

# Notes on the measurement of inflation

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Inflation may be described as a sustained rise in the general price level. Inflation is, therefore, reflected in a *general and widely diffused* increase in the prices of goods and services in the economy. The greater variability and higher level of the inflation rate during recent years have led to a greater need for the appropriate measurement of price changes in order to assess the prevailing level of inflation as well as current changes in the inflation rate with a view to assisting the authorities in the formulation of economic policy<sup>1)</sup>. The purpose of these notes is to discuss some of the alternative indicators of inflation and methods of measuring price changes, without commenting on the various conceptual and technical issues involved in the compilation of these indicators.

## Inflation indicators

Various price indices and deflators may be used as indicators of inflation. The more important commonly used indicators are the following:

*Implicit national accounts deflators* which are derived from national accounting aggregates, such as the gross national or gross domestic product, gross domestic expenditure and private consumption expenditure, by calculating ratios of current to constant price data for these aggregates.

*Production or wholesale price indices* which measure the prices of commodities (excluding services) sold at the non-retail level.

*Consumer price indices* which are designed to show changes over time in the prices of selected goods and services which are considered to be representative of the expenditure patterns of the consumer population concerned.

As indicators of inflation, these various deflators and price indices have certain advantages as well as disadvantages. Implicit price indices or deflators of national accounting aggregates have the advantage that they provide a more comprehensive coverage of the price level of domestic output or expenditure than consumer or production price indices. In addition, they are better suited for international comparisons because of greater standardisation of concepts and uniformity of methods of construction.

However, implicit price deflators have certain shortcomings which make them less useful for measuring domestic inflation. The levels of and changes in the prices of certain commodities are not determined by domestic demand or supply factors, but are fixed on international

markets. These international commodity prices are not representative of the domestic price level and, in addition, may show sharp changes from time to time. Such fluctuations may distort the price changes indicated by the gross national and gross domestic product deflators. For example, the sharp variation in the gold price, especially during the past decade, has had a significant impact on changes in the domestic product deflator. Reflecting the sharp rise in the gold price in 1980 and the subsequent decline in 1981, the rate of increase in the gross domestic product deflator accelerated sharply to 21 per cent in 1980, but slowed down to 9 per cent in 1981. However, excluding gold mining output, the rate of increase in the deflator amounted to 14 per cent in both 1980 and 1981.

Implicit price deflators do not only reflect changing prices, but also changes in the composition of output. They only measure changes in prices between the base and current periods and not changes within the intervening period. The reason is that these deflators are constructed according to the Paasch formula which uses constantly changing current period weights. Consumer and production price indices, on the other hand, are computed according to the Laspeyres formula using base period weights which are usually held constant for several years.

A further shortcoming of the implicit price deflators is that the national accounts statistics, from which they are derived, are only available with a certain time lag and, furthermore, are always subject to revisions.

Production price indices measure the level of and changes in the prices of goods produced in the manufacturing sector, foreign manufactured goods imported for domestic consumption and goods produced in other sectors of the economy. A sectoral breakdown of the production price index has the advantage that it enables the identification and quantification of the sources of price changes and the consequent impact of such price changes at successive levels of production or trade. These price indices have the disadvantage that they cannot be used for international comparisons, since coverage, definitions and methods of calculation often vary between countries.

The consumer price index is considered to be a measure of changes in the cost of living or the purchasing power of money in the hands of the consumer. The term "cost of living" refers to the cost of a representative "basket" of consumer commodities and services within a given period. Hence a rise in the cost of living will occur when the amount of money needed to obtain a similar "basket" of goods and services increases from one period to another.

The advantage of using the consumer price index as a measure of inflation is that it is directly compiled from

<sup>1)</sup> The rate of inflation, as measured by changes in the consumer price index, amounted on average to 3,2 per cent per annum during the period 1950-1970, but accelerated sharply to an annual average of 11,4 per cent during the subsequent period to 1984.

actual prices and not from imputed or derived prices. In South Africa the Central Statistical Services collect approximately 250 000 price quotations per year for about 600 commodities and services for the purpose of calculating monthly price indices. Notwithstanding this important advantage, the consumer price index has a number of disadvantages as a measure of inflation. Firstly, if a price index is used as an indicator of the general price level, it should reflect all or most of the prices in the economy and not only those relating to consumer expenditure. The consumer price index, for example, does not cover all the prices of government-produced goods and services or the prices of investment goods.

