ORGANISATION DE COOPÉRATION ET DE DÉVELOPPEMENT ÉCONOMIQUES
OECD OCDE
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

SEMINAR

Inflation Measures: Too High - Too Low - Internationally Comparable? Paris, 21-22 June 2005

7. Quality Adjustment with and without Hedonic Regression

Comparability of Approaches for Quality Adjustment for PCs

Paul Haschka
(Statistics Austria)

OECD Seminar, June 2005

Paul Haschka

Quality Adjustment with and without Hedonic Regression [1])

(Paper to be presented at the OECD Seminar in Paris 21-22 June 2005:
Inflation measures: too high – too low – internationally comparable)

Abstract

The paper compares approaches to with and without hedonic regression. The areas treated are:

- Potential similarities and differences in the treatment of 'simple' product groups like food
- For clothing as a difficult and problematic area for comparability an important study by Martin Ribe (2002) is used to justify conclusions

In both areas the hedonic regression results can be approximated with results of other methods. The advantage of the hedonic regression is that it gives a scientifically justified result. Simplified approaches might then use the most important results of the regression. In general a preference for explicit quality adjustment methods seems justified.

1. Introduction

There are three main types of quality adjustment procedure. The following distinction has been made both in the harmonisation work for the HICP system, and in the CPI Resolution of ILO (2003) and the International CPI Manual published by ILO et al. (2004):

- Direct comparison, where no quality change is observed and no adjustment is made.
- 'Explicit' (or 'direct') methods, which assess the value of the quality change between the replaced and the replacing model based on observed changes in characteristics of the models. Pure price change is estimated as the difference in the accordingly adjusted prices.
- 'Implicit' (or 'indirect') methods, which assess the pure price change between the replaced and the replacing model based on price changes observed for similar models. The difference between the estimate of pure price change and the observed price change is considered as change due to quality difference. The most important group of implicit methods is called bridged overlap. Monthly chaining and replenishment is a specific variant of bridged overlap.

Alternatively, explicit methods could be described as 'component-wise' methods, and implicit methods as 'holistic' methods. Namely, the explicit methods trace components of quality change by examining the characteristics of the models, while the implicit methods assess the quality change as a whole from price differences.

The table below is derived from the Austrian CPI/HICP system. The distinction is made between operational procedures rather than between major and minor changes in product specification. The replacement rate is the average number of replacements divided by the sample size in a category.

[1]) The author wishes to thank Mrs A. Beisteiner and Mrs. H. Schimak for their contributions and comments to this paper.

The re-sampling rate is defined analogously (e.g. as the number of new product offers in the sample divided by the sample size) but is 0 in this simplified Austrian case.

Table 1: Replacement in selected COICOP classes in the Austrian CPI/HICP 2004

	Price collection and QA statistics and kind of QA procedure	CPI/HICP Overall Index	01.1 Food	09.1.3 Data Proc. Equipment	07.1.1 Cars	03.1 Clothing
12N	Number of price observations per year	482.427	151.597	420	1.512	65.891
12#	Number of changes per year	13.444	2.445	86	93	4.730
N	Number of price series per month	40.202	12.633	35	126	5.491
#	Average number of changes per month	1.120	204	7	8	394
%	*Percent changes = replacement rate*	***2,79***	***1,61***	***8,33***	***6,15***	***7,18***
	of which (% of all changes):	**100**	**100**	**100**	**100**	**100**
Q4	Full price change is assessed as quality change	***6,4***	*2,3*	*2,3*	*5,4*	*4,1*
Qx QZ	Part of the price change is due to quality change	***21,7***	*13,5*	*54,7*	*78,5*	*12,8*
Q0	Price and quality move in different directions	***7,9***	*0,4*	*Incl. above*	*Incl. above*	*10,4*
S	Essentially equivalent, no quality change, full price change	***55,5***	*74,1*	*31,4*	*16,1*	*66,9*
Wx	Major outlet change, full or part of price difference is equal to quality change	***1,5***	*0,0*	*0,0*	*0,0*	*1,8*
W0	Small outlet change, essentially equivalent	***7,0***	*9,7*	*0,0*	*0,0*	*4,0*

2. Different quality adjustment approaches for ‘simple goods’ like food

Food is often seen as a very simple example in the case of quality adjustment. It is hard to find any references in the international CPI literature about quality adjustment for such ‘simple goods’. The present approach therefore can only mark a starting point to the approach.

As an example for what might happen on the micro level the following charts are taken from a study ba Timo Koskimäki (2003) (in Haschka et al. (2004)). It stems from another ‘simple good’ – scanner data for washing detergents of the same brand but different variety – but can be used to show the effect and potential differences of potential quality adjustment. The prices have been adjusted by package size but nothing else.

If the old and the new variety are directly compared with each other the time of the changeover does not have a big impact on the long term HICP. If however, any kind of overlap, bridged overlap or other implicit method is used then the development of the index depends strongly on the time point in which the adjustment is made. But this point in time can be determined in many different ways: It could either be the first time when the turnover of the new variety overtakes that of the old one or when the turnover of the old variety is lower than a certain threshold or when it disappears for the first time. All these possibilities will give a very different result for an implicit method but hardly matters for direct comparison. Also for a potential hedonic model the time

point of the calculation will matter significantly and therefore coefficients might not be stable where different stages of the market cycle are compared.

Diagrams 1 and 2: Weekly turnover and prices for old and new varieties of clothes washing liquid
QA with linking methods at different points in time will give very different results.

