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Clothing: the use of class mean imputation in the Swiss Consumer price index (CPI) – analysis and impact on the results

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Abstract:

Since January 2011, the class mean imputation method has been used in order to adjust the quality for clothing in the Swiss CPI when matched items are unavailable. In order to obtain good and correct imputed figures, the basket of goods and services retained special attention and the price collection rules were strictly defined. Our apprehension to observe falling results due to the chosen method prompted us to analyse the effect of this quality adjustment method on our results.

Summary

The quality adjustment for clothing has always been a problematic issue. This sector is characterised by successive seasons and as it is largely dictated by fashion trends it is very difficult for the data collectors to find a completely identical article several months after its price was last recorded.

Since 2011, on the basis of simulations that were carried out, the class mean imputation method has been used in the Swiss CPI to handle quality adjustment of clothing when significant differences in the quality of two models has been observed. For minor differences in quality, the method of direct comparison is maintained.

The class mean imputation method has, however, not been introduced without a certain number of strict rules relating to price collection and article replacement, as experiences made abroad have revealed the possible negative effects of this method. From its introduction, the FSO has followed very closely the impact of the class mean imputation and estimated its impact upon results.

1. Data collection of clothing prices until the end of 2010

Until the end of 2010, approximately 2800 prices were collected six times a year for clothing articles. This price collection was governed by several recommendations so as to facilitate the work of data collectors and to prevent them having to replace articles too frequently:

- Concentrate price collection on articles of classic style, less subject to fashion trends and therefore having greater longevity on the market than fashion articles.
- Take note of different characteristics, such as the brand, the fabric composition and possibly the colour so as to facilitate identification of articles for subsequent price collection and of any replacements necessary.
- Only use direct comparison for a replacement article made of identical or very similar fabric and in the same price range as the replaced article. In all other cases, remove the article and introduce a new price series.

With these few recommendations, the replacement rate was kept relatively low compared to other countries. In fact, whereas almost half the sample was replaced each year in other countries, the replacement rate in Switzerland was 15% on average in 2006, 20% in 2007 and 38% in 2008.

Although these guidelines facilitated article replacement, they were not entirely satisfactory; on the one hand they almost completely obscured the matter of change in the quality of clothing and on the other, quality was only defined by two variables: fibres and price whereas other factors such as the quality and country of manufacture, yoke and the type of stitching have a significant impact on the quality.

In addition to dissatisfaction regarding quality adjustment, the number of prices collected was far from sufficient according to Neyman's method of optimal allocation which has shown that three times as many prices should be collected (see Graph 1). The greatest problem area was women's clothing for which the number of prices should have been almost fivefold. In view of the characteristics of the Swiss market – a market dominated by international labels and large national distributors – and the difficulty and cost of price collection in this sector, this seemed completely unrealistic to us.

Graph 1 Neyman's optimal allocation, articles of clothing
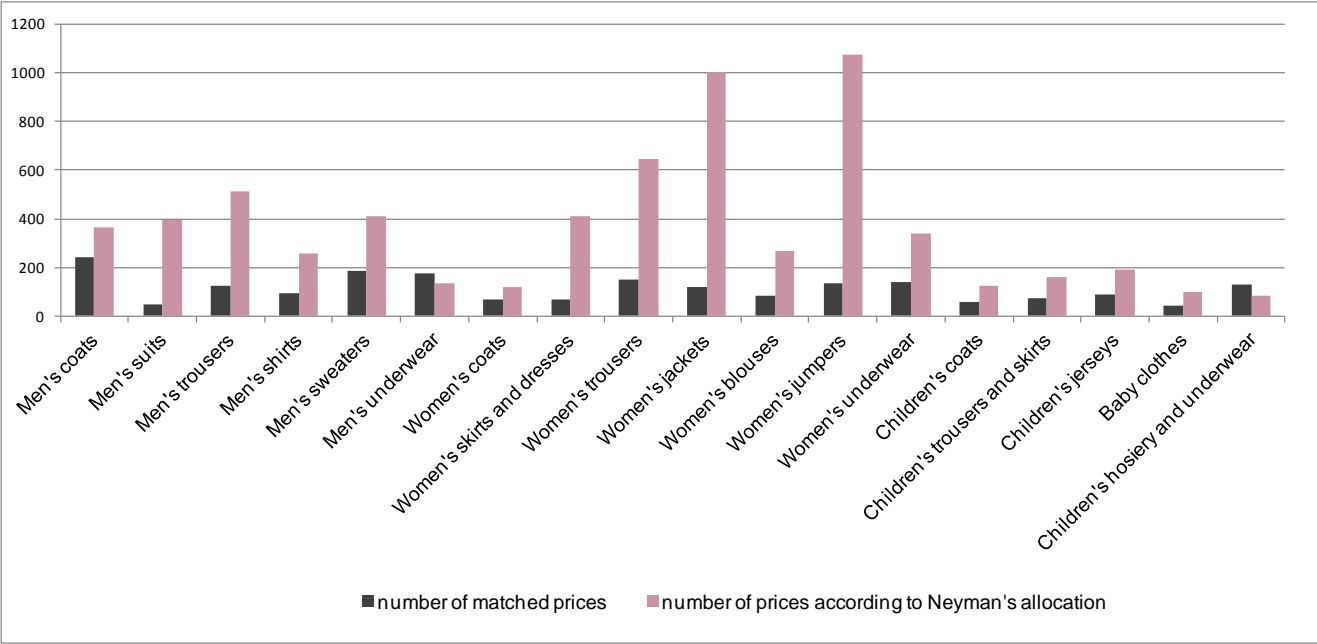
An insufficient number of prices together with unsatisfactory quality adjustment methods led us to a complete review of both the method of price collection and the quality adjustment techniques used in the clothing sector.

2. Data collection of clothing prices since 2011 and the introduction of class mean imputation

Given the widely expressed criticism of explicit quality adjustment methods, we chose to introduce an implicit quality adjustment method which enabled us, on the one hand, to homogenise the treatment of quality adjustments in a complex area such as clothing and on the other to distance ourselves from the concept of price in the process of quality adjustment.

Implicit methods are essentially price imputation methods based on the price change of other articles in the sample. There are three different types: overall mean imputation, targeted mean imputation and class mean imputation. All three involve imputing the price change of articles of unchanging quality with articles the quality of which has changed between two price collection periods. The main difference between them is the source of the rate of the price change imputed to the replaced product at the period t+1. The average price change of matched articles is used as imputation rate for the overall mean imputation and the targeted mean imputation whereas the imputation rate for class mean imputation takes into account the average price change of articles replaced by direct comparison.

