Sample Selection Bias in the Swedish CPI

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0. Abstract

A bias occurs for a consumer price index, CPI, if price collectors avoid product varieties on sale when selecting the sample in the reference month (December). Once the sample is fixed, price collectors cannot avoid sales prices since they are commissioned to collect prices almost as long as products are offered to consumers for purchase. In December twelve months later the proportion of reduced prices will normally be higher than in the reference month, creating a downward bias in the CPI.

If price collectors favor products that have low campaign prices in the reference month the opposite effect can occur.

Statistics Sweden (SCB) has applied an adjustment for selection bias for clothing and footwear in the Swedish CPI and the HICP since 1993. It has been discussed whether the same adjustment method is applicable and needed for other product groups as well. In this report, we evaluate methods for hindering selection bias to occur and explore the need for an adjustment of bias.

1. Sampling

The sampling of product offers has three stages; 1) sampling of outlets annually, 2) definitions of product groups (Strata) and definitions of the representative items and finally, 3) the selection of specific product offers for the combinations of outlets and representative items.

1.1 Sampling of Outlets

For product groups where local price collection or scanner data is used, outlets are divided into 38 retail trade and service strata according to the Swedish Standard Industrial Classification (SNI, which closely follows NACE, Rev. 2, the EU standard). In each stratum a gross sample of units (outlets) is drawn from the SAMU[1] version of the Central Business Register by the method Sequential Poisson sampling which is an *order πps technique*. This first gross sample is drawn about six months before the year in which it is to be used. This sample is screened in October and November, both in the central office and by the price collectors visiting the units. Some of the units initially drawn are excluded for various reasons. For example, they may be head offices rather than outlets, or they may not sell any of the targeted products. After screening, outlets are picked from the list one by one in order, until the predetermined net sample size is

[1] SAMU is a tool used by a majority of the business surveys at Statistics Sweden to establish a frame population to draw coordinated samples.

reached. Positive coordination of outlet samples between years is obtained through the use of random numbers "permanently" associated with each outlet in the sampling frame, Ohlsson (1995). Sampling rotation is performed so that 20 per cent of these random numbers are changed every year. Combined with market changes, this results in some 70-75 per cent of outlets remaining in the sample from one year (*y-1*) to the next (*y*).

1.2 Sampling of Representative Items

Following common practice, most products in the Swedish local price survey are chosen using the representative item method. General product specifications are drawn up in the central office using the Household Budget Survey (HBS) as one reference among others. Price collectors then get specific instructions on how to choose between the different varieties of each product.

Example 1 show four examples of product specifications from the central office. Some products have tight specifications with several criterions for the price collector to follow, illustrated here by the skirt. Other products, like yarn, have more generic or loose specifications.

Example 1: Item specification and selected variety

- **Skirt**: *Size 38-42 or similar. Not a pantskirt. Not wool, linen or silk*
- **Digital Camcorder**: *Digital recording, flash memory and HD supported*
- **Skis**: *Cross country skis, suitable for a recreational skier, length 200 cm*
- **Yarn**: *Wool, wool/synthetic mix or fully synthetic*.

For daily necessities like food, beverages, detergents etc. SCB makes a probability sample of fully specified products. Prices are collected from scanner data.

1.3 Sampling of Product Offers

Price collectors are instructed to choose the variety that is *"most sold"* in terms of volume within the specification of the representative item. The *"most sold"* rule also applies to replacements when an item disappears from the market. This method could be viewed as a special case of cutoff sampling. Outlet staff is often asked to assist in the judgments that have to be made when applying this criterion. For new varieties it is difficult to know in advance which items will have the highest sale numbers. It is by no means certain that this selection process in practice catches the variety that will be the most sold.

For the sample in the reference month, December year *y*, 25-30 per cent of the product offers are new because the outlets are new in the sample. For the outlets that are retained in the sample from the previous year, *y-1*, price collectors are instructed to keep the same product offers as in the final sample of year *y*. New product offers should be selected only if the old varieties no longer represent consumer behavior, as is the instruction for any other month. By applying this instruction the product offer is still the same for the final month of year *y-1* as for the reference month of year *y*.

1.4 Probability versus Non-Probability Sampling Techniques

Using judgmental sampling, i.e. letting price collectors choose the varieties when creating the new sample in the reference period, is of course a non-probability sampling technique. In a statistical setting, it is sometimes hard to argue the benefits of such methods. International Labour Organization (2004) supports such methods under certain circumstances (see Appendix A). In particular, when

non-probabilistic replacements are made throughout the measurement period the benefits of a probability sample is destroyed (chapter 5.31).

There are draw backs of non-probability sampling. Since products are chosen arbitrarily, there is no way to estimate the probability of any one product being included in the sample. Also, no assurance is given that each item has a chance of being included, making it impossible to estimate sampling variance. We believe it is a fair assessment that judgment samples can be highly prone to researcher bias. The selection bias introduced below, is a good example of how the subjectivity of the price collector can create issues in the resulting sample.

2. The Problem

The Swedish CPI is a chain index with annual links. In December, prices are collected for two partially overlapping samples from the same population: 1) the last measurement for year *y-1* and 2) the first measurement for year *y*. Every year about 25-30% of the outlets in the old sample are replaced and thereby the same proportion of product offers are new. Instructions for price collection say that all varieties, regardless of type of price, should be considered when choosing the product offer. However, we have observed[2] that price collectors "prefer" products they expect to remain in stores longer to avoid frequent replacements. When making the reference period selection, price collectors therefore tend to choose varieties sold at regular price and not varieties on sale, thereby creating a sample where sales prices are underrepresented.

While it is possible for the price collector to avoid varieties with sale prices in the reference period, the proportion of sales prices in the December sample one year later will reflect proportion of sale prices in the population more closely. The relative lack of sales prices in the reference period will lead to a downward bias in the CPI.

