

STAFF MEMO

Sticky prices and inflation expectations in Norway

NO 15 | 2014

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MONETARY POLICY



NORGES BANK

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ISSN 1504-2596 (online only)

ISBN 978-82-7553-836-7 (online only) Normal

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Sticky prices and inflation expectations in Norway

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Some consumer prices are changed often, while others are changed infrequently. In this memo, I investigate whether Norwegian consumer prices that are changed often – called flexible prices in this memo – and prices that are changed relatively infrequently – sticky prices – have different information content. I find some indications that sticky prices contain more information about inflation expectations in the medium term than flexible prices. This is as expected and in line with findings in other countries.

1. Introduction

In recent years, studies of the micro data used to compute the consumer price index (CPI) have received increased attention in both academia and central banks.² These studies generally show that there is some sluggishness in price adjustment at the micro level, and that the frequency of price changes varies widely across sectors.³ Applying Norwegian data, Wulfsberg (2009), for example, found that tomato prices were adjusted (at least) once a month on average, while prices for haircuts could, in some cases, remain unchanged for years.

Prices that are changed at different frequencies may provide information about various aspects of the inflation process. According to New Keynesian macroeconomic theory, prices are determined both by the current economic situation and by expectations about the future.⁴ When setting a price, the weight given to current versus future conditions may be affected by how frequently the price is changed. It is likely that the longer the period to which the price applies, the greater the weight that is given to expectations about inflation in the future. Prices that are changed infrequently may thus, as argued by Bryan and Meyer (2010), contain more information about firms' inflation expectations than prices that are changed more often.

For a central bank with an inflation target, it is useful to find indicators that contain information about inflation expectations. Anchoring inflation expectations can be seen as the overriding goal of monetary policy. Since inflation expectations affect future inflation, indicators that contain information about these may also contribute to improving inflation forecasts. However, inflation expectations are difficult to observe, and there are relatively few indicators that measure them. In Norway, for instance, inflation expectations are measured primarily through quarterly surveys.

In this memo, I first develop two aggregate consumer price indices based on how often prices are changed within different product sectors. The indices for sectors that

¹ I would like to thank Nina Langbraaten, Nina Larsson Midthjell, Per Espen Lilleås, Einar W. Nordbø, Kjetil Olsen, Øystein Sjølie, Norman R. Spencer, Nikka H. Vonen, and Fredrik Wulfsberg for comments and suggestions. Marius G. Hov, a former adviser at Norges Bank, contributed to an earlier draft.

² See Klenow and Malin (2010) for an overview.

³ There are various reasons why firms change prices at different intervals. Among these are different menu costs, seasonal variations and different supplier or customer contracts. In addition, sectors are subject to sector-specific shocks which occur at different frequencies.

⁴ See e.g. Woodford (2003).

change prices relatively frequently and relatively infrequently are denoted flexible and sticky price indices, respectively.⁵ Then I analyse empirically whether the sticky price index contains more information about inflation expectations than the flexible price index. This is done by comparing the indices with results from a quarterly inflation expectations survey and by investigating the indices ability to predict future changes in overall inflation.

The analysis is inspired by work at the Federal Reserve Banks of Atlanta and Cleveland on US consumer prices (see Bryan and Meyer (2010)). Also Millard and O’Grady (2012) at the Bank of England and Reiff and Várhegyi (2013) at the Central Bank of Hungary have analysed frequency-based consumer price indices, both theoretically and empirically.⁶ All these studies find indications that sticky prices provide information about inflation expectations in the medium term.⁷

The remainder of this memo is organised as follows: Section 2 describes how the sticky and the flexible price indices are constructed. The empirical analysis is presented in Section 3, while Section 4 concludes.

2. Sticky and flexible price indices

The sticky and flexible price indices were developed in two steps. First, product sectors of the CPI basket were classified as being either sticky or flexible. In doing this, I applied the results from Simensen and Wulfsberg (2009) on the average frequency of price changes for 39 sectors of the CPI in the period from 1999 to 2004. The 39 sectors are at the so-called COICOP⁸ group (three-digit) level, and they account for around 85 percent of the CPI in total.⁹ With the (unweighted) median sector chosen as the dividing line,¹⁰ sectors that on average change prices less frequently than the median sector were classified as sticky, and vice versa (see Chart A1 in the Appendix). Second, the aggregate sticky and flexible price indices were constructed by using the sectors’ corresponding CPI indices and weights. Some adjustments to the procedure described here were made, among other reasons, due to data availability (see the Appendix for more details).

