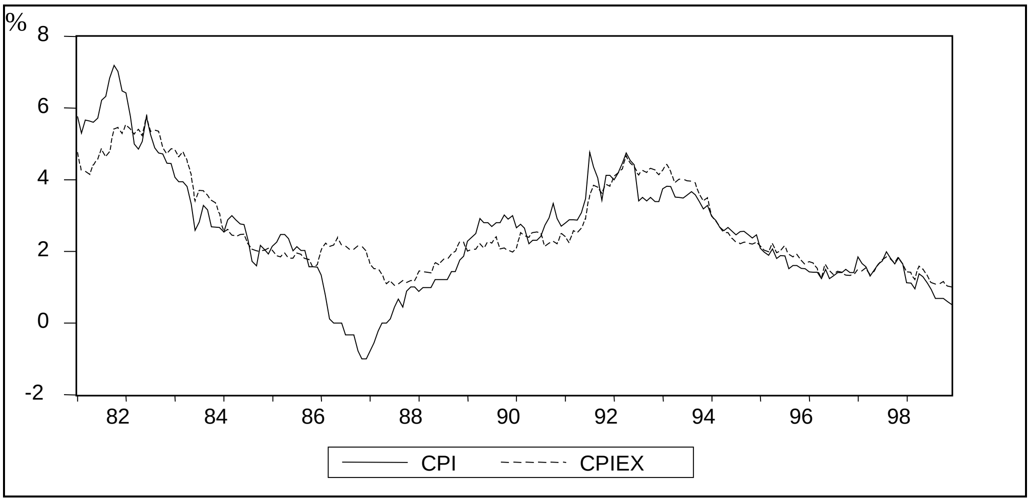



**Chart 2: CPI, VAR1 and VAR2**

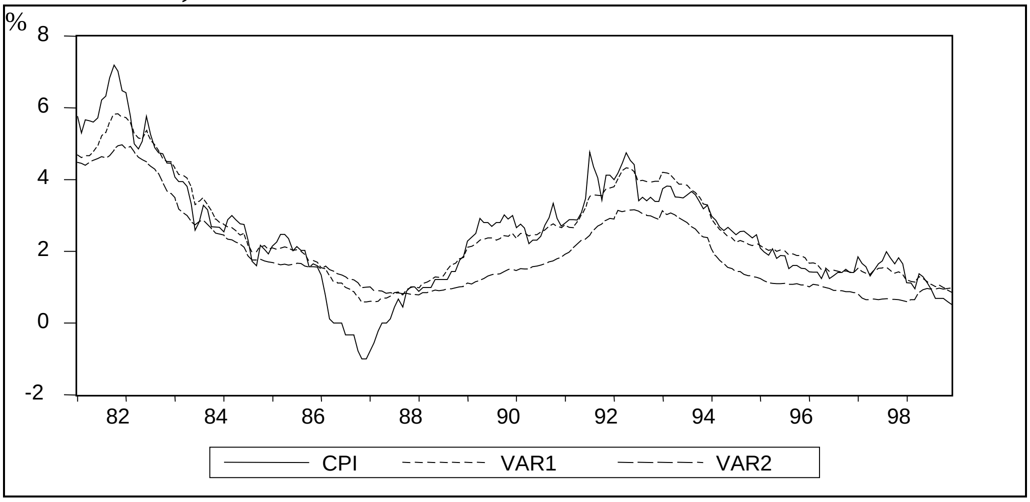
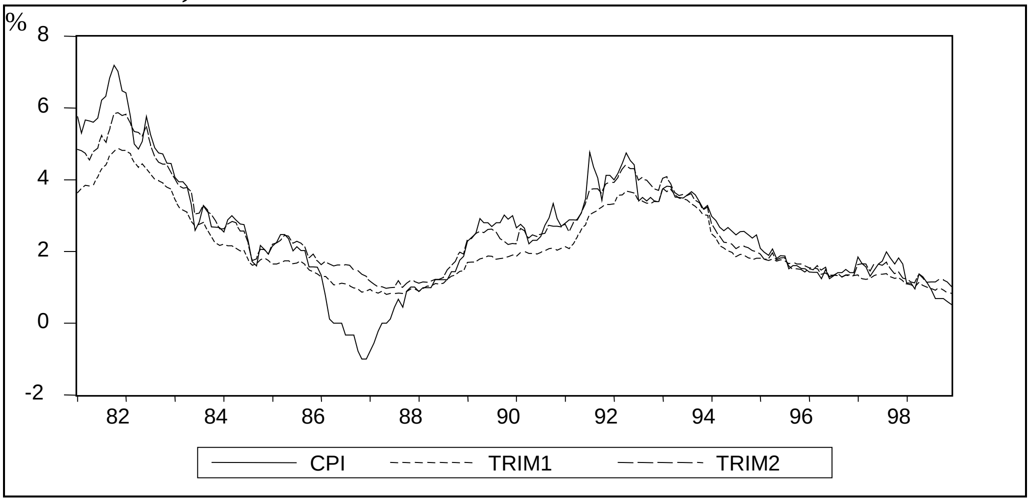
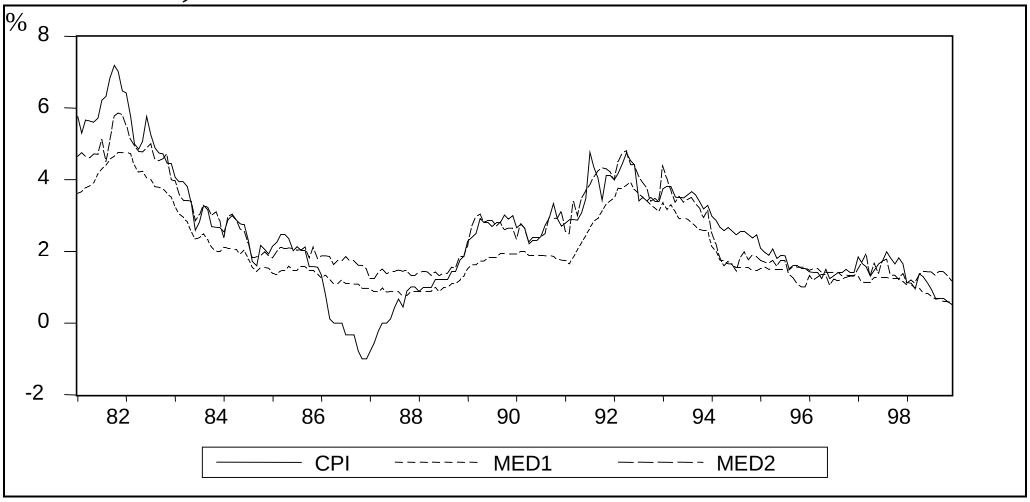


