Statistics Denmark,
Prices and Consumption

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Data editing in the Danish CPI

1. Introduction

This paper describes the data editing used in the Danish CPI in the different steps of the production phase. Special emphasis is put on the statistical data editing and the use of the HB-method developed by Hidiroglou-Berthelot.

2. A short description of the data sources in the Danish CPI

Data sources in the CPI

The consumer price index is calculated on the basis of 24,000 prices collected from approx. 1,800 shops, companies and institutions throughout Denmark. For clothing and fresh food etc., prices are collected by price collectors who visit the individual shops. For the remaining groups of goods and services, prices are mainly obtained from the shops via mailed questionnaires with the information requested. In addition, list prices of major grocery chain stores are used. Finally, Statistics Denmark obtains information on prices concerning a number of selected goods and services by telephone or via the Internet.

Most prices are by far collected monthly. For goods and services, where prices typically change less frequently, prices are collected more rarely, for instance quarterly or biannually. The prices are collected monthly during the period from the 7th to the 15th.

3. Data editing in the Danish CPI

4 steps of data editing

Data editing in the Danish CPI can be divided into 4 overall steps:

a) Manual editing of collected prices
b) Controls for consistency and logical errors
c) Statistical data editing
d) Editing of calculated price indices

a. Manual editing of collected prices

When data are entered into the database and statistical calculation system they are manually checked for obvious errors. For instance incompletely filled in questionnaires are dealt with at this step. In some cases implausible price changes are also detected at this step. If necessary the respondent or price collector is contacted by telephone for more information. In general a lot of the errors are identified and eliminated at this manual data editing step.

b. Controls for consistency and logical errors

When all data have been entered into the database the consistency of the data are checked. A program automatically checks whether the calculation of price indices is possible in the database. For instance it is checked whether all product groups contains at least one price match and the weights used in the calculations are controlled so the sum of the weights always equals 1. Other requirements for the successful calculation of indices are also controlled.

Then the following controls are performed and lists with prices not fulfilling the requirements are automatically produced:

- All goods and services are checked for having a price in both last and current period. Goods and services with no price match do not enter the calculations.
- All prices are examined for decimal errors. A potential decimal error is present if the current price equals the last price divided or multiplied by 10 or 100.
- For all respondents it is checked whether at least one reported price has changed in the last 12 months ("inlier" test). If no price has changed it suggest that the respondent is not updating the prices as required.

The prices on the produced lists are checked manually by looking at the questionnaires send in or possibly by contacting the respondent in question.

In annex 1 the procedures for data editing in the Danish CPI are depicted and the different output tables are mentioned.

c. Statistical data editing

When consistency of the data has been ensured all the prices are examined using statistical data editing. This is described in detail below.

d. Editing of calculated price indices

After the statistical editing of all the prices and the correction of identified errors, price indices are calculated. The price indices are then examined manually for unusual changes taking into account seasonal variations etc. The indices are also validated using other sources of information. For instance are the development in price indices on petrol and heating oil checked using other sources and price indices for electronic consumer goods are compared with the development of price indices from neighbouring countries with similar market conditions.

5. Background on the HB-method

Since 2001 the Hidiroglou-Berthelot method, in short the HB-method, has been used for statistical data editing in the compilation of the Danish CPI.