The median sector changes prices once every 8.5 months, on average. In the median sector of the flexible and sticky price categories, prices are, on average, changed once every six and 11 months, respectively. The flexible price sectors make up more than twice as much of the CPI basket – around 57 percent – as the sticky price sectors, which account for around 27 percent of the CPI.

⁵ In the academic literature, the terms “sticky” and “flexible” prices usually refer to how long it takes before a price adjusts to changing conditions: a sticky price is resistant to change, while a perfectly flexible price adjusts immediately. To simplify notation, in this memo the terms are used to characterise how often a price is changed, regardless of whether conditions have changed.

⁶ Another study on the issue is Choi and O’Sullivan (2013). The analysis in this memo is also related to previous work at Norges Bank (see Simensen and Wulfsberg (2009)). They constructed a frequency-weighted measure for underlying inflation, called CPI-FW. However, while CPI-FW weighted all the sub-indices into a single index, I compare the various characteristics of two sub-indices.

⁷ Bryan and Meyer (2010) and Millard O’Grady (2012) also found indications that flexible prices, on the other hand, could provide information about the current economic conditions.

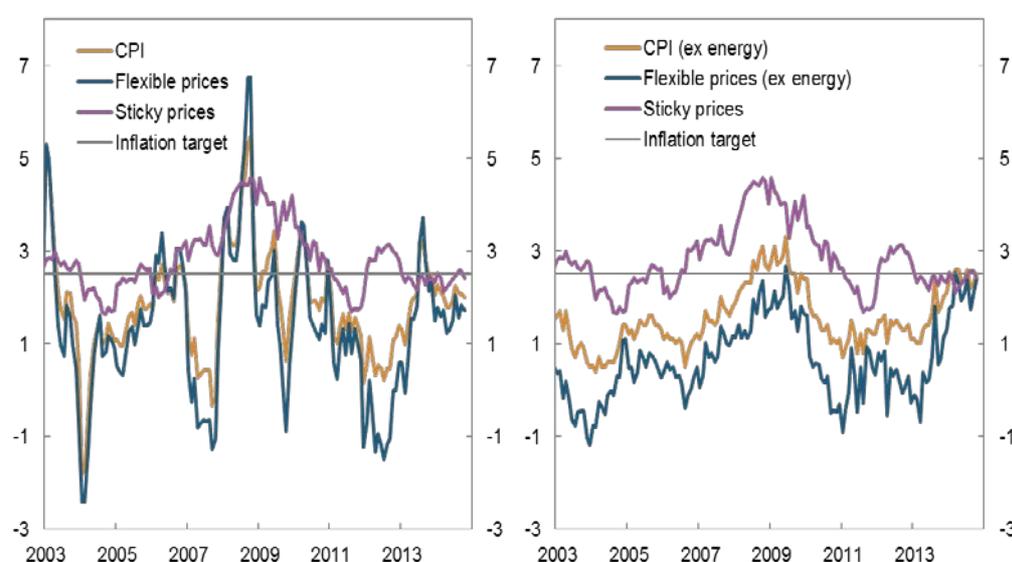
⁸ COICOP (Classification of individual consumption by purpose) is used to classify consumption in the CPI.

⁹ The remaining groups of the CPI, *Imputed rentals for housing*, which account for 13 percent of the CPI in 2014, *Water, miscellaneous services to dwelling* (weight in the CPI: 1 percent), and *Other services n.e.c.* (weight in the CPI: 1 percent), are not included in the analysis due to lack of data on frequency of price changes.

¹⁰ The choice of which dividing line to use is, of course, not straightforward. I apply the same measure as Millard and O’Grady (2012). Bryan and Meyer (2010) used the average frequency of price change as the threshold. In both these studies, the sticky price category accounts for a larger share of the CPI than in this study.