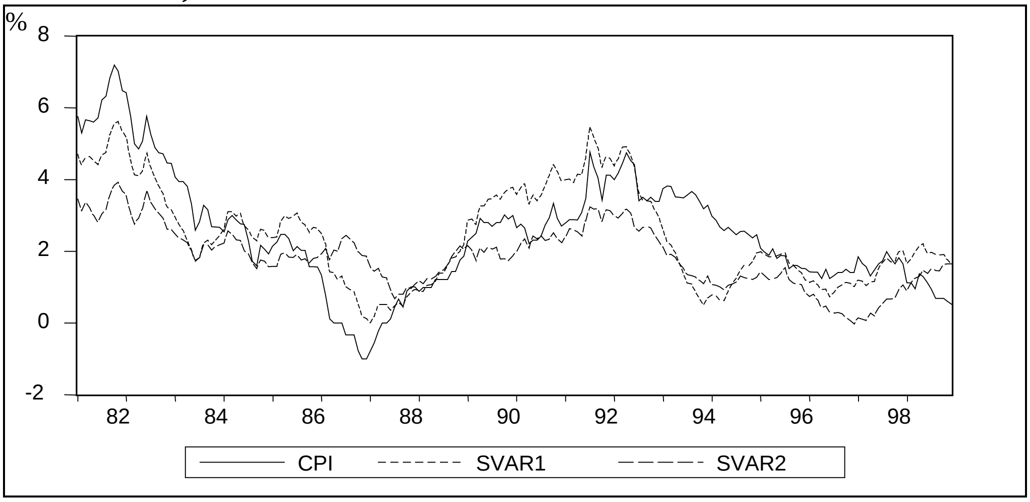

**Chart 3: CPI, TRIM1 and TRIM2**



## Chart 4: CPI, MED1 and MED2




## Chart 5: CPI, SVAR1 and SVAR2




## Chart 6: CPI and P*

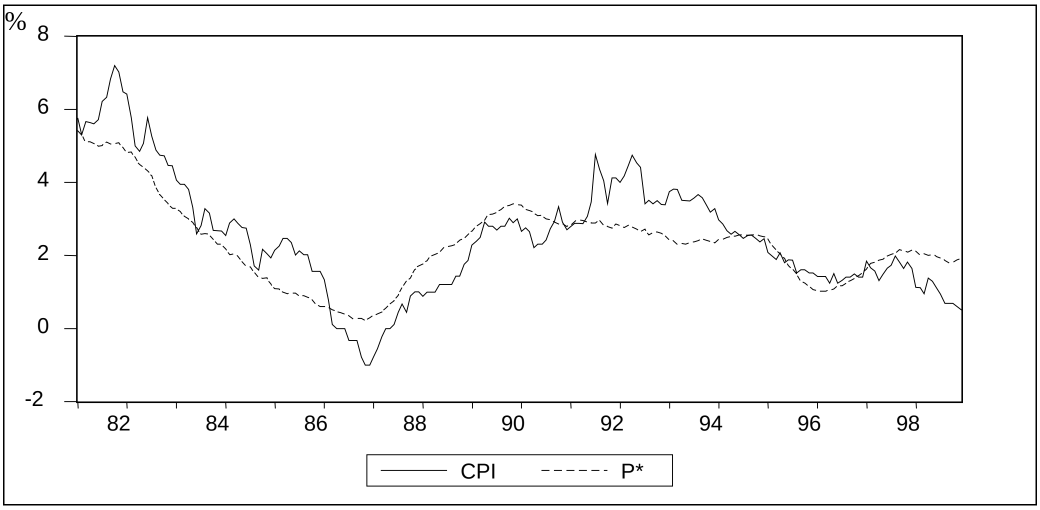


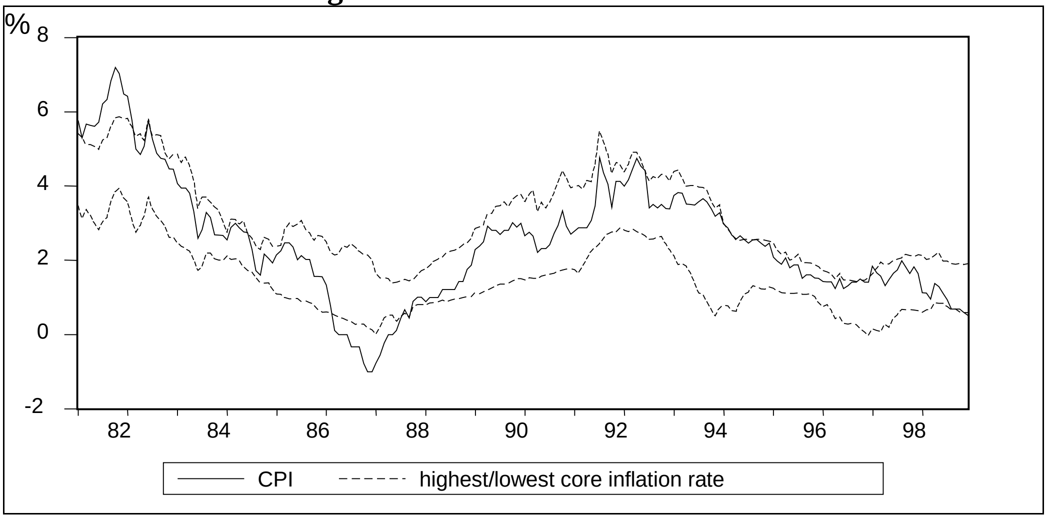
**Table 1: Correlation between core inflation rates during the period from 1981 to 1998**

a) Lower area: between annual rates

b) Upper, shaded area: between monthly changes in annual rates

| | CPIEX | VAR1 | VAR2 | TRIM1 | TRIM2 | MED1 | MED2 | SVAR1 | SVAR2 | P* |
|---|---|---|---|---|---|---|---|---|---|---|
| **CPIEX** | 1 | 0.56 | 0.40 | 0.41 | 0.60 | 0.32 | 0.41 | 0.30 | 0.42 | 0.02 |
| **VAR1** | 0.96 | 1 | 0.67 | 0.84 | 0.79 | 0.70 | 0.48 | 0.59 | 0.43 | 0.21 |
| **VAR2** | 0.95 | 0.96 | 1 | 0.74 | 0.50 | 0.68 | 0.41 | 0.28 | 0.25 | 0.18 |
| **TRIM1** | 0.97 | 0.99 | 0.96 | 1 | 0.67 | 0.86 | 0.50 | 0.40 | 0.31 | 0.11 |
| **TRIM2** | 0.96 | 0.99 | 0.97 | 0.98 | 1 | 0.54 | 0.64 | 0.50 | 0.45 | 0.12 |
| **MED1** | 0.96 | 0.98 | 0.96 | 0.99 | 0.98 | 1 | 0.43 | 0.33 | 0.25 | 0.12 |
| **MED2** | 0.94 | 0.95 | 0.94 | 0.95 | 0.98 | 0.96 | 1 | 0.29 | 0.22 | 0.05 |
| **SVAR1** | 0.64 | 0.74 | 0.70 | 0.70 | 0.76 | 0.72 | 0.80 | 1 | 0.76 | 0.21 |
| **SVAR2** | 0.76 | 0.74 | 0.79 | 0.72 | 0.80 | 0.74 | 0.83 | 0.85 | 1 | 0.06 |
| **P*** | 0.73 | 0.82 | 0.75 | 0.78 | 0.80 | 0.77 | 0.79 | 0.73 | 0.63 | 1 |

**Chart 7: CPI and the highest and lowest core inflation rate**




The period from mid-1991 to early 1993 is worth highlighting. Measured inflation was noticeably affected both by German reunification and by two tax shocks (increase in mineral oil tax rate as of July 1, 1991 and of VAT rate as of January 1, 1993). None of the methods recognise these shocks. In particular, SVAR1, the core inflation based on a bivariate SVAR, does not identify the movement of measured inflation as a supply shock. As the statistical methods focus on relative price changes, they recognise the increase in mineral oil tax, but not that in VAT. Most statistical core rates display a jump at the start of 1993 (see Charts 1 to 4).

It should also be mentioned that both ADF tests and KPSS tests reject the existence of a unit root in headline inflation CPI and in all core rates. The rates of inflation analysed are thus stationary.

## 4. Excursus: Weight adjustment in statistical methods

Before examining the features of the core rates, let us first consider the various weighting schemes resulting from the variability-weighted methods (Table 2). This is the equivalent of analysing the trimming frequency of the components in the case of trimmed means. Some striking features are shaded.

The trimming frequency of TRIM1 indicates, as a percentage of all observations, the share of observations in which a component is given a zero weight in the calculation of the core rate (or a lower weight than its expenditure share where a component exceeds the trim parameter). In the case of the components "Fruit, fruit products" and "Potatoes and other vegetables" this share is over 95%. The components "Energy (excluding fuels)" and "Fuels" show a similarly high trimming rate. This could be viewed as confirming the procedure in CPIEX, where it is precisely these groups of goods which are zero weighted. However, some other components are also subject to a relative high trim. For "Plants, gardening items", the trimming rate is also almost 95%; seasonal variations presumably play a role here. The smallest trimming rates are shown by the components "Hosiery, headwear, haberdashery", "Bread, cakes and pastries" and "Household appliances", at 13.2%, 16.7% and 17.2% respectively.

For many components trimming is relatively symmetric. This is not so for "consumer electronics", which, at a trimming frequency of 85.5%, is always trimmed at the left tail of the distribution; a similar finding has been observed, for example, in the United Kingdom (Andrade/O'Brien, 1999) and Japan (Mio/Higo, 1999). Ongoing technical progress has led to a continuous price decline for this category of goods. Within an overall scenario of rising prices, a component of this nature is almost always at the lower tail of the distribution and is trimmed. The resultant almost permanent exclusion is questionable, however, as the decline in the relative prices of consumer electronics can scarcely be recorded as a temporary price shock. This calls into question the interpretation of trimmed means as a yardstick for permanent price developments. It is a considerable shortcoming of these methods without a "memory" that they cannot distinguish between exceptional long-lasting price movements and transitory ones and exclude both to the same extent.

