Dealing with bias in the Norwegian superlative price index of food and non-alcoholic beverages

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Ingvild Johansen
Ingvild.johansen@ssb.no
Statistics Norway

Ragnhild Nygaard
ragnhild.nygaard@ssb.no
Statistics Norway

Abstract

Earlier analyses have documented downward bias in the Norwegian price index of food and non-alcoholic beverages in the Consumer Price Index (CPI). The price index of food and non-alcoholic beverages is entirely based on scanner data and calculated as a monthly chained Törnqvist price index at elementary level. In this paper we analyse to what extent missing observations have contributed to the downward bias. In experimental price indices imputations of missing observations, both seasonal and non-seasonal, are included and compared to a benchmark price index – a RYGEKS price index. In general, the bias caused by missing observations seems to be reduced in the experimental price indices. However, the experimental price indices show that different ways of dealing with imputations provide different results. The two experimental indices seem to complement one another and a combination of the two may be a possible solution for implementation. However, imputation of temporarily missing observations does not solve all the bias and some groups are still problematic.

1. Introduction

Statistics Norway has used scanner data price information from retail chains in the price index of food and non-alcoholic beverages in the CPI since the late 1990s. In August 2005 we expanded the use of scanner data by exploiting both price and quantity information for all items in our selected retail outlets calculating a superlative Törnqvist price index at elementary level. Statistics Norway is among very few statistical agencies that have included both price and quantity information received from retail chains in the official CPI calculation. There is however a growing interest among statistical agencies for the use of scanner data in index compilations and for the possibilities the scanner data provides. In 2010 Eurostat initiated a project, where the member states were able to apply for grants, in order to exploit the use of scanner data for Multi-Purpose Consumer Price Statistics.

The main advantages of scanner data are the enormous increase in the number of products and price observations, and the availability of both price and quantity information in real time, in addition to the low response burden[1]. At the same time, agencies are faced with huge challenges relating to how to aggregate this enormous amount of data in the best way. Back in 2005 Statistics Norway chose to introduce a monthly chained superlative price index at elementary level. The major advantage of monthly chaining is the quick update of all the entries and exits of items in the retail market. According to the ILO manual (2004) superlative price indices are the best choice and an ideal framework when both detailed price and quantity information are available, but at the same time it notes that “the use of chained superlative indices can lead to very biased results if there are large period-to-period fluctuations in prices and quantities”. Chain drift occurs in chained price indices when the index “does not return to unity when the prices in the current period return to their levels in the base period” (ILO, 2004). The shorter the chain period, the greater the bias. Recent papers by Ivancic, Fox and Diewert (2009) and de Haan and van der Grient (2009) confirm these important challenges in the use of scanner data. According to Ivancic, Fox and Diewert (2009), chained superlative price indices tend to show downward drift compared to their direct counterparts when items are put on sale. Chain drift may occur if the consumers stock up during sales periods and it takes some time before the turnover normalizes and thereby creating asymmetry in the weights.

Due to international focus on superlative indices, monthly chaining and chain drift, in addition to the intention of expanding the use of scanner data to other areas[2] in the Norwegian CPI, Statistics Norway started evaluating the scanner data-based price index of food and non-alcoholic beverages in 2009. Comparisons with a RYGEKS price index, used as a benchmark index, developed by Ivancic, Fox and Diewert (2009), gave indications of a downward bias in the price index during the period July 2006 to December 2009 at both aggregated and detailed level. The evaluation project concluded further that missing observations, both among seasonal and non-seasonal products, were contributing to the downward bias in the price index.

Compared to the benchmark price index, the bias in the official price index of food and non-alcoholic beverages is estimated to above 1 percentage point on an annual basis. The question is, to what extent do missing observations, both seasonal and non-seasonal, contribute to the estimated bias? Or are other causes of chain drift equally important, like unbalanced turnover levels before and after a sales period? In this paper, we look closer into the effects caused by missing observations in the official price index. Experimental Törnqvist price indices including imputations for missing observations are compared to the official price index and a benchmark RYGEKS price index. The benchmark price

[1] Statistics Norway doesn’t use price collectors in the CPI in the same way as most other countries. There was increasing pressure from the retail outlets on the retail chains’ headquarters to send scanner data, as the response burden (filling out large questionnaires) for the outlets was rather high. Statistics Norway receives the scanner data free of charge.
[2] Statistics Norway already receives scanner data in several areas, i.e. food and non-alcoholic beverages, alcoholic beverages (from the State wine and liquor monopoly), petrol and pharmaceutical products.

index shows very promising results, but due to the need for more experience Statistics Norway is not implementing the RYGEKS method in the short term. Instead, Statistics Norway is considering minor adjustments, i.e. implementing imputations in our Törnqvist price index.

The paper is organised as follows. In chapter 2 we look more closely at situations where missing observations create a downward bias. Two experimental price indices with different imputation methods are explained in chapter 3. The Törnqvist price indices including imputations are compared with the official CPI figures and the RYGEKS price index in chapter 4, and finally in chapter 5 we make some concluding remarks.

2. Missing observations

In the Norwegian CPI, missing prices are normally imputed. Temporarily missing prices are imputed with the price change of other price observations of the same item. Permanently missing prices are imputed with the average price of other price observations of the same item, based on the assumption that the consumer must now choose from the range of variants representing the same item. For seasonal products like clothing etc. prices out-of-season are imputed, following the new Eurostat regulation on the treatment of seasonal products. The first month out-of-season a “regular” price of the product is imputed while as of the second month the price development of all available products in the same COICOP group is used.

In the official price index of food and non-alcoholic beverages, missing observations based on scanner data have not been imputed. The price of an item may drop out of the scanner data either because the item is temporarily missing or because it has permanently disappeared from the market. Temporarily missing observations may occur for seasonal items out-of-season, because the quantity bought during the data collection period[3] falls to zero or because the item is temporarily sold out. The official price index doesn’t aggregate over stores or price profiles. The possibility of zero transactions at store level is higher compared to a more aggregated level, and therefore the number of temporarily missing observations may be quite large.

Permanently missing observations may occur for items on their way out of production or if retail chains change their purchasing strategy. The scanner-data based index compares an item from a certain store with the exact same item from the same store in the previous month by matching the products by EAN code and store. Even small changes in an item result in a new EAN code and the price development between the old and the new item will not be captured. Situations where the price of the old item is dumped prior to the introduction of a new item result in a downward bias in the price index. One way of solving this is by matching a replacement item with the old item manually, but this is naturally a time-consuming method.

Table 1 shows the number of matched price observations (EAN*store) over time distributed at different COICOP levels using January 2010 as price reference month. The number of matched items between two consecutive months is about 70 per cent for food and non-alcoholic beverages. After six months the number of matched observations is reduced to less than 50 per cent, and after 12 months the number is down to about 40 per cent. These figures indicate quite a high attrition rate of items during one year. The figures include both permanently and temporarily missing observations. Comparisons with earlier analysis made by Rodriguez and Haraldsen (2005) based on 2003 figures indicate that the number of matched items have decreased over time.

[3] The data collection period is the midweek of the month.

Table 1. Matching price observations with the price reference month after 1, 6 and 12 months, per cent

COICOP levels	After 1 month Share of sales	Number of price observations	After 6 months Share of sales	Number of price observations	After 12 months Share of sales	Number of price observations
01 Food and non-alcoholic beverages	84.3	69.8	54.4	46.9	51.5	40.5
011 Food	84.0	69.5	53.5	46.7	51.1	40.3
012 Non-alcoholic beverages	87.7	72.4	61.6	48.4	55.1	41.6
0111 Bread and cereals	83.4	69.6	54.6	47.7	46.5	39.4
0112 Meat	80.4	68.4	49.1	43.9	49.5	40.6
0113 Fish	79.3	69.2	49.9	49.4	48.0	40.2
0114 Milk, cheese and eggs	91.8	77.9	67.2	56.0	59.6	46.5
0115 Oils and fats	93.2	77.4	70.2	57.6	64.4	52.2
0116 Fruit	88.4	68.6	41.6	42.2	55.3	37.9
0117 Vegetables	88.5	72.7	52.0	45.9	51.6	41.3
0118 Sugar, jam, chocolate, confectionery	74.1	68.9	50.2	43.1	43.6	36.0
0119 Food products n.e.c.	80.5	64.2	53.0	45.0	47.9	40.0
0121 Coffee, tea and cocoa	87.5	71.6	62.8	50.0	56.8	44.2
0122 Mineral waters, soft drinks, juices	87.7	72.7	61.3	47.9	54.6	40.6

Source: Statistics Norway

2.1 Temporarily missing observations

Apart from strongly seasonal items only available during certain periods of the year, temporarily missing observations contributing to a downward bias are often products characterized by a high degree of periodic sales and advertising campaigns. In these situations the quantity increases considerably during the sales period and the observation might fall out of the data in the next price collection period, either due to the fact that the consumers have stocked up during the sales period, or because the products are temporarily sold out. We are not able to differentiate between the two situations, but in both cases, the Törnqvist index fails to capture the following price increase that usually takes place after a sales period, which results in a downward bias.