The HB-method

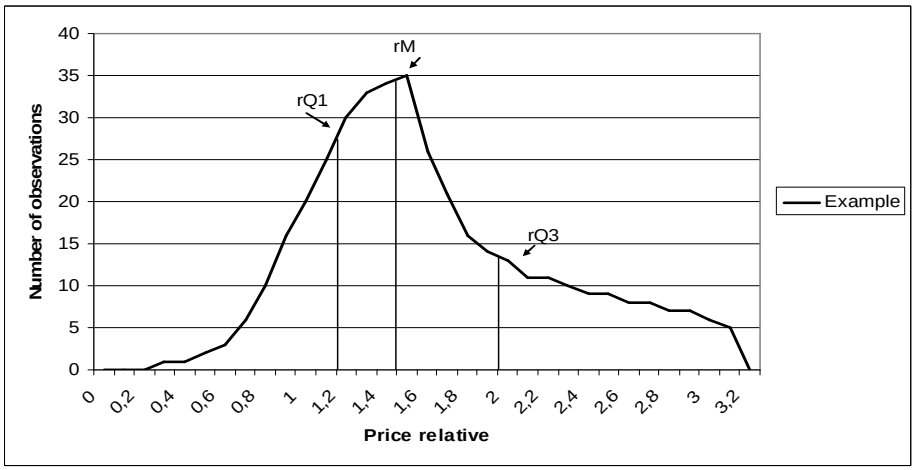
The HB-method defines an acceptance interval where price changes outside the interval are identified as possible errors. It is based on the median and quartiles of the price changes and hence unaffected by extreme observations. If the price changes are normally distributed around the median then the first and third quartiles are equidistant from the median. The principle is that the acceptance interval is constructed as multiples of the distances between the quartiles and the median.

Normal distribution of price changes

If the price changes are not normally (or at least symmetrically) distributed around the median then the acceptance interval will not be symmetrical. This is shown in figure 1 below which shows an example of the distribution of monthly price relatives for some product[1]. The median price relative (rM) is 1.5, the first quartile (rQ1) is 1.2 and the third quartile (rQ3) is 2.0. In this case the acceptance interval will not be symmetrical around the median.

[1] The figure is based on number of price relatives in different intervals (0-0.1, 0.1-0.2 etc.). For clarity a line has been used in the figure instead of columns.

Figure 1. Example on distribution of price relatives.



Suitable for checking price changes

Price changes are known to vary between different product groups and over time. In the HB-method a separate acceptance interval is calculated for each product group and it varies from month to month – depending on the median and quartiles of the product group in the particular month. Outliers, and possible errors, may be large price changes or very small price changes, if prices in general are falling or going up. Taken together, this makes the method particular suitable for price indices.

Applied on month-to-month changes; goods/services with no price change are excluded from the test

The test is applied for the month-to-month changes (but it may also be used on 12-month changes, for example). In practice most prices may not change each month. If for instance more than half the prices in a product group are unchanged then the median and the first and third quartile will coincide and all price changes different from 1 will be identified as outliers. Because of this, the method will identify an unduly high share of the price changes as potential errors. Goods and services with no price change are therefore left out of the test, i.e. only price relatives different from 1 is included. Price relatives, where the preceding price is adjusted, for example because of a quality change, is also included in the test.

6. The HB-method in steps

Step 1

For all goods or services where a price is observed in both the current and preceding month the price relatives are:

$$r_i = \frac{p_i^t}{p_i^{t-1}}$$

Step 2

For each product group the median, r_M, of the price relatives for the goods or services in the group is identified.

$$r_{jM} = \text{Median } [r_{1j}, r_{2j}, r_{3j}, \ldots r_{nj}]$$

If there are n r_{ij}'s and n is an uneven number, then the median equals price relative number $(n+1)/2$. If n is an even number, the median equals the average of price relative number $(n/2)$ and$(n/2 + 1)$.

The product group may be a certain group of relatively homogenous goods or services. In the Danish CPI the test is performed at the "product group" level,

where each elementary aggregate consists of one or more product groups (usually only one). However, it could also be performed at the elementary aggregate level, depending on how narrowly these are defined. The point is that the individual products in the groups are expected to have a similar price movement.

Step 3 To make the calculation of the distance from the centre the same for extreme changes on the low side as well as on the high side, the price relatives are transformed into the variable, s:

$$s_i = \begin{cases} 1 - \dfrac{r_M}{r_i} & \text{for } 0 < r_i < r_M \Rightarrow s_i < 0 \\ \dfrac{r_i}{r_M} - 1 & \text{for } r_{i \geq} r_M \Rightarrow s_i \geq 0 \end{cases}$$

With this transformation a price change from for instance 10 to 100 is just as likely to be identified as an outlier as a price change from 100 to 10 when the median price relative equals 1.