Diagram 1: Variety changeower - value of sales - clothes washing liquid

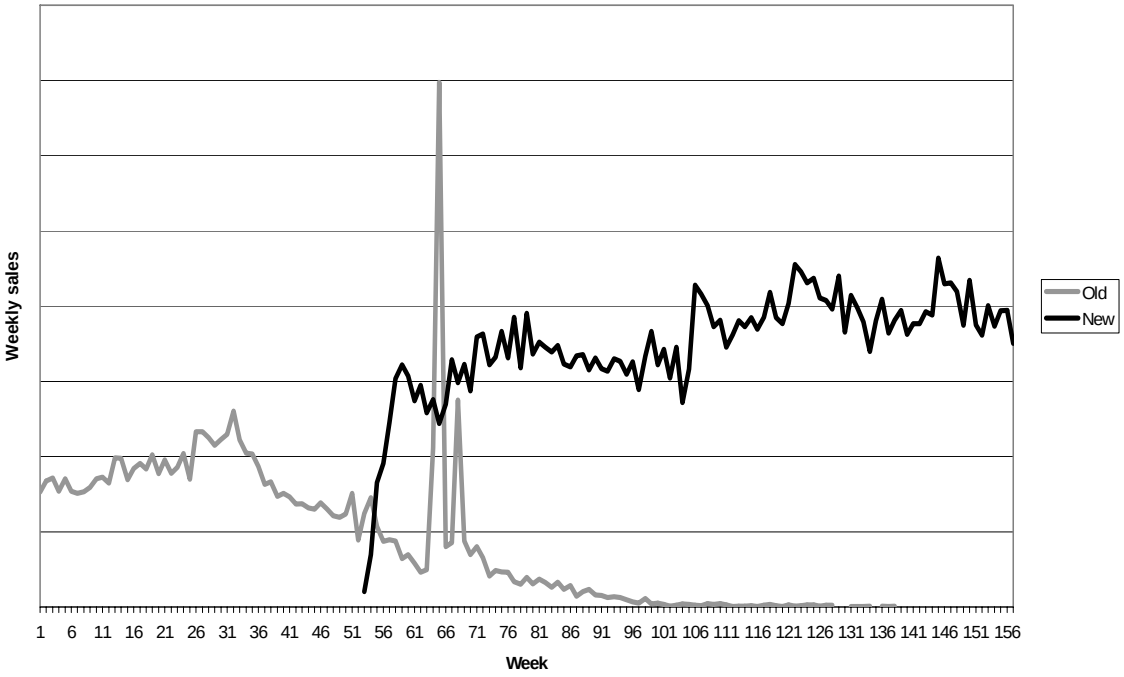
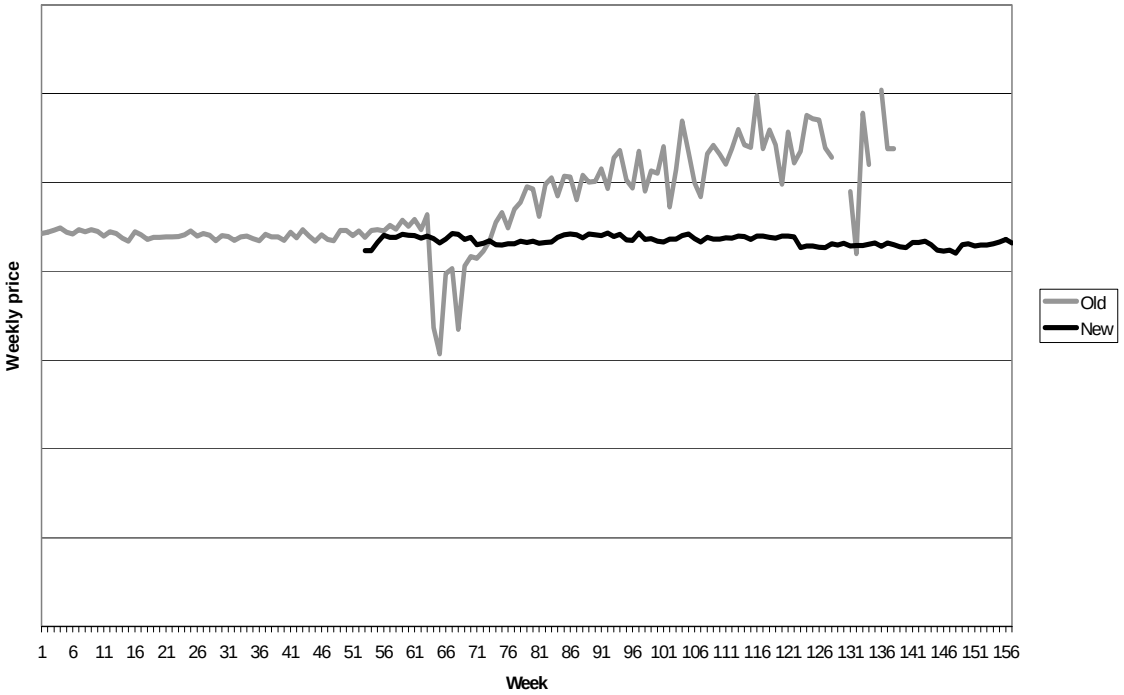


Diagram 2: Variety changeower - prices - clothes washing liquid



Hedonic models for food products

In order to try the relatively modern hedonic approach for the most traditional area of price statistics six products have been selected from the Austrian CPI/HICP data. The selection was made according to the availability of different explaining variables and to the variation of package sizes in the data. For food the maximum package size allowed for the Austrian CPI sample is typically two to three times lower than the maximum package size allowed. So very small and very large packages are initially excluded from price collection in order to allow for the standard procedure which is linear quantity adjustment within these borders.

It has to be admitted that this is only a small sample (there are more than 100 goods for food in the Austrian CPI) and therefore the results can only serve as an initial findings and preliminary conclusions. For every good there are almost 100 price observations, all of which were used in the regression and it was not checked whether all specification as reported from the price collectors were correct.

Generally it turned out that the most important variables were the brand dummy ("Marke", 1 for well known quality brand, 0 for other brands and unknown). The quantity (package size in grams, "Menge" in German) was also significant in many cases, but together not more than half of the variance is explained by the regression. A slight improvement of the regression model (in terms of R^2) can be achieved where the dependent variable is already calculated as price per unit. In this case a linear relation between price and quantity is already built into the model.

Results

In these models package size and brand together give results with R^2 between 40% and 70%. Improved models where the linear relationship is assumed (dependent variable is price per quantity) give higher results for R^2. Another important variable is the brand dummy (1 for well known brand, 0 for brands known as cheap). But it is hard to find a variable other than these two which has an impact. For the regression models in Annex 2 the 'upward procedure' was used. Marke and Menge were always among the variables included in the first three steps.

This leads to the conclusion that one main important variable is the quantity or package size. This is also where broad or narrow product definitions might matter. A narrow product definition for a product might determine the brand and variety and also the package size. A broader definition on the other hand does not define brand and variety and allows more freedom with the package size.

Where product definitions are narrow a general danger of loss of representativity has to be considered while broader definitions require the ability to make adequate quality adjustment procedures.

The decision whether a move to a somewhat bigger package at a somewhat lower price is a reduction in price or in quality cannot a priori be devoted to a regression model. Instead it might be useful to define borders for the package size within which the utility can be compared in a linear relation. If there is either a general move of the supply or of the demand to slightly larger package sizes at cheaper prices per unit then this can be regarded as price decrease.