Table 2 shows temporarily missing observations as a share of the total number of missing observations. For COICOP-6[4] groups with elements of seasonality, observations are defined as temporarily missing if they reappear within 14 continuous months[5]. For groups without important elements of seasonality, observations are defined as temporarily missing if they reappear within 3 months. This analysis is of course only possible to conduct retrospectively.

Table 2. Temporarily missing observations, per cent

COICOP levels		average 2008-2010
0111	Bread and cereals	71.5
0112	Meat	71.7
0113	Fish	80.4
0114	Milk, cheese and eggs	70.0
0115	Oils and fats	70.9
0116	Fruit	72.5
0117	Vegetables	73.9
0118	Sugar, jam, chocolate, confectionery	73.6
0119	Food products n.e.c.	82.8
0121	Coffee, tea and cocoa	83.9
0122	Mineral waters, soft drinks, juices	76.7

Source: Statistics Norway

Table 2 shows a relatively high share of temporarily missing observations for all groups, of which “Coffee, tea and cocoa” and ”Food products n.e.c.” have the highest shares. The remaining share

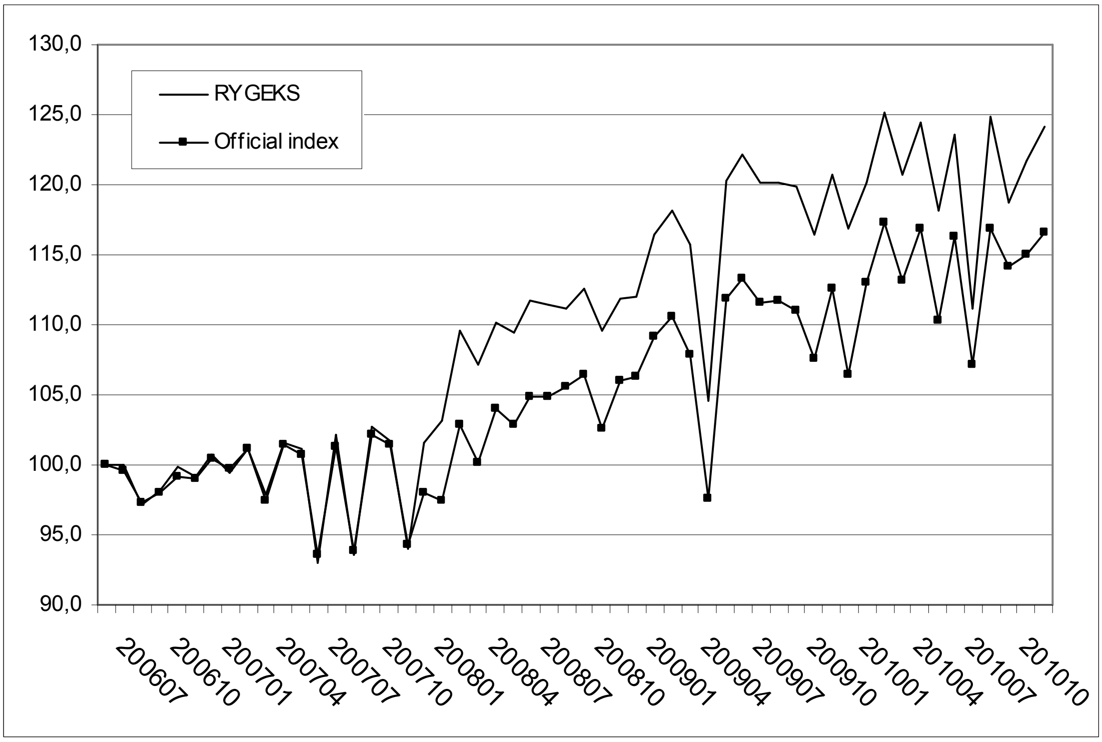
[4] Elementary level

[5] Allows for the Easter to occur in different months from one year to another.

which represents the permanently missing observations is considerably lower. Thus, the imputation methods as explained later will mainly focus on temporarily missing observations.

Figure 1 shows an example of an item characterized by a high degree of periodic sales, where the Törnqvist price index lies below the RYGEKS price index, particularly due to a break in January 2008.

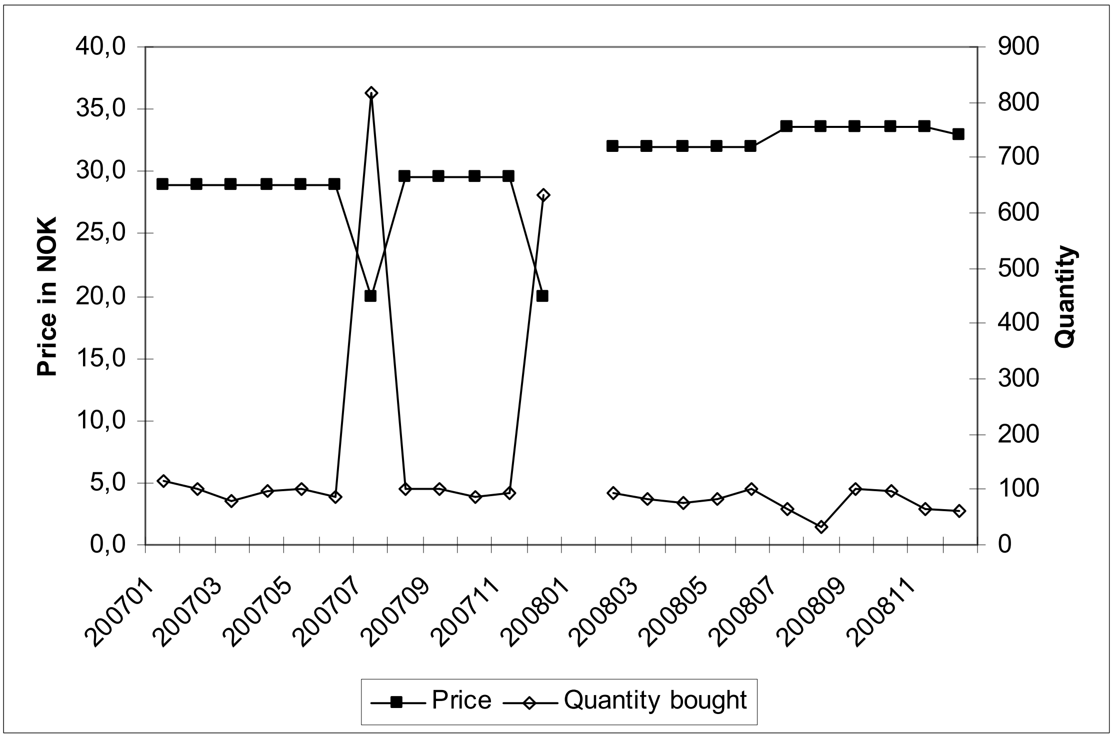
Figure 1. Price indices of pizza. July 2006 – December 2010. July 2006=100



Source: Statistics Norway

Figure 2 shows the relationship between price and quantity for one of the items within the COICOP-6 group “Pizza” for store X. The figure illustrates that consumers react quite strongly to a price reduction on this item. The example also shows a missing observation in the period following a sales period.

Figure 2. Price and quantity of pizza in store X. January 2007 – December 2008



Source: Statistics Norway

After a price reduction on pizza in December 2007, the item is missing in the following month. In February 2008, the item is again available in the store, but at a "normal" price. The monthly chained Törnqvist price index fails to register the price increase in this particular situation due to the missing observation, and hence the official index of pizza remains below the RYGEKS price index as shown in Figure 1.

