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# Economic commentaries

## CPIM: a model-based indicator of underlying inflation

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## 1 Introduction

The objective of Norges Bank's monetary policy is low and stable inflation. The operational target of monetary policy is annual consumer price inflation as measured by the consumer price index (CPI) of close to 2.5 per cent over time. In general, direct effects on consumer prices resulting from changes in interest rates, taxes and extraordinary temporary disturbances shall not be taken into account. However, monthly changes in headline inflation may vary considerably, influenced by temporary changes in one or more prices.

In real time it may be difficult to determine which price movements are permanent and those which only have short-term effects on the CPI. Indicators of underlying inflation, which seek to filter out temporary noise and show the more persistent trend in price developments, may be useful in this context. The indicators presented in the *Monetary Policy Report* are calculated using various methods:

- CPI adjusted for tax changes and excluding energy products (CPI-ATE)
- CPI adjusted for tax changes and excluding temporary changes in energy prices (CPIXE)
- CPI excluding outliers from period to period (trimmed mean)
- CPI adjusted for frequency of price changes (CPI-FW)

The CPIM is a new indicator of underlying inflation (see the October 2010 *Monetary Policy Report*). This indicator is based on the predictive power of the sub-indices of the CPI and thus differs somewhat from other indicators Norges Bank uses. The sub-indices are listed in Appendix 1. For each of the 34 sub-indices we have a simple model that projects the CPI one month ahead. The projections are weighted and averaged to an aggregate CPI projection. The sub-indices that over time more accurately explain movements in the CPI are then given a high weight in the CPIM. Conversely, the sub-indices that are less successful at capturing movements in the CPI will receive a lower weight. The weighted averaged projection provides an indication of underlying CPI inflation.

We demonstrate that the CPIM has good properties as an indicator of underlying inflation. Over time, the indicator has moved largely in line with the CPI. In addition, it has been more stable, which may indicate that the CPIM removes noise in the CPI without changing the underlying rate of increase. An additional advantage is that the indicator utilises the entire range of CPI data.

## 2 Calculating the CPIM

The CPIM is calculated on the basis of 34 sub-indices of the CPI. Formally the CPIM can be expressed, at time  $\tau$ , as:

$$(1) \text{CPIM}_{\tau} = \sum_{i=1}^{34} \omega_{i,\tau} h(Y_{\tau+1}|I_{i,\tau}), \quad \tau = \underline{\tau}, \dots, \bar{\tau}$$

where  $h(Y_{\tau+1}|I_{i,\tau})$  is a CPI projection one month ahead, from sub-index  $i$ ,  $i = 1, \dots, 34$ , conditioned on information  $I_{i,\tau}$ . We use an autoregressive (AR) process with four backdated values of the sub-indices to make the projections. The sub-indices are adjusted in advance to have the same average as the CPI. This is done to ensure unbiased projections. The 34 projections are weighted and averaged to an aggregate CPI projection. The weights,  $\omega_{i,\tau}$ , are positive and add up to 1, and they are determined by the Continuous Ranked Probability Score (CRPS) method.<sup>1</sup> As the weights are calculated as an average, they may vary through period  $\tau = \underline{\tau}, \dots, \bar{\tau}$ . The sub-indices that over time show a distribution close to that of the CPI<sup>2</sup> will be rewarded by a high weight in the CPIM.

## 3 Properties of the CPIM

Chart 2 shows the change in the CPIM together with the change in the CPI over the period January 2002 to September 2010. The chart shows that the indicator largely moves in line with the CPI. In this period the CPI has risen on average 1.9 per cent per year, whereas the CPIM has risen by 2.0 per cent. However, the CPIM has been more stable.

## 4 Criteria for an accurate indicator of underlying inflation

We attach weight to a number of criteria for an accurate indicator of underlying inflation.<sup>3</sup>

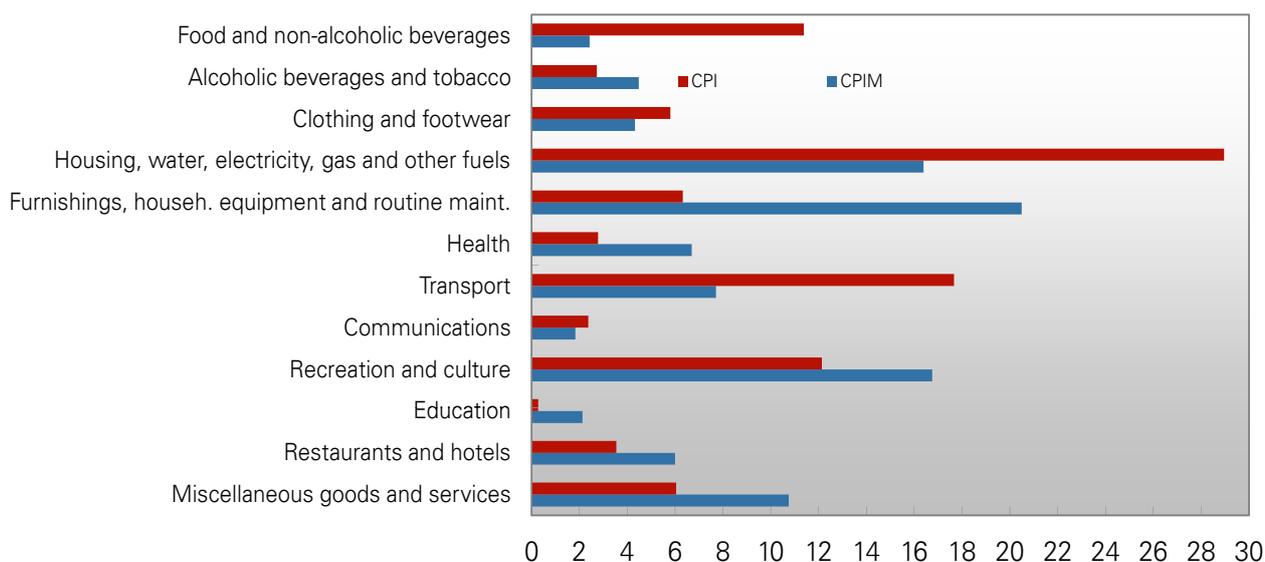
- a) The indicator should not systematically deviate from the CPI over a longer period.