Norberg (1993) brought this problem to the attention of the CPI Advisory Board. For the index year 1993 a correction/adjustment for the bias in clothing and footwear was introduced, referred to as a "sales price correction[3]." The actual adjustment factors are not normally recorded and saved, but between 1994 and 1998 they were (Norberg, 1998):

- 2,17
- 2,43
- 2,40
- 3,68 and
- 1,14 percent

The adjustment factor for 1998 was low because the same sample of outlets was used in 1997 and 1998. In can be noted that the estimated average bias for clothing has been around two percentage points downwards annually, which means a decrease in the total CPI of about 0.1 percentage points (Norberg, 1995 and 1998). Bias for footwear is somewhat lower.

[2] The authors accompanied several price collectors to learn about the collection process. We then made the observation that collectors purposely stay away from products with sales prices when making replacements.

[3] Since the introduction of the "sales price correction" it has become clear that the term is unfortunate. It is not a correction for sales prices occurring during the year but rather for the bias created when the price collector stays clear of sales prices when creating the base sample. A better fitting term is therefore "adjustment for selection bias."

An interesting aspect of the problem is that campaign prices can cause a bias in the opposite direction of that caused by sales prices. The difference is found in the character of the strategies behind the reduced prices. Sales are often used to quickly sell out merchandise to make room for new products. Campaigns on the other hand, can be used to introduce a new kind of merchandise or a seasonal product. While product offers sold at a sale price can be expected to disappear from the store, product offers part of a campaign are more likely to remain. The price collectors act consequently and when sales prices are avoided, campaign prices are inviting.

Figure 1 and 2 show the occurrence of sales and campaigns in prices for clothes, shoes and other quality assessed products[4] collected for the Swedish CPI between January 2010 and March 2014. Of interest is how different the two price strategies are; sales peak in January and July while campaigns seem to be more common in December. It should be noted than the strong seasonal occurrence of sale prices to a large extent is driven by the many price observations collected from clothes and shoes. However, the same pattern is found for other products as well, even if the effect is not as strong.

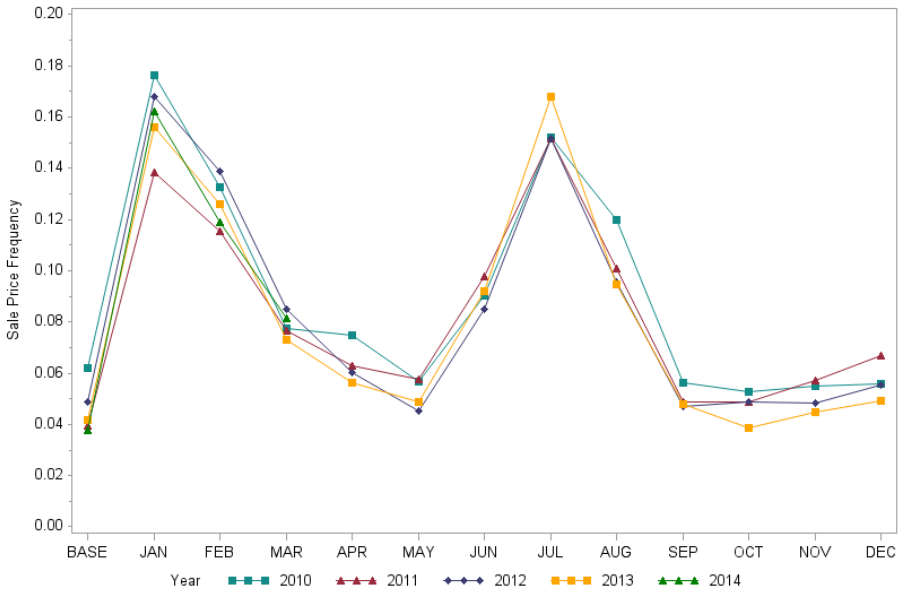

Figure 1: Frequency of sales prices in data for clothes, shoes and other quality assessed products, collected between January 2010 and March 2014.

Since the selection bias is caused by new products brought in to the sample in the reference period of the new year (y) it is of interest to compare the frequency of sales and campaigns for new products to the frequency of sales and campaigns of old products in the reference sample. In figures 3 to 6 we see the frequencies of sale or campaign prices in 2013 for products remaining in the sample from the previous year. For a clearer view, Clothes and Shoes are separated from other quality assessed products. Product group with no interesting sale or campaign activities are left out of the plot. To illustrate the origin of the selection bias the frequency of sales or campaigns for products introduced to the sample in the reference period of 2013 are added to the plot.

[4] Only products that are quality adjusted at price changes are included in the study since those are the only products where regular prices are collected together with the sale price continuously.

For the sale prices, we clearly see that the frequency is lower for new product than it is for old products, again indicating that price collectors have preferred products sold at regular price. For campaigns we see no clear pattern even though it seems price collectors tend to avoid those as well and by doing so adding to the effect of the sales prices. In some cases (ex. Household Equipment) price collectors have preferred campaign products, contributing to a bias in the opposite direction.

