Estimation of the Potential Bias of the French CPI due to the Annual Linking of Intermediary Aggregates

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Abstract: The Consumer Price Index is calculated in France through an annual linking of December-based indices. This method is suspected of overestimating inflation in the long-term. This could occur where elementary prices or subitem indices are " bouncing ", i.e. show relative movements negatively correlated in time. Chaining in this context is well known to generally lead to overestimation. This overestimation would be all the more serious as other positive biases may exist in CPIs (see [1],[2]).

We have recalculated the overall index in the long period, using adjusted weights in order to suppress the eventual « perversity » of the linking of intermediary aggregates. The bias due to the linking method can therefore be estimated as the difference between the original and the recalculated overall index.

Finally, the difference between the original and the adjusted index is in the expected direction but is, fortunately, very small. The recalculated index increases by + 86.328 % between 1980 and 1992 instead of 86.495 % for the original index. The difference is therefore only of 0.167 point for twelve years, i.e. 0.014 per year. However differences may be greater for some items and some periods.

1. A brief recapitulation of the computation of the French CPI

The monthly CPI is obtained by successive aggregations, starting from elementary indices which are simple ratios of intertemporal prices. The first step of aggregation leads to the index of the subitem in a given town, which is calculated using a micro-index formulas (unweighted) on elementary prices[2]. All subsequent steps are calculated using an explicitely weighted Laspeyres formula. The second step leads to the calculation of the subitem index for the whole country using explicit town weights. Then the index of the item is obtained, and at last the overall index. In this paper, intermediary agregates refer to the subitem indices for specific towns (SUBITEM x TOWN, or SBI x TOWN), subitems indices for the whole country (SUBITEM, or SBI), and to item indices (ITEM). In this whole process of aggregation, indices are price referenced to the month of December of the preceding year. Each year, new weights, obtained from the French National Accounts of year *n-2* and price updated to December of the preceding year, are used for the calculation of the overall index from the item indices (i.e., the last step of aggregation). Weights of subitems and towns are not updated and are kept unchanged for ten years or more. All indices are then linked in December and published in a fixed base form, 1980 = 100 for the data that will mainly be used in this paper, currently as 1990 = 100.

[1] It was the late Jean-Michel Rempp who, in December 1995, first had the idea of this paper. Unfortunately he died in late December of the same year and could not participate in the discussions. The advice of François Lequiller, head of the French CPI, and Lionel Viglino and Sandra Montiel, from the CPI division, was essential to the undertaking of this paper. Without the help of Alain Renard and Jacques Girault, from the CPI data computing division, nothing would have been possible concerning the data, in particular for the 1980 base. My thanks to all of them.

[2] As usual in price index studies, we call "micro-index" the index of an elementary aggregate of the CPI in which the series are not explicitely weighted.

For instance :

$$\frac{Month\ of\ \ year\ n}{90} \text{ is obtained by } \frac{Month\ \ n}{Dec_{n-1}} x \prod_{t=92}^{n} \frac{Dec_{t-1}}{Dec_{t-2}}.$$

This note shows the conditions in which this annual linking of intermediary aggregates may generate a bias which could be increasing with time.

2. The case of micro-indices

The first step of aggregation is to calculate the subitem for a certain town from elementary prices. The formula used in France for this step is either the ratios of meanprices (homogeneous subitems) or the equi-weighted arithmetic mean of price ratios (heterogeneous subitems)[3]. It is this last formula which leads to a serious problem when prices "bounce" back and forth.

Here is a numerical example, extremely caricatural:

	Time	0 (base)	1	2	3	4
Prices	A	2	1	2	1	2
	B	1	2	1	2	1
Indices t/t-1	A	-	1/2	2/1	1/2	2/1
	B	-	2/1	1/2	2/1	1/2
	Arithmetic Mean.	-	1.25	1.25	1.25	1.25
Chained index (base = 0)		-	1.25	$(1.25)^2$	$(1.25)^3$	$(1.25)^4$

In this extreme example the problem is overwhelming. In the even periods, prices come back to their base-value, but the chained index drifts from (1.25) to $(1.25)^2$, and then to $(1.25)^3$, $(1.25)^4$ which is equal to 2,44 !