Chart 1a depicts the aggregate inflation rates of the sticky and flexible price sectors together with overall CPI inflation. Sticky price inflation has, for most of the past decade, been higher than flexible price inflation. This may be due, in part, to differences in pricing strategy between sectors that change prices often and those that change prices infrequently. However, another probable explanation is that the two categories consist of different sectors. Goods inflation, which dominates the flexible price category, has generally been lower than service inflation, which there is a preponderance of in the sticky price category.¹¹

Charts 1a and b. CPI and frequency-based consumer price indices, with and without energy products. Twelve-month change. Percent. January 2003 – October 2014



Sources: Statistics Norway and Norges Bank

Flexible prices are highly correlated with the total CPI (see also Table 1). This is partly because the flexible price sectors account for almost 60 percent of the CPI and because the volatile energy prices are classified as flexible. The correlation between flexible prices excluding energy products¹² and the CPI excluding energy products (CPI-AE) is somewhat lower (see Chart 1b and Table 1). The variation in Norwegian energy prices is largely due to factors extraneous to economic developments in general.¹³ Therefore, energy products will henceforth be excluded from the analysis.

Flexible prices (excluding energy) have shown the same trend as sticky prices in some periods (see Chart 1b). Both measures showed relatively high inflation around 2008, with subsiding inflation in subsequent years. In the past few years, the series have shown divergent developments. Sticky price inflation has remained stable at around 2.5 percent, while inflation in the flexible price category rose markedly throughout 2013. The rise may be related to the depreciation of the Norwegian krone, which has pushed up inflation for many of the imported goods in the flexible price category. A change in Statistics Norway's method for calculating prices for food and non-alcoholic beverages has probably contributed in the same direction.

¹¹ Thus there are factors other than the frequency of price changes that distinguish the two categories. An analysis of the relationship between these other factors and the frequency of price changes is beyond the scope of this memo.

¹² The groups *Electricity, gas and other fuels* (weight in the CPI in 2014: 4 percent) and *Operation of personal transport equipment* (weight in the CPI: 7 percent) are excluded from the flexible price index excluding energy products.

¹³ Electricity prices are strongly influenced by the weather, and taxes form a large part of gasoline prices.

Table 1. Correlations between various inflation aggregates. Twelve-month change. January 2003 – September 2014

	CPI	CPI (ex energy)	Sticky prices	Flexible prices
CPI (ex energy)	0.51			
Sticky prices	0.44	0.67		
Flexible prices	0.97	0.41	0.31	
Flexible prices (ex energy)	0.40	0.94	0.47	0.35

The sticky price index is both less volatile and more persistent than the flexible price indices (both with and without energy products) (see Table 2). This is as expected, since, by definition, prices in this category are usually changed infrequently. In addition, the changes normally take place over a relatively long horizon (see Chart A1 in the Appendix). However, these features are also consistent with the hypothesis that sticky prices contain more information about inflation expectations than flexible prices. In the event of a shock to the economy, expectations about future conditions generally change less and more smoothly over time than the current economic situation. Prices that respond more to changes in inflation expectations than to the current economic situation may therefore be both less volatile and more persistent than other prices.

Table 2. Volatility and persistence. January 2003 - September 2014

	Volatility ¹	Persistence ²
CPI	0.60	0.60
CPI (ex energy)	0.25	0.94
Sticky prices	0.23	0.97
Flexible prices	0.84	0.13
Flexible prices (ex energy)	0.44	0.47

1 Measured as the standard deviation of the twelve-month change.

2 Measured as the sum of the coefficients in an autoregressive (AR) model, estimated on the basis of seasonally adjusted monthly data. The Akaike Information Criterion (AIC) is used to determine the number of lags.