Secondly, the consumer price index is criticised for having an upward bias built into it, since the index does not fully reflect the substitution of products and quality changes which are constantly taking place. New products enter the consumer market continuously. The determined base-year consumption pattern does not take account of the substitution of relatively less expensive for more expensive goods or of higher quality for lower quality goods in the market in successive price measuring periods.

Lastly, the consumer price index records the final prices of goods and services, including the effects of indirect taxes and subsidies on these prices. This procedure seems justified if the purposes of the index is to measure changes in the cost of living. Adjustments in indirect tax rates, however, may cause abrupt changes in the measured price level, which complicates the evaluation of the actual underlying rate of price changes<sup>2)</sup> in the economy. Adjustments to eliminate the effects of tax or subsidy changes are difficult to make. For example, it is possible to quantify the *direct* effect of an indirect tax change on the price of a particular commodity, but it would be extremely difficult, if not impossible, to evaluate its *indirect* or secondary price effects.

Despite the imperfections of the consumer price index, changes in the index are nevertheless considered to be the most appropriate measure of inflation<sup>3)</sup>.

## Methods of measuring price changes

In measuring price changes, i.e. changes in a chosen inflation indicator, the four distinguishable components of a time series, namely the long-term trend, the cyclical movement, seasonal variations and irregular fluctuations, should be taken into account. A meaningful measure-

ment of price changes should ideally not reflect irregular and seasonal fluctuations, but only movements in the more fundamental cyclical and long-term trend components of the chosen indicator. In this regard, the focus may be on measuring either the *level* of the inflation rate or the *tempo* of short-term changes in the inflation rate. The level of the inflation rate reflects changes in both the long-term trend and cyclical movement of prices, whereas the tempo of change in the rate of inflation reflects mainly short-term changes in the cyclical movement in prices over time intervals shorter than twelve months. The combined long-term trend and cyclical components of a price series may be approximated by way of regression, exponential smoothing or moving average methods. Short-term changes in the cyclical component, in turn, have to be based on a smoothed monthly series in which seasonal as well as irregular fluctuations have been eliminated.

### 1. Measuring the level of the inflation rate

The level of the inflation rate is measured as the annualised rate of change in the trend-cycle component of the consumer price index over a fairly long time span and, therefore, reflects the longer-term structural and cyclical developments of prices in the economy. In practice, the following methods are applied:

#### 1.1 Conventional method

Percentage changes in the price index are calculated over twelve-month intervals. By measuring price changes over such a time span, this method to some extent smooths out month-to-month fluctuations and eliminates the effect of seasonal fluctuations. The most important advantage of this method is that it is generally used and easily understood. In all official statistical and other documents of the International Monetary Fund, the United Nations, the Organisation for Economic Co-operation and Development and individual countries, changes in prices are mostly measured by this method. It is important to note that the rate of change in prices calculated in this way provides only an indication of the level of the inflation rate and may not be a reliable estimate of the tempo of short-term price changes<sup>4)</sup>. The same-month-year-ago comparisons indicate broadly what has happened over the twelve-month period, but not during the intervening period. This method has a built-in lag in measuring short-term price changes since the change is calculated from an observation twelve months prior to the current period. The effect of this is to overestimate current changes in the inflation rate when the observed rate of change is decelerating and to underestimate it when the observed rate is accelerating.

<sup>2)</sup> For example, the introduction of the general sales tax in 1978 occurred at a time when the rate of increase in consumer prices was decelerating. If the effect of the sales tax is excluded, this tendency continued during the second half of 1978 and the first quarter of 1979, but the measured rate of increase in consumer prices was distorted by the introduction of the tax to the extent that it showed a temporary increase.

<sup>3)</sup> International Monetary Fund, General Statistics Division: "Measures of Global Inflation", unpublished IMF document, 1979, p. 19

<sup>4)</sup> Bond, M.E. and McGuirk, A.K.: "Calculation of the Underlying Rate of Inflation for Seven Industrial Countries", Unpublished IMF document, International Monetary Fund, December 1977, p.2.