In the case of simple goods the assumption of a linear relation between quantity and price is either a result when 'menge' is an important variable or the relation is ex ante included in the model. The results suggest that if 'menge' and the other important variable 'marke' (brand) are included in the quality adjustment procedures these might be 'sufficiently similar' to hedonic regression.

For the request of international comparison implicit methods might suffer from the fact that their result depends strongly from the point of time at which they are applied. If applied too late the predecessor and the successor are in very different stages of their market cycle and bias in any direction might occur.

3. Clothing as a particularly difficult area for comparability

The area of clothing is well known as a particularly difficult area for price collection and quality adjustment (see e.g. Eurostat 2002c). Several difficulties coincide and have a considerable impact, one might even say that all difficulties which make price statisticians' life hard occur jointly:

- The prices of similar product offers have high variability in different shops and between different brands
- There is an important seasonal pattern in supply according to climate
- There is also a seasonal pattern in prices, sales at the end of a season and higher prices when a new fashion is brought on the market
- There is another seasonal pattern in demand, possibly in line with the price movement
- The price and of a product offer might vary considerably throughout a year
- Some product offers are not always available

The variation among the 25 EU countries in the in the results of COICOP group 03.1 (clothing) is considerable large in the annual average and still larger in specific months. In table 4 the standard deviation is compared with that of division 05. (Furniture and goods and services for routine maintenance of the household) a category of similar size and but without much seasonality and without many sale situations.

Table 2: Annual rate of change of COIOCP 03.1 Clothing in the 25 EU MS

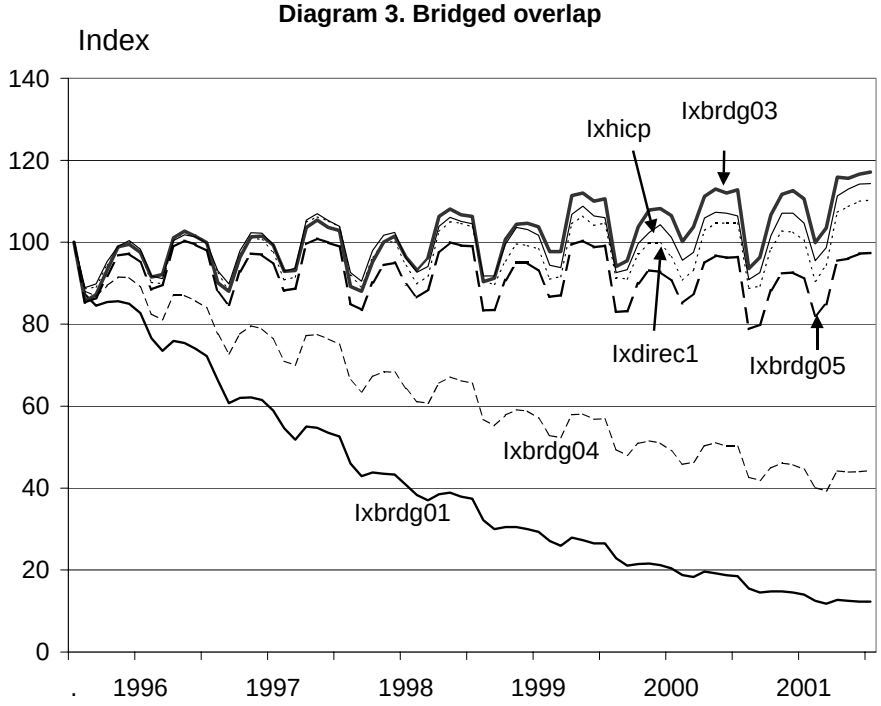
	Simple average	Standard deviation	Standard deviation of 05. Household equipment
2001	0,1	3,1	2,1
2002	0,4	3,2	1,9
2003	0,0	3,1	1,6
2004	-0,4	2,3	1,6
2005 (April)	-0,8	2,5	1,7

In the 2002 HICP Research report (paper 4a by Martin Ribe in Haschka et al. (2002)) as many as 20 different methods for QA methods are compared, most of them variants of bridged overlap. These quality adjustment methods are applied to Swedish price data for 1995-2001. The results indicate that a more or less substantial downward trend bias in the price index is often hard to avoid for imputation and overlap methods when these use actual prices only. A primary possibility to avoid the bias for e.g. bridged overlap is to use regular rather than actual prices for the bridging but this entails conceptual difficulties too. In any case in the application of bridged overlap a wide range of completely different results can be achieved with similar variants of the same method. Therefore if applied in different countries small differences in the application might lead to very high differences in the results.

To provide an example for these findings diagram 3 from that study is reproduced below. The many variants of methods all called 'bridged overlap' and their widespread results show the potentially high variation. For this reason the method bridged overlap might be called unstable,

because the results can vary a lot depending on the details of its application. The trend in the index series is mostly seen either to go more or less dramatically downward (the specific danger of clothing and other goods which are subject to sales) or to lie rather flat on a constant level or possibly go slightly upward.

Diagram 3. Bridged overlap



EXPLANATIONS - Ixdirect = Direct comparison within year, linked between years
Ixbrdg01 = Bridged overlap and sales correction
Ixbrdg03 = Bridged overlap from regular prices, and sales correction
Ixbrdg04 = Bridged overlap for changed brand/origin, + sales correction
Ixbrdg05 = Bridged overlap from reg. prices for changed brand/origin, + sales correction
Ixhicp = Regular Swedish method - hedonic adjustment and sales correction

The study continues to mention several findings, among which there are the following three:

- As expected monthly chaining from actual prices performs very badly, with a dramatic downward trend which obviously cannot be true. This should not surprise as this method is for well-known reasons unsuitable for clothing. The main reason is the newness quality factor affecting fashion clothing and the mechanic application of an automatic overlapping procedure, which tends to accumulate the price drops of models into the index

- For bridged overlap it matters much how it is applied. If bridged overlap based on actual prices is used indiscriminately (Ixbrdg01), a dramatic downward trend again occurs. The trend is still dramatic, even if notably less so, if the bridged overlap is used only for changes of brand/origin (Ixbrdg04), or for large price changes (Ixbrdg06, not in the diagram).

- However if the bridging is based on regular and not actual prices, the picture becomes different (Ixbrdg03). Then the trend becomes nearly flat, and the series evolves just slightly above that for direct comparison with sales corrected chaining (Ixdirec1). The conceptual question entailed is whether and how a ‘regular’ price can be clearly identified.