Even though the downward bias seems to be dominating, missing observations can also create an upward bias. In some cases, we fail to register the price decrease perhaps due to temporarily supply shortages. Instead we may register a succeeding price increase.

Temporarily missing observations also occur for items which are not characterized by a high degree of price and quantity bouncing, but which, for instance, have low turnover and might not be purchased regularly. If the quantity during the data collection period is zero, the observation falls out of the index. These items do however not create any bias in the index.

2.2 Seasonal items

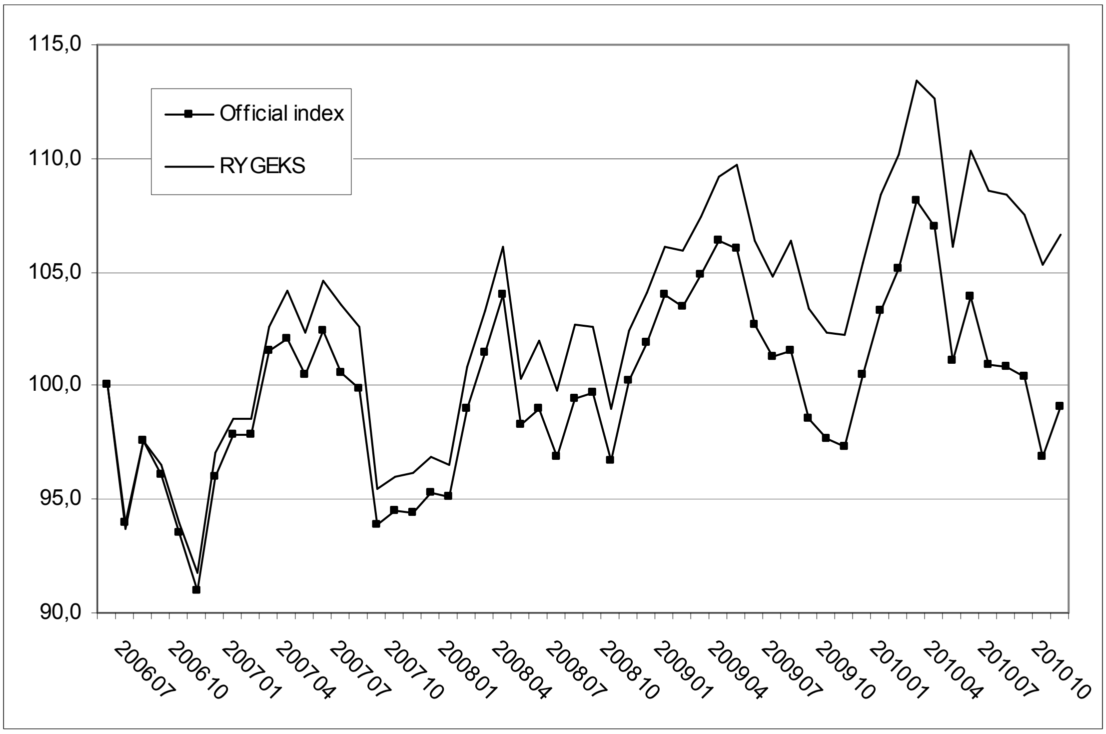
The new HICP regulation from Eurostat lays down minimum standards for the treatment of seasonal products. The standards should be applied for seasonal products like fish, fruit, vegetables, clothing and footwear. In order to meet the standards for the treatment of seasonal products, the consumption pattern and the seasons relating to each seasonal product must be defined. With 14 000 different items in the price index of food and non-alcoholic beverages, this task is impracticable. Therefore the regulation is only applied for non-food products.

Earlier analysis (Nygaard, 2010) of the official index has demonstrated that seasonal items within food and non-alcoholic beverages might have contributed to a downward bias in the index. The RYGEKS price index calculated with and without the same seasonal items showed that seasonal items have little effect on the price index, and that the RYGEKS price index treats seasonal items in a way that is free of bias. Using a monthly chained Törnqvist price index, we fail to register the price change of seasonal items from the last month they are in-season to the first month re-entering the price index. At the beginning of the in-season period, the seasonal items are normally available at a relatively high price compared to the end of the in-season period. Since the price increase from the last month the items are in-season to the first month re-entering the index is not captured and given the above conditions, seasonal items may cause a downward bias in the index. In order to avoid unfortunate biases up until now, Statistics Norway has excluded seasonal items with the strongest seasonal patterns (items available only for a short period of the year) from the price index of food and non-alcoholic beverages. Excluding seasonal items that might represent a high share of the consumption in a given period of time is obviously not an optimal solution.

Seasonal items are defined by the ILO manual (2004) as *commodities which are either: (a) not available in the marketplace during certain seasons of the year, or (b) are available throughout the year, but there are regular fluctuations in prices or quantities that are synchronized with the season or the time of the year.* The ILO manual also states that *there are two main sources of seasonal fluctuations in prices and quantities: (a) climate, and (b) custom.* Analysis made on the Norwegian scanner data of food and non-alcoholic beverages by Rodriguez and Haraldsen (2005), shows that, for groups like fruit and vegetables consumers do not respond as strongly to price reductions as for other food products. One explanation might be that the fluctuations in prices and quantities for fruit and vegetables are to a large degree driven by climate. Therefore seasonal items don't necessarily have symmetrical expenditure shares as opposed to non-seasonal items like pizza, Cola cola, coffee and so forth.

The index of vegetables is an example where the official price index has a downward drift compared to the benchmark as shown in Figure 3. The question is whether the downward drift is due to missing observations or if it is a result of the seasonal fluctuations in prices and quantities.

Figure 3. Price indices of vegetables. July 2006 – December 2010. July 2006=100



Source: Statistics Norway

The development in the index is not only dependent upon the prices and quantities for each and every product separately, but the prices and quantities relative to the other products within the same

COICOP-6 group. This means that, even though the prices and quantities in the current period return to their levels prior to a price reduction period, the index might not return to unity if the quantity relative to the other products has changed significantly.

Another COICOP-6 group containing a large share of seasonal items is “Confectionery”, where the availability of the products along with the fluctuations in prices and quantities are to a large degree driven by custom. Many of the products are available throughout the year, while some are only available around Christmas. Figure 4 and 5 shows an example of the movement in price and quantity for a seasonal item within the group. The prices of many of the Christmas-related products are rather high in December, but nonetheless the customers buy the product. In January, however, the prices fall considerably and the consumers respond strongly to the price decrease with a large quantity increase. After the price decrease in January some of the products are not available again until next Christmas. As a result, an index without any treatment of seasonal items will tend to drift downwards.

Figure 4. Price in NOK of confectionery “Gode ønsker” in store X. December 2006 – December 2010