## Table 2: Trimming frequency in TRIM1 and weights of VAR1 and VAR2

| | Share of observations in which components were trimmed (%) | | | | CPI weights Base year: 1991 | Weight in VAR1 | Weight in VAR 2 |
|---|---|---|---|---|---|---|---|
| | At the lower tail | At the upper tail | Total | | | | |
| Meat, meat products, fish | 31.3 | 10.1 | 41.4 | | 36.6 | 42.7 | 10.2 |
| Milk, milk products, eggs, oil | 37.4 | 11.5 | 48.9 | | 22.8 | 28.6 | 12.3 |
| Fruit, fruit products | 41.0 | 55.9 | 96.9 | | 9.8 | 0.8 | 0.0 |
| Potatoes and other vegetables | 41.0 | 54.2 | 95.2 | | 11.2 | 0.8 | 0.0 |
| Bread, cakes and pastries | 5.3 | 11.5 | 16.7 | | 18.0 | 27.2 | 49.7 |
| Sugar, confectionery, jam | 41.9 | 6.6 | 48.5 | | 10.3 | 14.4 | 28.0 |
| Other food items | 22.9 | 4.0 | 26.9 | | 12.9 | 18.4 | 48.6 |
| Drink, tobacco | 29.5 | 13.7 | 43.2 | | 57.7 | 32.5 | 1.5 |
| Meals in canteens, restaurants | 5.7 | 12.3 | 18.1 | | 45.9 | 67.5 | 25.3 |
| Men's outerwear | 15.4 | 11.0 | 26.4 | | 13.5 | 17.8 | 44.9 |
| Ladies' outerwear | 23.3 | 10.1 | 33.5 | | 26.1 | 32.9 | 41.7 |
| Boys' outerwear | 22.5 | 12.8 | 35.2 | | 2.0 | 2.4 | 28.1 |
| Girls' outerwear | 27.8 | 12.3 | 40.1 | | 2.8 | 1.7 | 2.1 |
| Sportswear | 22.5 | 9.3 | 31.7 | | 1.8 | 1.6 | 6.4 |
| Underwear, babywear | 8.4 | 14.5 | 22.9 | | 9.4 | 12.6 | 36.4 |
| Hosiery, headwear, haberdashery | 6.2 | 7.0 | 13.2 | | 6.3 | 9.1 | 94.1 |
| Shoes | 10.6 | 13.7 | 24.2 | | 11.0 | 13.8 | 29.4 |
| External alterations and repairs | 4.4 | 15.9 | 20.3 | | 1.1 | 1.5 | 28.4 |
| Housing rents (incl. incidentals.) | 1.3 | 53.7 | 55.1 | | 192.1 | 285.4 | 20.7 |
| Energy (excluding fuels) | 51.5 | 33.5 | 85.0 | | 53.5 | 17.0 | 0.4 |
| Furniture | 6.2 | 12.3 | 18.5 | | 22.4 | 30.5 | 20.4 |
| Floor coverings, household fabrics | 14.1 | 7.5 | 21.6 | | 11.6 | 16.2 | 35.3 |
| Heating and cooking appliances | 21.1 | 2.2 | 23.3 | | 13.5 | 20.1 | 53.3 |
| Crockery | 8.8 | 11.9 | 20.7 | | 8.3 | 10.9 | 21.2 |
| Household appliances | 10.6 | 6.6 | 17.2 | | 6.9 | 9.0 | 19.7 |
| Household services | 4.8 | 30.0 | 34.8 | | 6.6 | 3.0 | 1.1 |
| Wallpaper and paint | 7.5 | 21.6 | 29.1 | | 7.8 | 7.4 | 7.1 |
| Health care non-durables | 21.1 | 14.1 | 35.2 | | 7.1 | 1.4 | 0.2 |
| Health care durables | 8.8 | 9.3 | 18.1 | | 2.9 | 4.4 | 36.3 |
| Doctors' services | 25.6 | 15.4 | 41.0 | | 18.3 | 19.5 | 8.0 |
| Hospital services | 22.9 | 32.6 | 55.5 | | 4.6 | 3.2 | 2.9 |
| Toiletries | 20.7 | 2.6 | 23.3 | | 11.4 | 17.3 | 74.7 |
| Personal hygiene durables | 17.6 | 3.5 | 21.1 | | 1.0 | 1.6 | 51.2 |
| Personal hygiene services | 0.4 | 37.9 | 38.3 | | 8.2 | 12.5 | 13.0 |
| Motor vehicles and bicycles | 29.1 | 26.9 | 55.9 | | 71.1 | 52.5 | 2.9 |
| Non-durables, motor vehicles/bicycles | 17.2 | 10.6 | 27.8 | | 5.2 | 2.6 | 1.4 |
| Fuels | 48.9 | 42.3 | 91.2 | | 28.3 | 3.7 | 0.1 |
| Durables, motor vehicles/bicycles | 9.7 | 16.3 | 26.0 | | 1.1 | 1.6 | 23.4 |
| External repairs/services | 1.3 | 35.7 | 37.0 | | 29.5 | 31.5 | 6.7 |
| External transport services | 33.5 | 39.2 | 72.7 | | 14.0 | 8.0 | 1.3 |
| Communications | 44.5 | 9.7 | 54.2 | | 18.8 | 2.7 | 0.1 |
| Consumer electronics | 85.5 | 0.0 | 85.5 | | 15.5 | 20.8 | 6.2 |
| Other training-related durables | 29.1 | 1.3 | 30.4 | | 19.0 | 24.3 | 13.7 |
| Books, newspapers, magazines | 4.4 | 39.2 | 43.6 | | 12.7 | 14.6 | 8.1 |
| Other consumer non-durables | 11.5 | 9.7 | 21.1 | | 5.2 | 7.5 | 41.9 |
| Educational services | 12.3 | 29.1 | 41.4 | | 6.4 | 4.4 | 2.7 |
| Training services | 16.7 | 11.5 | 28.2 | | 17.9 | 6.9 | 0.7 |
| Plants, gardening items | 51.1 | 43.6 | 94.7 | | 10.4 | 1.8 | 0.1 |
| Animals, animal-care items | 23.8 | 5.7 | 29.5 | | 3.4 | 3.8 | 10.7 |
| External repairs to consumer durables | 4.0 | 24.2 | 28.2 | | 1.2 | 1.7 | 15.3 |
| Personal goods | 20.7 | 7.0 | 27.8 | | 6.7 | 7.6 | 9.8 |
| Hotel services | 35.2 | 34.4 | 69.6 | | 12.6 | 1.4 | 0.1 |
| Package holidays | 37.4 | 29.1 | 66.5 | | 16.7 | 1.4 | 0.0 |
| Services by banks /insurance firms | 17.6 | 31.7 | 49.3 | | 19.6 | 12.7 | 1.7 |
| Other services/repairs. | 33.0 | 15.4 | 48.5 | | 9.3 | 3.0 | 0.5 |

With regard to VAR1 and VAR2, it is noticeable that the fruit and vegetable components are assigned an extremely low weight. Energy is also given a low weight, though the reduction is less marked in VAR1. Overall, in 80% of the cases the weight is adjusted in the same direction in both methods. However, the adjustment in the case of VAR1 tends to be less extreme than in VAR2, which is, in part, due to the anchoring to the expenditure weights of the basket of goods in VAR1. By applying the standard deviation as the inflation signal in VAR1 rather than the variance as in VAR2, volatile components are not "penalised" quite so severely. In the case of components whose weights are adjusted in different directions, the component "rents" is particularly striking. Whereas its weight is increased in VAR1, it is reduced considerably in VAR2. An important factor is that CPI inflation is used for calculating the relative price variability in VAR1. The rent component exerts a major influence on the CPI because of its substantial weight. This is not the case for VAR2, as the unweighted mean is initially used in the calculation as a "reference variable".[34]

## 5. Compliance with the desirable properties of a core inflation rate

### 5.1 Unbiasedness

Table 3 shows the mean of all inflation rates analysed. At first glance, it appears that unbiasedness does not hold for most core rates. Given a tolerance of +/- 0.1 percentage point, only four core rates meet this criterion throughout the period under review: VAR1, TRIM2, MED2 and SVAR1. It is hardly surprising that CPIEX has a strong bias as seasonal food and energy prices can possess a completely different trend from the other components over a long period of time. A similar logic explains the deviations in SVAR2 and P*; in these cases it is mainly the exclusion of indirect taxes which cause the bias. During the period under review the latter recorded exclusively upward changes. If they are excluded, the result is inevitably below the average CPI increase.[35] However, additional F tests of mean equality show that even the mean values of CPIEX and P* do not diverge significantly from the CPI average.

The differences in bias between the methods in which weighting is based on relative price variability can be explained by the different treatment of the expenditure weights of the

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[34] The different weights of consumer electronics is also attributable to the fact that VAR1 is geared to relative price changes, which means that adjustments are made around a possibly sustained relative price trend. This is not the case in VAR2, which is geared to relative prices; a sustained relative price trend is interpreted as price variability.

[35] The deviation in the case of P* is also due, albeit to a minor extent, to the fact that the price norm on average tends to be slightly below the average of the actual inflation rate.

basket of goods. In the case of VAR1, where these weights are simply modified, it is quite likely that, on average, the result will not deviate significantly from measured inflation. The initial weights act as a kind of anchor. This anchor is not used in VAR2, resulting in a possibly large deviation from measured inflation.

**Table 3: A comparison of inflation rates**

| | Mean[1] | | Variation coefficient[2] | |
|---|---|---|---|---|
| **Period** | **1981-1998** | **1993-1998** | **1981-1993** | **1993-1998** |
| **CPI** | 2.51 | 1.99 | 0.64 | 0.45 |
| **CPIEX** | 2.66 (0.28) | 2.11 (0.39) | 0.47# | 0.44# |
| **VAR1** | 2.54 (0.83) | 2.04 (0.72) | 0.52# | 0.45 |
| **VAR2** | 1.94 (0.00) | 1.32 (0.00) | 0.60# | 0.55 |
| **TRIM1** | 2.15 (0.00) | 1.80 (0.19) | 0.50# | 0.45 |
| **TRIM2** | 2.56 (0.69) | 1.95 (0.81) | 0.49# | 0.43# |
| **MED1** | 2.02 (0.00) | 1.59 (0.00) | 0.53# | 0.42# |
| **MED2** | 2.56 (0.70) | 1.82 (0.26) | 0.48# | 0.45 |
| **SVAR1** | 2.45 (0.72) | 1.46 (0.00) | 0.56# | 0.33# |
| **SVAR2** | 1.83 (0.00) | 1.02 (0.00) | 0.47# | 0.50 |
| **P*** | 2.31 (0.14) | 1.95 (0.77) | 0.50# | 0.25# |

1 Result of an F-test of mean equality of CPI and the core rate is shown in parenthesis (P-values). - 2 Standard deviation/mean. - # indicates lower volatility compared with CPI (no statistical test).