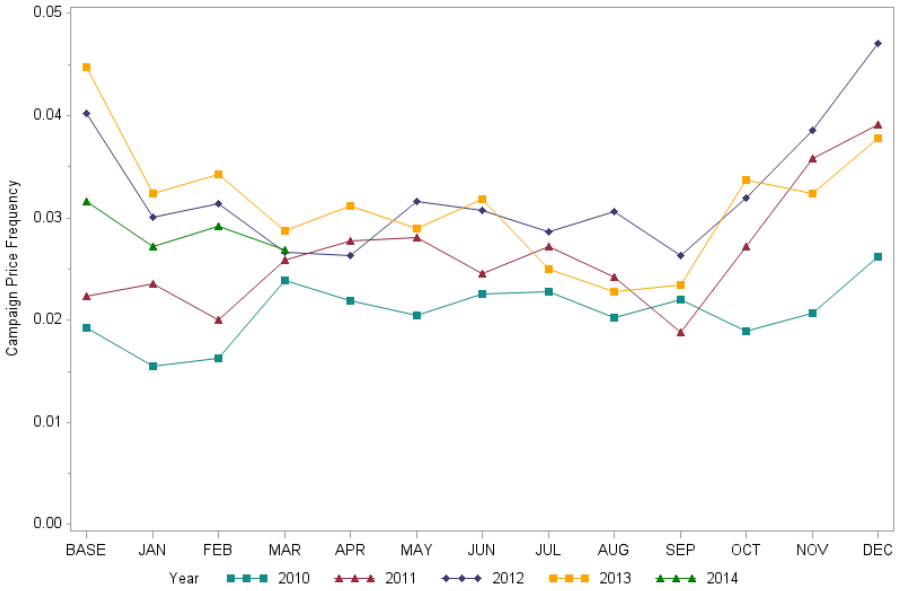

Figure 2: Frequency of campaign prices in data for clothes, shoes and other quality assessed products, collected between January 2010 and March 2014.

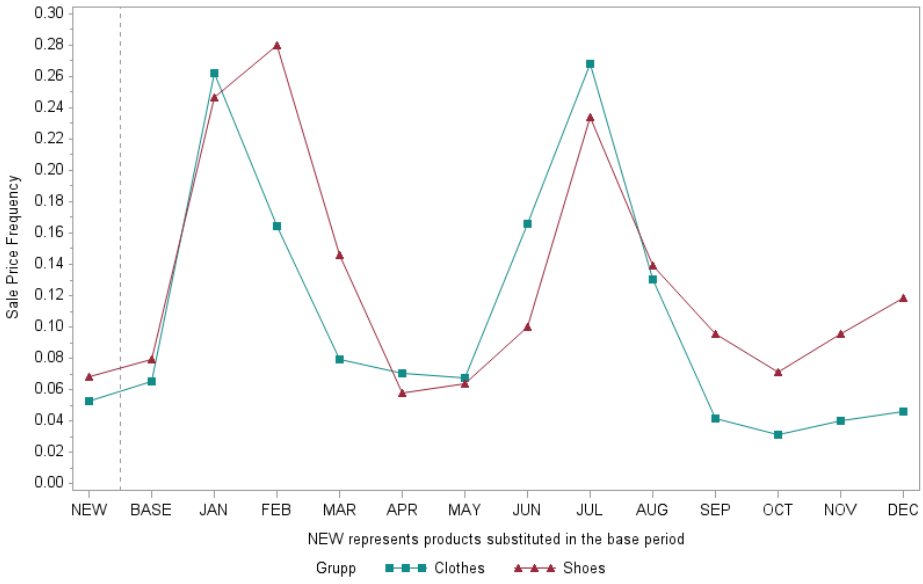

Figure 3: Frequency of sale prices for clothes and shoes remaining in the sample from 2012 to 2013. BASE represents price observations in the reference period for products remaining in the sample from the previous year. NEW represents price observations for new products that entered the sample in the reference period for 2013.

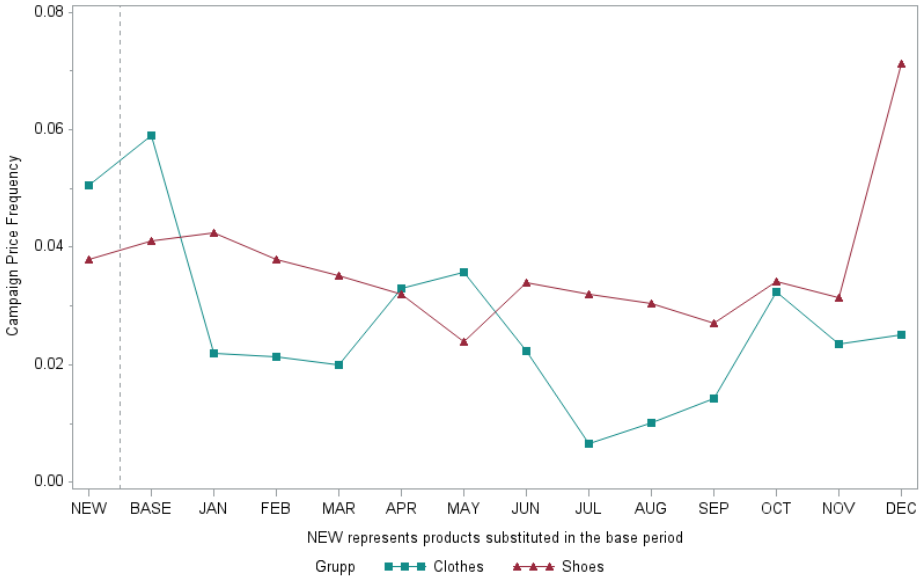

Figure 4: Frequency of campaign prices for clothes and shoes remaining in the sample from 2012 to 2013. BASE represents price observations in the reference period for products remaining in the sample from the previous year. NEW represents price observations for new products that entered the sample in the reference period for 2013.