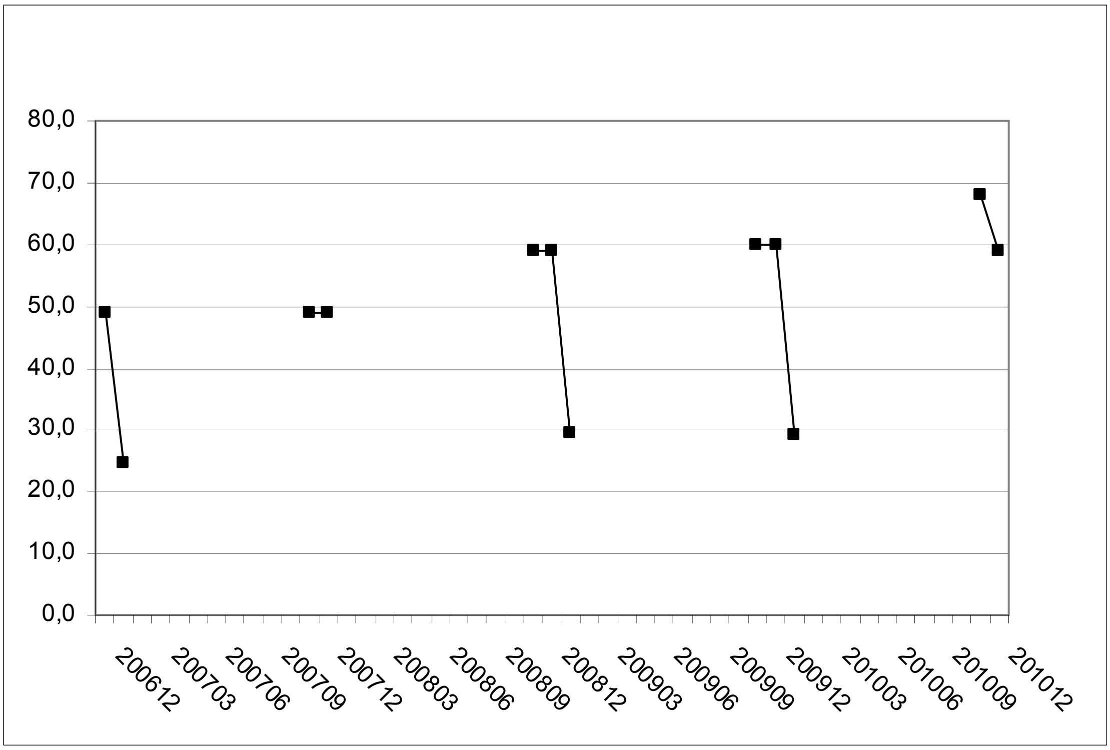
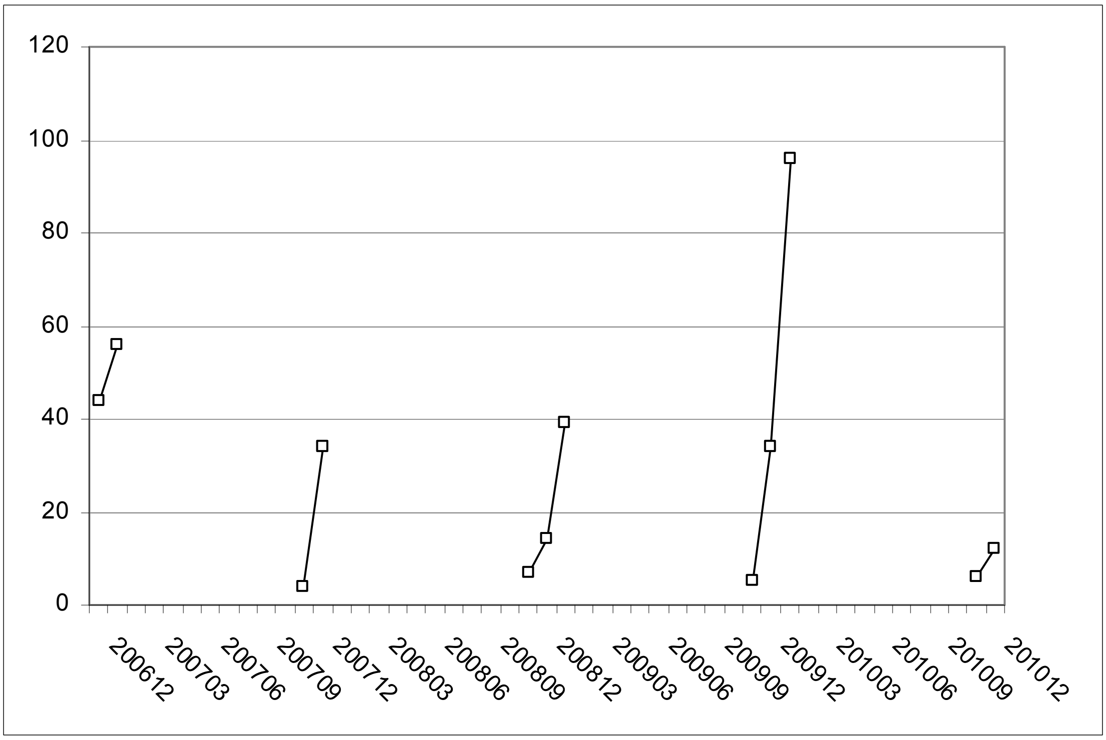


Figure 5. Quantity of confectionery "Gode ønsker" in store X. December 2006 – December 2010



Source: Statistics Norway

In the following chapters we present methods for imputing the missing observations, and analyse the results by comparing Törnqvist indices including imputations to our official index of food and non-alcoholic beverages and to the benchmark RYGEKS index.

3. Experimental price indices including imputations and all seasonal items

In Chapter 2 we show that missing observations and unsatisfactory treatment of seasonal items may cause possible bias in the official price index. In experimental price indices, we try to deal with these challenges by imputing missing observations, both seasonal and non-seasonal.

Different ways of imputing missing prices are well documented in the international literature. As statistical agencies very often lack access to weight information at elementary level, there is less guidance on how to impute missing quantities in superlative price indices. The ILO manual (2004) recommends that "whenever possible, weights should be used that reflect the relative importance of the sampled items". Using a superlative price index formula however poses some challenges as the missing quantities as well as the missing prices must be imputed. The scanner data show that for products often put on sale the consumers respond immediately and strongly to the decrease in price with great shift in quantity bought, and according to de Haan and van der Grient (2009), the consumers hardly buy the product at all when it's not on sale. Consumers may however act quite differently when seasonal products finally re-enter the market buying the products almost no matter the price. This indicates that it's not always easy to know how the consumer responds to changes in price. Calculations made on the relationship between the changes in prices and quantities show that the price elasticity differs between the different elementary aggregates (COICOP-6) as commented in chapter 2.3. Below we explain how we impute missing prices and missing quantities in our experimental price indices.

3.1 Two different imputation methods

With the exception of imputations and the inclusion of *all* seasonal items, the experimental price indices are calculated in the same way as the official price index;

- no aggregation across stores, price profiles nor chains,
- a weighted Jevons price index formula on elementary level[6] using expenditure shares from both base and current period generating a Törnqvist price index,
- monthly chaining on elementary level,
- Laspeyre aggregates with annual chaining on higher levels.

As mentioned earlier, in order to avoid unfortunate bias, Statistics Norway has excluded from the official price index of food and non-alcoholic beverages strongly seasonal items only available for a short period of the year. Seasonal items that are available throughout the year have been included and treated in the same way as any other item. Potential bias caused by asymmetrical weighting of seasonal items present all year round, is not possible to deal with as long as we choose to use the same price index formula. In the experimental price indices we include *all* seasonal items, even the items only available during a short period of the year, such as Christmas-related products.

Normally in a CPI we would like to treat temporarily and permanently missing observations differently. Using scanner data we don't know whether an observation is temporarily or permanently missing, this can only be analysed retrospectively. Even though the permanently missing observations may cause bias as well, in the experimental price indices we mainly try to deal with the temporarily missing observations as they are easier to deal with using more traditional methods. Despite other causes to missing observations, we assume in our imputation methods that all missing observations are temporarily. By including imputations of missing observations, we also try to improve the treatment of seasonal items.

In our experimental price indices we choose to impute all missing observations in order to maintain the sample. We impute price and quantity at EAN/PLU[7] code level which is the lowest observation level. All product codes enters a COICOP-6 group, the lowest computation level[8] representing rather homogenous groups like "Flour", "Bread", "Pizza", "Milk" etc. About 20 per cent of the total[9] COICOP-6 groups can be characterized by practically zero seasonal elements. Missing observations classified in these COICOP-6 groups are, like missing prices for other commodity groups in the Norwegian CPI, imputed for a period of 3 months[10]. For the remaining elementary COICOP-6 aggregates which contain elements of seasonal items, the period of imputation is prolonged to 14 months in order to allow seasonal items to re-enter the index.

3.1.1 Imputation method based on rate of change

In this experimental price index we estimate the missing observations based on the price and the quantity movements of all the other observations within the same COICOP-6 group. The imputed price in month *t* is the price in period *t-1* (which may also be an imputed price) adjusted for the monthly rate of change of the other observations calculated by a Törnqvist price index. In order to estimate the imputed quantity, the expenditure in month *t* is the expenditure in period *t-1* adjusted for

[6] COICOP-6 item level

[7] Chain specific barcodes. Stands for "Product Look-Up" or "Price Look-Up", a 4-digit code for items that don't have an EAN code. Mostly used for fruit and vegetables.

[8] We may however make some aggregation before entering a COICOP-6 level. For products on sale we often get reported both the discounted price and the regular price, in these cases an average unit price is calculated.