Example on transformation of r_{ij} to s_{ij} where r_{jM} = 1.087:

Product group no.	Last Price	Current price	Price relative r_{ij}	s_{ij}
11131611	3	2.95	0.983	**-0.106**
11131611	3.25	3.5	1.077	-0.009
11131611	3.25	3.5	1.077	-0.009
11131611	3.25	3.5	1.077	-0.009
11131611	3	3.25	1.083	-0.004
11131611	2.75	3	1.091	0.003
11131611	2.5	2.75	1.1	0.012
11131611	3	3.5	1.167	0.073
11131611	1	1.25	1.25	0.149
11131611	1.5	2	1.333	0.226

Example: $0 < r_{ij} < r_{jM}$:

$$s_{ij} = 1 - \frac{r_{jM}}{r_{ij}} = 1 - \frac{1.087}{0.983} = -0.106$$

Step 4 The variable s_i is independent of the price levels. To facilitate that the level of the prices can influence the acceptance interval, s is transformed into a new variable, E:

$$E_i = s_i \cdot \left(\max\left\{p_i^{t-1}, p_i^t\right\}\right)^U, \quad 0 \leq U \leq 1$$

E is calculated as s multiplied by the largest of the prices in period t or t-1, raised to the power U. The variable U determines to what degree the price level influence the acceptance interval. The larger U, the larger the influence of the price level. If U = 0 the price level plays no role. This facility is helpful, if one wishes to pay more attention to a price increase from 100 to 110 than one from 10 to 11.

Example on transformation from s_{ij} til E_{ij}: (U equals 0.4)

Product group no.	Last price	Current price	s_{ij}	E_{ij}
11131611	3	2.95	-0.106	**-0.164**
11131611	3.25	3.5	-0.009	-0.016
11131611	3.25	3.5	-0.009	-0.016
11131611	3.25	3.5	-0.009	-0.016
11131611	3	3.25	-0.004	-0.006
11131611	2.75	3	0.003	0.005
11131611	2.5	2.75	0.012	0.018
11131611	3	3.5	0.073	0.121
11131611	1	1.25	0.149	0.164
11131611	1.5	2	0.226	0.298

Example:

$E_{ij} = s_{ij} * [\text{ Max } (p_{ij,t-1}, p_{ij,t})]^{U} = -0.106 * [\text{Max } (3; 2.95)]^{0.4}$

$= -0.106 * 3^{0.4} = -0.164$

Step 5 For each product group the median, E_M, and first and third quartile, E_{Q1} and E_{Q3}, of the E_i's are found, and the following values calculated:

$d_{Q1} = \text{Max } \{E_M - E_{Q1}, |AE_M|\}$
$d_{Q3} = \text{Max } \{E_{Q3} - E_M, |AE_M|\}$

A is a constant that enters $|AE_M|$ the purpose of which is to ensure a minimum acceptance interval. A low value of A raises the probability that $(E_M - E_{Q1})$ or $(E_{Q3} - E_M)$ determines d_{Q1} or d_{Q3}, and vice versa. If, for instance, A is set to 0.05, $|AE_M|$ will be quite small so that $(E_M - E_{Q1})$ or $(E_{Q3} - E_M)$ are likely to determine d_{Q1} or d_{Q3}, even if the dispersion of the E_i's are relatively small. If, on the other hand, the dispersion of the E_i's becomes very small, $|AE_M|$ determines d_{Q1} and d_{Q3}. Hence, A can be used to avoid that too many price changes are identified as possible errors for product groups with only small price changes.

In the calculation system quartiles for *n* price relatives are calculated as follows:

The first quartile:

$$Q1 = (1- f_{Q1})*r_i + f_{Q1} * r_{i+1} \qquad i = 1, 2, \ldots, n$$

The third quartile:

$$Q3 = (1- f_{Q3})*r_i + f_{Q3} * r_{i+1}$$

Where f_{Q1} + an integer no. *i* in the sequence = $\frac{n-1}{4}+1$

and

f_{Q3} + an integer no. *i* in the sequence = $\frac{3(n-1)}{4}+1$

If for instance *n* equals 10 then the first quartile equals (1 - 0.25) times the price relative number three (in an ordered sequence) plus 0.25 times price relative number four.