1 See Ravazzolo and Vahey (2010) for a detailed description of the method.

2 The distribution of the CPI is approximated using Monte Carlo simulations with 5,000 draws.

3 See for example Roger (1998) and Wynne (1999).

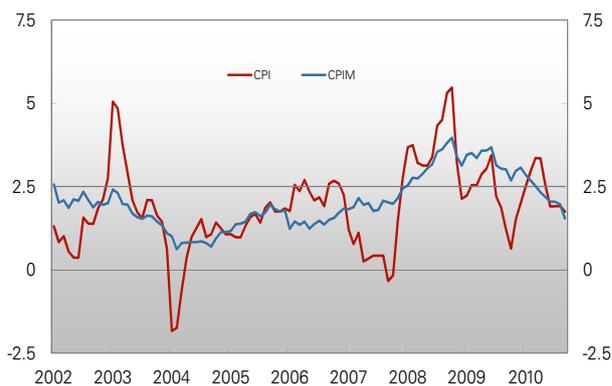
Chart 1 Weights in the CPI and in the CPIM<sup>1)</sup>.  
Average. Per cent. January 2007 – September 2010



1) Model-based indicator of underlying inflation  
Sources: Statistics Norway and Norges Bank

- b) It should be possible to estimate the indicator at the same time as the total CPI is published, and previously published observations should not be revised when new data are released.
- c) The indicator should be able to predict future developments in overall inflation.
- d) It should be calculated by institutions other than the central bank and be verifiable.
- e) The indicator should be easy for the public to understand, with deviations from projections able to be explained fairly quickly.
- f) The indicator should be grounded in economic theory.

Chart 2 CPI and CPIM<sup>1)</sup>.  
12-month change. Per cent. January 2002 – September 2010



1) Model-based indicator of underlying inflation  
Sources: Statistics Norway and Norges Bank

In this Economic Commentary we will follow Jonassen and Nordbø (2006) and perform empirical tests related to criterion (a). The tests have been used in a number of international studies of underlying inflation (see for example Rich and Steindel (2005) and Catte and Sløk (2005)). The tests examine whether the CPIM and the other indicators of underlying inflation have:

- had the same average as the CPI over time
- tracked a moving average of the CPI over time
- been less volatile than the CPI

#### 4.1 Average rate of increase compared with the CPI

In this section we examine whether the CPIM has over time risen at the same pace as the CPI. Substantial deviations over a longer period mean that not only temporary price disturbances, but also more permanent price movements have been stripped out of the calculation of underlying inflation.

Table 1 shows the difference between the average 12-month rise in the various indicators and in the CPI. A positive number means that CPI inflation has been lower than the indicator over time, and a negative number means that CPI inflation has been higher. Figures in bold type mean that the average difference is statistically significant. That the difference is statistically significant means here

that the constant term in the regression

$(\pi_t^{CPI} - \pi_t^U) = \alpha + \varepsilon_t$ , where  $\pi_t^{CPI}$  and  $\pi_t^U$  is the CPI and the relevant indicator, respectively, in period  $t$ , is found to be different from zero at a significance level of 10 per cent. The covariance matrix of the residual terms is estimated by the method proposed by Newey and West (1987).

The average 12-month rise in the CPIM was somewhat above the average 12-month rise in the CPI, but the difference from the CPI is not significant (see Table 1). The CPIM scores somewhat lower than the CPIXE and trimmed mean.