[9] In the period from August 2008 to December 2010 there were 138 COICOP-6 groups in the index of food and non-alcoholic beverages.

[10] But beyond that, the imputation methods between the experimental indices of food and non-alcoholic beverages and the CPI in general differ.

the monthly rate of change in total COICOP-6 expenditure. The imputed quantity in month t is then generated from the imputed expenditure and the imputed price. If the missing observation re-enters within a 3 month period (or a 14 month period for seasonal observations), the imputed price and the quantity in month *t-1* is compared to the price and quantity in month t. The imputed price $\hat{p}_m^t$ can be defined as;

$$(1)\ \hat{p}_m^t = p_m^{t-1} * \prod_{m=1}^{n} (p_m^t / p_m^{t-1})^{(s_m^{t-1}+s_m^t)/2}$$

where the s_m^{t-1} and s_m^t are the expenditure shares, p_m^{t-1} and p_m^t are the prices for item *m=1,...,n items* in the COICOP-6 group in periods t and *t-1*.

To estimate the imputed quantity $\hat{q}_m^t$ first we find the imputed expenditure $\hat{v}_m^t$ based on the monthly rate of change in total COICOP-6 expenditure;

$$(2)\ \hat{v}_m^t = v_m^{t-1} * (\sum_{m=1}^{n} v_m^t / \sum_{m=1}^{n} v_m^{t-1})$$

The imputed quantity $\hat{q}_m^t$ is then defined as;

$$(3)\ \hat{q}_m^t = \hat{v}_m^t / \hat{p}_m^t$$

3.1.2 Imputation method based on actual observations

In a second experimental price index we try to create some kind of symmetry in the cases where the price and quantity returns to presale levels. In this index we impute the missing observations with zero weight. The first month an observation is missing the observation is imputed with zero quantity both in month t and month *t-1* (the price reference month), i.e. we reallocate the weights among the other products in the COICOP-6 aggregate. We continue to impute zero weight in all the out-of-index months. If the missing observation re-enters within 3 months for non-seasonal items or 14 month for seasonal items, the price and the quantity from the last month before leaving the index is carried forward to the month *t-1 (new price reference month)* creating a value for the price reference month which is compared to the price and quantity in month t. If for instance a product re-enters after being out-of-index for a period of 2 months the price index formula for period t compares the price and quantity information of the item in period *t-3* to the actual price and quantity in period t. For seasonal items the price and the quantity during the last month of the in-season are compared to the first month of the following in-season.

For an index where we allow observations to re-enter into the index, the prices and quantities for the observations are from period t and from the last in-the-index period;

$$(4)\quad \prod_{m=1}^{n} (p_m^t / p_m^{t-T})^{(s_m^{t-T}+s_m^t)/2}$$

Where T months=*1,2,3* for observations in “non-seasonal” COICOP-6 groups and *T=1,...,14* for observations in “seasonal“ COICOP-6 groups. In general, the COICOP-6 aggregates consist of a mixture of actual month-to-month price changes in addition to re-entering observations with price changes from a period prior to *t-1*.

Using an imputation method based solely on actual observations we create some kind of symmetry in the weight over time in the cases where the price and quantity returns to presale levels. If an item falls out of the price index on sale it will make a temporarily impact on the index, but this effect will be counteracted if and when it re-enters to its regular price. If the missing item however, does not re-enter within 3 months for non-seasonal items or 14 months for seasonal items, the item is excluded from the index calculation following the regular Norwegian CPI procedure. Even though we allow a price decrease to be counteracted if it re-enters, this method does not create perfect symmetry in the weighting of price decreases and offsetting price increases. The relative importance of an item may be different in the month re-entering the index compared to the month leaving the index, resulting in different expenditure shares on the price movements in question.

Entirely new products entering the market using monthly chaining are not registered in the price index before the period $t+1$. As in the official price index we don't impute values in the price reference month for entirely new products.

3.2 Data cleaning procedures

In the official price index the scanner data goes through different data cleaning processes[11] before the index calculations. Using a superlative price index where both price and quantity are included, strong emphasis may be put on a single price observation and whether a price observation is declared valid or not can have a significant impact on the results. In the official price index, extreme month-to-month price ratios are automatically removed. Also observations with the strongest contributions which deviate from the rest of the data are manually controlled and possibly eliminated[12].

In the experimental price indices we exclude *automatically* observations with the strongest contributions to the COICOP-6 elementary level[13] in order to eliminate errors in the data. In addition, this might reduce the effect of items permanently falling out of the index when on sale. Every price ratio's contribution[14] to the COICOP-6 level is calculated and all contributions outside some defined threshold[15] of the COICOP-6 average contribution are flagged as critical observations and are automatically declared invalid and treated as temporarily missing observations. Our results indicate that there is some work left on developing more advanced automatically data cleaning techniques and we are doubtful to whether it is possible to calculate a superlative price index without any form of manual interference. The automatic procedure seems to be necessary for the experimental price indices and does not, in general, jeopardize the movements in the long run. We also think it is important to underline that the elementary price indices do not aggregate across any stores or price profiles within chains and the removal of observations is performed at the most detailed level, i.e. a single item within a single store may be removed. Using more aggregated data, removal of data is likely to affect the results more.

In the official price index the extreme month-to-month price ratios higher than 3 or lower than 0.33 are removed. A problem with the automatic procedure is the potential bias this exclusion may cause. If a price decreases strongly, it might be excluded, but if the offsetting price goes up gradually it might instead be included in the price index causing an upward bias. In the experimental price indices these extreme price changes are still classified as implausible, but instead of simply dropping out of the index they are now being treated as temporarily missing observations following the same imputation routines as described earlier.

[11] Statistics Norway uses SAS software for data cleaning and calculations. Data are stored in Oracle databases.

[12] A very small amount is eliminated each month, somewhere around 20 price ratios.

[13] About 150-200 observations or approx 0.05 per cent of the sample are automatically excluded. About 50 of these come from non-volatile groups while the rest are extreme contributions from strongly seasonal groups. In a superlative price index it is however the expenditure shares that matter more than the number of observations, indicating that the removal of these observations may affect the movements in the short run, but less likely in the long run.

[14] The contribution depends both on the price change and the expenditure shares of both period t-1 and period t.

[15] Values based on simulations.

We also choose to use a dumping filter in order to avoid bias caused by items being dumped with no offsetting price increases due to stock clearances. In cases where a strong price decrease is combined with a strong decrease in quantity, the price observation is declared invalid and imputed. Based on simulations we choose to impute price observations in cases where

$$p^t / p^{t-1} < 0.75 \text{ and } q^t / q^{t-1} < 0.75$$

Using a superlative price index formula and expenditure shares from both the reference and current month the items with low expenditure shares in period *t* and high shares in period *t-1* are causing an impact on the results. The dumping filter looks promising for groups with a specific seasonal pattern- such as Christmas- and Eastern-related items like chocolates, tea cakes/biscuits etc. Christmas-related items may be dumped in January at a low price and fall out of the index in February. Due to the high expenditure shares in the reference month the dumped items may cause a downward bias. The number of dumped items varies throughout the year, with approximately 100-300 observations each month, while in January the number increases to over 1 000 observations related to the Christmas celebrations. Many of these observations do however re-enter the index next season. We choose to use the dumping filter on all the COICOP-6 groups except from seasonal groups not showing any clear signs of a dumping pattern[16].

In chapter 4 we validate our experimental price indices by comparing them to a benchmark price index - the RYGEKS price index.