3. Empirical analysis

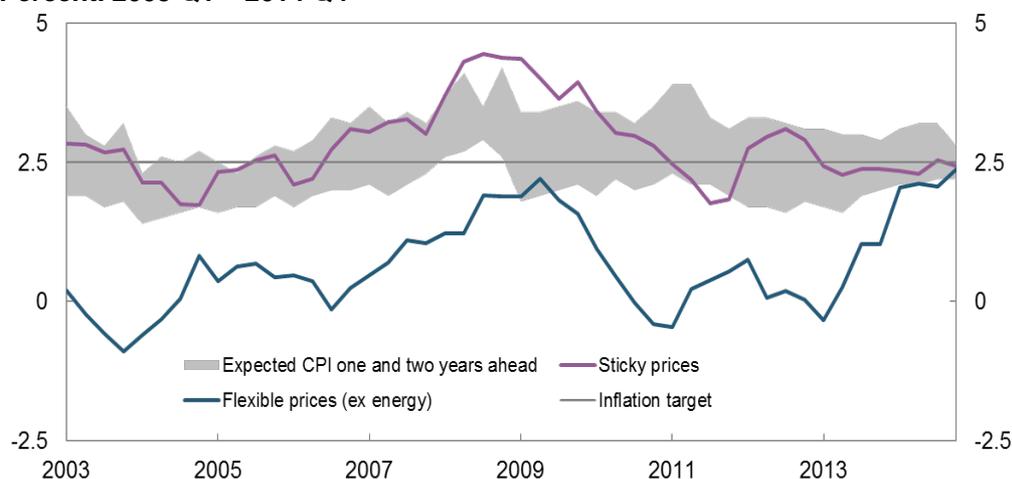
To take a closer look at whether sticky prices may contain more information about inflation expectations than flexible prices, two different approaches are used. First, in Section 3.1, I compare the sticky and flexible prices with the results of an inflation expectations survey. Then, in Section 3.2, I investigate the ability of the sticky and flexible price indices to predict future changes in overall inflation.

3.1 Comparison with an inflation expectations survey

Each quarter, Opinion conducts a survey of inflation expectations among various economic agents in Norway. Chart 2 shows results from this survey along with changes in sticky and flexible (excluding energy) prices. The grey band in the chart shows the interval between the highest and lowest average expectations for annual CPI inflation one and two years ahead among business leaders, economists, and employee/employer organisations. These inflation expectations are generally at the

same level as sticky price inflation (purple line) and are higher than flexible price inflation (blue line).

Chart 2 Expected consumer price inflation one and two years ahead¹⁾ (annual change) and frequency-based consumer price indices (four-quarter change). Percent. 2003 Q1 – 2014 Q4²⁾



1) The grey band shows the interval between the highest and lowest expectations of business leaders, employer/employee organisations and economists in the financial industry and academia.

2) October 2014 is the latest observation for the frequency-based consumer price indices.

Sources: Opinion and Norges Bank

Changes in inflation expectations from one quarter to the next, as measured by the expectations survey, are also, for most of the groups, more highly correlated with changes in sticky prices (see Table 3). Both these findings are consistent with the hypothesis that sticky prices may contain more information about inflation expectations one and two years ahead than other prices.

Table 3 Correlations between various groups' expected consumer price inflation one and two years ahead (annual change) and inflation aggregates (four-quarter change). 2003 Q1 – 2014 Q3

Inflation expectations	CPI	CPI ex energy	Sticky prices	Flexible prices ex energy	Flexible prices
Business leaders one year ahead	0.48	0.38	0.62	0.28	0.41
Business leaders two years ahead	0.42	0.47	0.64	0.32	0.31
Economists one year ahead	0.54	0.55	0.62	0.47	0.51
Economists two years ahead	0.45	0.51	0.66	0.39	0.38
Employer/employee organisations one year ahead	0.71	0.56	0.62	0.48	0.68
Employer/employee organisations two years ahead	0.61	0.56	0.62	0.49	0.58

3.2 Forecasting properties

Inflation expectations can also influence actual future inflation. If sticky prices contain more information about inflation expectations than other prices, these prices may be more able to predict future changes in overall inflation than other prices.