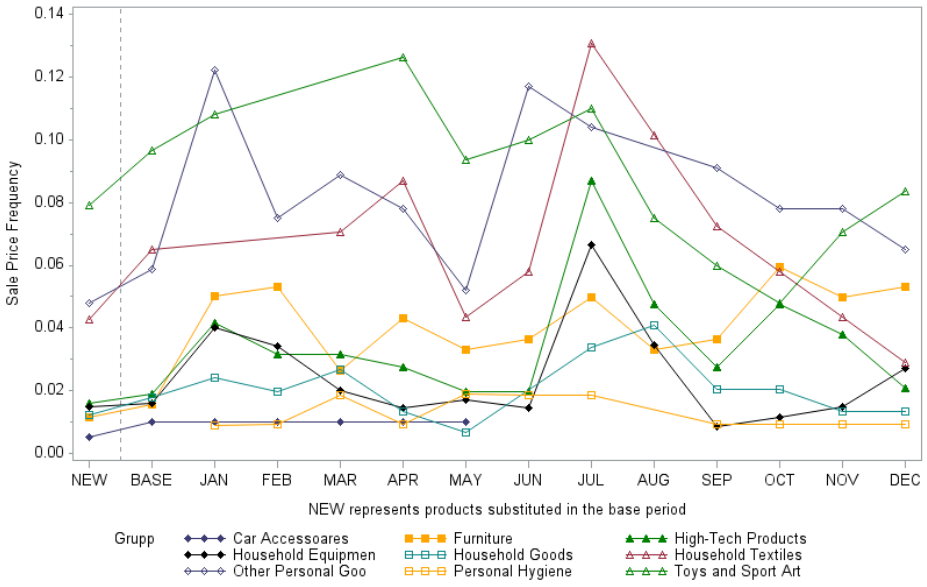

Figure 5: Frequency of sale prices in 2013 for quality assessed products remaining in the sample from the previous year. BASE represents price observations in the reference period for products remaining in the sample from the previous year. NEW represents price observations for new products that entered the sample in the reference period for 2013.

To summarize, sale prices signals that the product offer will disappear from the store. It is not favored by the price collector in the reference period since it will cause a quick replacement. This will lead to a downward bias in the CPI. Product

offers sold in a campaign will remain in the store and they are very likely "most sold." Therefore they could be favored in the reference period and this could lead to an upward bias in the CPI. However, it is obvious from Figure 2 that campaigns are not as common as sales and we see no clear pattern of action from the price collectors.

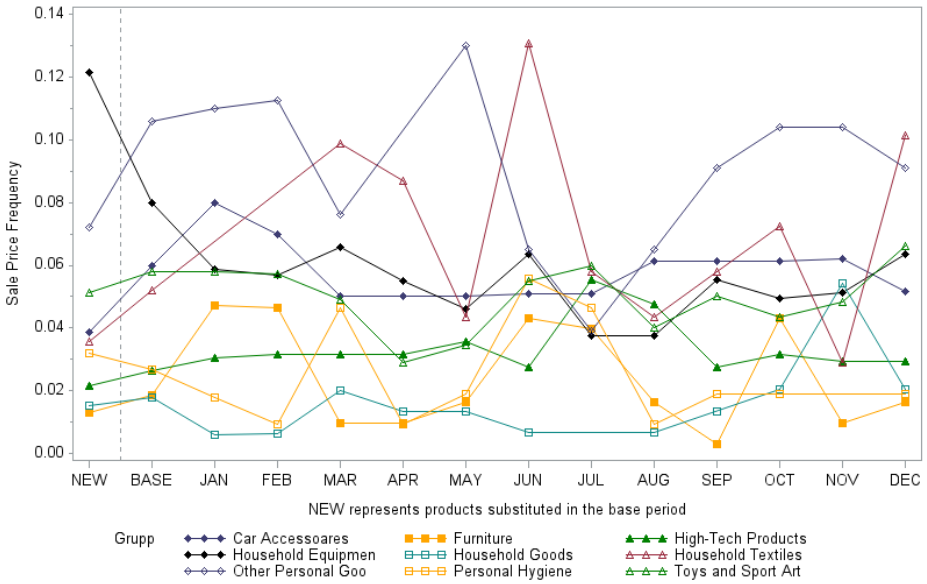

Figure 6: Frequency of campaign prices in 2013 for quality assessed products remaining in the sample from the previous year BASE represents price observations in the reference period for products remaining in the sample from the previous year. NEW represents price observations for new products that entered the sample in the reference period for 2013.

We suggest two groups of methods to deal with the selection bias;

- Hinder the bias to arise
- Adjust for the bias when/if it occurs

3. Methods for Avoiding the Bias

We present three methods for avoiding the bias that result when price collectors tend to keep away from sales prices.

3.1 More Extensive Instructions to Price Collectors

Instructions say product variants sold at sale or campaign prices should be selected if they are the *most sold*. Price itself must not be decisive for the selection. Instructions are clear, but we can see a definite tendency that this requirement is not fulfilled. We strongly question if more education of price collectors would be a cost effective solution to the problem.

3.2 Draw New Samples in September or October

Selecting the sample for year *y* a couple of months earlier than the reference period would allow the proportion of sales prices in the sample to increase until they reach a stationary phase that is a good representation of the population. The price measurements from the reference month (December) is then used for price index calculations.

Norberg (1993) proposed that new samples were collected in November rather than December for clothes. As it turned out, collecting the new sample one month early did have some of the desired effect but it was not strong enough. Although the selection bias was reduced, it was not completely eliminated. Up for discussion is the possibility to draw the new sample already in September or October. Three months might be enough for the proportion of sales prices in the sample to better mimic that of the population.

One obvious drawback of carrying double samples is the added cost. For two or three months price collectors will have to collect 25-30 per cent more prices , which will be more time consuming and expensive than collecting prices for one sample.

On the other hand, an added benefit to drawing the new sample in September or October would be the improvement in work environment for the price collectors. Preparing a new sample and choosing new varieties in December, when Christmas shopping is at a peak, is very stressful. It would be easier and less stressful to perform this time consuming task in October when stores are not heavily occupied by anxious Christmas shoppers.

3.3 Changing the CPI Linkage Months

December is not the best month to link short term indices based on the following reasons:

- There are a lot of price activities in December. Activities like end of stock sales and campaigns brings variance to the price index link for the month and chaining one index link with low statistical quality to another with low statistical quality is worse than having two higher quality index links. Table 1 below show the percentage of sale or campaign prices in the sample, indicating that September and October are the overall best choices for linking.
- For working conditions for the price collectors in outlets it is an advantage to move the almost double workload of the overlap period from December to a less busy shopping month. September and October seems to be good alternatives.
- For working condition at the central CPI office at SCB it would be an advantage to spread the heavy annual update workload over a longer period.