4. Comparisons between Törnqvist price indices including imputations and the RYGEKS price index

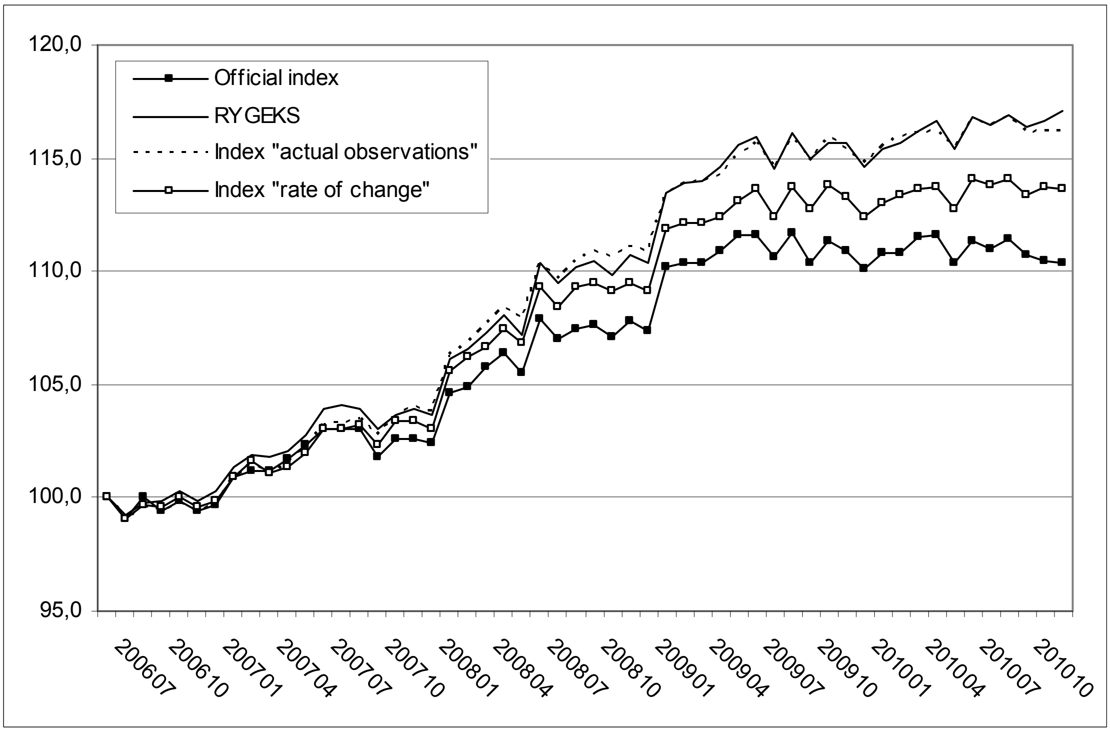
Our main goal with the experimental price indices is to calculate a price index where we exclude as much as possible of the indicated bias in the official price index of food and non-alcoholic beverages caused by missing observations. In this chapter we compare the Törnqvist price indices including imputations with our official CPI figures and with a benchmark price index, the RYGEKS price index. Ivancic, Fox and Diewert (2009) have come up with a way of calculating chained superlative-type price indices free of chain drift based on scanner data, applying a multilateral GEKS method used for price comparisons across countries and adjusting it to price comparisons over time. The GEKS approach makes optimal use of all matches in the data, and imputation to deal with missing price observations is not necessary. The authors have also created a "Rolling year" version of the GEKS method in order to avoid revising already published figures.

The RYGEKS price index that we calculate is based on superlative price indices calculated in the same way as the official price index, namely a Törnqvist price index. Higher level aggregations are also performed in the same way as the other indices. Except for a common procedure for removal of extreme month-to-month price ratios (*t*/*t-1*) the price indices have different data cleaning procedures. As opposed to the official price index and the experimental price indices, the RYGEKS price index has no removal of contributions[17]. Figure 6 shows the price development of the COICOP-2 aggregate of the different price indices in the period July 2006 to December 2010.

[16] Simulations show that seasonal item groups like fruit and vegetables (where the source of the fluctuations in prices and quantities is climate more than custom) are not dumped in the same way as for instance Christmas-related items. Simulations with a dumping filter on *all* groups show unfortunate effects on these seasonal groups as too many of the items are removed.

[17] We have not controlled the ratios of all the direct bilateral price indices used for the RYGEKS method which may affect the movements of the RYGEKS price index.

Figure 6. Price indices of food and non-alcoholic beverages. July 2006-December 2010



Source: Statistics Norway

Figure 6 indicates no systematic bias in the experimental index using an imputation method based on actual observations compared to the benchmark index. The difference between these two indices amounts to only 0.9 percentage points from July 2006 to December 2010. Compared to the RYGEKS index, there is still some bias in the experimental index including imputations based on rates of change. The experimental price indices show that different ways of dealing with imputations provide different results. The results indicate that temporarily missing observations seem to be an important source of bias in the official price index.

The influence of chain drift caused by the consumers stocking up items on sale is difficult to analyse since the different methods for imputing missing observations give different results. This effect may, however, be more visible given a longer data collection period. The data collection period of the official price index covers only the midweek of the month. During the midweek, an observation may fall out of the data, which is either a result of the product being temporarily sold out, out-of-season, out of production or there being no transactions for the product. Since we do not have this information, we treat all missing observations as being temporarily sold out and the missing observations are imputed. With a longer data collection period, the quantity sold might *not* being zero, but instead very low, more clearly demonstrating the "stocking up effect". We are now working to prolong the data collection period, which may accentuate the effect with lower turnover in an after-sale period compared to a pre-sale period.

At more disaggregated level there are more variations between the price indices, which will be discussed below.

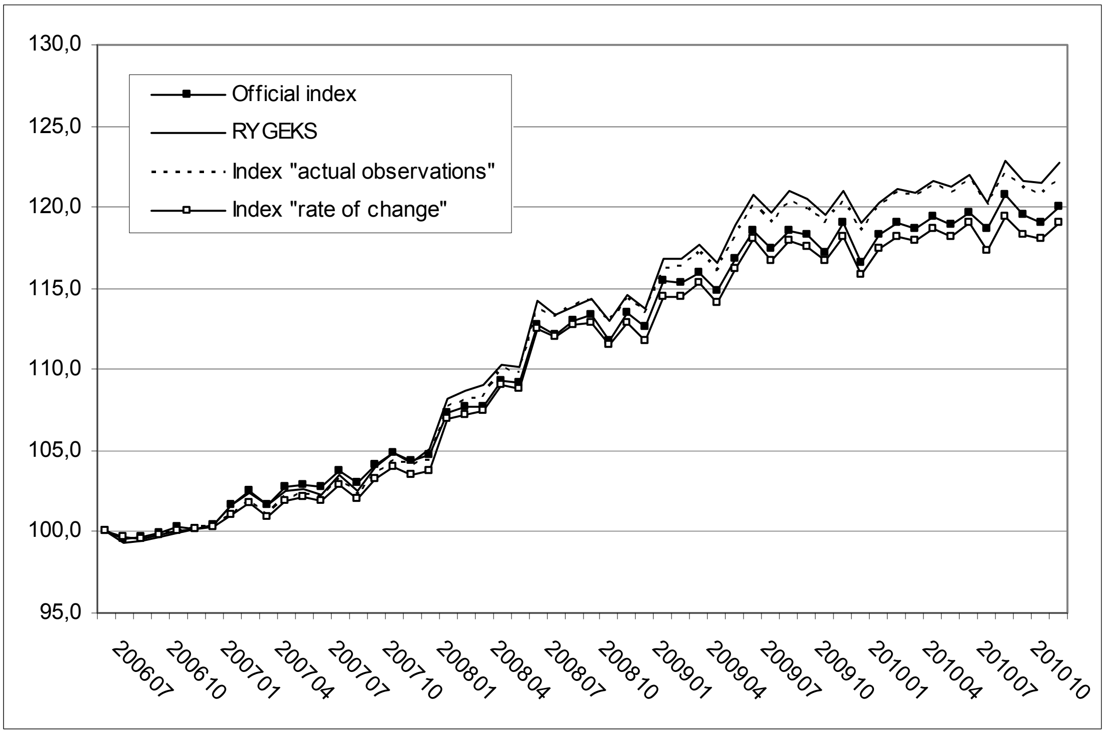
4.2 Comparisons at more detailed level

Compared to the RYGEKS benchmark, all COICOP-4 aggregates, with the exception of "Oils and fats" and "Milk, cheese and eggs", show a downward bias in the official price index to different extent. Even though the experimental index based on actual observations removes much of the bias at aggregated level, there is still some bias at more detailed level. For groups like "Bread and cereals" and "Food products n.e.c", the experimental price index and the benchmark price index show practically identical development over time. In the groups "Vegetables" and "Sugar, jam, chocolate, confectionery" much of the bias still remains, while the bias in the "Mineral waters, soft drinks and juices" is now upwards. For the remaining COICOP-4 aggregates, like "Meat", "Fish" and "Fruit", the bias has been reduced.