## 1.2 Moving average methods

These methods measure the level of the inflation rate by means of percentage changes, usually over twelve-month intervals, in the combined long-term trend and cyclical components of the consumer price index, as approximated by moving averages. The number of terms used in the moving averages may vary, and the averages may be based on weighted observations in order to improve the goodness of fit or smoothness of the underlying trend.<sup>5)</sup> This method eliminates irregular movements as well as any residual seasonal influences in the monthly figures. However, it has the disadvantage that moving average values at the beginning and end of the series are lost.<sup>6)</sup>

Empirical evidence suggests that a centred twelve-month moving average<sup>7)</sup> is an appropriate approximation of the trend-cycle component of the consumer price index. Furthermore, percentage changes over a twelve-month time span in the centred moving average values provide an acceptable indication of the level of the inflation rate.

An often-used variation of the moving average method of measuring the level of the inflation rate is to calculate percentage changes in the annual averages of price index observations for successive calendar years. The disadvantage of this variation is its discontinuity and, accordingly, it is suitable merely for long-range historical studies in which only annual figures are used.

To overcome the disadvantage of losing end values and applying complicated extrapolation methods, another variation of the moving average method may be used. Instead of basing rates of price change on comparisons of moving average values in both the current and base periods, the actual price index observation in the current period may be compared with the centred moving average base figure. The disadvantage of this method is that irregular fluctuations in current period observations are retained in the calculated rates of price change. On the other hand, such rates of change may represent a more realistic reflection of actual price movements. The advantage of using a smoothed base figure in calculating price changes is that the irregular fluctuations in current period observations are neither accentuated nor suppressed.

<sup>5)</sup> Weighted moving averages may be calculated where the weights are determined by the fitting of a polynomial of a specified degree to segments of the time series. See Kendall, M.: *Time-Series*, Charles Griffen and Company Ltd, London, 1976, pp.29-38.

<sup>6)</sup> The end values could be estimated by extrapolating the determined average centred values by regression or ARIMA models, but these estimates are subject to change as new data become available.

<sup>7)</sup> The average for the twelve months is centred between the 6th and the 7th months. Taking the mean value for successive twelve-month averages, centres the moving averages on calendar months. A centred twelve-month moving average is equivalent to a thirteen-month average with weights 1/24 (1, 2, 2, ..., 2, 2, 1).

## 1.3 Evaluation of alternative methods of measuring the underlying level of the inflation rate

An evaluation of the alternative methods leads to the conclusion that the level of the inflation rate is best measured by rates of change over a time span of twelve months in the centred twelve-month moving average values of the consumer price index. This procedure is not materially different from standard practice, except that the measurement of price changes is based on a smoothed price index series which approximates the long-term trend and cyclical components of the original series. Inflation rate levels calculated in this way are not distorted by irregular fluctuations. However, the loss of end values limits the use of this method in current inflation analyses. This method is nevertheless well suited for historical analyses based on monthly rather than annual price index data.

In current inflation analyses, the method of basing price changes on a comparison (over a twelve-month time span) of current price index observations with centred twelve-month moving average base values appears to provide the best results. The measured inflation rate levels reflect current price developments more accurately, without irregular fluctuations being accentuated or suppressed. In this respect, this method is superior to the earlier discussed "conventional" method of measuring the level of the inflation rate, which uses unsmoothed base figures in its comparison (also over a twelve-month time span) of price index observations.

In the top section of Graph 1 inflation rate levels based on changes in moving average values in both the current and base periods are compared with those based on changes in actual current period price index observations relative to moving average base period values. The bottom section of Graph 1 compares the results of the latter method with that of the so-called conventional method.

## 2. Measuring the tempo of short-term changes in the inflation rate

The short-term underlying rate of change in prices could deviate from the longer-term level of the inflation rate because it takes into account short-term changes in direction and tempo of only the cyclical component of the chosen inflation indicator, in this case the consumer price index. The ideal indicator of the tempo of change in the inflation rate would be a smooth month-to-month change, at an annual rate, in the *actually* observed monthly data. However, as in other countries, underlying price changes in South Africa are more often than not obscured by highly irregular fluctuations in the monthly figures. In order to eliminate or minimise the distortions of non-cyclical fluctuations, the measurement of short-term price changes have to be based on seasonally adjusted data, while the effect of irregular variations have to be suppressed either by using a somewhat longer time span than one month for measuring price changes or by basing changes on smoothed data.