The calculation process for these imputation methods is illustrated in the following example. The model a is replaced by the model b for the month t. The actual price change between the replacing

model b and the replaced model a is 16%. The average price change of matched models (c, d, e) is 10%. Given that the price change between models a and b, without change in the quality between the two models, would have been 10%, a fictitious price of model b for the month t-1 is calculated i.e. 58/1.10 ≈ CHF 52.70. The price difference between the two models in t-1 is considered as a quality difference and is therefore excluded from the index.

Example 1 : use of imputation method

Periods	t-3	t-2	t-1	t
Replaced model a	60	55	50	
Replacing model b			**52.70**	58
Price change		-8.3 %	-9.1 %/ **+16.0 % / +10.0 %**	
Model c	50	45	40	44
Model d	40	35	30	33
Model e	32	26	20	22
Average price change of models c, d, e		-13.7 %	-16.1 %	**+10.0 %**

*Source: HICP Quality Adjustment – Cenex Handbook*

In order to evaluate the impact on the index of quality adjustments carried out using an imputation method, we simulated the effects of overall mean imputation as if it were used systematically for article replacement. The imputation rate was calculated at the level of elementary aggregate; data from the years 2006 to 2008 were used as a basis for the retrospective simulation of the indices. This simulation allowed us to establish that the systematic use of overall mean imputation to handle quality adjustments in the area of clothing would lead to a lower index than that published. The difference observed, at the level of main group "Clothing and footwear" in December 2008 was 3.70 points (Graph 2).

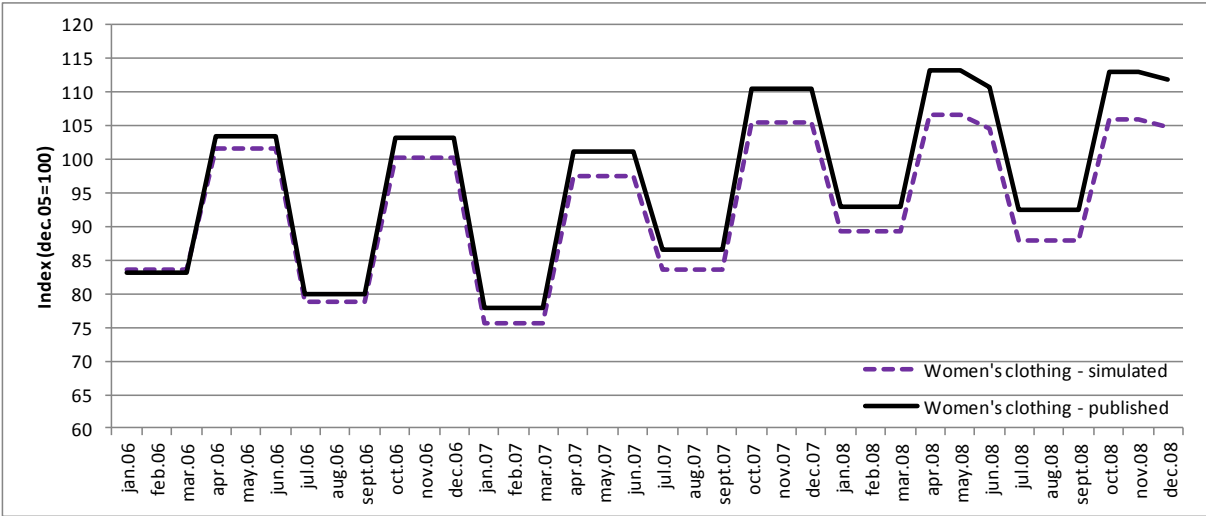**Graph 2 Influence of the use of overall mean imputation on the index of clothing and footwear**
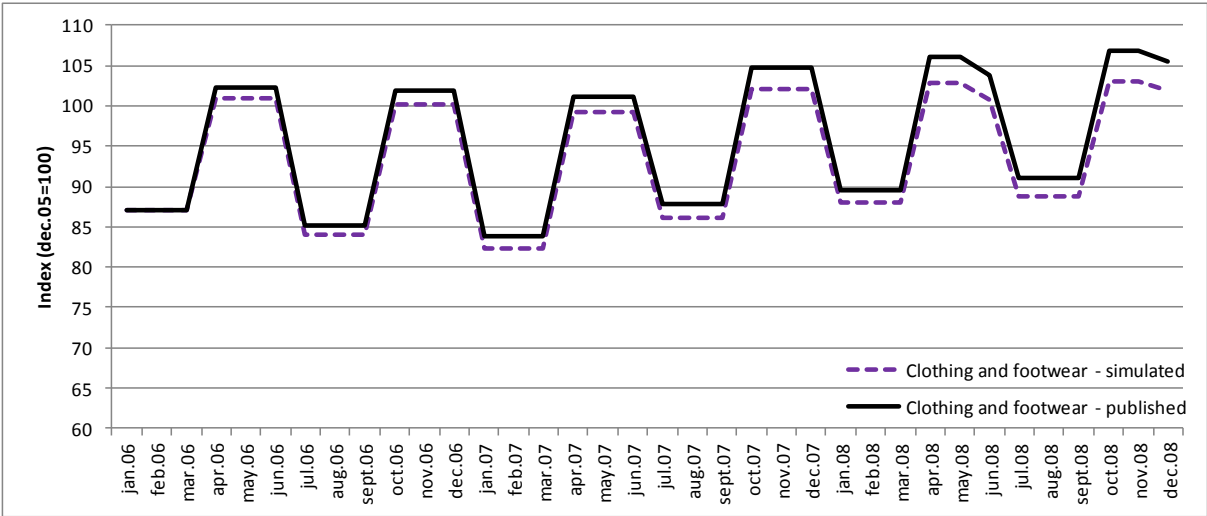
Not surprisingly, the differences are great in men's clothing, women's clothing and sportswear. These categories of goods are those that have historically brought most of the problems to data collectors during price collection.
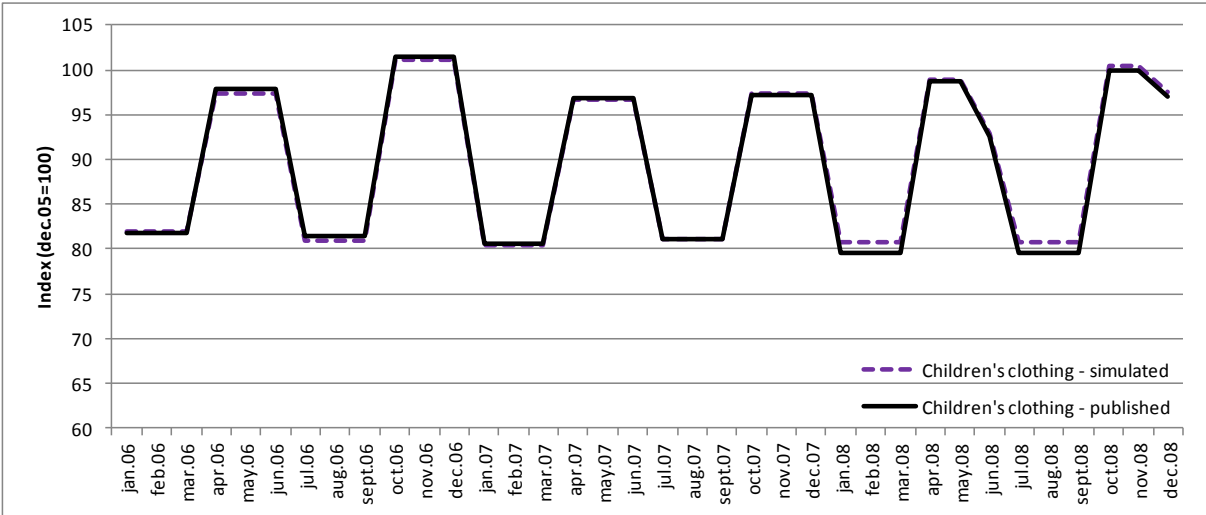
Graph 3 Influence of the use of overall mean imputation on the men's clothing index
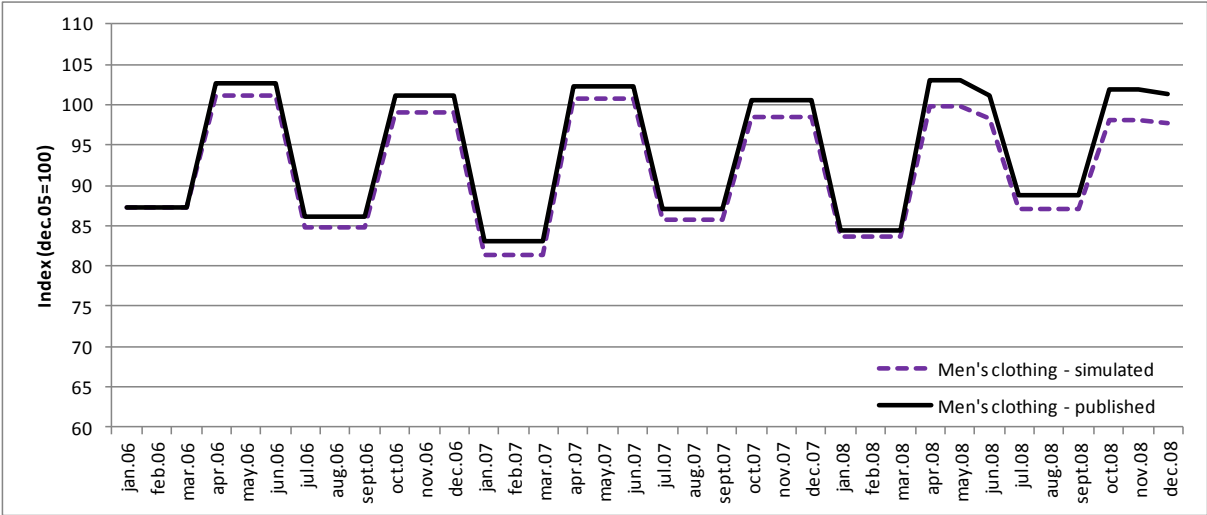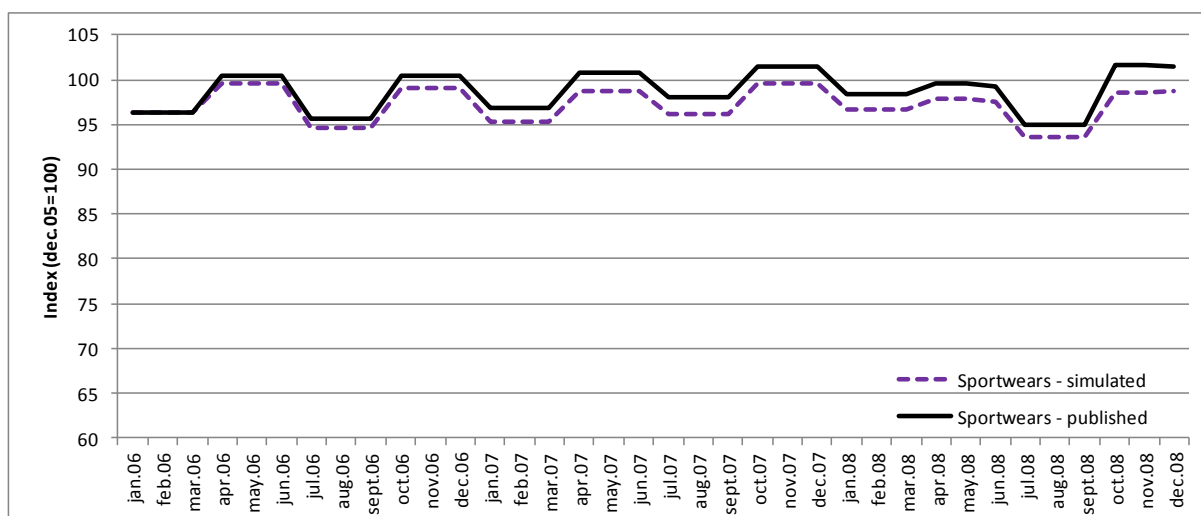
Graph 4 Influence of the use of overall mean imputation on the women's clothing index