In the case of the robust estimators, TRIM1 and MED1, which are based on month-on-month rates, deviate significantly from CPI on average, while TRIM2 and MED2, which are based on year-on-year rates, show no bias. This outcome is not easy to understand. The question of bias depends on the skewness of the distribution. On average, neither distribution is symmetric (for the empirical distribution of west German inflation rates see Annex A). The distribution of month-on-month rates is skewed to the left with an average skew of -0.21, while the distribution of year-on-year rates is skewed to the right (0.37). All trims might accordingly be expected to deviate from the average of measured inflation. Moreover, in the case of the monthly inflation rates the left skew ought to imply that the median is above the CPI on average rather than around ½ percentage point below it, as here. This applies at least to continuous distributions. Owing to the uneven weights of the basket of goods, however, the distribution is largely discretionary. Furthermore, the skewness of the distribution varies markedly over time and there are a large number of outliers. The discrepancy appears to be attributable to the interplay of these factors. The lower kurtosis and skewness in the year-on-year rates lead to the fact that the symmetric trims being empirically unbiased despite a positive skewness.

Analysing a shorter period (1993-1998), the results are largely confirmed. However, while the trimmed mean based on month-on-month rates (TRIM1) is then unbiased, the core rate SVAR1 loses this characteristic.

## 5.2 Low volatility

The volatility of the indicators is analysed using the variation coefficient (standard deviation/mean), which takes account of the fact that the indicators have different means. Table 3 shows all core inflation rates to be less volatile than measured inflation. However, the differences compared to the CPI variability are not always marked (see, e.g., VAR2). The overall outcome is also less positive for the shorter period from 1993 to 1998.

The autocorrelation coefficient is used as a further measure of volatility (Table 4, covering the period under review as a whole). The first-order autocorrelation coefficients are virtually identical for all inflation rates and very high. Slight differences are evident for the autocorrelation of sixth and twelfth order. All statistical core rates and P* have a higher autocorrelation coefficient than CPI. As the lag order increases, however, the difference becomes smaller or even reverses. In the case of a 24-month lag only VAR1 and VAR2 are more strongly autocorrelated than the CPI.

**Table 4: Autocorrelation coefficients**

| Order | 1 | 6 | 12 | 18 | 24 |
|---|---|---|---|---|---|
| **CPI** | 0.97 | 0.82 | 0.58 | 0.39 | 0.20 |
| **CPIEX** | 0.98* | 0.86* | 0.64* | 0.40* | 0.16 |
| **VAR1** | 0.99* | 0.88* | 0.67* | 0.45* | 0.22* |
| **VAR2** | 0.99* | 0.88* | 0.67* | 0.44* | 0.23* |
| **TRIM1** | 0.99* | 0.88* | 0.65* | 0.42* | 0.19 |
| **TRIM2** | 0.98* | 0.86* | 0.64* | 0.41* | 0.19 |
| **MED1** | 0.99* | 0.85* | 0.60* | 0.36 | 0.14 |
| **MED2** | 0.97 | 0.84* | 0.62* | 0.41* | 0.18 |
| **SVAR1** | 0.98* | 0.82 | 0.52 | 0.23 | 0.02 |
| **SVAR2** | 0.97 | 0.82 | 0.56 | 0.35 | 0.19 |
| **P*** | 0.98* | 0.85* | 0.61* | 0.35 | 0.12 |

* Shows a higher autocorrelation than CPI (no statistical test).

## 5.3 Robustness

*CPIEX*

The CPIEX is robust from the outset, as the components to be permanently excluded are determined at a specific time once and for all. In addition, these components (like all others) are not revised *ex post*.[36] However, the question is whether the rule, once established, should be retained over time. Empirically, nonetheless, the volatilities have not changed significantly over the period under review (Table 5). The volatility of energy

[36] The change of base year is not considered a revision of data in this context.

inflation is only slightly lower in the short period than in the entire period. Much the same applies to seasonal food inflation. By contrast, headline inflation fluctuates far less during the short period than in the overall period, showing almost the same volatility as CPIEX.

**Table 5: Variability* in the main components of the CPI**

| | 1981-1998 | 1993-1998 |
|---|---|---|
| CPI | 0.64 | 0.45 |
| Food | 1.07 | 0.52 |
| Seasonal food [1] | 2.70 | 2.67 |
| Manufactured goods | 1.15 | 0.71 |
| Manufactured goods excluding energy | 0.64 | 0.64 |
| Energy | 5.82 | 4.02 |
| Use of housing and garages | 0.38 | 0.38 |
| Services | 0.47 | 0.49 |
| CPIEX | 0.47 | 0.44 |

* Standard deviation/mean.

*VAR1 and VAR2*

To test whether relative price variability has changed over time, VAR1 and VAR2 are calculated recursively, i.e. the period over which the weighting scheme is calculated is progressively extended by one month. The analysis starts with the period from 1980:2 to 1991:1, extending the end of the sample period to 1998:12.

Both VAR1 and VAR2 turn out to be relatively robust. This can be seen clearly in Charts 8 and 9, which show the value of the core inflation rate for January 1991 over an increasing sample period. The first estimation of the price trend for January 1991 needs hardly any revision even allowing for the inclusion of new data. This implies that the variability of relative prices has changed very little over time.

**Chart 8: Development of VAR1 (January 1991), recursive estimation**

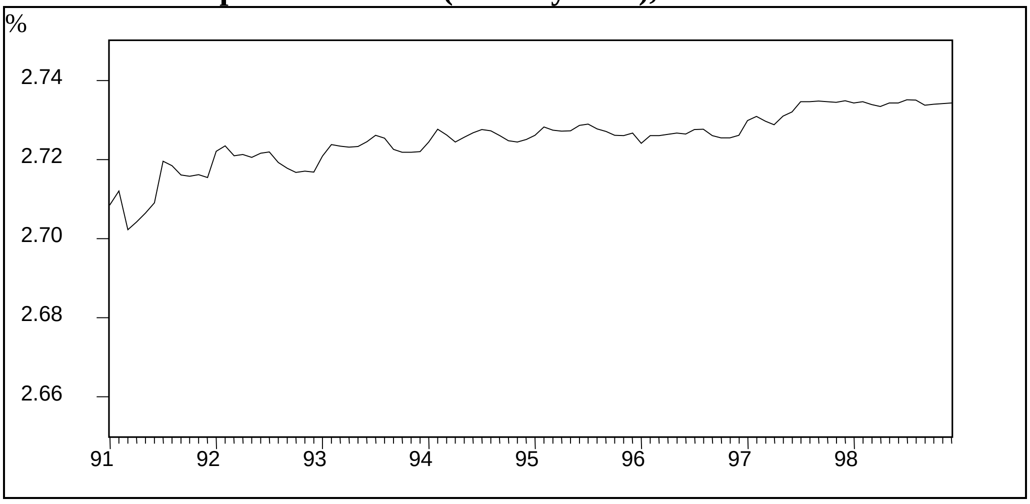
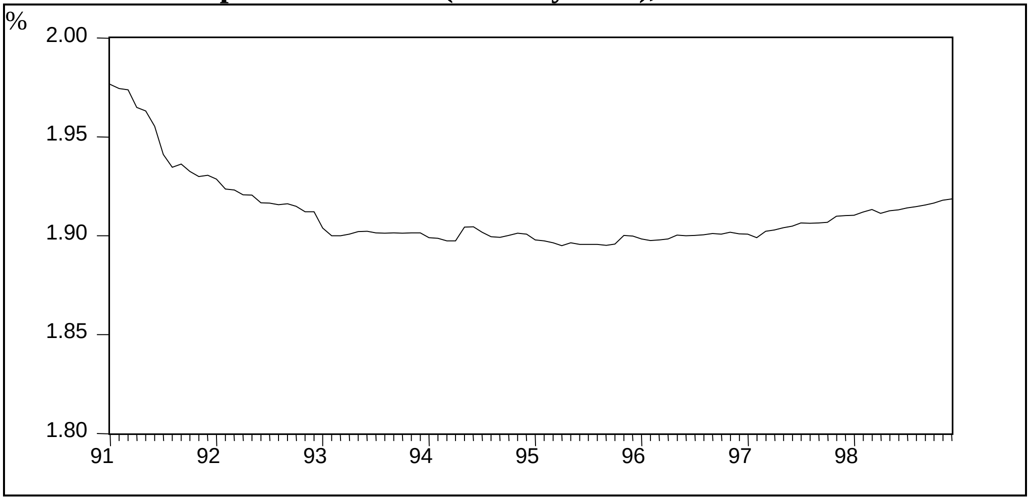