The "perversity" of this chained formula (often called "formula bias") has been extremely well analyzed by Schultz [3] and by Moulton and smedley [6], and is mentioned in many other papers [2], [4], [5]. It has been also recently discussed in Eurostat in the context of the CPI harmonization process. Lets note quickly that the geometricmean of indices t/t-1 is a solution to the problem. In the example above geometric means would always be unity, showing an unchanged index over the whole period. However, the geometric mean is not the formula which is going to be discussed in this paper.

[3] Starting January 1997, the latter will be replaced by a geometric mean.

Another option than the geometric mean, less simple but almost as satisfying, would be to keep an arithmetical mean, but using varying weights. The weight in time 2 would be lower for A than for B. This in proportion of the two index movements observed in the precedent period. And so forth[4]. Thus the weights, instead of staying at 0.5, would become:

Time	**1**	**2**	**3**	**4**
A	0.5	0.2	0.5	0.2
B	0.5	0.8	0.5	0.8
Leading to the following t/t-1index	1.25	0.8	1.25	0.8
and the following chained index	1.25	1.0	1.25	1.0

One can conclude that, in this case, the chained index does not drift and, at least for even periods, returns to 1 (= 1.25 x 0.8). This index is in fact equal to the unchained (direct) Laspeyres index[5]. At this lower level of aggregation, the use of the geometric mean has been recommended among EU countries rather than this type of formula based on varying weights. As mentionned before in a footnote, France has subsequently decided to use the geometric mean for "heterogeneous" subitems in which the arithmetic mean of price ratios is currently used. The introduction of geometric means will be done progressively, over a period of two years, and after examination case by case, starting in January 1997.

However it appears that this problem, which, at the outset, was generally thought to be restricted to micro-indices could also concern other intermediary aggregates in the French index. Indeed, the above mentioned drift may exist for aggregations in which the series are, this time, explicitly weighted, as long as the weights are not updated in parallel with the chaining. This would simply be a generalization of the above example. This situation exists in the French index where SUBITEM x TOWN indices are aggregated to SUBITEM, themselves aggregated to ITEM, in a linking context and without their weights being reconsidered each year. Hence the drift could exist for intermediate aggregates.

The present paper concerns the estimation of the potentiel bias originating from this situation.

3. General case and intermediary aggregations

First, one should note that, fortunately, the eventual drift does not occur each month in the French index. Indices of a given month are directly obtained by referring to prices of the month of December of the preceding year and not by a monthly "M/M-1" linking method (It is rather M/M-1 which is obtained by dividing M/Dec. and M-1/Dec.). This drastically reduces the scale of the problem, but without resolving it. In fact, there wouldn't be any problem if indices were directly referred to those of the fixed base (1980 in the last base, or 1990 currently). However usage has progressively been to annually link all levels, including those for which it would not have been necessary to do it ... with the risk which is the subject of this paper !

[4] This is in fact equivalent to keeping unchanged the implicit « quantities » in the index (as it should be the case in a Laspeyres index).

[5] One could use a harmonic mean rather than an arithmetic one. This harmonic mean would equal 0.8 at each period and, chained, would dangerously drift toward zero ! One can prove easily that the harmonic mean is a Paasche index with implicit quantity weights equal to the inverse of prices of current period. Conversely to the situation of the above, the correction of weights would «adjust » this drifting index by introducing 1.25 changes at even periods.

Bouncing, such as above illustrated, is also possible at higher levels of aggregation such as, first of all, the SUBITEM x TOWN level from which a weighted arithmetic mean (Laspeyres) is calculated in order to obtain the SUBITEM index for the whole country. At this step, it would be imprudent to use a geometric mean, the results of which would be significantly lower to the arithmetic mean, even with the same weights. It would rather be advisable to use the method of varying weights which has been previously illustrated in a simple case.

The reader will have now understood that the method that we will use to correct the drift will be to modify the weights of the SUBITEM x TOWN and the SUBITEM[6].

We will use the following notations (for example, in the case of aggregation from SUBITEM x TOWN to SUBITEM) :

SBI	Subitem
n	year (0 for base)
W_i	initial weight of SBI x TOWN i, W_i^n is the weight for year *n*
$W_i^{'}$	adjusted weight
$I_i^{n/n\text{-}1}$	annual index of the SBI x TOWN i
$I_{SBI}^{n/n\text{-}1}$	adjusted index of the SBI obtained by way of the $W_i^{'}$
$\sum$	always indicates a sum on i

The current method uses the weight W_i in order to obtain the mean $\sum W_i I_i^{n/n-1}$. The following table shows the adjusted weights and the results of the method to correct the possible drift.