Graph 5 Influence of the use of overall mean imputation on the children's clothing index

Graph 6 Influence of the use of overall mean imputation on the sportswear index

Why does the systematic use of the overall mean imputation have this effect? In the clothing sector, replacements take place mostly during the launch of new collections on the market, which in our case had been collected in April and October. Furthermore, these price collections are the first to take place after the sales. That is why the index registers significant price increases in April and October due to the return to normal prices after the sales. The systematic use of overall mean imputation, calculated without a limit[1], would lead to a smaller increase in the indices because the price changes registered after direct article replacement are in the majority of cases considerably higher than those registered for matched articles[2].

Since the results show that the systematic use of overall mean imputation for handling quality adjustments could introduce a downward bias in the index, we were motivated to introduce a mixed method of quality adjustment.

Therefore, as of January 2011, quality adjustments have been carried out:

a) By direct comparison, when the quality difference between the replaced article and the replacing article is deemed to be nil or negligible.

b) By using class mean imputation when the difference in quality between the two articles is deemed to be significant. The results of the simulation motivated us to use a variant of class mean imputation, which also takes into account price changes of replaced articles, the quality of which

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[1] In our simulation, all the prices of matched articles were used as a basis for imputation, including articles which were temporarily unavailable or seasonal, the price of which had been carried forward as well as sales articles.

[2] As the change in imputed prices is less than the price change by direct substitution, it contributes towards a smaller increase in indices when replacement articles are chosen.

is judged to be constant, rather than the overall mean imputation because it has been shown that the latter present different price trends than those of matched articles.