It can therefore again be observed that for all implicit methods the exact point in time is of utmost importance, the point in time at which the replacement and quality adjustment is performed. The use of regular prices in the chart above is equivalent to moving the replacement back in time. The price movement between the last observation of the regular price and the replacement is then difficult to interpret and the notion of a regular price relates to a concept which is difficult to observe. Where regular prices are not used the application of any kind of bridged overlap leads to serious downward bias. The Swedish method of sales correction – although perhaps sophisticated and only applied in few countries – is obviously not sufficient to avoid the downward bias which would occur through the application of bridged overlap methods.

One of the difficulties of comparability of the implicit methods is again founded in the details of the point in time of the replacement. The use of direct comparison and hedonic regression is therefore recommendable for international comparisons. The very limited use of implicit methods might complement the use of direct comparison in countries in which no hedonic model is available.

Conclusions

The initial question of the paper is whether and where different quality adjustment methods as applied in different countries may lead to comparable results. Tentative conclusions would read as follows:

For food hedonic regression does not give convincing results, R^2 ranging only between 40 and 70%. R^2 can be increased where the dependent variable is price per quantity. Much more than 70% is difficult to obtain.

In the case of simple goods the assumption of a linear relation between quantity and price is either a result when ‘Menge’ is an important variable or the relation is ex ante included in the model. The results suggest that if ‘Menge’ and the other important variable ‘marke’ (brand) are included in the quality adjustment procedures these might be ‘sufficiently similar’ to a hedonic regression.

For clothing the use of implicit methods can lead to serious downward bias. In Sweden the results of the hedonic regression were similar t the application of direct comparison. This well known result has again been shown by Ribe (2002). The detailed point in time at which the replacement is made matters most.

As brand class is the most important variable in the Swedish regression models for clothing it might also be sufficient to use brand class for quality adjustment as a proxy for the complete model.

For the **comparison of the application of methods** the effects of replacement and re-sampling can be measured with the replacement rate and the re-sampling rate, respectively. Where these are calculated consistently the replacement rate and the re-sampling rate together describe the newness of the respective part of the market in a country.

More research on this might be relatively easy because many countries collect many prices for food products. Simplified models seem promising.

References

Eurostat (1996). Explanatory memorandum to the Statistical Programme Committee meeting in Brussels on 15 March 1996, Document CPS 96/20/2 DE

Eurostat (1998). Report from the Commission to the Council on Harmonisation of Consumer Price Indices in the European Union, COM(1998) 104 final, Brussels, 27. 02. 1998

Eurostat (2002b), HICP concepts. The foundation of the HICP, HCPI 02/408-rev., Meeting of the Working Party HICP, July 2002.

Eurostat (2002c), Final report from Task Force on QAS, HCPI 02/428, Meeting of the Working Party HICP, September 2002.

Eurostat (2003), The HICP as an Index defined on fixed user purposes, HCPI 03/446, Meeting of the Working Party HICP, March 2003.

Haschka, P. (2003), Simple Methods of Explicit QA for Services in Complex Pricing Schemes; Paper presented at the 7th meeting of the Ottawa Group on Price statistics in May 2003; available at: http://www.ottawagroup.org/search/document.asp?link=07/QA%20for%20Services%20-%20Haschka%20(2003).pdf

Haschka, P., Beisteiner, A., Dalen, J., Gluchowska, A., Koskimäki, T., Ribe, M., Schimak, H., Sellwood, D., (2002). HICP Research. Quality Adjustment, Sampling, Aggregation Level Missing Prices, Newly Significant Goods, Seasonality, Harmonisation of Sub-Indices. Final Report 2002 on behalf of Eurostat.

Haschka, P., Beisteiner, A., Dalen, J., Koskimäki, T., Ribe, M., Schimak, H., Sellwood, D., (2004). HICP Research. Quality Adjustment, Sampling, Aggregation Level Missing Prices, Newly Significant Goods, Seasonality, Harmonisation of Sub-Indices. Final Report 2003 (amended) on behalf of Eurostat.

ILO/IMF/OECD/UNECE/Eurostat/The World Bank (2004), Consumer price index manual: Theory and practice, Geneva: International Labour Office, available on www.ilo.org , http://www.ilo.org/public/english/bureau/stat/guides/cpi/index.htm.

Koskimäki, T. (2003), Paper 4c in Haschka et al. (2004)

Ribe, M. (2002), Paper 4a in Haschka et al. (2002)

Schultze, C. & Mackie, C., (Eds.) (2001). At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes, Panel on Cost-of-Living Indexes, Committee on National Statistics, National Research Council, Washington DC: National Academy Press.

Annex 2: Results of Regression for food products

The following examples relate to six food products. The prices are taken from standard HICP price collection in April 2005. The products have been selected according to relatively high variation of package sizes within a range of about 1 to 2 or 1 to 3 (minimum to maximum package size).

Example 1: Where regression seems to work

Regression: Full model for salted peanuts (115 observations used data from April 2005) (Linear model)

Wurzel MSE	0.22348	R-Quadrat	0.7923
Abhängiger Mittelwert	1.47957	Korr. R-Qu.	0.7877
Koeff.var	15.10409		

Parameterschätzwerte

Variable	Etikett	Freiheitsgrade	Parameterschätzer	Standardfehler	t-Wert	Pr > |t|
Konstante	Konstante	1	0.20590	0.07238	2.84	0.0055
Menge	Menge	1	0.00304	0.00017965	16.90	<.0001
Marke	Marke	1	0.63482	0.04887	12.99	<.0001

(Semilog model, same data)

Wurzel MSE	0.17470	R-Quadrat	0.7354
Abhängiger Mittelwert	0.33823	Korr. R-Qu.	0.7296
Koeff.var	51.65081		

Parameterschätzwerte

Variable	Etikett	Freiheitsgrade	Parameterschätzer	Standardfehler	t-Wert	Pr > |t|
Konstante	Konstante	1	-0.50996	0.05658	-9.01	<.0001
Menge	Menge	1	0.00201	0.00014044	14.28	<.0001
Marke	Marke	1	0.43304	0.03821	11.33	<.0001

Examples 2 and 3: Where regression does not perform well (in terms of R^2)

The models for red cabbage and whole grain bread have coefficients with the expected signs but have relatively little explanatory power