Year	Adjusted Weight	Subitem index to December	Chained adjusted index
1	W_i	$I_{SBI}^{1/0} = \sum W_i I_i^{1/0}$	$I_{SBI}^{1/0} = I_{SBI}^{1/0}$
2	$W_i^{'2} = \frac{W_i I_i^{1/0}}{\sum W_i I_i^{1/0}}$	$I_{SBI}^{2/1} = \sum W_i^{'2} I_i^{2/1}$	$I_{SBI}^{2/0} = I_{SBI}^{2/1} I_{SBI}^{1/0}$
3	$W_i^{'3} = \frac{W_i^{'2} I_i^{2/1}}{\sum W_i^{'2} I_i^{2/1}}$	$I_{SBI}^{3/2} = \sum W_i^{'3} I_i^{3/2}$	$I_{SBI}^{3/0} = I_{SBI}^{3/2} I_{SBI}^{2/1} I_{SBI}^{1/0}$
n	$W_i^{'n} = \frac{W_i^{'n\text{-}1} I_i^{n\text{-}1/n\text{-}2}}{\sum W_i^{'n\text{-}1} I_i^{n\text{-}1/n\text{-}2}}$	$I_{SBI}^{n/n\text{-}1} = \sum W_i^{'n} I_i^{n/n\text{-}1}$	$I_{SBI}^{n/0} = I_{SBI}^{n/n\text{-}1} x ... I_{SBI}^{1/0}$

[6] For those interested: there are 295 items in the 1980 base of the French CPI and 265 items in the 1990 base. Item weights are updated annually. At the same time, they are also broken down by SUBITEM and by SUBITEM x TOWN using an unchanged proportion. Thus, numerically, weights of SUBITEM x TOWN and weights of SUBITEM may appear as if they had changed every year because the weight of the ITEM may have changed. In fact they are left unchanged.

If, as it is very frequent, initial W_i are unchanged in structure we can also write :

$$W_i^{'n} = \frac{W_i \; I_i^{n\text{-}1/0}}{\sum W_i \; I_i^{n\text{-}1/0}} \text{ , with } \sum W_i \; I_i^{n-1/0} = \prod_{n=2} I_{SBI}^{n-1/n-2} \text{ , where only } I_{SBI}^{1/0} \text{ is unchanged.}$$

$$I_{SBI}^{n/n\text{-}1} = \frac{\sum W_i \; I_i^{n/0}}{\sum W_i \; I_i^{n\text{-}1/0}}$$

$$I_{SBI}^{n/0} = \sum W_i \; I_i^{n/0}$$

This last formula well shows that the "perversity" of the chaining method is now eliminated.
However the W_i are not always stable (replacements, new items, etc., cf. following section). So we prefer to use:

$$W_i^{'n} = \frac{W_i^n \, I_i^{n\text{-}1/0}}{\sum W_i^n \, I_i^{n\text{-}1/0}}$$

And, at last :

$$I_{SBI}^{n/n-1} = \frac{\sum W_i^n I_i^{n/0}}{\sum W_i^n I_i^{n-1/0}}$$

Computations using this adjusted formula have been conducted for the 1980 base of the CPI. This base covers a sufficiently long time-series (1980-1992) to consider the cumulated difference between the official calculation and the result of the adjusted method significant. Computations have been made only for December indices. We have also extended the computations to the first years of the 1990 base, from December 1992 to May 1996.

4. The treatment of replacements

At the elementary level of the French CPI index, as in any CPI, products often disappear from the market and are replaced by others. It is also the case at the SUBITEM level in the French CPI, but only annually, on the occasion of the updating of the weights of the ITEM level. For instance, a subitem stops being followed in December 1985, or continues but in a different TOWN. "In-coming" as well as "out-going" SUBITEM x TOWN represent between 3 and 10 % of all SUBITEM x TOWN′s (except in 1991 and 1992 for which 20 % are out-goings). Weights of in-coming are different from weights of out-goings. The formula using the adjusted weights $Wi'^{\,n}$, in terms of old weights, is applied without problem for out-goings. But the same formula cannot correctly cope with in-comings. Two solutions are possible :

- exclude the in-comings by "transferring" their weights to other SUBITEM x TOWN′s of the same SUBITEM, or other SUBITEM′s of the same ITEM. However, this would not use all the information we have and the price trends of these new SUBITEM′s may be atypic. Despite this drawback, we have conducted some computations using this method of excluding in-comings.