The introduction of this mixed method entailed numerous practical adjustments to our price collection system:

- First we had to define the criteria that would enable us to evaluate the quality of an article of clothing. To do this we consulted specialists in the field such as large international chains as well as big distributors. The quality of manufacture, the type of stitching, the "made in" as well as the yoke were widely cited as criteria for quality. As it is not possible to ask data collectors to collect data on so many characteristics, we chose quality of manufacture (represented by the brand[3]) and the composition of the fabric (fibres). Fields were introduced in the software application and data collectors filled them in for each replacement.

- As the imputation was only to be made on homogeneous price changes and for a price collection of articles of clothing done on a monthly basis, we redefined our basket of goods and services so that it was possible to distinguish between seasonal entries and year-round entries. Parallel to this we increased considerably the number of prices collected for each entry, so that the source of the imputed rate of price change contained a sufficient number of prices. Up until 2010, some 2800 price series went into the calculation of the clothing index every month. In December 2012, almost 4500 price series were included in the index calculation. Furthermore, we have even increased this number again for the 2013 price collection with an additional 250 price series collected per month.

- The introduction of class mean imputation also made necessary big changes at the level of the index calculation process, with the definition of a new imputation plan. The imputed price change corresponds to the average price change of matched articles and articles replaced by direct comparison. The sales, missing articles as well as articles the price of which has been carried forward, are excluded from the calculation of the price change to be imputed[4].

- This method has brought with it a fundamental change in the role of the data collector in the process of quality adjustment. Henceforth, the data collector collects prices on a monthly basis. He or she makes the replacement of missing articles when necessary and indicates them as such. He or she collects data on the required characteristics but no longer makes quality adjustments. This task falls to specialised staff at the FSO who decide, depending on the characteristics for which data has been collected, whether the replacement should be made by direct substitution or by imputation.

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[3] As it is complicated for a data collector to judge the quality of manufacture, we have chosen the brand to represent this characteristic.

[4] The calculation of price change takes all changes into account. A targeted imputation by distribution channel is unadvisable due to an insufficient number of prices.

- We have also defined new rules for the price collection specific to each month and to each type of article (seasonal or not) and made available to data collectors a guide to price collection dedicated exclusively to articles of clothing. It contains all rules specific to the field, in particular those governing the carrying forward of prices and the replacement of articles. For example, it is forbidden to replace an article while the sales are on and all articles missing during the first price collection of the season must be replaced.

- At the same time we also had to decide when to apply direct substitution and when to apply class mean imputation. In practice, only an article of the same brand and with a fibre composition that differs no more than +/- 10 % is considered comparable and can be replaced by direct substitution. In all other cases, class mean imputation is applied.

The introduction of this system enabled us to guarantee consistent quality adjustments based on objective criteria. However, the strict rules governing quality adjustment have led to an increase in the number of non-comparable replacements thereby reducing the number of replacements made by direct comparison. We estimate that on average between 25% and 35% of replacements carried out today by imputation would have been made by direct comparison if the old rules of price collection were applied.

## 3. Impact of class mean imputation on results following its introduction

Following the introduction of class mean imputation, it seemed important to us to be able to follow and quantify the effect of this new method of quality adjustment on the index, especially in view of the fact that certain countries which have used it have been faced with a negative effect, i.e. a strong downward tendency of the indices in question (particularly for technological products). A comparative analysis has therefore been conducted since January 2011.

Since then, the published indices are compared to indices that have been recalculated on the basis of the old method of quality adjustment[5]. To do this, a new calculation which does not take into account the imputations made by class mean imputation has been defined and the indices recalculated. It should be noted that class mean imputation is not used during the sales months, i.e. January and July.

The graph below would seem to show that the use of class mean imputation to deal with quality adjustments in the area of clothing does not have a downward effect. On the contrary, the use of class mean imputation would appear to have a slightly upward influence on the indices.

Although the differences are slight at the level of the total CPI, they are much more marked at the clothing level, as shown in Graph 7. When the first prices of the season are collected, the two indices tend to grow apart. In contrast, when the sales are on, they come closer together.

Graph 7 Influence of the use of class mean imputation on the articles of clothing index

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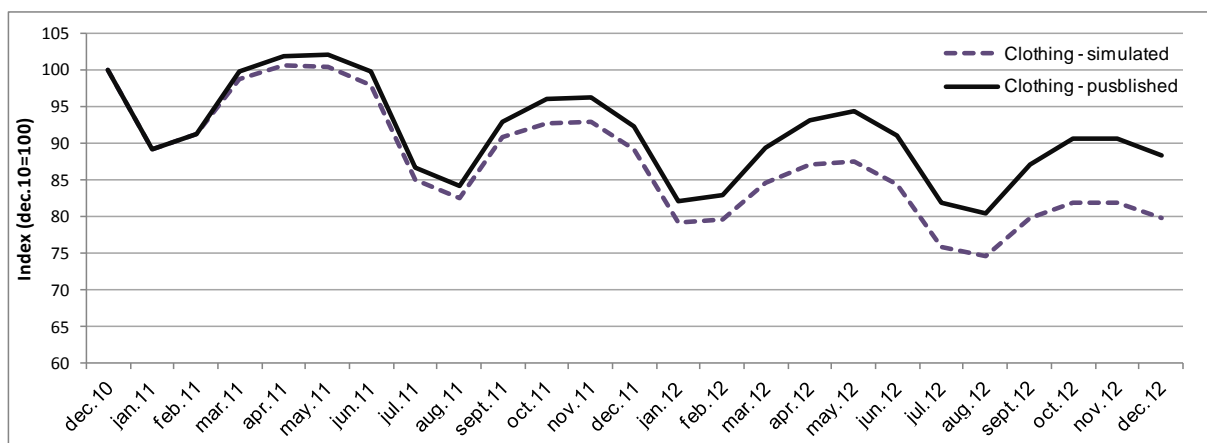
[5] Until December 2010, an article was deleted for good if no replacement article of identical quality could be found on the market. A new representative article was chosen to replace it. This led to the deletion of the old price series and the introduction of a new one. The disadvantage of this technique was that the trends in a price series could not be monitored on a long-term basis.

The impact of using class mean imputation for quality adjustments tends to push the index upwards during the months when new collections are put on the market, mainly in March and September[6]. The graph below shows the number of replacements made depending on the different months of the year. Comparison of the graph below with Graph 7 shows clearly that the greater the number of prices processed by means of class mean imputation, the greater the gap between the two indices.