Graph 1: Level of the inflation rate



The choice of an appropriate time span depends on the degree of volatility of the monthly series. Changes should be measured over a span of months that is sufficiently short to capture the short-term direction and tempo of price changes, without allowing irregular fluctuations to dominate short-term tendencies. The use of longer time spans will yield less volatile results, but has the danger of suppressing true cyclical changes. Averages or moving averages may be used for smoothing price index series. The chosen number of terms for a moving average should be sufficient to reduce irregular variations, but to reflect also as accurately as possible the underlying cyclical change.

The following methods may be applied to measure the tempo of change in the inflation rate:

2.1 Three-month-moving-average method

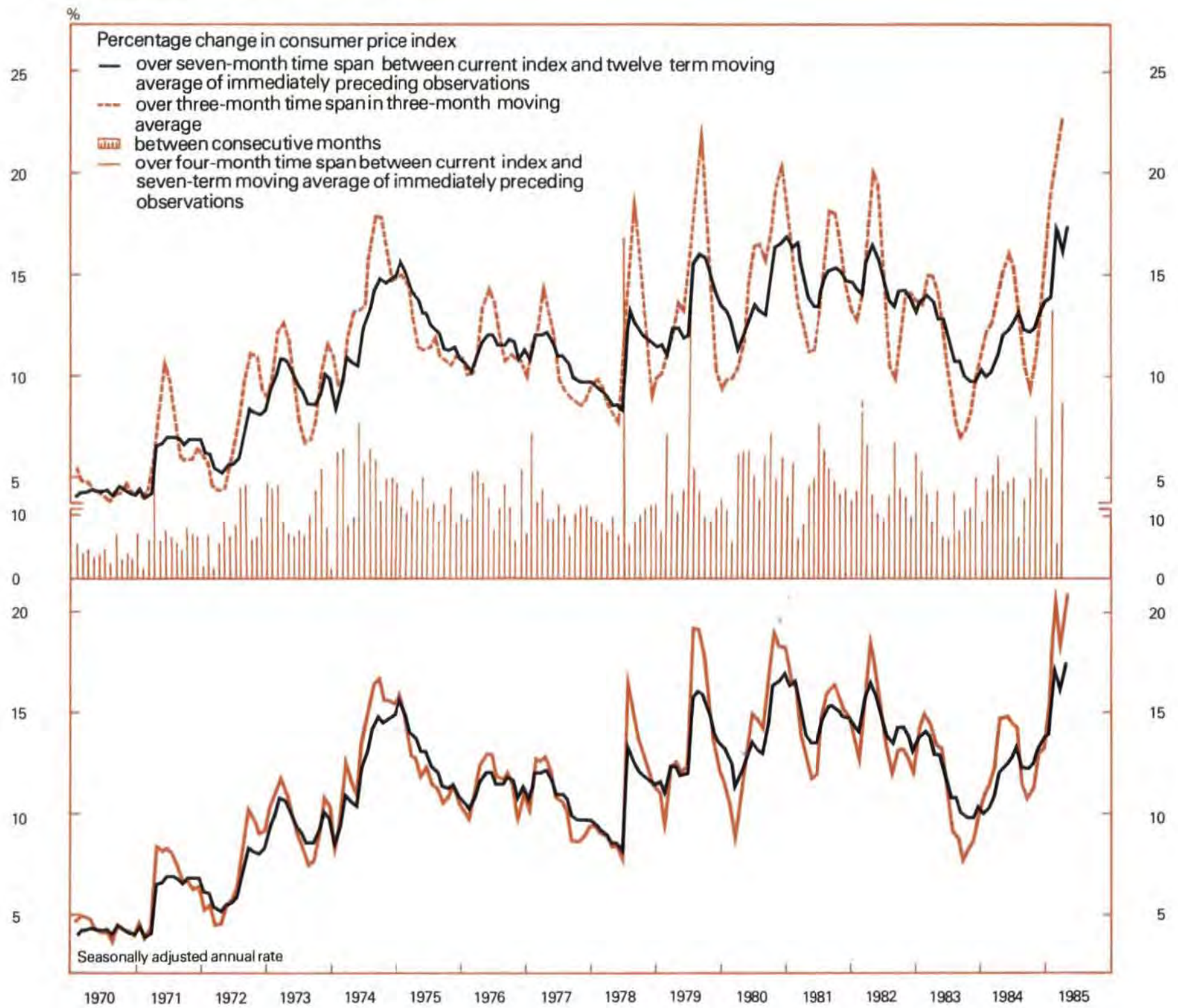
Percentage changes, at an annual rate, are calculated over a three-month time span in the seasonally adjusted three-months moving average of monthly price indices.