Step 6 The acceptance interval is finally defined as

$$\text{Acceptance interval} = \{E_M - C*d_{Q1};\ E_M + C*d_{Q3}\},$$

where ($E_M - C*d_{Q1}$) is the lower bound and ($E_M + C*d_{Q3}$) is the upper bound of the interval. The variable C is an extra handle and it may in principle be assigned any value. The larger C, the larger the acceptance interval, and the fewer extremes and potential errors will be identified.

Currently, the following values for the parameters are used

U = 0,4 (influence of the price level)
A =0,05 (allows a minimum of smaller price changes)
C = 5 (broadness of the acceptance interval)

Simple test for product groups with less than five price changes

Testing has shown that the HB-method becomes unreliable when the number of price relatives in a product group is very low. The HB-method is therefore only applied for those product groups where there are at least five price relatives different from one. For product groups with less than five price relatives different from one, outliers are simply identified as changes above a fixed percentage. At present prices that changes by more than 10 percent are identified as outliers in product groups with less than five price changes.

7. Output of the statistical editing

The program that performs the HB test is integrated in the statistical calculation system and the test is run automatically as part of the compilation process of the monthly CPI. The system produces two tables,

- A table with the HB outliers, which contains all observations identified as possible errors (example attached in annex 2).
- A table showing the impact of the HB outliers (and the 'simple' outliers for product groups with less than five price relatives) on the elementary aggregate indices (example attached in annex 3).

The impact from the outliers on the elementary aggregate indices is calculated as follows:

$$\text{Impact on elementary aggregate} = w_{i,EA} * \frac{p_{i,t} - p_{i,t-1}}{p_{i,t-1}}.$$

$$\text{where} \quad w_{i,EA} = \frac{1}{n} * x * y.$$

n is the number of prices from the outlet in question, *x* is the weight of the outlet in the product group and *y* is the weight of the product group in the elementary aggregate.

The Danish CPI consists of 450 elementary aggregates and each elementary aggregate consists of one or more product groups. In all there are around 700 product groups. Some 24.000 prices enter the monthly index.

On average the table with HB outliers contains around 300 observations. A similar table is produced for the 'simple' outliers which usually contains 160-180 observations. The table which shows the impact of the outliers on average contains around 70 elementary aggregates, where the HB outliers (or the simple outliers) contribute with one per cent or more to the monthly percentage rate of change.

For statistical reasons it may be sufficient to check only those outliers which have a significant impact on the elementary aggregate indices. For the Danish CPI, all outliers which influence the monthly elementary aggregate indices with more than one per cent are checked. However, also extreme outliers are checked, even if they have no significant influence.

8. Use of the HB-method on February 2008 data

February 2008 data in the Danish CPI

In February 2008 22,810 observations in the sample had a price in both the last and the current month. For 17,414 observations the price was unchanged and hence only for 5,396 observations a price change was recorded spread over 431 product groups. For the observations with a recorded price change statistical editing was applied. For 245 product groups there were less than 5 price changes in the sample and for these the simple percentage-method was applied. For 186 product groups there were sufficient price changes to use the HB-method. In terms of prices 4903 prices were edited using the HB-method. The findings are summarized in table 1 below.

Table 1. The data set in February 2008.

No. of matches (total)	**22810**
No. of matches with price change	**5396**
HB-method:	
Product groups	**186**
No. of prices	**4903**
Simple % change test:	
Product groups	**245**
No. of prices	**431**

Errors detected in February 2008 using the HB-method

Using the HB-method in February 2008, 375 outliers was identified when using the parameters U=0.4, C=5 and A=0.05. When manually checking these outliers, 8 errors were found. The errors are shown in table 2 below. Some are typing errors and others concern matching of incomparable products.