Graph 8 Trends in the sample of clothing articles
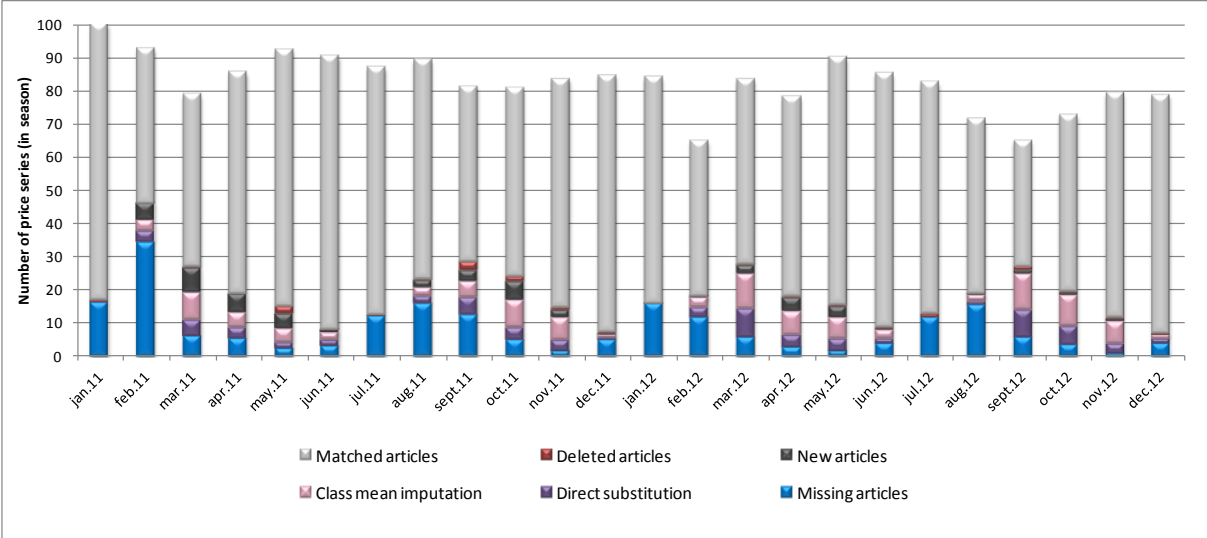
At the level of product groups, the influence is greatest for women's clothing. It provides a perfect image for the effect of fashion and the numerous replacements of articles with those from the new collection and which are not always comparable. Clothing for men and children as well as sportswear, are less affected because they are more classic and more stable with regard to brand and fabric and therefore with regard to quality.

For the time being, only sportswear appears to behave no differently than before. The other indices show a slight upward tendency.

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[6] With the introduction of monthly price collections, we have defined a different frequency for each type of clothing. Data on winter coats for example are collected from October to January whereas data on winter sportswear are only collected between December and January. New collections, therefore, enter the index in March, April and May for the spring/summer collection and in September, October, November and December for the autumn/winter collection. Previously, we collected data from April to July for spring/summer and from October to January for autumn/winter. By defining one frequency per clothing type we were able to reduce the number of missing articles and at the same time to increase the number of prices collected for each type.
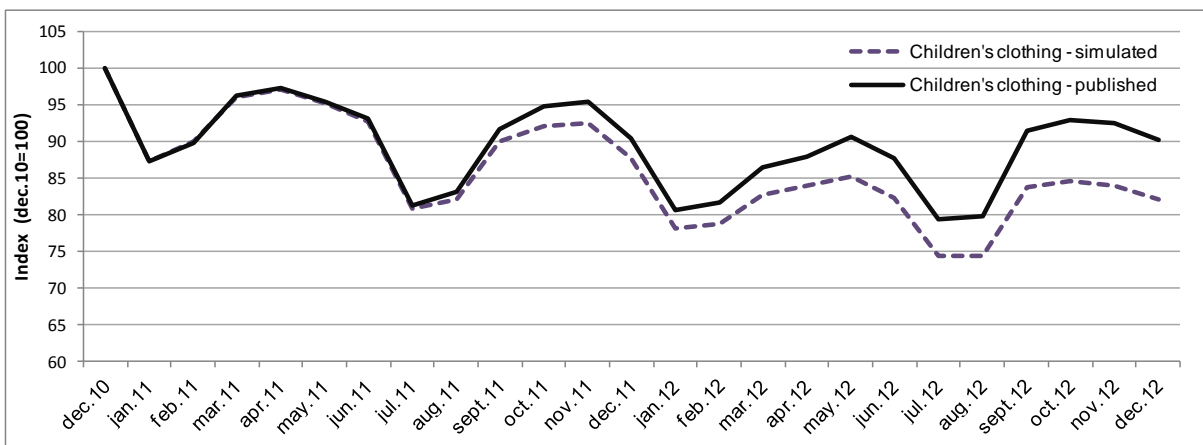
Graph 9 Influence of the use of class mean imputation on the men's clothing index
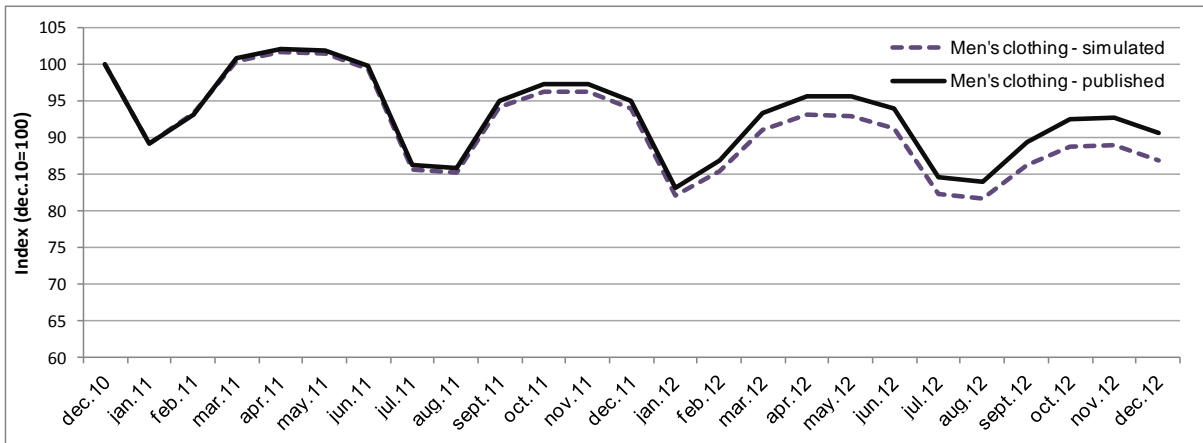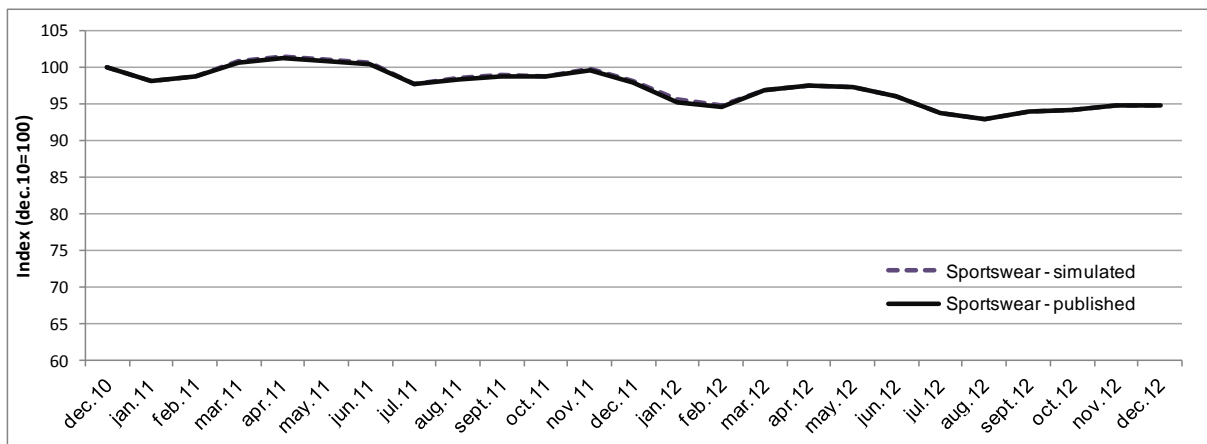