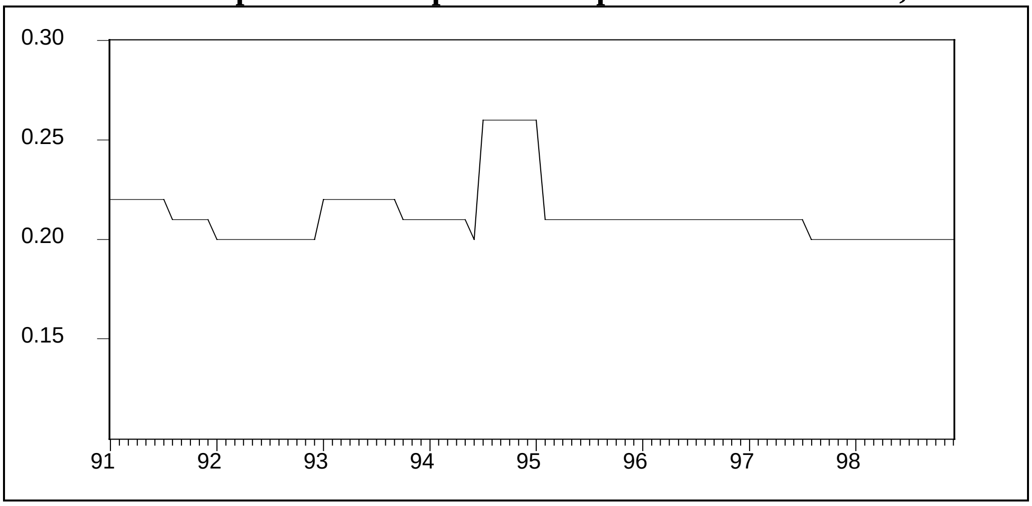
**Chart 9: Development of VAR2 (January 1991), recursive estimation**




*TRIM1, TRIM2, MED1 and MED2*

A trimmed mean with a specific trim parameter is robust *per se* as the *ex post* inflation data on which the trimming is based do no change. This implies that both medians (MED1 and MED2) are time-invariant and do not need to be analysed more closely. The situation is different if an optimal trimming parameter is determined using the method proposed by Bryan/Cecchetti/Wiggins (1997). This parameter does not have to be constant over time but may depend on the development of the moments of the cross-sectional distribution.

**Chart 10: Development of the optimal trim parameter for TRIM1, recursive analysis**




The trim parameter of 20% used in TRIM1 was determined by minimising the RMSE over the entire sample period. The sensitivity of this parameter is analysed recursively starting with the period from 1980:2 to 1991:1. As shown in Chart 10, the optimal trimming parameter for monthly data varies over time but moves within relatively narrow bounds. As the trim parameter 20% was defined *ad hoc* for TRIM2 for the purpose of comparison, its robustness does not need to be tested. It should be mentioned, however, that the optimal trim (6%) in the case of annual rates is stable. The overall good result for the trims matches findings for the United States (Bryan/Cecchetti/Wiggins, 1997) but is not in line with the findings for UK data (Bakhshi/Yates, 1999).

*SVAR1 and SVAR2*

In order to determine the sensitivity of SVAR1 and SVAR2 with respect to the sample period, the two SVAR models have been estimated recursively and in each case the core rate for January 1991 has been calculated over increasing estimation periods (see Charts 11 and 12). In both models the re-estimation frequently causes a revision of the past. This revision is far more marked than in the methods analysed above. In particular, SVAR1 shows large swings at the beginning, which are caused by the increase in mineral oil tax rate in July 1991. Moreover, the core rate fails to stabilise at the end of the estimation period in both measures. Depending on the base period, the core inflation rate for January 1991 moves within a band of 0.6 percentage point, in the case of SVAR1, and of more than 0.4 percentage point in the case of SVAR2. This confirms the frequently expressed suspicion that these methods lead to non-robust results.

**Chart 11: Development of SVAR1 (January 1991), recursive estimation**

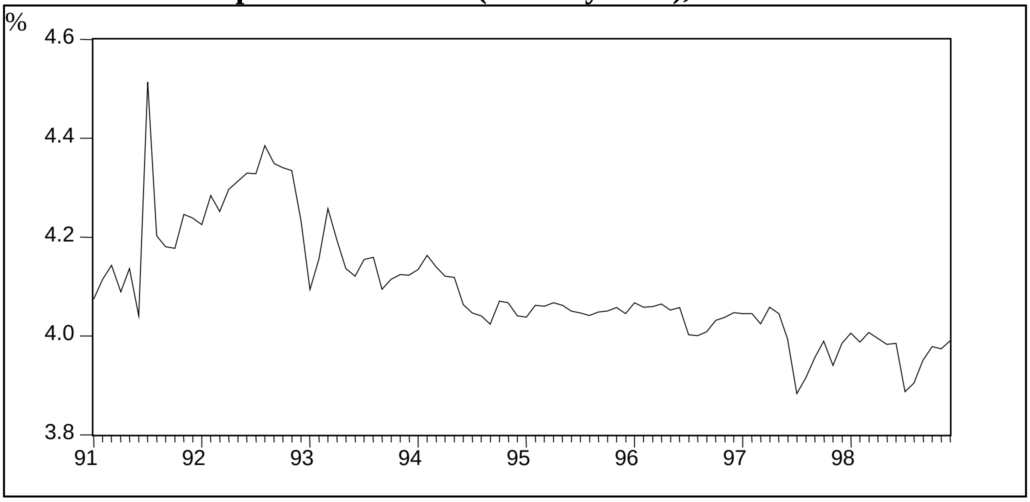
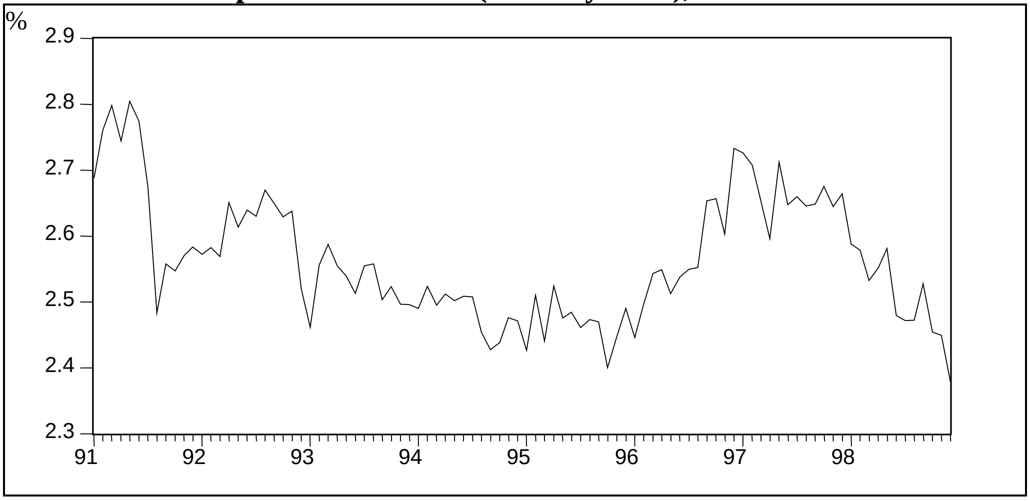


**Chart 12: Development of SVAR2 (January 1991), recursive estimation**




*P**

In the recursive analysis of the P* core rate, both the dynamic price equation and the long-run price level have been estimated for increasing sample periods. Chart 13 makes it clear that this core rate, too, needs to be revised *ex post*. However, the revisions are less abrupt than in the SVAR approaches and the core rate for January 1991 moves within a somewhat narrower band of around 0.3 percentage point.

**Chart 13: Development of P* (January 1991), recursive estimation**


Comparing these findings, only the medians prove to be absolutely robust. The other statistical methods are relatively robust. By comparison, the methods based on econometric estimations show some instability. In addition, the data for other variables, e.g. industrial production, were assumed to be time-invariant in the analysis, although in practice they are subject to frequent revisions. The revision requirement is therefore likely to be even greater than shown here.

## 5.4 Independence between core inflation rates and shocks

The mutual independence of shocks and core rates is tested following Roger (1997) by running bivariate Granger causality tests, with the respective null hypothesis $H_0 : \sum_{i=1}^{12} \gamma_i = 0$:

(5.4.1)
$$Core\,rate_t = \alpha + \sum_{i=1}^{12} \beta_i Core\,rate_{t-i} + \sum_{i=1}^{12} \gamma_i Shock_{t-i} + \varepsilon_t$$
$$Shock_t = \alpha + \sum_{i=1}^{12} \beta_i Shock_{t-i} + \sum_{i=1}^{12} \gamma_i Core\,rate_{t-i} + \varepsilon_t$$

The results are shown in Table 6. As indicated by the p-values (which give the marginal significance level), only VAR1, VAR2 and TRIM1 are independent of the shocks at the 5% level over the entire sample. The excluded components have no leading-indicator property compared with these core rates and vice versa.