This method has the disadvantage of losing end values and the measuring of price changes can, accordingly, not be brought up to date. An often used variation of this method is to calculate percentage changes in the monthly averages of seasonally adjusted data for successive calendar quarters.

2.2 Smoothed-base method

This method is designed to overcome the disadvantage of losing end values in the measurement of price changes based on moving average values. Accordingly, changes in the actual current period observations (adjusted only for seasonal variations) are measured relative to smoothed base period figures. As mentioned earlier, this method has the disadvantage of retaining irregular variations in the measured rates of price changes, but has the advantage of reflecting price movements more accurately without accentuating or suppressing observed price fluctuations.

Graph 2: Tempo of change in the inflation rate



Apart from the use of a three-month moving average in the method referred to under 2.1, empirical evidence suggests that the use of seven- to twelve-term moving average for smoothing base figures yields satisfactory results. In the smoothed-base method the principle is accepted that, in the measurement of price changes, the current period observation is compared with the moving average value of immediately preceding observations. If a seven-term moving average is used, price changes are effectively measured over a four-month time span, while the use of a twelve-term moving average means that the price changes are measured over a time span of six and a half months. If the twelve-month moving average is centred, as in the previously discussed method of measuring the level of the inflation rate,

the price changes are measured over a time span of seven months. The practice is to express these changes in terms of annual rates. This method is, therefore, essentially the same as that used for measuring inflation rate levels, except that price changes are measured over shorter time spans and that different moving averages are used for smoothing base figures.