Graph 10   Influence of the use of class mean imputation on the women's clothing index
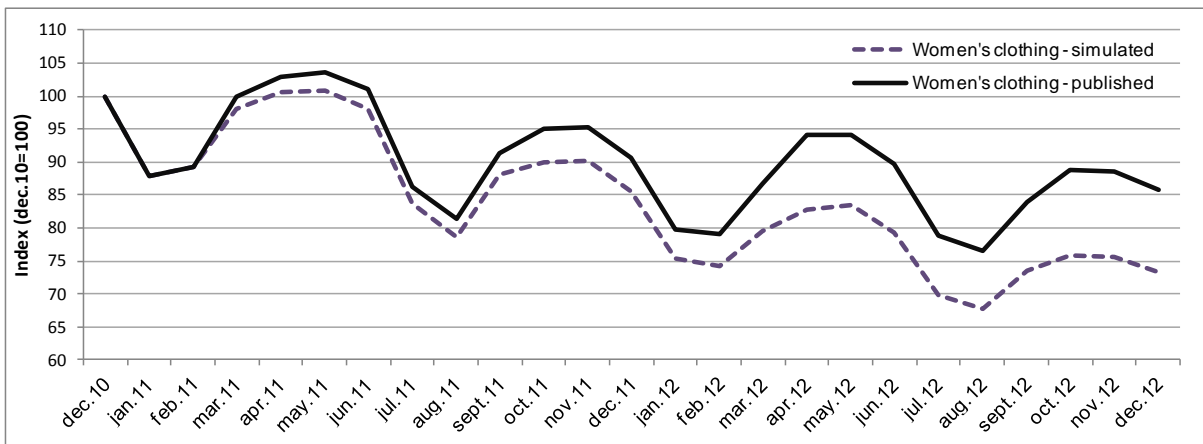
Graph 11   Influence of the use of class mean imputation on the children's clothing index

Graph 12   Influence of the use of class mean imputation on the sportswear index

The above graphs reveal an increase in the level of different indices. Is this always the case and should this method of quality adjustment be considered as leading to an upward bias?

An analysis at entry level shows that, at a detailed level, the effect can go in three directions:

- **Neutral effect**

The use of class mean imputation for quality adjustment can have a neutral effect. Men's woollen sweaters are a perfect example of this. In October 2011, 40% of the sample was replaced. Half of the replacements were made with non-comparable articles which were then imputed with a price change. However, the effect on the indices is almost imperceptible.