An important reason for the relatively few errors found with the HB-method is that the manual checking of observations when entering the prices into the statistical calculation system eliminates a lot of errors.

Table 2. Errors found with the HB-method in February 2008.

Product	COICOP	Price (t-1)	Price (t)	Price relative	Description of error
Beef	01121201	49.90	599.00	12.00	Typing error. Price equals 59.90
Turkey breast	01125301	55.90	106.96	1.91	Price for wrong product used
Cheese	01144302	77.08	123.80	1.61	Price for wrong product used
Potatoes, ecological	01172401	13.33	7.90	0.59	New price not from ecological potatoes
T-shirt	03121901	399.95	40.00	0.10	New product. not comparable
Sweat-shirt	03121901	41.60	149.95	3.60	New product. not comparable
Handkerchief	03130101	50.00	299.00	5.98	Typing error. Price equals 99.95
Belt	03130201	125.00	24.00	0.19	Typing error. Price equals 249.00

Results with different parameter values in the HB-method

The number of outliers identified depends on the parameter values used in the HB-method. This was examined in February 2008 and the results are summarized in table 3 below. When C (broadness of the acceptance interval) is set to 1 around half the observations are identified as outliers. This is no surprise as the acceptance interval is then defined by the first and third quartile. All 8 errors are found using C=1 and no other errors were found in the many outliers. When C is large (=100) the acceptance interval is very broad and very few observations are marked as outliers. The result is that most of the 8 errors are not identified.

When C equals 5 the number of identified outliers decreases significantly and all 8 errors are still found when U=0.4 (influence of the price level). When U equals 0.1 approximately the same number of outliers are identified, but only 6 of the 8 errors are found. When U equals 1 more outliers are identified but not all errors are found. It therefore seems beneficial to let the acceptance interval depend on the price level, but only to some extent.

It is seen in table 3 that for small A's (allows a minimum of smaller price changes) there is no influence. In other words the acceptance interval is defined by the distance between the median and the quartiles.

Table 3. No. of outliers using different parameter values. February 2008.

U	C	A	No. of outliers	No. of identified errors
0.1	1	0.05	2399	8
0.1	1	0.2	2399	8
0.1	5	0.05	370	6
0.1	5	0.2	370	6
0.1	100	0.05	20	0
0.1	100	0.2	20	0
0.4	1	0.05	2396	8
0.4	1	0.2	2396	8
0.4	**5**	**0.05**	**375**	**8**
0.4	5	0.2	375	8
0.4	100	0.05	21	0
0.4	100	0.2	21	0
1	1	0.05	2393	8
1	1	0.2	2393	8
1	5	0.05	454	7
1	5	0.2	454	7
1	100	0.05	19	1
1	100	0.2	19	1

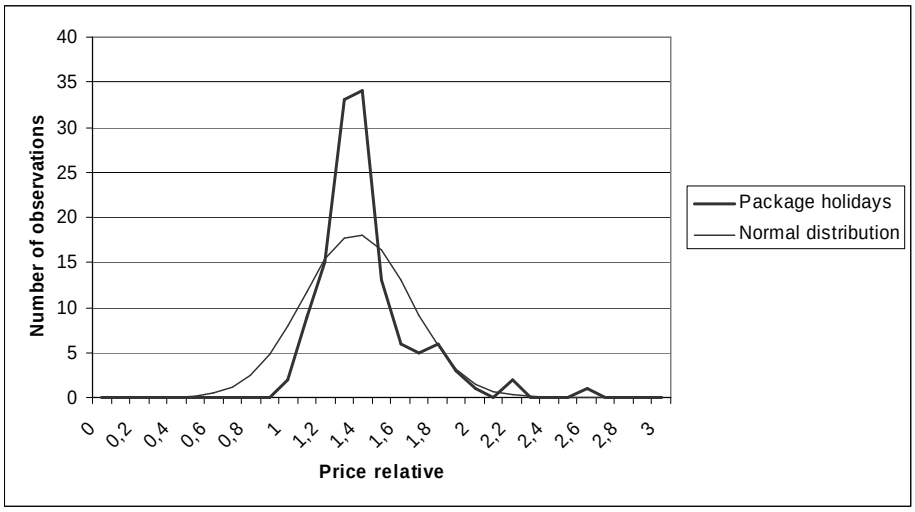
Checking the distribution of price relatives in February 2008