A drawback with this method is that computation will be a little bit more complex. The operationalization of the new index structure for the CPI as suggested by *Commission on the Review of the Swedish Consumer Price Index (CPI),* SOU 1999:124, documented in Ribe (2003), was approved by the CPI Advisory Board at the meeting 219 in 2003.

The CPI construction works with a year-to-month-index $I_{y-2;g}^{y,m}$ for the product group g, which in the simplest form is

$$I_{y-2;g}^{y,m} = \frac{I_{y-3,\mathrm{Dec};g}^{y-2,\mathrm{Dec}}}{\frac{1}{12}\sum_{m=1}^{12} I_{y-3,\mathrm{Dec};g}^{y-2,m}} \cdot I_{y-2,\mathrm{Dec};g}^{y-1,\mathrm{Dec}} \cdot I_{y-1,\mathrm{Dec};g}^{y,m} \ .$$

For the months after September, if linking is indeed moved to September, the last piece can be computed as

$$I^{y,m}_{y-1,Dec;g} = I^{y,Sept}_{y-1,Dec;g} \cdot I^{y,m}_{y,Sept;g}.$$

In fact, the implementation can be made like imputation of reference prices. For all product offers within a product group, the reference price for the last months are the price in September divided by the index from December last year, *y-1,Dec* to September current year, *y,Sept*.

Table 1: Percentage of price observations that are on sale or part of a campaign, per month 2010 to 2013.

Group	*Month*											
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***
Car Accessories	6	5	4	4	4	5	5	4	4	5	6	6
Clothes	31	21	12	10	9	18	32	19	7	7	9	12
Footwear	35	35	23	15	11	16	27	22	11	9	12	13
Furniture	9	7	6	6	6	7	8	6	5	6	6	6
High-Tech Products	16	10	11	13	12	14	19	11	10	13	10	9
Household Equipment	17	10	10	10	9	11	16	13	10	12	11	12
Household Goods	6	5	4	5	4	4	6	4	3	3	3	3
Household Textiles	20	16	14	15	10	16	17	18	12	14	14	17
Kitchen, Bath and Floors	6	7	7	7	6	7	6	6	5	9	9	8
Office Equipment	2	1	1	1	1	2	1	3	3	2	1	1
Optics	0	0	1	1	0	0	0	0	0	1	1	1
Other Personal Goods	14	14	13	16	15	15	16	17	14	9	10	12
Personal Hygiene	5	3	5	3	3	4	5	3	4	3	7	5
Tools & Garden Equipment	3	5	2	5	5	4	4	6	4	3	3	3
Toys and Sport Articles	16	19	20	16	15	16	18	16	16	16	15	15
Yarn & Fabric	1	2	1	1	0	0	1	1	1	0	0	0

4. Adjustment Method

December is the last month of last year's link and the price reference period for the next year's link. This means that prices and information are collected for two partially overlapping samples during the same week(s). Based on the two samples we make two estimates of the effect of sales and campaigns on the mean price level. If there is a purposive avoidance of sales prices in price reference period, the effect of sale prices will be higher for the final December sample than for the price reference period sample, for the identical period. The ratio between these two estimates of the sales price effect is not only stochastic but also systematic and would lead to a continuous bias in the CPI for the affected products.

The formula for the index link for an elementary aggregate from December last year *y-1,Dec* to the current month this year *y,m* in the Swedish CPI is

$$I^{y,m}_{y-1,Dec;g} = \frac{\left(\prod_k w_k p_k^{y,m}\right)^{\frac{1}{n}}}{\left(\prod_k w_k p_k^{y-1,Dec}\right)^{\frac{1}{n}}}$$

We use a similar formula as for the elementary aggregate of CPI-computation to calculate the effect of sale prices. Put the observed prices in the place of the comparison period prices, *y,m*, and the regular prices in the place of the price reference period prices, *y-1,12* to calculate the sales effects for the two samples. For the final month of year *y-1* we have for the product group *g*

$$S_{y-1,12,reg;g}^{y-1,12,obs} = \frac{\left(\prod_k w_k p_{k,obs}^{y-1,12}\right)^{\frac{1}{n}}}{\left(\prod_k w_k p_{k,reg}^{y-1,12}\right)^{\frac{1}{n}}}$$

For the reference month of year *y* we have

$$S_{y,0,reg}^{y,0,obs} = \frac{\left(\prod_k w_k p_{k,obs}^{y,0}\right)^{\frac{1}{n}}}{\left(\prod_k w_k p_{k,reg}^{y,0}\right)^{\frac{1}{n}}}$$

The bias of the prices of the base period is on average

$$BIAS_g = \frac{S_{y,0,reg;g}^{y,0,obs}}{S_{y-1,12,reg;g}^{y-1,12,obs}}$$

Prices in the reference month are now adjusted by the ratio of the sales price effect for the final December sample and the sales price effect for the price reference period sample (1/BIAS). Alternatively an adjustment to the monthly price index is made by the ratio between the sales price effect of the reference month of the new sample to that of the final month of the old sample (BIAS). This adjustment is applied during the following year, *y*.

Example 2: Calculation of Adjustment for Selection Bias
All prices are collected in December some year *y-1*. There are four varieties in the survey of the present year *y-1* and five varieties to be measured the following year *y* beginning in this month December.