2.3 Evaluation of alternative methods of determining the tempo of change in the inflation rate

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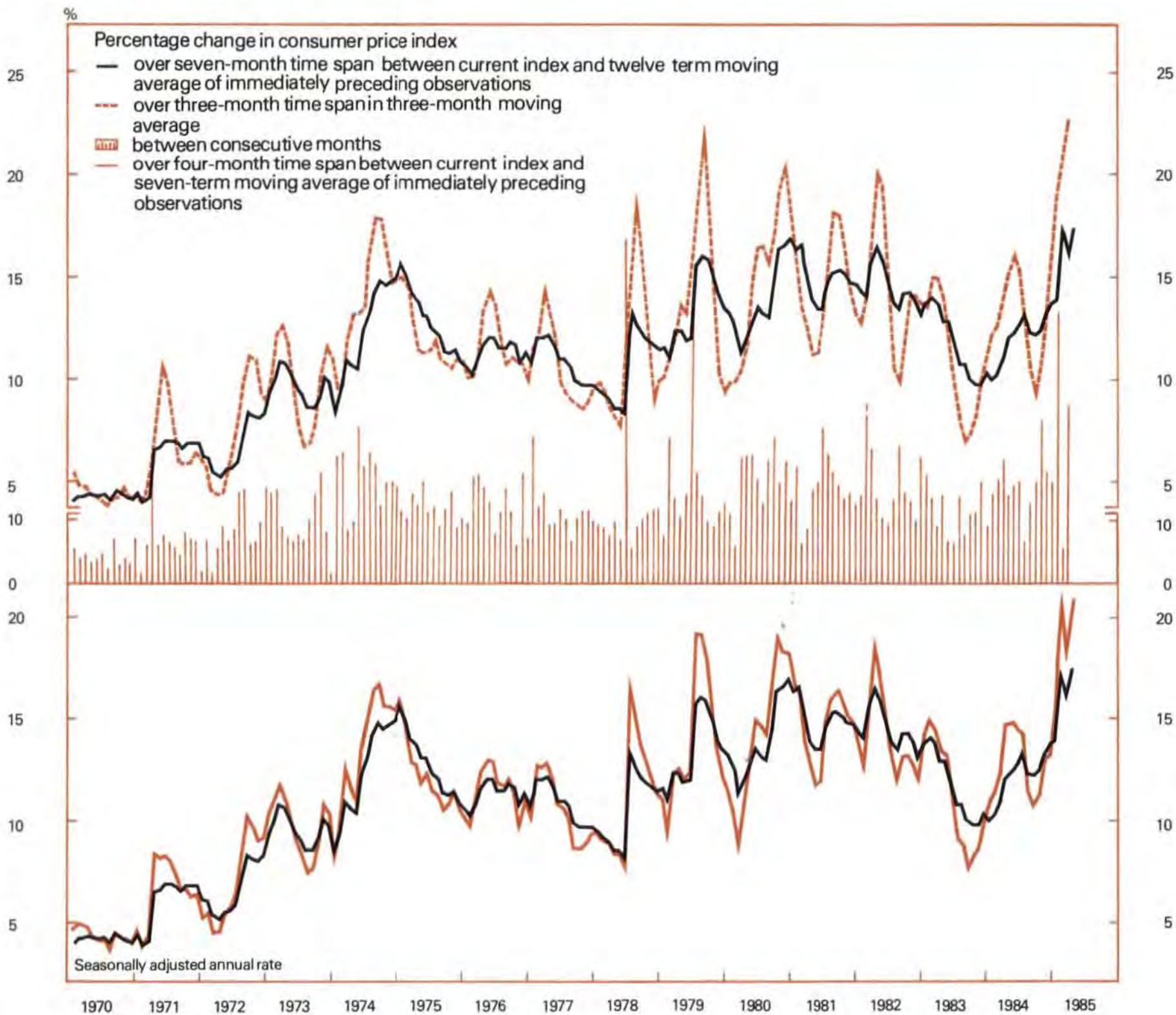
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rate. The results of the three-month-moving-average method correspond closely to the general tendency in monthly changes, but are more smooth. Nevertheless, they still show sharp oscillations over the short term. Price changes according to the smoothed-base method using a centred twelve-term moving average follow the monthly changes fairly closely, but with a marginal lag. Variations in these changes are smaller, i.e. the amplitude of changes is smaller than those measured by the three-month-moving-average method or, as shown in the bottom section of Graph 2, by the smoothed-base method using a seven-term moving average.

Considering these results, it appears that the smoothed-base method, using a centred twelve-term moving average and measuring price changes over a time span of seven months, is the most appropriate for measuring the tempo of short-term changes in the inflation rate.

## Conclusion

In the measurement of inflation a clear distinction should be made between the underlying level and the current rate (tempo) of price changes. An appropriate method of measuring the level of the inflation rate is to calculate percentage changes over a twelve-month time span in a centred twelve-month moving average of the consumer price index. However, because end values are lost in the calculation of such a moving average, changes in actual price index observations may be measured relative to centred twelve-month moving average base figures as an alternative approach.

Changes from one month or quarter to another reflect short-term price tendencies, but the latter are often obscured by short-term irregular fluctuations. Such fluctuations cannot be eliminated altogether from measured short-term price changes, but should not be accentuated or unrealistically suppressed by the method of measuring price changes. For this reason, an appropriate method of measuring the current tempo of price changes appears to be the so-called smoothed-base method. This method measures current price changes over a time span of seven months relative to base figures smoothed by means of a centred twelve-term moving average. It also has the advantage of indicating changes earlier than the conventional method of comparing the current month with the same month a year ago.

Reference has already been made to the distortion of consumer price changes by indirect tax adjustments. Whenever the focus is on measuring the underlying tempo of price changes, the effect of such tax adjustments should be excluded from the consumer price index. However, in determining the level of the inflation rate, interpreted in the sense of the rate of change in the cost of living, the effect of indirect tax adjustments should not be eliminated.