To check the forecasting properties of the sticky and flexible (excluding energy) price indices the following relationship is estimated:¹⁴

$$\pi_{t+h} - \pi_t = \alpha + \beta(x_t - \pi_t) + u_{t+h}.$$

In the equation, π_t is the 12-month change in the total CPI in period t , while x_t is the 12-month change in either the sticky or the flexible (excluding energy) price index in the same period. The parameter β expresses how the difference between the sticky or flexible (excluding energy) price index and the CPI in period t relates to the deviation between the CPI in period $t+h$ and period t . If $\alpha = 0$ and $\beta = 1$, the difference predicts total inflation in the period $t+h$ perfectly. If $\beta < 1$, but significantly different from 0, the deviation may predict the direction of, but underestimate the effect on, the change in future CPI. Conversely, if $\beta > 1$, the effect is overestimated. The constant α is included in the equation to permit different inflation rates in the indices and the CPI.

Table 4 shows the estimated values of β in 12 different estimations. In all the estimations, the 12-month change in the CPI excluding energy products (CPI-AE) is used to represent overall inflation (π_t),¹⁵ while the 12-month change in the sticky and flexible (excluding energy) price indices represent x_t in six estimations each. Horizon h varies between 1 and 24 months in the various estimations, and the estimation period is from January 2003 to September 2014. The estimation method is ordinary least squares (OLS).

The results indicate that sticky prices have predictive power for future developments in the CPI-AE 12 and 18 months ahead. The estimated β -parameters are 0.39 and 0.74, respectively, both of which are significantly greater than 0. In the other estimations, none of the β -parameters are significantly different from 0. The results are consistent with the hypothesis that sticky prices contain more information about inflation expectations in the medium term than other prices.

Table 4. Forecasting properties. Estimated values of β ¹

Horizon	Sticky prices	Flexible prices (ex energy)
1 month	0.05	-0.10
3 months	0.05	-0.04
6 months	0.04	0.02
12 months	0,39*	-0.27
18 months	0,74**	-0.49
24 months	0,39	-0.26

¹ Estimation period: January 2003 to September 2014. * and **: Significant at the 10 percent and 1 percent level, respectively. The standard deviations are adjusted for heteroskedasticity and autocorrelation (Newey-West).

4. Conclusions

In this memo, I have decomposed the Norwegian consumer price index into frequency-based sub-indices and examined various aspects of these series. I find

¹⁴ This test is also used by, among others, Cogley (2002), Jonassen and Nordbø (2006) and Reiff and Várhegyi (2013).

¹⁵ The CPI is usually used in tests of this kind. Here, I use the CPI-AE since the twelve-month change in the CPI in Norway, within the time horizon examined in this memo, is strongly influenced by developments in energy prices. Energy prices are, as noted above, largely influenced by factors extraneous to economic developments in general.

indications that aggregate inflation in sticky price sectors contain more information about inflation expectations in the medium term than changes in flexible price sectors. Inflation in the sticky price category is generally at the same level as inflation expectations one to two years ahead as measured by surveys. Changes in sticky price inflation from one quarter to the next also correlate more with changes in these expectations than other prices. In addition, unlike flexible prices (excluding energy), sticky prices appear to be able to predict changes in overall CPI (excluding energy products) 12 and 18 months ahead. The results in this memo are in line with findings in other countries.

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The sticky price sectors, as defined in this memo, account for around 27 percent of the CPI. This analysis indicates that the aggregate inflation in these sectors might contain useful information about inflation expectations, and thereby potentially of future inflation. Further research could exploit the forecasting abilities of the sticky price index to predict overall inflation in the medium term.