Full linear model for frozen red cabbage (92 observations, R^2=42%, HICP data, April 2005)

Parameterschätzwerte						
Variable	Etikett	Freiheits-grade	Parameter-schätzer	Standard-fehler	t-Wert	Pr > |t|
Konstante	Konstante	1	0.19862	0.25114	0.79	0.4311
MENGE	MENGE	1	0.00238	0.00043226	5.50	<.0001
Marke	Marke	1	0.68493	0.10203	6.71	<.0001

As above but without constant term

Parameterschätzwerte						
Variable	Etikett	Freiheits-grade	Parameter-schätzer	Standard-fehler	t-Wert	Pr > |t|
MENGE	MENGE	1	0.00270	0.00015915	16.95	<.0001
Marke	Marke	1	0.72106	0.09104	7.92	<.0001

Full linear model for whole grain bread (115 observations, R^2=45%, HICP data, April 2005)

Variable	Parameter-schätzer	Standard-fehler	Typ II SS	F-Statistik	Pr > F
Konstante	1.08088	0.22229	8.50259	23.64	<.0001
MENGE	0.00185	0.00028148	15.58510	43.34	<.0001
Marke	0.26758	0.13142	1.49072	4.15	0.0442
OPTIONB	-0.68784	0.28716	2.06329	5.74	0.0183
OPTIOND	-0.37216	0.21077	1.12115	3.12	0.0802

Option B: Packed (as opposed to open and freshly made)
Option D: sliced

Examples 4 and 5: Poor results for the regression for frozen pizza and eggs.

Relatively small R^2 and very small coefficients for Menge give results which differ significantly from expectations and from common sense.

Semilog model for frozen pizza (96 observations, R^2=46%, HICP data from April 2005)

Parameterschätzwerte						
Variable	Etikett	Freiheits-grade	Parameter-schätzer	Standard-fehler	t-Wert	Pr > |t|
Konstante	Konstante	1	0.62574	0.04298	14.56	<.0001
Menge	Menge	1	0.00054806	0.00010475	5.23	<.0001
No brand	No brand	1	-0.43079	0.05893	-7.31	<.0001

Semilog model for eggs (154 observations, R^2=42%, HICP data from April 2005)

Variable	Parameter-schätzer	Standard-fehler	Typ II SS	F-Statistik	Pr > F
Konstante	-0.01530	0.11687	0.00110	0.02	0.8960
MENGE	0.02813	0.01184	0.36124	5.64	0.0188
Marke	0.16624	0.05237	0.64480	10.08	0.0018
Freiland	0.43083	0.04774	5.21179	81.44	<.0001
Boden	0.22168	0.05795	0.93636	14.63	0.0002
XL	0.05656	0.05939	0.05805	0.91	0.3424

- Menge: Quantity (6 or 10 eggs)
- Marke: 1 for well known brand
- Freiland: ecological eggs from chicken kept outdoor
- Boden: eggs from chicken kept in halls on the floor (as opposed to cages)
- XL: extra large eggs

Improved semilog model for eggs, the dependent variable is the Log of the price per 10 eggs (154 observations, R^2=67%, HICP data from April 2005)

Variable	Parameter-schätzer	Standard-fehler	Typ II SS	F-Statistik	Pr > F
Konstante	1.26176	0.11687	7.45939	116.56	<.0001
MENGE	-0.09958	0.01184	4.52675	70.74	<.0001
Marke	0.16624	0.05237	0.64480	10.08	0.0018
Freiland	0.43083	0.04774	5.21179	81.44	<.0001
Boden	0.22168	0.05795	0.93636	14.63	0.0002
XL	0.05656	0.05939	0.05805	0.91	0.3424

Example 6: Unsuitable model for muesli.

The failure of the regression is obvious, the reason might be due to bad price collection or to the selection of the wrong variables. However, these variables were initially selected for comparison of price observations. The variables are those which are visible on the package (Quantity, brand certain additions). An improvement can be found if prices are defined per package size.

Regression: Full linear model for muesli (85 observations, R^2=6%, HICP data, April 2005)

Variable	Parameter-schätzer	Standard-fehler	Typ II SS	F-Statistik	Pr > F
Konstante	0.60676	0.14495	1.57934	17.52	<.0001
MENGE	0.00020406	0.00020902	0.08590	0.95	0.3315
OPTIONA	-0.08406	0.06423	0.15438	1.71	0.1939
Marke	0.13741	0.08857	0.21692	2.41	0.1243

- Menge: Package size in grams
- Marke: 1 for well known brand
- Option A: Crunchy muesli

OECD Seminar, June 2005

Paul Haschka

Comparability of Approaches for Quality Adjustment for PCs [2])

(Paper to be presented at the OECD Seminar in Paris 21-22 June 2005:
Inflation measures: too high – too low – internationally comparable)

Abstract

The paper compares approaches to quality adjustment within the EU and with a view to US. Starting from a definition of comparable quality adjustment it is investigated where difficulties and problem areas might occur. In addition there is also provided an overview of data from EU countries. This selection at this stage relates to the use of hedonic regression and similar methods and their effects for PCs.

This background seems important to know for an approach to compare sampling and quality adjustment systems in different countries. It might be used in future design of questionnaires and comparison surveys among EU or OECD countries. The replacement rate, the rate of direct comparisons and the rate of re-sampled observations are among the important variables for classification of the approach of a country. These figures do not only tell facts about the CPI procedures in a country but also about the market circumstances.

1. What is Quality Adjustment and why is it needed?

Quality adjustment is needed to make price indices show pure price changes, not unduly disturbed by the quality changes in goods and services. In other words, the quality-adjusted index shall show the price changes that the goods and services would have had if their quality was unchanged over time. The Annex to this chapter describes various methods for quality adjustment.

The Consumer Price Index compares the price levels of goods and services at different points in time. Prices for a "basket" of products are collected every month. These prices are compared to prices that were collected at an earlier point in time for *the "same" products*. From the prices compared over time the price statisticians can compute the average price change. The average relative price change over one year is published as the inflation rate.

In price collection the "same" model or product variety can turn out to be discontinued in the market. One or more other models have taken its place on the shelf in the shop, or its place in the market. It becomes necessary to select a replacement model for the price collection. The price and the features of the selected replacement model have to be compared to those of the previous model.