In principle a normal distribution (or at least a symmetrical distribution) should hold for every product group examined with the HB-method if the acceptance interval should be symmetrical on the median. As an example this is tested for the product group with most price changes in February 2008 which is package holidays, where there were 130 price changes. In practise this has been done by grouping the price relatives in intervals of size 0.1 (0-0.1, 0.1-0.2 etc.) and then comparing with a normal distribution. This is seen in figure 2 below where the distribution is compared with a normal distribution with the best fit in terms of a chi-square test[2]

It appears that the distribution for package holidays is not normally distributed. Too many price relatives are centred on the median of 1.4 and somewhat of a tail are seen to the right. The distribution does therefore not even seem symmetrical. The chi-square test with 25 degrees of freedom confirms the non-normality of the distribution. The test statistic gives 61.1 and the resulting probability of normality is only 0.00007.

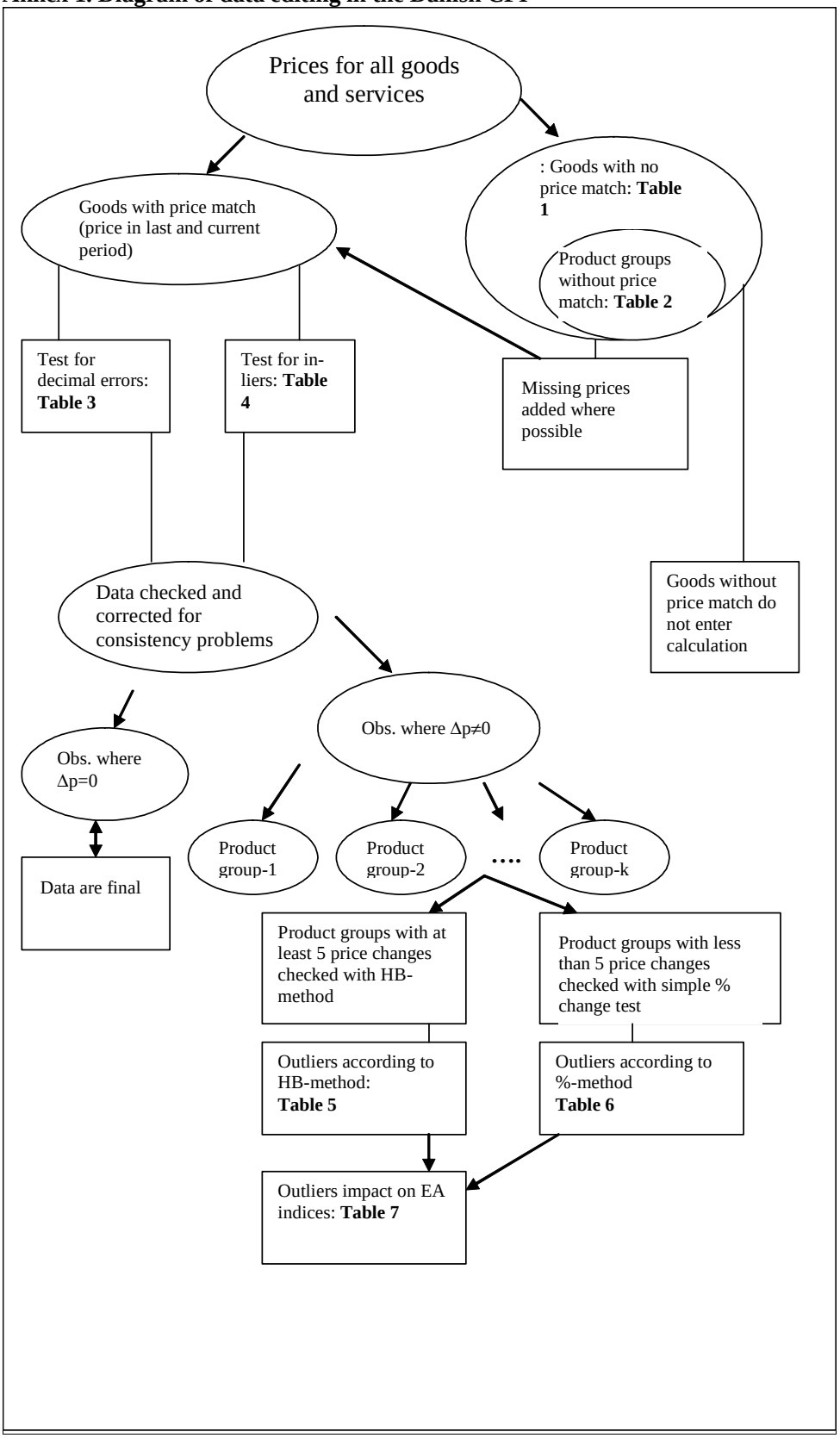
In case of package holidays the acceptance interval is therefore not symmetrical on the median, but even in this case the HB-method should be helpful in identifying potential errors.