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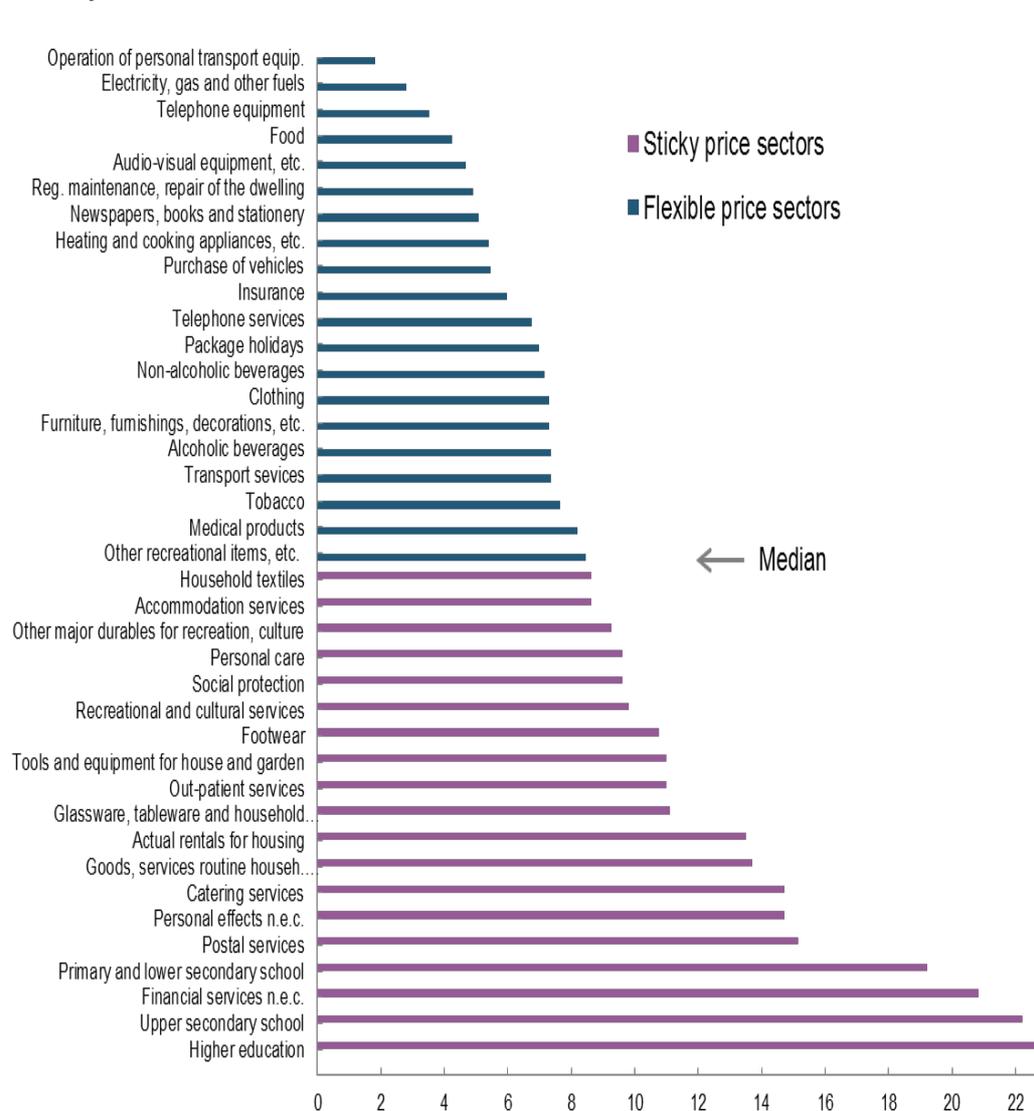
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Appendix

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Chart A1. Duration of a price change for COICOP groups of the CPI.¹ Average for the period 1999-2004. In months



¹ The CPI groups *Imputed rentals for housing*, *Water*, *miscellaneous services to dwelling* and *Other services n.e.c.* are not included in Chart A1 or in the calculation basis for the frequency-based indices due to lack of data on frequency of price changes. Furthermore, in constructing the sticky and flexible price indices, the following exceptions from the classification in Chart A1 were made: *i*) For the group *Transport services*, estimates of the frequency of price changes at the COICOP sub-group 1 (four-digit) level from Wulfsberg (2009) were applied. There are considerable differences in the frequency of price changes between these sub-groups, and unlike many other sub-group 1 series, these prices are available. The sub-group 1 *Passenger transport by air* is thus classified as a flexible price sector, while the remaining components of *Transport services* are categorised as sticky. *ii*) For the COICOP division (two-digit) *Postal and telecommunications services*, group level price series are not available prior to August 2008. Thus, the entire division is classified as flexible, even though the group *Postal services* (weight in the CPI in 2014: 0.1 percent) has prices that are sticky. *iii*) The group *Social protection* (weight in the CPI in 2014: 2 percent) was excluded from the indices. This is because regulations have, in some periods, heavily influenced these prices.

Sources: Simensen and Wulfsberg (2009) and Norges Bank