Final month of last year's link			Price ref. month of new year link	
Regular price	Actual price		Regular price	Actual price
199	199		199	199
199	149		199	149
98	98		98	98
595	495			
			599	599
			899	899
Index (actual/regular) = 88.8			Index (actual/regular) = 94.4	

In this example two out of four varieties had sales prices in the final month of last year's link and the actual prices were on average 88.8 per cent of the regular prices. Analogously the actual prices in the new price reference period sample were on average 94.4 per cent of the regular prices. The price index for every month of the new year must be adjusted up-wards with the ratio 94.4/88.8 = 1.062.

5. Analysis of CPI Data

5.1 Data

Analysis has been carried out on real CPI data from the years 2010, 2011, 2012 and 2013 to see if any product and industry combination shows a big selection bias, indicating that some kind of action, either to prevent the bias from occurring or adjust for it when it occurs, would be beneficial.

Tableau: Product categories considered in this study

Category	Products
Clothing	All clothing
Footwear	All footwear
High-tech products	Television set, CD/cassette player, stereo, camcorder, DVD player, home theatre, MP3 player
Household goods	China and utensils, drinking glass, pots and pans, kitchen scales
Household textiles	Towel, bedding, comforter, curtains and cloth for curtains
Recreational goods	Toys, sport articles, ski equipment, recreational goods, bike, music instruments
Personal hygiene	Cosmetics, electric razor
Furniture	Kitchen table, chair, upholstered chair, sofa, mirror, bed, shelves, rug, mattress, ceiling lamp
Car accessories	Tires, car accessories, booster seat
Optics	Glasses, contact lenses
Household equipment	Laundry machine, dishwashing machine, vacuum cleaner, electric stove, refrigerator, microwave oven, coffee maker, water boiler
Yarn and fabric	Yarn, thread, fabric
Kitchen, bath and interior	Bathtub, toilet, kitchen cupboard, kitchen sink, wooden floor, door
Tools and garden equipment	Hammer, grass mower, knife, garden spade, light bulb, electric screwdriver
Office equipment	Writing paper, ink for printer
Other personal goods	Watch, bag

5.2 Results

Results from the analysis can be seen in the tables 2-5 (tables 4 and 5 are found in Appendix B.

It is not uncommon that some products have low counts in some of the industries and thereby accidently introduce a significant bias. For example, in 2011 the bias for baby pants sold in hypermarkets is extremely high (Table 5 in appendix B). A closer inspection of the prices show that there are eight pairs of baby pants sold in hypermarkets in the reference period with only one pair sold at a discount. In December twelve months later there is only one pair left, sold at 35% of the original price.

Clothing and footwear are adjusted for the selection bias every year. Looking at table 2 it is clear that this adjustment is motivated. The extent of the bias varies from year to year and depends on the particular product varieties chosen in the reference month sample.

Table 2: Geometric mean of biases for product groups. 2010 to 2013.

Group	*Weight ‰*	*Mean Bias 2010*	*Mean Bias 2011*	*Mean Bias 2012*	*Mean Bias 2013*	*Geometric Mean Across Years*
Clothes	**44.7**	**1.01**	**1.01**	**1.00**	**1.01**	**1.011**
Footwear	**8.3**	**1.01**	**1.01**	**1.02**	**1.02**	**1.011**
High-Tech Products	8.6	1.01	1.01	1.03	1.01	1.015
Household Goods	6.2	1.01	1.00	1.00	1.02	1.010
Household Textiles	5.8	1.00	1.00	1.01	1.03[1)]	1.009
Recreational Goods	12.5	1.01	1.02	1.01	1.00	1.008
Personal Hygiene	3.1	1.00	1.02	1.01	1.00	1.006
Furniture	20.8	1.00	1.00	1.00	1.01	1.003
Car Accessories	6.2	1.00	1.01	1.00	1.00	1.002
Optics	3.7	1.00	1.00	1.00	1.00	1.000
Household Equipment	5.5	1.00	1.00	1.01	0.99	1.000
Yarn & Fabric	0.6	1.00	1.00	1.00	1.00	1.000
Kitchen. Bath and Interior	5.6	1.00	1.00	1.00	0.99	0.999
Tools & Garden Equipment	6.5	1.00	1.00	1.00	1.00	0.998
Office Equipment	0.9	0.99	1.00	1.00	1.00	0.997
Other Personal Goods	3.6	1.01	0.95	1.01	1.02	0.996

1) The high value for “Household Textiles” in 2013 is due to a high proportion of sale prices for curtains in home furnishing textile stores.
2) The low mean adjustment for “Other Personal Goods” in 2011 is due to a big proportion of campaign prices for men’s watches and women’s purses in the reference sample.

Further examination of the results show strong indications that several additional product groups are affected by the selection bias.

- High-tech products have been a source of uncertainty for the CPI calculations for a long time. Rapid development and changes of the products makes month to month comparisons hard. Prices in this product group are volatile with frequent sales and campaigns.
- Several items in the group Household Goods show high biases (see table 4 in appendix B).
- Recreational goods can be highly seasonal (ex. ski equipment). Campaigns can be common in the beginning of a product’s season while sales are more common toward the end of the season.
- Other personal goods are often sold at the same outlets as clothes and prices can be expected to fluctuate in a similar fashion. The mean adjustment in table 2 is heavily affected by the one very low value for 2011.
- Household textiles such as towels and curtains seem to be subject to sales to a large extent.

5.3 Discussion of Method

During the measurement year the products chosen in the original sample will go on sale and finally disappear and get replaced. In this fashion, the sample will evolve from the originally low proportion of sales prices toward a proportion of sales prices close to that of the general population. If price collectors in December chose products completely new to the market we can expect this process to take several months since sales prices usually occur in the tail end of the product life. Since the adjustment factor is the same for all month of the measurement year we could end up with a reverse bias in the beginning of the year. Even if this is the case, the adjustment of selection bias will have a positive effect overall.

Another thing to keep in mind is the quality of the reported regular prices. Calculations of the bias is dependent on the assumption that the regular price of a sale item is "correct". For some product groups it is common practice to use "recommended price" or "list price" rather than a "true" regular price. A recommended price is almost never paid by the customer, but is used to make a sale price more attractive. In such cases we would overestimate the selection bias.