Figure 2. Distribution of price relatives for package holidays. February 2008.



[2] a line has been used in the figure instead of columns for clarity

Annex 1. Diagram of data editing in the Danish CPI



Annex 2. HB outliers. February 2008

Outlet code	Product description	Product group code	Preceding price	Current price	Price change in %
612	Rullemadras:	5200601	165,00	329,00	99,39
2001	Partner EJ 70/alcantara	5113301	12500,00	16503,00	32,02
1898	Garant, Berlin	5120001	79,00	50,00	-36,71
1304	Herretrusser	3122001	59,00	99,00	67,80
1741	Livrem af læder: H&M	3130201	125,00	24,00	-80,80
2303	Vinterbukser: Zara	3121501	149,00	449,00	201,34
769	Slips: Emanuelle Georgio	3130301	99,00	399,00	303,03
2286	Habit uden vest: Baümler	3121301	2499,00	1499,00	-40,02
2286	Halstørklæde: Citta di Milano	3130101	199,00	99,00	-50,25
2286	Slips: Kenzo	3130301	499,00	399,00	-20,04
2297	Vinterfrakke: Phillip	3121101	1600,00	800,00	-50,00
2297	Vinterskindjakke: Pierre Cardin	3121201	3500,00	1750,00	-50,00
2297	Herreundertrøje: JBS	3122001	100,00	120,00	20,00
3239	Vinterbukser: Sunwill	3121501	500,00	400,00	-20,00
3239	Halstørklæde: Morgan	3130101	300,00	100,00	-66,67
2454	Vinterfrakke: Sand	3121101	3500,00	1750,00	-50,00
3432	Vinterbukser: Batistini	3121501	249,50	150,00	-39,88
3317	Vintervindjakke: Gant	3121102	2999,00	1499,00	-50,02
3317	Skjorte,bomuld/polyester: Gant	3121801	499,00	399,00	-20,04
3317	Vinterpullover: Gant	3122201	499,00	399,00	-20,04
3319	Slips: Manfield	3130301	99,95	79,95	-20,01
3324	Herretrusser: Armarni	3122001	59,15	169,00	185,71
3324	Herreundertrøje: Armarni	3122001	154,00	220,00	42,86
3326	Vintervindjakke: Bison	3121102	500,00	1499,00	199,80
3335	Vinterbukser: Meyer	3121501	600,00	300,00	-50,00
3335	Blazer/Jakke: Lawrence	3121701	1000,00	300,00	-70,00
3335	Skindhandsker: Garant	3130201	300,00	100,00	-66,67
3343	Sommerbukser: Northfield	3121501	166,30	149,95	-9,83
3343	Vinterpullover: Filati	3122201	20,00	149,95	649,75
2191	Vinterfrakke: PBO	3121101	2000,00	1000,00	-50,00
3356	Vintervindjakke: S-4	3121102	1300,00	500,00	-61,54
3356	Vinterskindjakke: Garant	3121201	1500,00	600,00	-60,00
3375	Vinterbukser: Meyer	3121501	500,00	350,00	-30,00
3383	Vinterpullover: Tommy Hilfiger	3122201	599,00	299,50	-50,00
3383	Halstørklæde: Mr.	3130101	299,00	149,50	-50,00
3384	Sommerbukser: Gant	3121501	893,13	800,00	-10,43
3384	Herretrusser: JBS	3122001	89,00	90,00	1,12
3384	Herreundertrøje: JBS	3122001	89,00	90,00	1,12
3392	T-shirt, bomuld/polyester: Red/Green	3121901	399,95	40,00	-90,00