**Table 6: Granger causality tests of independence between shocks and core inflation rates (p-values)**

| | | **1981 - 1998** | **1993 – 1998** |
|---|---|---|---|
| **CPIEX** | Shock → Core rate | 0.00 | 0.52 |
| | Core rate→ Shock | 0.07 | 0.42 |
| **VAR1** | Shock → Core rate | 0.06 | 0.06 |
| | Core rate→ Shock | 0.26 | 0.75 |
| **VAR2** | Shock → Core rate | 0.07 | 0.15 |
| | Core rate→ Shock | 0.39 | 0.07 |
| **TRIM1** | Shock → Core rate | 0.08 | 0.03 |
| | Core rate→ Shock | 0.12 | 0.06 |
| **TRIM2** | Shock → Core rate | 0.03 | 0.14 |
| | Core rate→ Shock | 0.52 | 0.93 |
| **MED1** | Shock → Core rate | 0.01 | 0.26 |
| | Core rate→ Shock | 0.01 | 0.00 |
| **MED2** | Shock → Core rate | 0.00 | 0.94 |
| | Core rate→ Shock | 0.10 | 0.79 |
| **SVAR1** | Shock → Core rate | 0.06 | 0.04 |
| | Core rate→ Shock | 0.01 | 0.02 |
| **SVAR2** | Shock → Core rate | 0.03 | 0.14 |
| | Core rate→ Shock | 0.20 | 0.01 |
| **P*** | Shock → Core rate | 0.00 | 0.00 |
| | Core rate→ Shock | 0.00 | 0.06 |

In the case of CPIEX, TRIM2, MED2 and SVAR2 the transitory component of measured inflation contains information about the course of trend inflation, i.e. some price movements considered to be temporary are actually permanent in nature. The opposite is the case for SVAR1. By contrast, a feedback relationship exists in the case of MED1 and P*. The overall result improves somewhat over the shorter period (1993-1998), with at least five indicators showing independence of the shocks (CPIEX, VAR1, VAR2, TRIM2, MED2).

## 5.5 Improved forecast of future measured inflation

The predictive power of core inflation rates is tested using naive forecasting equations that follow the methodology used by Bryan/Cecchetti (1994):

(5.5.1) $$\frac{12}{k}\left[\ln(CPI_{t+k})-\ln(CPI_t)\right]=\alpha+\beta\left[\ln(p_t)-\ln(p_{t-12})\right]+\varepsilon_t$$

where p stands alternately for the 11 indices (CPI to P*). The results for measured inflation (CPI) are used as benchmark. In order to gain information about the forecasting performance over different horizons, the year-on-year rate, the 18-month and two-year rates are used as a forecasting variable (k therefore stands for 12, 18 and 24 months). This equation is initially estimated up to 91:12; and the value for 92:1 is forecast on the basis of the equation. Subsequently, the estimation period is extended by one observation each time, the equation is estimated again and used for the forecast. Hence we make a series of statistic forecasts whose errors are measured using the RMSE.

In Table 7, a * indicates whether the RMSE declines when a core measure is used to make the forecast as opposed to the CPI. The evidence with regard to the forecasting power of the core inflation rates is not uniform. Only in the case of MED2, the median of the year-on-year rates, the forecasting error is smaller for all horizons. With the exception of the short forecasting horizon, the core rates based on SVAR models contain a similar or much higher information content as the CPI. By contrast, CPIEX and TRIM1 perform poorly.

In order to test the information content of the core rates which exceeds that already contained in the previous CPI inflation, Granger causality tests are also carried out (for the entire period and for a sub-period) under the null hypothesis $H_0:\sum_{i=1}^{12}\gamma_i=0$:

(5.5.2) $$CPI_t=\alpha+\sum_{i=1}^{12}\beta_i CPI_{t-i}+\sum_{i=1}^{12}\gamma_i Core\,rate_{t-i}+\varepsilon_t\,.$$

As Table 7 shows, CPIEX, VAR1, TRIM2, MED1 and P* Granger-cause headline inflation at the 5% level. The remaining core rates do not contain any information for the forecast of CPI. In the short sample, six core rates (CPIEX, VAR1, VAR2, MED1, SVAR1 and SVAR2) display the causality feature.

**Table 7: A comparison of the forecasting performance of core inflation rates**

| | Naive forecasting equations[1] | | | Granger causality test[2] | |
|---|---|---|---|---|---|
| | k=12 | k=18 | k=24 | 1981-1998 | 1993-1998 |
| **CPI** | 0.71 | 0.82 | 0.85 | - | - |
| **CPIEX** | 0.75 | 0.90 | 0.94 | 0.00 | 0.01 |
| **VAR1** | 0.68* | 0.83 | 0.88 | 0.02 | 0.05 |
| **VAR2** | 0.66* | 0.87 | 0.93 | 0.19 | 0.03 |
| **TRIM1** | 0.71 | 0.87 | 0.91 | 0.08 | 0.08 |
| **TRIM2** | 0.63* | 0.80* | 0.85 | 0.05 | 0.42 |
| **MED1** | 0.70* | 0.87 | 0.91 | 0.01 | 0.01 |
| **MED2** | 0.62* | 0.75* | 0.81* | 0.12 | 0.44 |
| **SVAR1** | 0.73 | 0.64* | 0.58* | 0.29 | 0.01 |
| **SVAR2** | 0.79 | 0.76* | 0.71* | 0.20 | 0.05 |
| **P*** | 0.82 | 0.82 | 0.74* | 0.00 | 0.47 |

1) RMSE for the period from 1992:1 to 1998:12. – 2) P value. – * Indicates a decline of the RMSE (no statistical test).

## 5.6 Link between core inflation rates and inflation expectations

To analyse the link between the core rates and inflation expectations, a measure of inflation expectations has to be selected. We use the results of the GfK monthly consumer survey to this end.[37] The data relate to the inflation expectations of consumers at time t-12 for time t. In the test they are contrasted with the year-on-year core rates at time t, calculating the RMSE in respect of the inflation expectations.[38] Inflation expectations are only available from 1985:1. Hence the analysis starts in 1986:1.

**Table 8: Deviations between inflation rates and inflation expectations**

| CPI | CPIEX | VAR1 | VAR2 | TRIM1 | TRIM2 | MED1 | MED2 | SVAR1 | SVAR2 | P* |
|---|---|---|---|---|---|---|---|---|---|---|
| **1986-1998** | | | | | | | | | | |
| 0.98 | 0.83* | 0.75* | 0.65* | 0.55* | 0.78* | 0.61* | 0.95* | 1.39 | 1.00 | 0.93* |
| **1993-1998** | | | | | | | | | | |
| 0.51 | 0.55 | 0.54 | 0.92 | 0.59 | 0.51 | 0.72 | 0.64 | 1.07 | 1.25 | 0.44* |

* Indicates a decline of the RMSE (no statistical test).

It is noticeable that, at 0.98, the RMSE of the CPI (Table 8) is relatively high given mean inflation expectation of 1.8 % over the period under review, even when taking account of the fact that, on average, the CPI is about 0.2 percentage point above inflation expectations. Although some core measures, on average, deviate from expectations to a similar extent, the RMSE is below that of the CPI in eight out of the ten core rates observed. In the case of TRIM1, the RMSE nearly halves. Only the core rates based on SVAR models have higher deviations than the CPI. In the shorter period the RMSE for measured inflation is far lower

[37] These data are purely qualitative but can be converted into quantitative data. See Reckwerth (1997).

[38] As proposed by Blix (1995), another possibility would be to forecast core inflation rates and to assess the forecasting performance on the basis of inflation expectations.

and is outperformed only by P*. The link between all other core rates and inflation expectations is either worse than or similar to the CPI score.

## 5.7 Timeliness and comprehensibility by the public

Looking at the German date release calendar, only the statistical methods can be classed as being available on a timely basis. All the data required by these approaches for calculating core inflation are available at the same time as the final CPI data are published. The problem with theory-based methods is that the data used in addition to inflation are generally only released some weeks after CPI data; these core rates are therefore not available at the same time as the CPI data.

Whether the methods are understandable for the public is a matter for conjecture. Assuming that the general public understands the calculation of headline inflation, it can be assumed that the exclusion method (CPIEX), the Bank of Canada's approach (VAR1) and the trimmed means, including the median, are comprehensible to them, too. In the case of the trimmed means, however, it might not be easy to explain the determination of the optimal trim. The Dow/Diewert method (VAR2) and the structural VAR approaches are quite complex, with the result that it might be difficult to explain them to the public. Although the P* approach is likewise quite demanding, the basic concept, at least, should be understandable because of its close link to the Bundesbank's former monetary target strategy.

If this criterion is expanded to take in transparency aspects, none of the methods fulfils the requirement in full. All of them contain a certain degree of subjective selectivity, which in the case of statistical methods, for example, begins with the question of the level of aggregation and, in the case of theory-based methods, particularly concerns the choice of the additional variables to be included. In order to ensure transparency, an explicit explanation of the alternatives and their selection is necessary.

## 5.8 Summary of the results

In order to make the assessment easier, Table 9 summarises the results, with ✰ indicating compliance with the specific criterion and – non-compliance. However, it is not possible to make a clear-cut distinction in every case; ✰/– is used to indicate an ambiguous result. This is used, in particular, whenever the results for the entire period under review deviate from those of the short sample.