This is where *quality adjustment* comes in. First, criteria of comparability are necessary to decide whether the observed price is for the "same" model or product variety as before. When that is not

[2]) The author wishes to thank Mrs A. Beisteiner and Mrs. H. Schimak for their contributions and comments to this paper.

so, the prices have to be adjusted before use in the index. The adjustment has to eliminate the effect of the change in product quality that may occur in the replacement. By this adjustment the prices can still be treated as if the models in the basket were the "same" over time.

Making these adjustments for quality change is conceptually and practically a difficult task. Various methods can be used but care needs to be taken about the potential non-comparability between different methods of QA.

In all countries there is a level of aggregation above which the components of the index basket remain fixed for at least one year. Below that level changes of models or varieties are allowed through QA, or direct comparison where changes are small. Recently Eurostat has initiated a discussion on plans to harmonise this level, with the notion of "basic purpose" or "(basic) consumption segment".

Typically, such replacements do not occur "often", and only a small proportion of the prices collected each month may require QA. But over a year or more, this proportion can build up, and so the adjustment procedures may have a notable impact on the total inflation rate. Also, the proportion of replacements that need QA will vary between different parts of the basket. For example, quality changes are important for high-tech goods, where new features are continuously being developed. It has to be noted that quality changes can also occur in services, although this is usually more difficult to adjust for.

There are three main types of quality adjustment procedure. The following distinction has been made both in the harmonisation work for the HICP system, and in the CPI Resolution of ILO (2003) and the International CPI Manual published by ILO et al. (2004):

- Direct comparison, where no quality change is observed and no adjustment is made.
- 'Explicit' (or 'direct') methods, which assess the value of the quality change between the replaced and the replacing model based on observed changes in characteristics of the models. Pure price change is estimated as the difference in the accordingly adjusted prices.
- 'Implicit' (or 'indirect') methods, which assess the pure price change between the replaced and the replacing model based on price changes observed for similar models. The difference between the estimate of pure price change and the observed price change is considered as change due to quality difference.

Alternatively, explicit methods could be described as 'component-wise' methods, and implicit methods as 'holistic' methods. Namely, the explicit methods trace components of quality change by examining the characteristics of the models, while the implicit methods assess the quality change as a whole from price differences.

2. HICP Regulation context

The HICP Regulation rules for quality adjustment are given in Commission Regulation (EC) No 1749/96. Article 2 (c, d and h) gives the following definitions.

> *'Quality change' occurs whenever the Member State judges that a change in specification has resulted in a significant difference in utility to the consumer between a new variety or model of a good or service and a good or service previously selected for pricing in the HICP for which it is substituted. A quality change does not arise when there is a comprehensive revision of the HICP sample.*

'Quality adjustment' is the procedure of making an allowance for a quality change by increasing or decreasing the observed current or reference prices by a factor or an amount equivalent to the value of that quality change.

'Replacement price' is an observed price for a good or service which is taken as a direct substitute for a good or service the price of which was in the target sample.

In the same Regulation, Article 5 states the following minimum standards for the procedures of quality adjustment.

1. HICPs for which appropriate quality adjustments are made shall be deemed to be comparable. Where quality changes occur, Member States shall construct price indices by making appropriate quality adjustments based on explicit estimates of the value of the quality change. In the absence of national estimates, Member States shall use estimates based on information provided by the Commission (Eurostat) where these are available and relevant.

2. Where no estimates are available, price changes shall be estimated as the difference between the price of the selected substitute and that of the item it has replaced. In no case should a quality change be estimated as the whole of the difference in price between the two items, unless this can be justified as an appropriate estimate. Where replacements have to be made after goods or services have been offered at reduced prices, those replacements should be selected according to their similarity of utility to the consumer and not according to similarity of price.

The HICP regulation from the year 1996 has a certain preference for explicit quality adjustment methods but does not determine which method shall actually be used. This is more closely specified in several HICP standards which are currently under discussion.

From the HICP Regulation text two simple messages can be derived

- Only a replacement can trigger a quality change
- Quality adjustment procedures shall be based on the value of the quality change

The original intention of the regulation was to encourage the use of explicit methods and to make countries not too often apply the 'all or nothing' method as Eurostat (1996) put it, many countries at that time used either full price difference equals quality difference or entirely equivalent.

An evaluation of the application of this regulation requires a table like mentioned below. Such a table is produced annually for the documentation of methodology. For the comparison of replacement and quality adjustment procedures mainly the replacement rate is the important figure. This figure tells us how many cases turn up in the monthly average and how many cases of QA are performed. The replacement rate has to be combined with the re-sampling rate (which was 0 in the Austrian case) in order to give full information about the newness of the sample. Where sampling and replacement follow the same principles these figure describe the innovation on the market.

The additional information which can be derived from the replacement rate is the internal change of the markets during the year, particularly in the case of clothing. Thus for countries with similar

climate again the markets can be compared.

Table 1: Replacement in selected COICOP classes in the Austrian CPI/HICP 2004
The table below is derived from the Austrian CPI/HICP system. The distinction is made between operational procedures rather than between major and minor changes in product specification.

	Price collection and QA statistics and kind of QA procedure	CPI/HICP Overall Index	01.1 Food	09.1.3 Data Proc. Equipment	07.1.1 Cars	03.1 Clothing
12N	Number of price observations per year	482.427	151.597	420	1.512	65.891
12#	Number of changes per year	13.444	2.445	86	93	4.730
N	Number of price series per month	40.202	12.633	35	126	5.491
#	Average number of changes per month	1.120	204	7	8	394
%	*Percent changes = replacement rate*	***2,79***	***1,61***	***8,33***	***6,15***	***7,18***
	of which (% of all changes):	**100**	**100**	**100**	**100**	**100**
Q4	Full price change is assessed as quality change	***6,4***	*2,3*	*2,3*	*5,4*	*4,1*
Qx QZ	Part of the price change is due to quality change	***21,7***	*13,5*	*54,7*	*78,5*	*12,8*
Q0	Price and quality move in different directions	***7,9***	*0,4*	*Incl. above*	*Incl. above*	*10,4*
S	Essentially equivalent, no quality change, full price change	***55,5***	*74,1*	*31,4*	*16,1*	*66,9*
Wx	Major outlet change, full or part of price difference is equal to quality change	***1,5***	*0,0*	*0,0*	*0,0*	*1,8*
W0	Small outlet change, essentially equivalent	***7,0***	*9,7*	*0,0*	*0,0*	*4,0*

The replacement rate is the average number of replacements divided by the sample size in a category. The re-sampling rate is defined analogously but is 0 in this simplified Austrian case.