If all observed regular prices are generally X % higher than the "true" regular prices there will be no effect on the adjustment for the selection bias. If, on the other hand, regular prices for sale products are increased to make the sale appear better, we will overestimate the selection bias. Table 3 shows that this practice is not very common in Sweden. It appears that it is as common for the regular price to decrease before a sale.

Table 3: Change of regular price from month before the sale price to the month with sale price. Proportions of price observations with price decrease and price increase.

Group	*Decrease (%)*	*Increase (%)*	*Number of obs*
Car Accessories	1.7	2.3	346
Clothes	1.1	0.5	12 591
Footwear	1.0	0.9	5 078
Furniture	1.5	1.8	1 499
High-Tech Products	3.4	2.5	1 551
Household Equipment	2.9	3.0	1 811
Household Goods	1.2	1.6	429
Household Textiles	2.3	3.0	1 898
Kitchen. Bath & Floors	1.1	1.8	438
Office Equipment	7.5	5.7	53
Optics	0.0	0.0	10
Other Personal Goods	0.7	1.7	539
Personal Hygiene	1.7	2.2	179
Tools & Garden Equipment	1.5	2.3	263
Recreational Goods	0.9	2.0	2 056
Yarn & Fabric	10.0	0.0	10

We realize that the quality or relevance of regular prices can be questioned. After examination of the regular prices in the Swedish CPI system, our opinion is that they are trustworthy and of good enough quality to use in our bias calculations.

It should also be mentioned that since the estimates of the effects of sales prices are stochastic, big (or small) values of the bias adjustment can appear randomly. Table 5 in Appendix B shows that in 2011, the adjustment for baby pants in hypermarkets is 2.48 which must be considered uncommonly high. In this case there was only one product offer. It is obvious that the estimated bias has high variance but there is also a strong negative covariance between the estimated adjustment factor for year *y* and the index link between December year *y-2* and December year *y-1*. Adjusting for the bias should therefore result in less variance in estimates of long term price movement.

6. Conclusions

Statistics Sweden has adjusted for the selection bias for clothing and footwear for the past 20 years. Analysis carried out in this study supports this and continues to point out clothing and footwear as product groups where selection bias is present. Other product groups where the analysis indicate there is a selection bias are High-Tech products, Household Goods, Household Textiles, Recreational Goods and Other Personal Goods. The bias is not as strong or consistent in these product groups, but sometimes big enough that something should be done to counteract it.

Applying the method of adjusting for the selection bias to all or some of the above mentioned product groups seems an intuitive solution to the problem. For more uncommon situations as the example with a reverse bias due to campaign prices in the reference month (i.e. the proportion of reduced prices is higher in the reference sample than in the population) an adjustment will also be beneficial.

Criticism of the correction method is that it appears to be volatile. As the analysis show, some products can sometimes show “accidently” high biases due to low counts in some products. This is variance. The quality of the “regular prices” is also a matter of concern, the objection is that the so called regular prices are not relevant or “true”.

After careful consideration and discussion in the Swedish CPI Advisory Board the method we recommend for dealing with the selection bias is early selection of the new sample. By choosing the new sample already in September or October, the proportion of sale or campaign prices will mimic those in the population. Although more expensive, this method is preferable over the adjustment method since it is better to hinder the bias to arise than to adjust for it when it is reality. For clothing and footwear the present adjustment method is approved.

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Appendix A: The Consumer Price Index Manual

Reasons for using non-probability sampling

5.28 *No sampling frame is available*. This is often true for the product dimension but less frequently so for the outlet dimension, for which business registers or telephone directories do provide frames, at least in some countries, notably in Western Europe, North America and Oceania. There is also the possibility of constructing tailor-made frames in a limited number of cities or locations, which are sampled as clusters in a first stage. For products, it may be noted that the product assortment exhibited in an outlet provides a natural sampling frame, once the outlet is sampled as a kind of cluster, as in the BLS sampling procedure presented above. So the absence of sampling frames is not a good enough excuse for not applying probability sampling.

5.29 *Bias resulting from non-probability sampling is negligible*. There is some empirical evidence to support this assertion for highly aggregated indexes. Dalén (1998b) and De Haan, Opperdoes and Schut (1999) both simulated cut-off sampling of products within item groups. Dalén looked at about 100 groups of items sold in supermarkets and noted large biases for the sub-indices of many item groups, which however almost cancelled out after aggregation. De Haan, Opperdoes and Schut used scanner data and looked at three categories (coffee, babies' napkins and toilet paper) and, although the bias for any one of these was large, the mean square error (defined as the variance plus the squared bias) was often smaller than that for pps sampling. Biases were in both directions and so could be interpreted to support Dale´ n's findings. The large biases for item groups could, however, still be disturbing. Both Dalén and De Haan, Opperdoes and Schut report biases for single-item groups of many index points.

5.30 *We need to ensure that samples can be monitored for some time*. If we are unlucky with our probability sample, we may end up with a product that disappears immediately after its inclusion in the sample. We are then faced with a replacement problem, with its own bias risks. Against this, it may happen that short-lived products have a different price movement from the price movement of long-lived ones and constitute a significant part of the market, so leaving them out will create bias.

5.31 *A probability sample with respect to the base period is not a proper probability sample with respect to the current period*. This argument anticipates some of the discussion in Chapter 8 below. It is certainly true that the bias protection offered by probability sampling is to a large extent destroyed by the need for non-probabilistic replacements later on.

Appendix B: Result Tables

Table 4: Products and industries with the largest biases in 2013.