In the experimental price index based on rates of change the groups that perform best compared to RYGEKS index are "Mineral waters, soft drinks and juices" and "Vegetables". One the other hand, "Bread and cereals", "Food products n.e.c" and "Sugar, jam, chocolate, confectionery" are still problematic. Also in this index, the bias in the remaining COICOP-4 aggregates has been reduced.

The price development of "Bread and cereals" is illustrated in Figure 7.

Figure 7. Price indices of bread and cereals. July 2006 - December 2010. July 2006=100

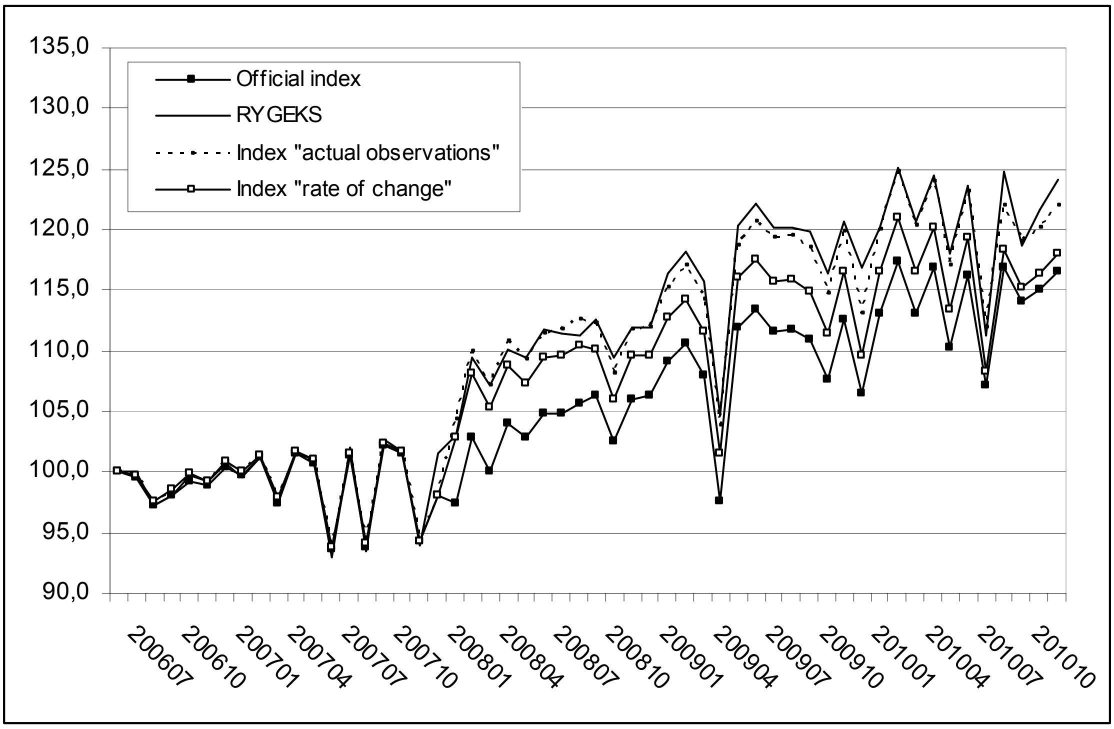


Source: Statistics Norway

The official price index of "bread and cereals" indicates a downward bias compared to the RYGEKS price index. The experimental index based on actual observations shows more or less the same price development as the RYGEKS price index. The experimental index based on rates of change on the other hand, actually performs worse than the official index. One explanation might be that products like gingersnaps and other strongly seasonal Christmas-related products are excluded from the official price index.

The example illustrated earlier in Figure 1, showed a downward bias in the official index of pizza. Figure 8 shows that by imputing the missing observations the downward bias, due to the one-off incident in January 2008 in the index of pizza, disappears. However, in the index based on rates of change it still seems to be some systematic bias.

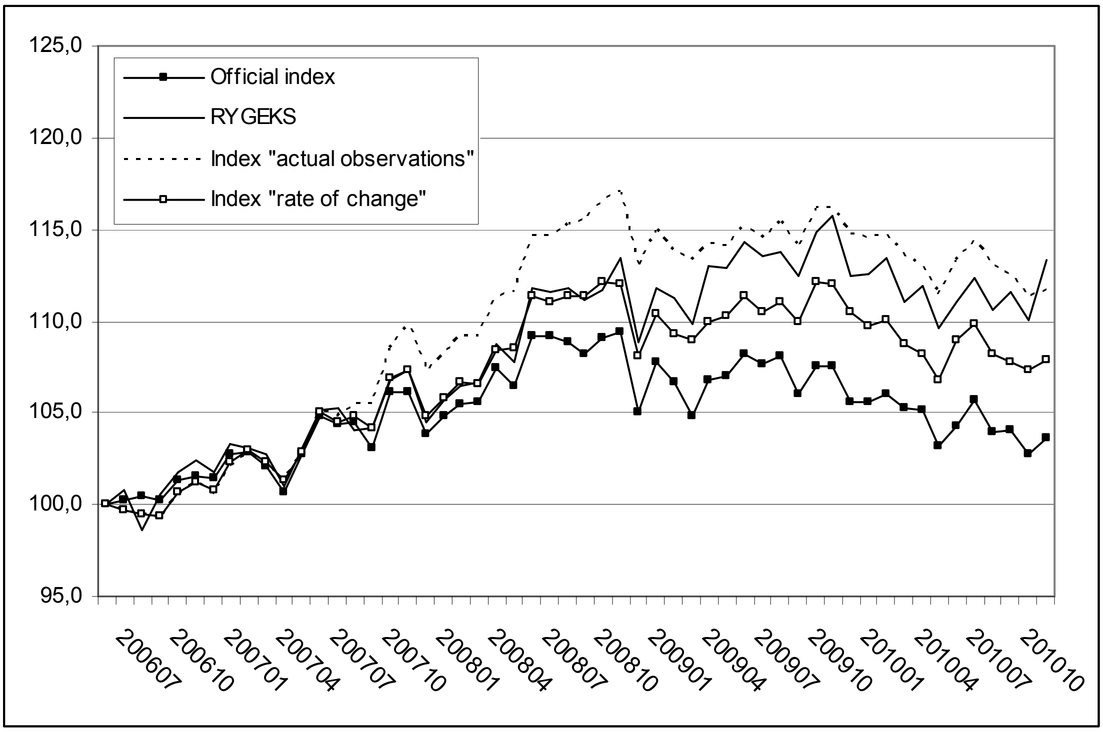
Figure 8. Price indices of pizza. July 2006-December 2010. July 2006=100



Source: Statistics Norway

The COICOP-4 aggregates “Meat” and “Fruit” have in common that they may show some marked deviations from the RYGEKS index in the short run. In the long run, both groups show an upward bias in the experimental index based on actual observations and a downward bias in the other experimental index. However, compared to the benchmark, much of the bias is removed. The price indices of meat products are compared in Figure 9.

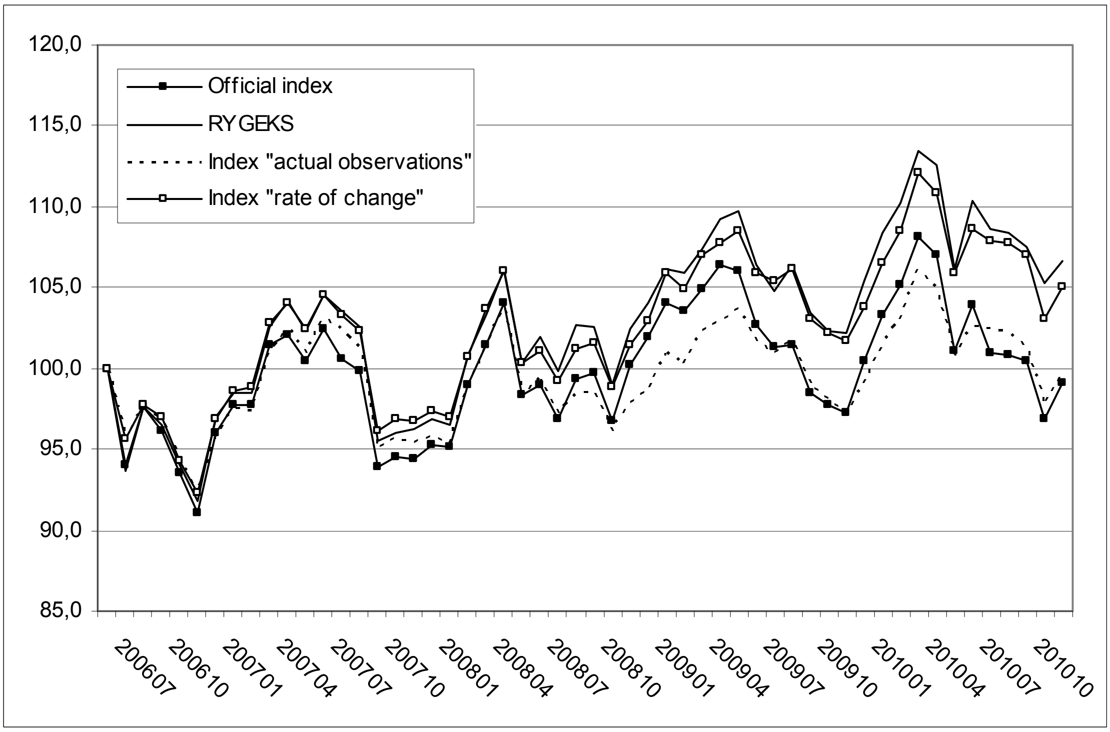
Figure 9. Price indices of meat. July 2006-December 2010. July 2006=100