A comprehensive overview about available quality adjustment methods is given in the annex to this paper. This annex is taken from a draft of the forthcoming HICP manual and was originally written by Martin Ribe and Paul Haschka. It might be used as a starting point for questionnaires and a methodological data base for EU or OECD countries.

3. The effects of different quality adjustment methods for PCs

For the test and comparison of different methods for quality adjustment in numerous studies PCs are taken as an example, first because there is obvious rapid change of both quality and prices. Second one might assume that the markets are relatively similar in many countries as PCs are traded internationally and demand and supply is similar in developed countries. And third it is relatively easy to derive a regression model for PCs where independent variables are easily available and closely related to quality.

For these reasons the results of COICOP class 09.1.3 which contains data processing equipment were taken for a comparison of different methods.

Different methods used in EU in COICOP class 09.1.3 and results

Dalen (in Haschka et al. (2002)) has made an inquiry about the QA methods used for PCs. The questionnaire was addressed to the 15 EU countries at that time and in addition to these also four other European countries[3]) with PCs in their HICP answered deliberately. From these 19 countries the majority used only or mainly implicit methods for quality adjustment for PCs. Only Austria, Germany, Hungary and UK had a significant majority of QA cases where explicit methods have been applied, and Lithuania applying explicit and implicit methods at approximately the same share.

From HICP data published in NewCronos, it is in a second step attempted to compare the effects of the use of these different methods. The unweighted standard deviation was compiled for 25 EU countries and for subsets of countries.

Table 2: Inflation rates and standard deviation of 09.1.3 Data processing equipment

Standard deviation of inflation rates	**2005***	**2004**	**2003**	**2002****	**2001**
Countries which use mainly explicit methods	4,5%	3,7%	2,1%	8,1%	0,8%
Countries which use mainly implicit methods	7,5%	7,7%	9,4%	8,4%	9,4%
All 25 EU countries	5,8%	6,3%	7,4%	6,8%	8,3%
Unweighted mean of inflation rates	**2005***	**2004**	**2003**	**2002****	**2001**
Countries which use mainly explicit methods	-15%	-14%	-20%	-16%	-22%
Range (for countries which use explicit methods)	LT:-9% UK:-20%	LT: -11% UK:-21%	HU: -17% UK:-23%	HU: -4% AT:-26%	UK:-21% AT:-23%
Countries which use mainly implicit methods	-14%	-13%	-14%	-13%	-13%
US CPI for computer equipment	-16%	-14%	-18%	-22%	-30%
All 25 EU countries	-14%	-14%	-15%	-13%	-13%

* 2005 only Month April

** Comments to Hungary and Austria see text below

- Countries which use mainly explicit methods are Germany (from 2002), Lithuania (from 2002), Hungary (from 2002), Austria and UK.
- Countries which use mainly implicit methods are Belgium, Denmark, Germany (until 2001), Greece, France, Ireland, Italy, Portugal, Slovenia, Finland and Sweden.
- The other countries either use only direct comparison or did not respond in 2002.

The explicit methods used in the five countries mentioned above were mostly option price adjustment in four countries and hedonic regression adjustment in Germany. A recent study by Linz (2004) has shown that option cost and hedonics are close together in the case of PCs .

[3]) Hungary, Lithuania, Norway and Slovenia. - Bulgaria and Romania are not mentioned here because they did not collect prices for PCs at that time.

The implicit methods used were mainly overlap, bridged overlap and monthly chaining and replenishment which all give similar results if applied similarly, but can also differ largely as Ribe has shown for clothing (see below).

From that table quite interesting results can be derived. The standard deviation of the annual rate of change in the subgroup 09.1.3 is always except in 2002 much smaller for those countries which use explicit methods. This is even the case despite the fact that two of these five countries are new member States where one might assume a different market situation from the "old" EU. There has also not been any co-ordination between the calculations of PC price indices between these countries and despite they claimed that four countries used the option price method one can assume that the method was applied differently. In Austria the application of the option price method was improved in 2002 when the option prices used turned out to be outdated (and it is a strength of this method that such imprecision can be detected. In Hungary 2002 was the first year when prices for PCs have been collected. In Germany hedonic regression is used for QA since mid 2002. Their price index is always at or very close to the average of these five countries.

For those countries which use implicit methods the standard deviation between countries is much larger than the standard deviation between countries which use explicit methods but also larger than between all 25 Member States. This is an important fact: Although all these 10 (in 2001: 11) countries claim that they use methods which have the same name and which can be proved that they give very similar results when they are applied to the same data set, in practice the results for different samples in these countries vary surprisingly much. The highest inflation rates and lowest inflation rates having always a difference of 20 percentage points and more and the standard deviation being two or three times larger than for those countries which use explicit methods. Differences in the markets of these countries are not likely to be in this size.

The reason for the high variability between countries which apply more or less the same method can at least partially be explained with micro circumstances which refer to very specific details of the application of implicit methods. Such circumstances (how long to wait before replacements, how popular models are and whether sales are included) are very difficult to describe and to harmonise. It depends also on the number of observed variables and whether only well sold models are observed or all available models. All these variants are difficult to handle without detailed knowledge and make the results difficult for international comparison.

Supplement: Car price development and different quality adjustment methods

For cars (class 07.1.1) similar observations as for PCs can be made. Five countries are known to perform option cost methods extensively or in the case of Finland a form of hedonic adjustment. The variation of the price indices for cars in these five countries is mostly much lower than the variation in the other EU countries.

However the evidence is weaker in this area because there is not enough documentation about which methods are applied how frequently. In addition, all countries where explicit methods are used are relatively rich countries in the "old" EU, so the market development might be different from the average in this case.

Table 3: Standard deviation of inflation rates of 07.1.1 Passenger cars

Standard deviation of inflation rates	2005*	2004	2003	2002	2001
Countries which use mainly explicit methods	1,0%	1,5%	2,2%	1,3%	2,6%
All other countries from EU-25	4,6%	4,4%	3,6%	2,9%	1,8%

All 25 EU countries	4,0%	4,0%	3,4%	2,6%	2,2%

*2005 only Month April

- Countries which (as known to the author) use mainly explicit methods are Germany, UK, Sweden, Finland and Austria.

4. Conclusions

The initial question of the paper is whether and where different quality adjustment methods as applied in different countries may lead to comparable results. This has been investigated with a view to the results of the annual HICP of COICOP class 09.1.3.