The table clearly shows that no method fully meets all the criteria. Conversely, no single criterion is met by all approaches. In particular, the forecasting power of the core rates with respect to measured inflation and the results regarding independence between the different inflation components are rather poor.

**Table 9: Core inflation rates and their performance**

| Criterion | CPIEX | VAR1 | VAR2 | TRIM1 | TRIM2 | MED1 | MED2 | SVAR1 | SVAR2 | P* |
|---|---|---|---|---|---|---|---|---|---|---|
| Unbiasedness | ☆ | ☆ | – | ☆/– | ☆ | – | ☆ | ☆/– | – | ☆ |
| Lower volatility than CPI | ☆ | ☆/– | ☆/– | ☆/– | ☆ | ☆ | ☆/– | ☆ | ☆/– | ☆ |
| Robustness | ☆ | ☆/– | ☆/– | ☆/– | ☆ | ☆ | ☆ | – | – | – |
| Independence between shock and Core rate | ☆/– | ☆ | ☆ | ☆/– | ☆/– | – | ☆/– | – | – | – |
| Improved predictability | ☆/– | ☆/– | ☆/– | – | ☆/– | ☆/– | ☆/– | ☆/– | ☆/– | ☆/– |
| Link with inflation expectations | ☆/– | ☆/– | ☆/– | ☆/– | ☆/– | ☆/– | ☆/– | – | – | ☆ |
| Timeliness | ☆ | ☆ | ☆ | ☆ | ☆ | ☆ | ☆ | – | – | – |
| Understandable by the public | ☆ | ☆ | ☆/– | ☆/– | ☆/– | ☆ | ☆ | – | – | ☆/– |

Comparing the two groups of methods, the performance of the statistical approaches is much better than that of the theory-based methods. The core rate based on the exclusion method (CPIEX), the rate according to the Bank of Canada’s method (VAR1), the 20% trimmed mean and the median based on annual rates (TRIM2 and MED2) comply with almost all requirements. The trims based on month-on-month rates (TRIM1 and MED1) and the Dow/Diewert method (VAR2) clearly have bias problems. Empirically, the correspondence with inflation expectations causes problems in almost all approaches in this group, at least over the shorter period. Nor are the core rates always robust.

Methods based on economic theory, however, suffer even more from the need for continuous revision. As information from other macroeconomic variables are needed for their computation, their results are available later than measured inflation and their complexity makes them hard to communicate to the public. It is nonetheless striking that within this category the new approach to calculating core inflation based on P* is, overall, more convincing than the SVAR approaches.

These results must, however, be relativised in several respects. For example, the method of evaluation is very subjective. No account is taken of whether compliance with a criterion is extremely good or barely adequate and the criteria are not weighted. Furthermore, the results relate only to available data for western Germany in the corresponding period. For other base periods or countries such an analysis will not necessarily produce the same results.

## V. Conclusions

This study analysed a number of different methods of calculating core inflation rates from a theoretical standpoint and subsequently applied them to data for western Germany. The computed core inflation rates were then tested to see whether they contain characteristics, which are desirable and plausible for core inflation rates. The following conclusions can be drawn.

The study shows that the core inflation rates do not always meet the requirements made of them. The methods frequently find it difficult to differentiate adequately between the transitory and permanent components of measured inflation. Avoiding bias is also generally a major problem. In particular, a dilemma occurs if measured inflation is adjusted for the effects of taxation. On the one hand, tax changes make a major contribution to the volatility of measured inflation rates. *Ex ante* they are – insofar as second-round effects are avoided – of a purely transitory nature and do not alter the inflation trend. On the other hand, methods which identify and filter out these effects run the risk – insofar as the tax changes always move in the same direction – of deviating on average from the mean of measured inflation. Consumers are ultimately affected by (overall) measured inflation. Divergences between the core rate and measured inflation may therefore lead to credibility problems, particularly if monetary policy is focused on a core rate that is on average “too low”. As adjustment to take account of tax effects entails major problems,[39] it appears better to forgo such adjustment and instead to explain specific price movements that are due to tax changes.[40] Owing to the generally somewhat problematic results, it would not appear advisable to use core inflation rates as the sole monetary policy indicator. However, information about the price trend is needed and there is no real alternative to core rates.

The plurality of core inflation variables, some of which have been presented here, highlights several defects in this concept. On the one hand, the problems are at the theoretical level. There is to date no uniform theoretical definition of the term. This applies

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39 As statistical methods cannot identify all tax effects, the specific adjustment method is frequently employed (see, for example, Roger, 1995). This requires detailed knowledge of the size and timing of the shock and the extent and duration of the pass-through. The method is therefore difficult to implement and very subjective.

40 See also Svensson (2000).

both to the normative aspect (Which inflation rate should the central bank use for the definition of its objective?) and to the positive aspect of the problem (Which type of inflation is the product of monetary factors?). On the other hand, the difficulties lie on the practical side (How is a theoretical concept best translated into a concrete yardstick?).

At the policy-making level, the choice of methods depends not least on the purposes that core inflation is intended to serve. If it is perceived solely as an aid to (internal) price analysis, the prime requirements are low volatility, non-dependence between shocks and the core rate and the predictive power. If core inflation is used to communicate monetary policy decisions to the public, as a benchmark for the *ex post* assessment of monetary policy performance, or is even used to define the goal of price stability, greater importance will be attached to political and economic criteria such as unbiasedness, robustness, public comprehensibility and the correspondence with inflation expectations. The question is then how a central bank should proceed. It is not advisable to view all the different methods in combination. Although the different approaches do complement each other to a certain extent as they are based on different sets of information, the probability that they will all point in the same direction at a given point in time is very low. A central bank is thus confronted with a fan-like spread of core inflation rates, which tends to add to the confusion rather than reduce it. The combination of a small number of approaches drawn from different methodological categories offers a solution, especially as this allows very different sources of information to be used.

## Annex A: Moments of the cross-sectional distribution of price changes

Table A1 gives the moments of the cross-sectional distribution of the inflation rates in western Germany for various horizons over the period from 1980 to 1998.[41] Regarding the moments of the raw data for 55 components, the standard deviation of month-on-month rates of change is generally very high. It decreases over longer horizons, which indicates that transitory movements of individual components over these periods become less important. The average skewness of the distribution likewise varies with the horizon. Furthermore, the skewness varies considerably, especially for the short time horizon (the standard deviation is 4.12). This implies that monthly inflation rates are often extremely skewed. The distribution is, moreover, strongly leptokurtic. In the case of monthly rates, the average kurtosis is 27.45; even in the case of three-year averages it is, at 5.83, still above the kurtosis for normal distribution (which is 3). Both the skewness and the kurtosis fluctuate very markedly over time. Charts A1 and A2 clearly show these pronounced movements of the higher moments. Overall, it can be seen that the empirical distribution is non-normal. On the basis of Jarque-Bera tests, the hypothesis of normal distribution must always be rejected for monthly and quarterly rates of change; even in the case of three-year rates, the hypothesis is accepted in less than half of the observations.

In analysing a deeper level of disaggregation (three-digit SEA, 181 components) the deviation of the empirical distribution from normal distribution is even more evident. The extremely high kurtosis for month-on-month and quarterly rates and their extreme dispersion are particularly striking. If the Jarque-Bera test is applied, the hypothesis of normal distribution is accordingly rejected over all time horizons in almost all cases.

*Taking account of seasonality*

Seasonal variations in some components, which are likely to be particularly important in the monthly and quarterly rates, may affect the moments of distribution. Using seasonally adjusted data, this reduces the standard deviation of the monthly and quarterly changes by around 40% in each case (third section of Table A1). By contrast, the impact on the weighted skewness is close to zero and the kurtosis also remains at a problematically high level.

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41 For the calculation of the moments of the cross-sectional distribution see, for example, Bryan/Cecchetti/Wiggins (1997).