Graph 13   Influence of the use of class mean imputation on the men's woollen sweaters index
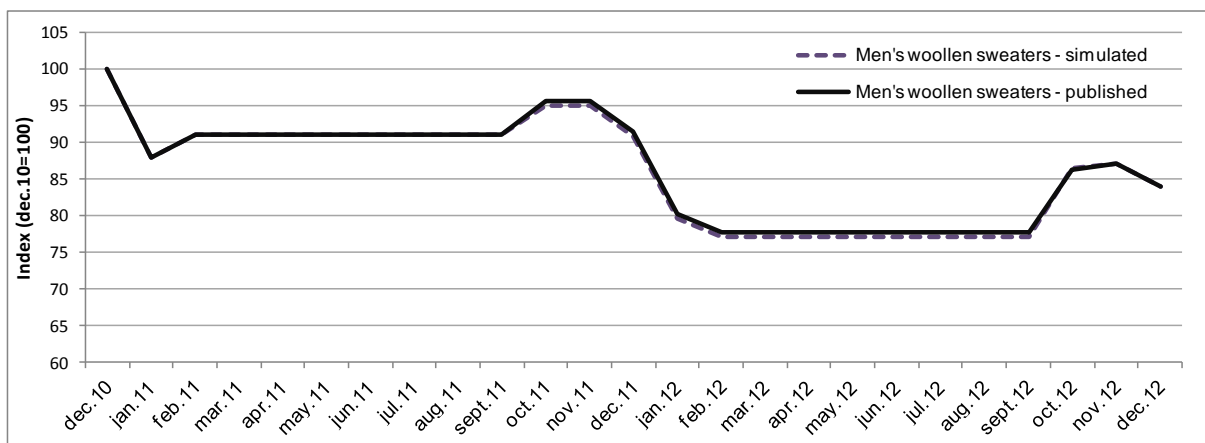
The same applies to men's winter coats. The imputation has no effect other than the deletion of a price series and its replacement by a new price series. Almost a quarter of articles were replaced by imputation in October 2011.
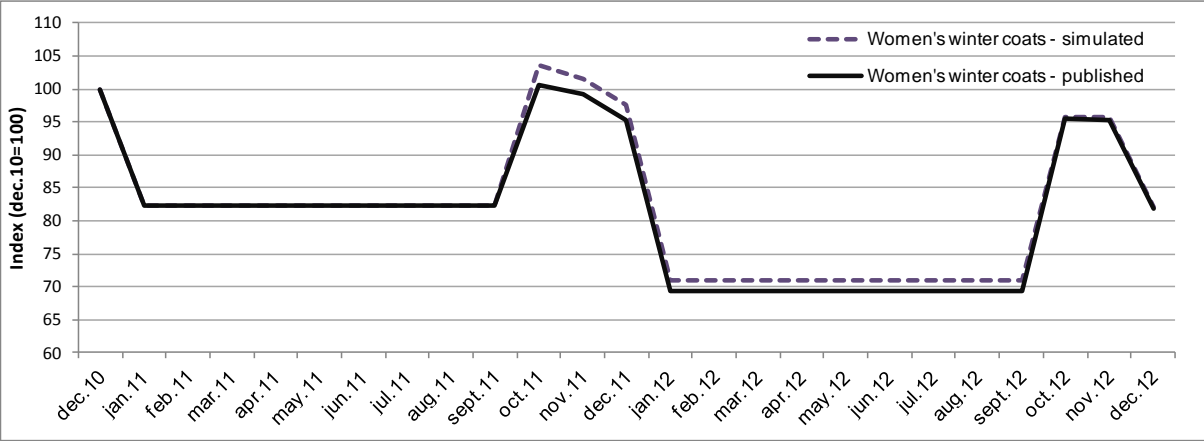
Graph 14   Influence of the use of class mean imputation on the men's winter coats index
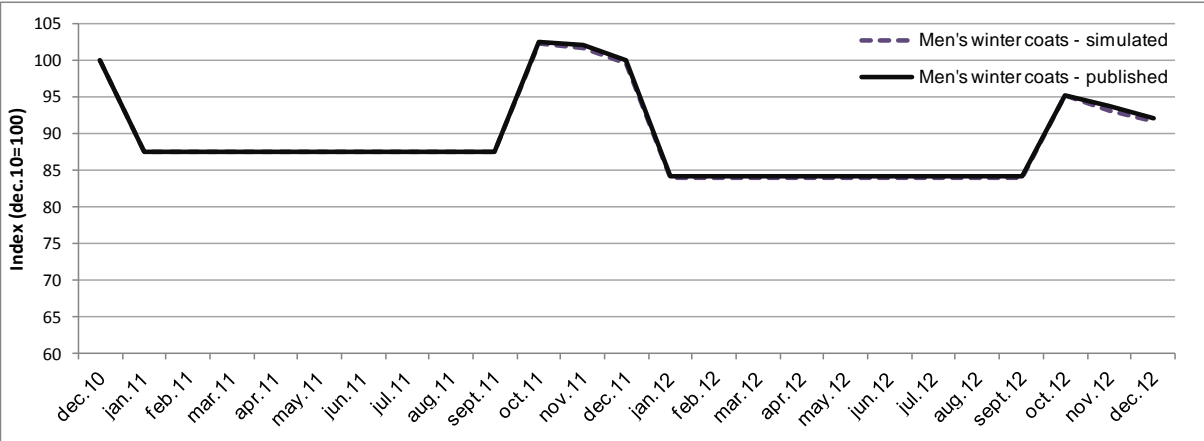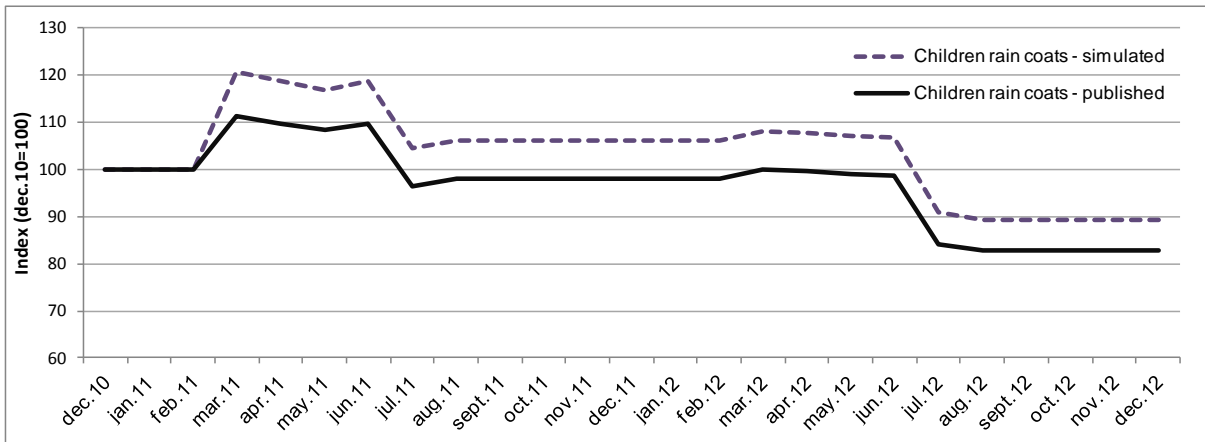

- **Downward effect**

The use of class mean imputation can also have a downward effect. The price increase recorded for women's winter coats is thus lower with quality adjustment than without adjustment. Without quality adjustment, the price increase would have been 21 points between September and October 2011. The use of class mean imputation reduces this increase by 3 points.

Graph 15   Influence of the use of class mean imputation on women's winter coats index

The same effect, but on a much greater scale, can be seen for children's raincoats.
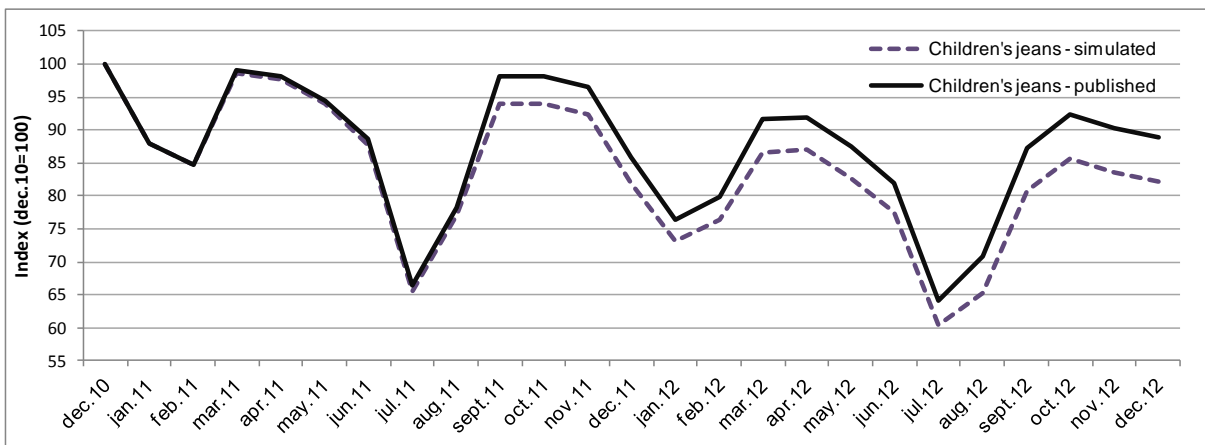
Graph 16   Influence of the use of class mean imputation on children's raincoats index