Product	*Industry*	*Index Dec*	*n Dec*	*Index Base*	*n Base*	*BIAS*
Drinking glass	Glassware. china and kitchenware	90.24	7	100.00	12	1.11
Salad bowl	Glassware. china and kitchenware	88.46	8	97.42	11	1.10
Floor mat	Home furnishing textiles	64.32	3	70.73	2	1.10
Woman's coat	Clothing	79.89	58	87.59	71	1.10
Street shoe	Hypermarkets	93.87	7	100.00	6	1.07
Digital camera	Photographic equipment	89.00	12	94.72	15	1.06
Cordless telephone	Telecommunications equipment	90.34	37	95.29	37	1.05
Curtain	Home furnishing textiles	82.37	40	86.40	43	1.05
Men's watch	Watches and clocks	84.42	18	88.07	24	1.04
Men's shoe	Footwear	90.68	39	94.54	40	1.04
Woman's wool coat	Clothing	87.14	78	90.71	122	1.04
Curtain	Hypermarkets	92.50	19	96.26	18	1.04
Floor hockey stick	Sport and leisure	84.96	77	88.07	87	1.04
Rubber boots	Sport and leisure	94.88	23	98.12	27	1.03
Gloves	Sport and leisure	91.39	28	94.44	33	1.03
Coffee mug	Hypermarkets	95.31	23	98.38	25	1.03
Suite case	Hypermarkets	91.86	21	94.64	20	1.03
Men's sweater	Clothing	93.37	107	96.10	126	1.03
Wall mounted mirror	Home furniture	97.46	27	100.00	24	1.03
Woman's boots	Footwear	91.30	68	93.60	66	1.03
Woman's heavy boots	Footwear	93.60	92	95.79	89	1.02
Men's heavy boot	Footwear	94.78	104	96.94	102	1.02
Woman's skirt	Clothing	92.05	82	94.14	119	1.02
Woman's pumps	Footwear	90.99	82	93.03	91	1.02
Salad bowl	Hypermarkets	90.60	7	92.61	9	1.02
…	…					
Booster seat	Other retail sale in specialized stores n.e.c.	91.31	14	89.94	12	0.98
Stroller	Other retail sale in specialized stores n.e.c.	96.26	23	94.72	21	0.98
Door. storage unit	Wood and other building material	100.00	18	98.17	19	0.98
Mountain bike	Sport and leisure	94.38	36	92.59	37	0.98
Washing machine	Electrical household appliances	91.96	13	90.15	20	0.98
Jeans	Sport and leisure	92.18	5	90.32	4	0.98
Men's coat	Sport and leisure	91.24	67	89.37	79	0.98
Espresso machine	Hypermarkets	89.72	18	87.77	18	0.98
Pot	Hypermarkets	99.21	12	97.01	16	0.98
Pot	Glassware. china and kitchenware	96.86	7	94.61	10	0.98
Electric razor	Electrical household appliances	100.00	8	97.14	11	0.97
Hammer	Hypermarkets	100.00	11	96.30	13	0.96
Cordless screw driver	Wood and other building material	100.00	16	95.78	20	0.96
Coffee maker	Electrical household appliances	99.32	14	94.88	18	0.96
Refrigerator	Electrical household appliances	96.49	7	92.11	10	0.95
Mountain bike	Hypermarkets	81.64	10	77.60	11	0.95

Table 5: Products and industries with the largest biases in 2011.

Product	*Industry*	*Index Dec*	*n Dec*	*Index Base*	*n Base*	*BIAS*
Baby pant	Hypermarkets	35,35	1	87,81	8	2,48
Man's shirt	Hypermarkets	49,75	1	100,00	5	2,01
Home theatre	Photographic equipment, specialized stores	62,50	1	88,23	1	1,41
Floor mat	Hypermarkets	78,52	3	100,00	5	1,27
Television set, small	Photographic equipment, specialized stores	79,99	1	100,00	2	1,25
Men's coat	Hypermarkets	84,09	4	100,00	5	1,19
Jeans	Hypermarkets	83,31	8	96,84	9	1,16
Electric razor	Electrical household appliances, specialized stores	86,37	8	100,00	8	1,16
Dishwashing machine	Electrical fittings, specialized stores	83,26	1	91,25	2	1,10
Woman's coat	Sport and leisure goods	88,30	10	96,48	46	1,09
Digital camcorder	Photographic equipment, specialized stores	86,30	3	93,88	7	1,09
Children’s sweater	Hypermarkets	92,15	17	100,00	11	1,09
Floor hockey stick	Sport and leisure goods	86,00	36	91,59	60	1,06
Electric razor	Electrical fittings, specialized stores	88,52	2	94,09	4	1,06
Wool coat	Clothing	86,55	45	91,77	46	1,06
Storage unit doors	Wood and other building material	92,43	21	97,94	10	1,06
Dishwashing machine	Electrical household appliances, specialized stores	92,58	8	97,25	8	1,05
Woman's wool coat	Clothing	84,07	106	88,11	88	1,05
Television set, big	Photographic equipment, specialized stores	95,74	2	100,00	4	1,04
Towel	Home furnishing textiles, specialized stores	72,12	30	75,30	37	1,04
Men's pullover	Sport and leisure goods	92,36	13	96,40	19	1,04
Women's top	Sport and leisure goods	94,62	19	98,65	46	1,04
Digital camera	Hypermarkets	89,60	5	93,36	8	1,04
Electric kettle	Electrical fittings, specialized stores	90,86	4	94,67	7	1,04
Towel	Hypermarkets	94,39	31	98,10	36	1,04
Back pack	Sport and leisure goods	91,76	12	95,36	17	1,04
Toilet	Carpets, rugs, wall and floor coverings, specialized stores	89,42	2	92,82	3	1,04
Push chair for kids	Games and toys, specialized stores	95,91	30	99,50	25	1,04
Beddings	Home furniture, specialized stores	93,46	41	96,90	44	1,04
Women's dress	Clothing	93,82	78	97,24	95	1,04