For PCs and PC equipment the comparison of EU data has shown an interesting development of the EU average which is very parallel for countries which use explicit and implicit quality adjustment methods. The 'risk' for deviation from the EU average is much higher for countries which use implicit methods. There is therefore reasonable evidence that explicit methods if applied appropriately give comparable results even if the detailed circumstances of their application are not harmonised.

This evidence depends on the assumption that the market development within the EU has already converged to some extent. This assumption can be justified since markets are competitive in the area of data processing equipment and there are no national barriers.

Option prices for PCs tend to give very similar results as hedonic regression even when there is no co-ordination between the countries. Countries which use implicit methods including monthly chaining and replenishment might also be close to that in some cases but might also arrive at quite different results in other cases.

In addition the use of explicit methods makes it possible to discover mistakes or lack of precision. A potential mistake is the use of wrong prices for the options in the case of option price method. Potential mistakes for implicit methods (e.g. the wrong timing of the replacement) are much more difficult to detect.

For international comparison the replacement rate gives the potential number of cases where quality adjustment might be applied. This number gives also an idea about the behaviour of the market if the CPI sample is seen as a picture of the market. In addition the re-sampling rate (e.g. the number of new product offers in a sample in relation to the sample size) gives information on how much newness is introduced in CPIs during a review of the sample.

The number of cases of quality adjustment and of direct comparison (as no adjustment for quality), respectively are a supplement for this information. It would be easier to calculate such information than other more difficult information about the aggregated effects of the quality adjustment.

References

Eurostat (1996). Explanatory memorandum to the Statistical Programme Committee meeting in Brussels on 15 March 1996, Document CPS 96/20/2 DE

Eurostat (1998). Report from the Commission to the Council on Harmonisation of Consumer Price Indices in the European Union, COM(1998) 104 final, Brussels, 27. 02. 1998

Eurostat (2001), Methods used for the Quality Adjustment of cars, HCPI 01/363, Meeting of the Working Party HICP, September 2001.

Eurostat (2002a), HICP Compendium 2001, Meeting of the HICP Working Party, February 2002

Eurostat (2002b), HICP concepts. The foundation of the HICP, HCPI 02/408-rev., Meeting of the Working Party HICP, July 2002.

Eurostat (2002c), Action 4: Classification of QA methods on a case by case basis — Final reports from Task Force on QAS, WP-HICP Meeting October 2002, Document HCPI 02/428, Parts A-E.

Haschka, P. (2003), Simple Methods of Explicit QA for Services in Complex Pricing Schemes; Paper presented at the 7th meeting of the Ottawa Group on Price statistics in May 2003; available at: http://www.ottawagroup.org/search/document.asp?link=07/QA%20for%20Services%20-%20Haschka%20(2003).pdf

Haschka, P., Beisteiner, A., Dalen, J., Gluchowska, A., Koskimäki, T., Ribe, M., Schimak, H., Sellwood, D., (2002). HICP Research. Quality Adjustment, Sampling, Aggregation Level Missing Prices, Newly Significant Goods, Seasonality, Harmonisation of Sub-Indices. Final Report 2002 on behalf of Eurostat.

Haschka, P., Beisteiner, A., Dalen, J., Koskimäki, T., Ribe, M., Schimak, H., Sellwood, D., (2004). HICP Research. Quality Adjustment, Sampling, Aggregation Level Missing Prices, Newly Significant Goods, Seasonality, Harmonisation of Sub-Indices. Final Report 2003 on behalf of Eurostat.

ILO/IMF/OECD/UNECE/Eurostat/The World Bank (2004), Consumer price index manual: Theory and practice, Geneva: International Labour Office, available on www.ilo.org , http://www.ilo.org/public/english/bureau/stat/guides/cpi/index.htm.

Linz, S. Lebenshaltungskostenindex für Computer, contribution to a workshop, , available at http://www.statistik.at/fachbereich_02/workshop/computerindex.pdf in Vienna in October 2004

Schultze, C. & Mackie, C., (Eds.) (2001). At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes, Panel on Cost-of-Living Indexes, Committee on National Statistics, National Research Council, Washington DC: National Academy Press.

Annex: Quality adjustment Methods
(from the forthcoming HICP manual)

No adjustment for quality:

- **Direct Price Comparison** means that the value of the quality change is assessed as zero.

‘

Explicit’ methods:

- **Package Size Adjustment** means that the value of a change in package size, as a proportion of the price, is assessed as the relative change in package size.
- **Single-Variable Adjustment** means that the value of the quality change between a replaced and a replacing model, as a proportion of the price, is assessed as the relative change in a given function of one particular characteristic of the models.
- **Option Pricing** means that the value of the quality change between a replaced and a replacing model is assessed as some fixed proportion of the market price of features by which the two models differ.
- **Production-Cost Adjustment** means that the value of the quality change between a replaced and a replacing model is assessed as some fixed proportion of the difference in production cost between the two models.
- **Judgmental Quality Adjustment**, and **Supported Judgmental Quality Adjustment**, means that the value of the quality change between a replaced and a replacing model is assessed by judgement of some assigned person(s), in the latter case based on supporting instructions and information.
- **Hedonic Regression for Pricing of Characteristics** means that the value of the quality change between a replaced to a replacing model is assessed as the value of characteristics by which the two models differ, computed from a regression equation.
- **Hedonic Regression Methods in general** mean that the quality adjustment is in some way based on a regression model, which expresses the price as a function of product characteristics.
- **Combined Approach** means that different methods are used for different replacement situations within the same elementary aggregate, depending on whether given conditions are met.

’Implicit’ methods:

- **“Price change taken as quality change”** means that the value of the quality change is assessed as the change in price since the preceding period.
- **Overlap** means that the value of the quality change between a replaced and a replacing model is assessed as the difference in price between the two models in a period when both models are available.
- **Bridged Overlap** means that the relative price change in a replacement since the preceding period (last month) is assessed as the relative price change since the preceding period for other models.
- **Monthly Chaining and Replenishment** means that the aggregate relative price change between any two adjacent periods is assessed as the aggregate relative price change for the set of all models that are available in both those periods (a special case of bridged overlap).
- **Class Mean Imputation** means that the relative price change in a replacement since the preceding period (last month) is assessed as the relative price change for models that in the same period are replaced with Direct Price Comparison or other known quality adjustment.
- **Retrapolation** means that the relative price change in a replacement since the base period is assessed as the relative price change since the base period for models that are not replaced