- **Upward effect**

An upward effect is the one observed most often. This means that in the past, quality differences could have been overestimated overall.
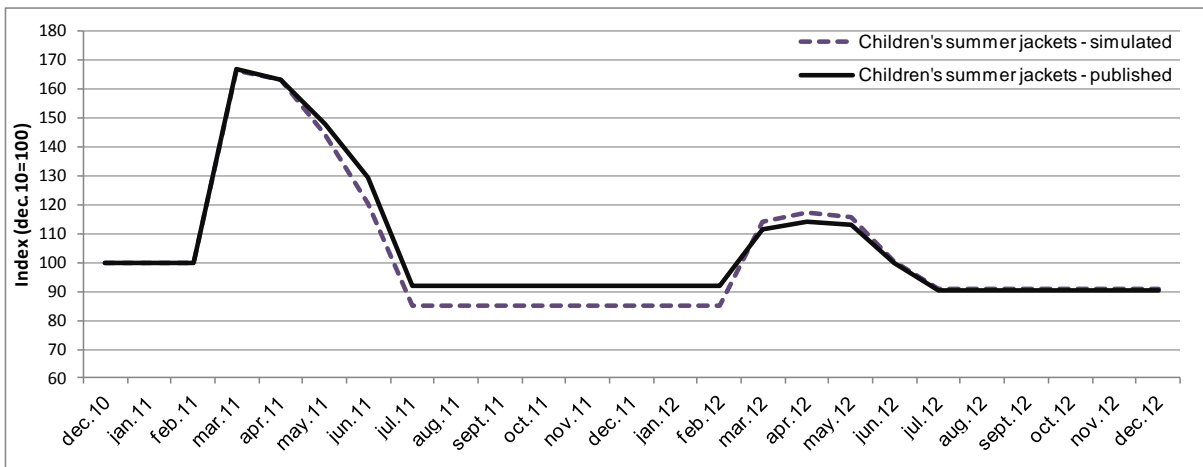
Graph 17   Influence of the use of class mean imputation on children's jeans index

The above graphs show that the effect of class mean imputation can take any direction and not only a downward one as other countries have observed.

Does the effect of class mean imputation on an entry's index always take the same direction over time so that an upward or downward bias can be suspected? The graphs below show that this is not the case either, and that an index influenced in an upward direction can be subject to a downward influence at another time.

Graph 18   Influence of the use of class mean imputation on children's summer jackets index

Graph 19   Influence of the use of class mean imputation on women's summer sweaters index
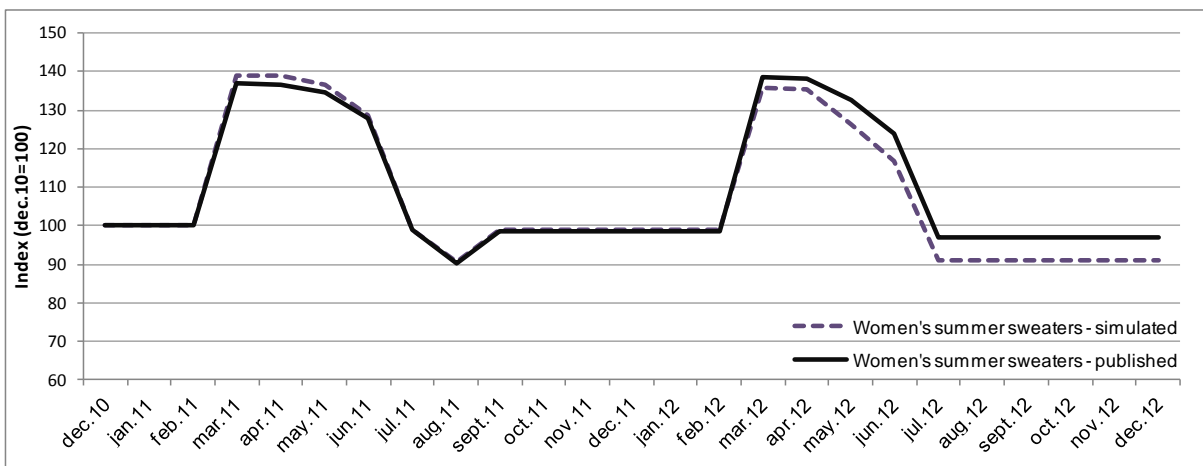
4. Conclusion

In our experience, the introduction of an imputation method should be undertaken with caution. Many decisions may, in fact, have an important influence on trends in the index. In our opinion it is absolutely necessary to be particularly attentive to the following points:

- As shown by the differences in results between the first simulation and in practice, the choice of imputation method and the choice of the imputation basis may lead to indices which develop in totally different ways. It is important to define the imputation method as well as the price changes which will be entered into the imputation basis and those that will be excluded from it. An imputation based on price changes directly at the level of the distribution channels would appear to be the most appropriate method as long as the number of price series is sufficient. This is currently not the case in the Swiss CPI, since our imputation is based on price changes at elementary aggregate level.

- A basket of goods and services that make a distinction between articles available all year round and seasonal articles is essential in order to ensure the consistency of the imputation basis.

- The number of price series in each of the entries must also be sufficient to ensure a consistent imputation basis. In this respect, the most difficult entries are the seasonal ones. Although we increased the number of prices collected and ensured that price collection was concentrated on classic articles, when new collections come out we observe that the number of replacements is very high and that the majority of them are non-comparable ones. In addition we took steps to try and increase the number of replacements by direct comparison and thus to increase the number of prices used for the imputation basis: on the one hand we increased in 2012 and again in 2013 the number of articles collected for each of the seasonal entries and on the other we relaxed the criteria enabling direct comparison of two articles.

- Particular attention must be paid to data collectors training. They must have access to clear rules for each of the price collection months, differentiated by clothing type (seasonal or not). Two years after the introduction of this new system we have noticed that some data collectors are still applying the old price collection rules and that they delete articles when they cannot find a comparable article. This is basically due to the fact that the data collectors carry out many types of price collections for which the old price collection rules are still valid.

- The price collection for articles of clothing demands a great deal of time and commitment. The number of quality criteria for which data must be collected by data collectors must be limited and the necessary information should be easily accessible.

Overall we are generally satisfied with the use of class mean imputation to deal with quality adjustments for articles of clothing. This process has enabled us to achieve the goals we had set

ourselves, i.e. to dispense with quality adjustments on the basis of explicit methods and not to consider price as a criteria for quality. This system has also allowed us to have more control over the quality adjustment process and to ensure adjustments of consistent quality, based on objective criteria. Its introduction has also facilitated the work of data collectors and the FSO staff. However we are aware of improvements that could be made to the system: we are considering the creation of interchangeable clusters of brands of identical quality within the process of quality adjustment, particularly for sportswear[7]. This could lead to more equivalent replacements.

It should also be noted that the simulation of data collection is not easy, whether using a new or old method. The first simulation carried out before the introduction of class mean imputation was extremely simplified because all direct substitutions were removed and replaced by an overall mean imputation. Regarding the second simulation, the old method could only be reconstructed to a very limited extent as there would perhaps have been more direct substitutions if the class mean imputation had not been used. The differences should therefore be interpreted with caution.

However, what we can confirm, and this was the point of the exercise, is that there does not appear to be systematic and significant upward or downward bias. We will ensure that analysis will be continued in the future.

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[7] At the present time, each brand is considered to be of a different quality. For other articles of clothing, given the abundance of brands, the creation of clusters is not possible.