Annex 3. Effect of outliers on monthly elementary aggregate indices. February 2008

Outlet code	Product description	El. agg. code	Elementary aggregate name	Product group code	Preceding price	Current price	Price change in %	Effect on monthly EA index in %
2178	Vinterskindjakke: Morgan	31212	Herrejakke, skind	3121201	1500,00	600,00	-60,00	-1,07
483	Strikkepinde, nr. 3: Pony	56122	Søm	5612201	20,00	26,00	30,00	1,07
612	Overdyne. Cambric vår, kvadratsyet stoppet medgåsedun, 135 x 200 cm.	52002	Dyne, dynetæppe	5200201	250,00	448,00	79,20	2,20
679	Frottehåndklæde, Str. 50 x 100 cm Håndklædet	52004	Håndklæde	5200401	79,95	47,95	-40,03	-2,50
230	Damestøvler, enkel model: Marco Tozzi	32124	Støvler, sandaler	3212401	199,00	299,00	50,25	1,01
587	Thermokande, forchromet, ca. 1 l. Emsa	54032	Termokande	5403201	459,00	299,00	-34,86	-1,12
2467	Margrethe-skål, 3 liter	54033	Opvaskebalje	5430301	109,00	149,00	36,70	1,15
1669	Upotonda	53104	El-emhætte	5310401	995,00	2499,00	151,16	3,36
1669	Electrolux EMM 2000	53132	Microbølgeovn	5313201	999,00	599,00	-40,04	-1,43
759	Deodorant til herrer, Hugo Boss	121310	Deodoranter	12131001	150,00	99,00	-34,00	-3,78
760	Deodorant spray til damer, Lagerfeld Chloe	121310	Deodoranter	12131001	99,00	195,00	96,97	5,39
775	After shave, Armani	121307	After shave	12130701	345,00	385,00	11,59	1,29
1129	Diesel	72203	Dieselolie	7220301	7,02	7,34	4,56	1,05
1	Sennep	11922	Sennep	1192201	8,95	9,95	11,17	1,56
1	Flåede tomater, dåse	11751	Grønkonserves på dåse	1175105	2,75	2,25	-18,18	-1,25
1	Bordsalt med jod, fint	11911	Salt	1191101	3,95	2,75	-30,38	-4,25
109	Salatdressing, Kraft	11925	Salatdressing	1192501	16,95	19,95	17,70	1,06
109	Rejer,frosne - Greenland, vnr. 35443	11339	Rejer	1133901	23,96	16,65	-30,51	-1,83
118	Vanillesukker, Tørsleff nr. 10	11913	Vanillesukker	1191301	11,95	14,95	25,10	1,32
118	Tændstikker, Tordenskjold Std.æsker	56126	Tændstikker	5612601	7,50	8,95	19,33	1,22
2547	MÅNEDENS BOG: Der er tillevering/betaling i den aktuelle periode.	95102	Bogklub	9510201	199,00	179,00	-10,05	-3,35
2548	MÅNEDENS BOG: Der er tillevering/betaling i den aktuelle periode.	95102	Bogklub	9510201	149,00	179,00	20,13	6,71

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