Source: Statistics Norway

The price index of "Vegetables" show a systematic downward bias in the official CPI compared to the RYGEKS index as seen in Figure 10. In the experimental price index based on rates of change, most of the bias seems to be removed. The experimental index based on actual observations on the other hand, has approximately the same development as the official index. The result is evidently strongly influenced by the choice of imputation method.

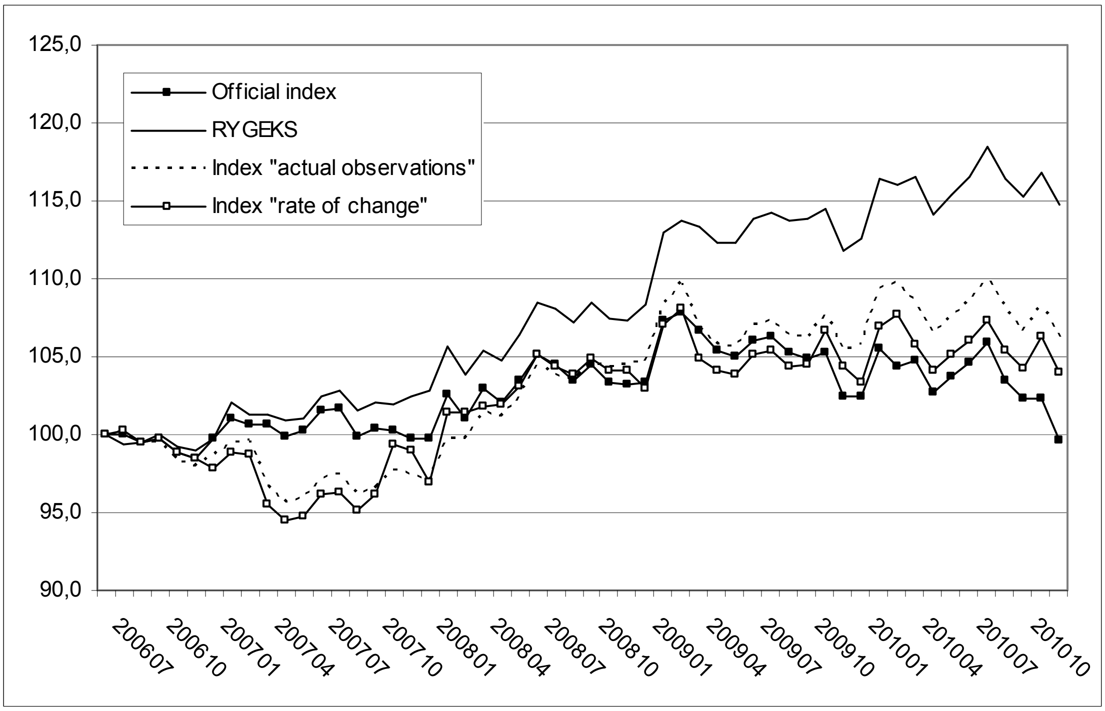
Figure 10. Price indices of vegetables. July 2006-December 2010. July 2006=100



Source: Statistics Norway

For the COICOP-4 aggregate "Sugar, jam, chocolate, confectionery" both imputation methods seem to fail. Many elementary aggregates within the COICOP-4 level seem to suffer from an extreme price and quantity bouncing, often combined to Easter and Christmas celebrations, see examples in Figure 4 and 5. Products may also reappear the next year with different layout and different EAN codes, consequently being treated as separate products. In Figure 11 the price indices of "Sugar, jam, chocolate, confectionery" are illustrated. The experimental indices hardly remove any of the bias. However, it is important to underline that in the experimental price indices the strongly seasonal items are included.

Figure 11. Price indices of "Sugar, jam, chocolate, confectionery". July 2006-December 2010. July 2006=100



At a more detailed level some of the COICOP-6 groups in the experimental price indices show large deviation from the RYGEKS price index and in some cases even larger than the official price index. In the experimental index based on actual observations, these groups are characterized by large element of seasonal items, which may not be included in the official index. Among the COICOP-6 groups which consist of more standardised non-seasonal items, the experimental price index based on actual observations is, in general, better than the official price index. Many of the groups in the experimental index based on rates of change seem, on the contrary, to work better on seasonal item groups and worse on standardised item groups.

This may indicate that it is more important to take the price development of similar items into consideration for seasonal items than for non-seasonal items. Seasonal items often tend to show similar price and quantity movements during a year, while among non-seasonal items there are often only a few products put on sale simultaneously. Seasonal items are imputed for a longer period compared to non-seasonal which enhances the importance of taking the price and quantity development during that period into consideration. Based on the empirical results it is difficult to conclude that one of the methods of imputation is superior to the other.

5. Concluding remarks

Statistics Norway's evaluation project in 2009 gave indication of a downward bias in the official CPI price index of food and non-alcoholic beverages. We concluded that the lack of imputation of missing observations and unsatisfactory treatment of seasonal item contributed to a systematic bias in the index.

New experimental price indices are calculated based on imputation of temporarily missing observations and where all seasonal items are included. Results indicate that, at aggregated level, the systematic bias seems to be reduced in both the experimental indices using the RYGEKS index as a benchmark. Even though we mainly focus on the temporarily missing observations and do not treat the permanently missing observations specifically, the experimental index based on actual observations, seem to remove most of the biased effect at aggregated level. At detailed level some of the COICOP-6 groups, mostly seasonal, show systematic bias in different directions; at aggregated level, however, the biases seem to offset each other. The experimental index based on rate of change seems to reduce less of the bias at aggregated level, but performs better on some seasonal item groups. We see that the choice of imputation method is crucial. An imputation method has not yet been implemented in the official index. A combination of the two experimental indices could potentially be a solution.

We consider the missing observations, both seasonal and non-seasonal, as an important source of bias in the price index. This underlines the importance of imputations in a traditional superlative index despite monthly chaining. We treat all missing observations as being temporarily sold out, though they may in fact be a result of zero transactions during the price collection period. With a prolonged data collection period, the quantity sold might not be zero, but instead very low, more clearly demonstrating the “stocking up effect” when products are on sale. Including imputations in a traditional superlative price index will not solve this problem.

As a part of the evaluation project, the RYGEKS price index was tested and the results have been very promising[18]. Today, Statistics Norway has established a shadow production system calculating the benchmark every month. However, Statistics Norway is not implementing the RYGEKS method at this point in time. As concluded in an earlier paper, we think it is too soon to do this. No statistical agency has yet incorporated this method into their official CPI calculations. Even though several international papers have been written about the RYGEKS method in recent years, more international experience is needed, as is an acceptance of this method as international good practice. Statistics Norway also needs more experience with the RYGEKS price index in order to adapt the method to Norwegian scanner data. In the short run, Statistics Norway will try to make minor adjustments in our existing price index by including imputations of missing observations and with that also improving the treatment of seasonal products.

[18] The RYGEKS price index was tested at COICOP-6 level and further aggregation was based on official methodology.

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