Table 1. Difference between average 12-month rise in the various indicators and CPI inflation. Percentage points. January 2002 - September 2010

	Difference
CPIM	0.15
CPIXE*	-0.03
CPI-ATE	<b>-0.37</b>
CPI-FW	<b>0.26</b>
Trimmed mean	0.11

\*Figures prior to August 2008 based on oil and electricity futures prices from August 2008. Real-time figures as of August 2008

Source: Norges Bank

## 4.2 Deviations from a moving average of CPI inflation

In this section we test for whether the CPIM has over time tracked the underlying rise in the CPI, measured as a moving average of CPI inflation. In accordance with Catte and Sløk (2005), the moving average is calculated by applying a centered moving 25-month average of 12-month CPI inflation. Changes in the moving average and in the CPIM are shown in Chart 3. Table 2 shows how the rise in the CPIM and in the other indicators has tracked the moving average of CPI inflation. This is measured by looking at the mean square error (MSE) between the moving average of the CPI and the different indicators. The MSE is expressed as:

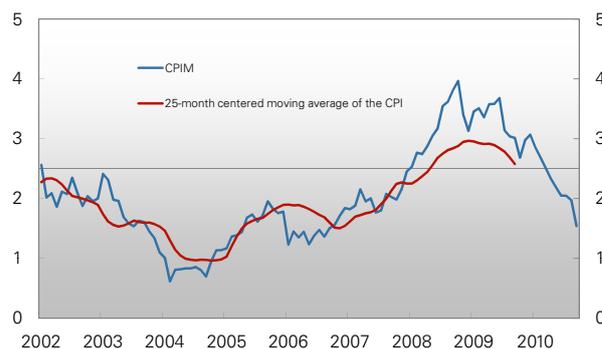
$$(2) \quad \frac{\sum_{t=1}^T (\pi_t^U - \pi_t^{ma})^2}{T},$$

where  $\pi_t^U$  and  $\pi_t^{ma}$  are the relevant indicator and the moving average, respectively, in period  $t$ .

Of the indicators followed by Norges Bank, the CPIM has been closest to the moving average of CPI inflation in the period from January 2002 to September 2010. With this test, indicators with a different average than the CPI over

time will perform less well. From section 4.1 we know that the average increase in the CPI-ATE and CPI-FW have differed from average CPI inflation. We therefore recalculated the MSE after demeaning all the indicators. The results are shown in the last column of Table 2. The CPIM continues to show the smallest deviation from the moving average of CPI inflation.

Chart 3 CPIM<sup>1)</sup> and 25-month centered moving average of the CPI. 12-month change. Per cent. January 2002 – September 2010



1) Model-based indicator of underlying inflation  
Sources: Statistics Norway and Norges Bank

Table 2. Deviation from a centered moving average of CPI inflation. January 2002 - September 2009

	Without same average	Same average
CPIM	0.14	0.14
CPIXE*	0.21	0.21
CPI-ATE	0.38	0.22
CPI-FW	0.49	0.46
Trimmed mean	0.28	0.27
CPI	1.41	1.41

\*Figures prior to August 2008 based on oil and electricity futures prices from August 2008. Real-time figures as of August 2008

Source: Norges Bank

### 4.3 Has the CPIM varied less than CPI inflation?

As headline inflation can show wide monthly swings, an indicator of underlying inflation should be less volatile than the overall CPI. The volatility measure used to test for this is the standard deviation of the monthly change in the 12-month rise (see Table 3).

All indicators in Table 3 have varied considerably less than the CPI in the period January 2002 to September 2010. However, in this period, the CPIM, CPIXE and the CPI-ATE are the ones that have varied least from month to month.

Table 3. Volatility of the various indicators and the CPI. January 2002 - September 2010

	Volatility
CPIM	0.22
CPIXE*	0.24
CPI-ATE	0.24
CPI-FW	0.38
Trimmed mean	0.27
CPI	0.66

\*Indicates period February 2002 to September 2010. CPIXE calculated only as far back as January 2002. Figures prior to August 2008 based on oil and electricity futures prices from August 2008. Real-time figures as of August 2008

Source: Norges Bank

## Sources

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## Appendix 1: Sub-indices in the CPIM

Number of sub-index	COICOP division		Name of sub-index
1	1	groups	Food
2	2	groups	Alcoholic beverages
3	2	groups	Tobacco
4	3	groups	Clothing
5	3	sub-groups 1	Shoes, other footwear
6	4	groups	Actual rentals for housing
7	4	groups	Imputed rental for housing
8	4	groups	Regular maintenance and repair of the dwelling
9	4	groups	Water, miscellaneous services to dwelling
10	4	groups	Electricity, gas and other fuels
11	5	groups	Furniture, furnishings and decorations, carpets and other floor coverings
12	5	groups	Household textiles
13	5	groups	Heating and cooking appliances, refrigerators, washing machines, similar household appliances
14	5	groups	Glassware, tableware and household utensils
15	5	groups	Tools and equipment for house and garden
16	5	groups	Goods and services for routine household maintenance
17	6	groups	Medical products
18	6	groups	Out-patient services
19	7	groups	Purchase of vehicles
20	7	groups	Operation of personal transport equipment
21	7	groups	Transport services
22	8	division	Communications
23	9	groups	Audio-visual, photographic and information processing equipment
24	9	groups	Other major durables for recreation and culture
25	9	groups	Other recreational items and equipment, gardens and pets
26	9	groups	Recreational and cultural services
27	9	groups	Newspapers, books and stationery
28	10	division	Education
29	11	groups	Catering services
30	11	groups	Accommodation services
31	12	groups	Personal care
32	12	groups	Social protection
33	12	groups	Other services n.e.c.
34	12	groups	Insurance