## Table A1: Moments of the cross-sectional distribution (1981 –1998)

| Horizon | M/M | 3M/3M | 12M/12M | 24M/24M | 36M/36M |
|---|---|---|---|---|---|
| **55 components – unadjusted values** | | | | | |
| *Standard deviation* | | | | | |
| Average | 14.01 | 9.15 | 2.78 | 2.12 | 1.84 |
| Standard deviation | 6.49 | 3.49 | 1.18 | 0.72 | 0.55 |
| *Skewness* | | | | | |
| Average | -0.21 | 0.00 | 0.37 | 0.23 | -0.03 |
| Standard deviation | 4.12 | 3.80 | 2.07 | 1.55 | 1.29 |
| *Kurtosis* | | | | | |
| Average | 27.45 | 24.57 | 10.07 | 7.29 | 5.83 |
| Standard deviation | 14.73 | 12.39 | 10.36 | 6.15 | 3.54 |
| **181 components – unadjusted values** | | | | | |
| *Standard deviation* | | | | | |
| Average | 19.76 | 13.20 | 3.97 | 2.86 | 2.39 |
| Standard deviation | 7.54 | 4.03 | 1.60 | 1.00 | 0.75 |
| *Skewness* | | | | | |
| Average | 0.00 | 0.93 | 0.30 | 0.19 | -0.11 |
| Standard deviation | 6.16 | 6.52 | 3.32 | 2.54 | 2.07 |
| *Kurtosis* | | | | | |
| Average | 80.88 | 90.07 | 30.75 | 18.00 | 12.64 |
| Standard deviation | 71.25 | 71.53 | 22.80 | 12.67 | 7.72 |
| **55 components – seasonally adjusted values** | | | | | |
| *Standard deviation* | | | | | |
| Average | 8.47 | 5.14 | 2.77 | 2.11 | 1.83 |
| Standard deviation | 5.30 | 2.69 | 1.18 | 0.72 | 0.54 |
| *Skewness* | | | | | |
| Average | 0.02 | 0.01 | 0.30 | 0.14 | -0.14 |
| Standard deviation | 3.21 | 2.80 | 2.06 | 1.54 | 1.27 |
| *Kurtosis* | | | | | |
| Average | 19.88 | 16.21 | 10.05 | 7.27 | 5.81 |
| Standard deviation | 14.88 | 13.63 | 10.29 | 6.06 | 3.48 |
| **55 components – unadjusted values, unweighted** | | | | | |
| *Standard deviation* | | | | | |
| Average | 15.82 | 10.59 | 2.71 | 2.05 | 1.76 |
| Standard deviation | 7.52 | 4.00 | 1.03 | 0.55 | 0.37 |
| *Skewness* | | | | | |
| Average | -0.04 | 0.16 | 0.32 | 0.26 | 0.03 |
| Standard deviation | 3.69 | 3.34 | 2.21 | 1.87 | 1.65 |
| *Kurtosis* | | | | | |
| Average | 21.77 | 18.62 | 10.83 | 8.70 | 7.53 |
| Standard deviation | 8.79 | 7.19 | 7.68 | 6.40 | 5.02 |

*Effect of weighting*

The Dow/Diewert method is based on the assumption of normal distribution of the individual price changes. As the initial expenditure weights are ignored under this method, it is interesting to look at the moments of distribution without these weights. The empirical findings clearly show that the weighting has hardly any bearing on the moments. Notable differences are evident only in month-on-month and quarter-on-quarter changes. In these cases the weighting actually has a dampening effect on the standard deviation while accentuating the kurtosis. With regard to skewness, there are differences as regards asymmetry; the variability of the skewness, by contrast, remains virtually constant.

**Chart A1: Skewness of distribution of year-on-year rates, 1981–1998**

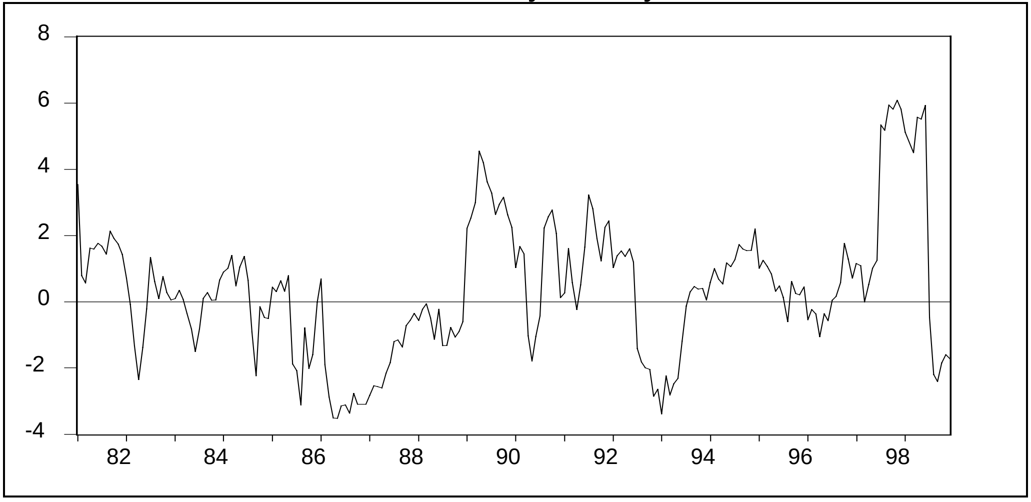
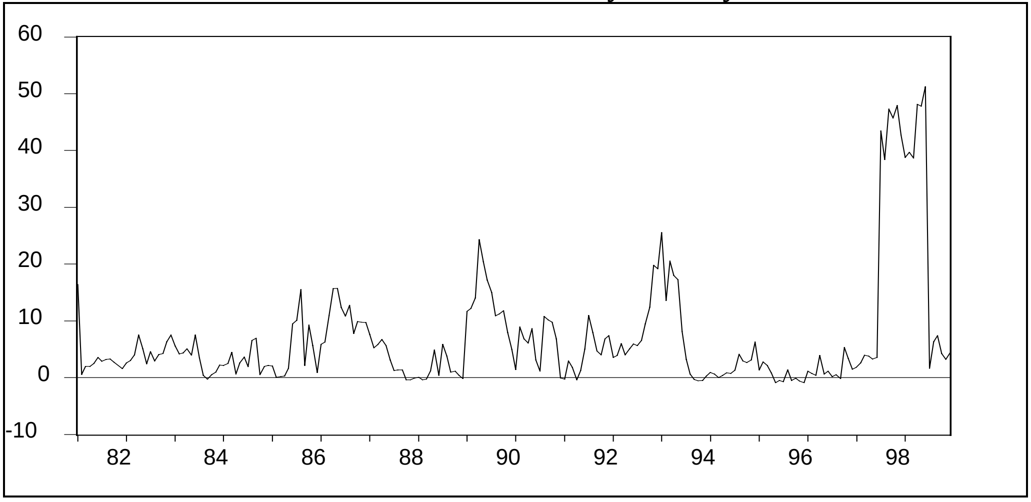



**Chart A2: Excess kurtosis of distribution of year-on-year rates, 1981–1998**



## Annex B: Determination of west German core inflation using the P* approach

In order to calculate a monthly core inflation using P*, first, the equilibrium price level has to be determined. An inverted long-run money demand function is estimated using the M3 monetary aggregate (*m*) and the data for potential output of the Bundesbank (*y**)[42] . As the data for potential output are only available on a quarterly basis, they are interpolated. Until May and June 1990 respectively, m and y* relate to western Germany and after those dates to Germany as a whole. The dependent variable is the west German CPI. All variables are logarithmic. The OLS estimation yields the following results for the estimation period from 1979:1 to 1998:12:

$$p_t^* = m_t - 1{,}51 y_t^*$$

The equation also contains a constant, seasonal dummies and a dummy, which takes account of the fact that the shift in the money stock at the time of German unification occurred one month earlier than in the case of the potential output. The long-run income elasticity of the real money demand is estimated as 1.51. This value is scarcely different from the estimated results for quarterly data (e.g. Tödter/Reimers, 1994). The (logarithmic) equilibrium price level corresponds to the fitted values of this equation.

In a second step an equation is estimated for the inflation rate in first differences by means of an error correction model (see equation (2.2.5), Section III.2.2). To capture supply shocks the change in the nominal oil price in D-Mark (*doel*) and dummies for changes in VAT (*dmwst*) and mineral oil tax (*dmist*) are included in the estimation. The Bundesbank's medium-term price assumption, calculated on a monthly basis, is used as the central bank's inflation target (*pziel*).[43] The lag structure (eight lags) has been chosen in such as way that the residuals are serially uncorrelated, homoscedastic and normally distributed. The coefficient for the price gap was calibrated at 0.02. If this value is expanded to quarterly intervals, it corresponds to the adjustment parameter that arises from an estimate using quarterly data. The estimation for the inflation rate equation produces (including seasonal dummies not shown):

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[42] See Deutsche Bundesbank (1995).

[43] For this variable and the tax data, see Reckwerth (1997).

| Variable | $doel_t$ | $dmwst_t$ | $dmist_t$ | $\sum_{i=1}^{8}\Pi_{t-i}$ | $pziel_t$ | $(p*-p)_{t-1}$ |
|---|---|---|---|---|---|---|
| Coefficient (t-value/F-value) | 0.01 (4.6) | 0.31 (2.3) | 0.05 (4.5) | 0.59 (4.1) | 0.41 (13.1) | 0.02 |
| $\bar{R}^2$=0,5 | BG-LM(12) = 1.3 | White = 1.4 | | | | |

At 0.5, the explanatory power of this estimation is relatively good, given a function estimated in first differences and using monthly data. Although some of the lag-endogenous variables are not significant, a Wald test showed them all to be statistically significant.

For the purpose of calculating core inflation, the temporary influences (*doel*, *dmwst, dmist*) and the residuals are set at zero. The equation for core inflation (including the estimates for the seasonal dummies) thus reads:

$$\Pi_t^* = 0{,}59\sum_{i=1}^{8}\Pi_{t-i} + 0{,}41\,pziel_t + 0{,}02(p*-p)_{t-1}.$$

The course of this inflation rate can be seen from Chart 6 in Section IV.3.

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