- "restore" a fictitous past for in-comings with the same relative price movements, as those of the same category (SBI, ITEM or overall). To obtain such a past, one only have to use the formula $W_i^{'n} = f(W_i^n, I_i^{n-1/0})$. This method has been used for our "central" computation.

5. Numerical results

Appendix 1 contains the December to December change of the adjusted overall index, the corresponding figure of the official index and the difference between these two time series, annually and cumulated over the twelve years of our study. The first conclusion is that the difference is, fortunately for the compilers of the French CPI, very small: on twelve years, the bias is equal to 0.167 percentage points, i.e. 0.014 % per year[7]. It is in the expected direction (i.e., positive bias).

Let's try to analyze this result.

First, the small size of the bias comes from the fact that bouncing at the level of intermediary aggregates such as SUBITEM′s is, when it exists, less marked than at elementary levels. Furthermore, and as already mentionned, chaining is done only once per year rather than every month. The less chaining, the less the index drifts.

Second, concerning the direction of the bias, the results show that the intertemporal correlations of movements, for a same SBI x TOWN, are more often, or more markedly, negative than positive[8].

a. More precisely, lets consider each SBI x TOWN of a same item and their relative movements *n/0* and *n+1/n*. Results show that SBI x TOWN of which prices were first rising the most are precisely those which, in the subsequent year, rise less (or fall more), and vice versa. In this case, our correction of the weighting structure consists of increasing the weights of the SBI x TOWN which have risen less from *n* to *n+1*, to the detriment of the others, thus reducing the level of item index.

A concrete example, among the most conspicuous ones, is the case of "dried vegetables". This item contains two subitems and 61 SUBITEM x TOWNs, with a total weight of 300 over one million in 1981. In this item one will not find as extreme "bouncing" of prices such as in the simple example that was proposed at the beginning of this paper, around the average movement of the item (+ 70.0 % in 1981 and + 64.5 % in 1982) those of some of the SUBITEM x TOWNs are often inverted, that is high for 1981 and low for 1982 and inversely.

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7 Appendix 2 gives the bias obtained by the way of initial weights, using $w_i^{'n} = f(w_i^{'n-1}, I_i^{n-1/n-2})$. We prefer the method leading to the results shown in Appendix 1.

8 Schultz [3], based on Bortkiewicz, shows that the difference between a linked Laspeyres and a direct Laspeyres has the opposite sign of the correlation between the successive changes of prices : linked Laspeyres/direct ≅ intertemporal product of terms having the form: $1 + r_{xy}.V_x.V_y$ with $X = P_t/P_{t-1}$, $Y = q_{t-1}/q_0$, r_{xy} = correlation between X and Y, t = time of linking. *Let* $Z = P_{t-1}/P_0$ and $r_{yz} < 0$ (typical of product substitution). Then if $r_{xz} < 0$ (bouncing), the linked Laspeyres is generally higher to the direct Laspeyres. On the other way round, if $r_{xz} > 0$, the linked Laspeyres is lower to the direct Laspeyres (and vice versa for Paasche). Note that Schultz does not conclude on which index, chained or direct, is "better".

b. The results also show a change in the direction of the bias during the period. The bias is systematically positive from 1981 to 1989 and then becomes negative from 1990 to 1992. Note that nothing permits to extrapolate this negative bias to subsequent years.

   A detailed examination of years 1990 and 1991 has not revealed anything exceptional which would explain this change in the direction of the bias. Correlations simply appear to be more strongly (or more often) positive than negative.

One should note that the calculation conducted on the new 1990 based index on years 1993 to 1996 show once more a clear positive bias, confirming that positive bias is the most frequent situation.

5. Conclusion

We have used a method of adjusted weight to offset the non-transitivity of an index obtained by linking. This decreases the index which is led to drift too high in the most common situation of price bouncing.

This adjustment seems all the more justified as other biases may occcur in the same direction. Indeed, within a given year (i.e., without linking) weights are fixed. It is well known that such a fixed weighted index (Laspeyres) will be overestimating the cost of living because, in reality, substitution occurs between products, leading consumers to decrease the consumption of products which price are (relatively) hiking and increase the consumption of products which prices are (relatively) falling. Conversely, the Paasche formula anticipates too quickly this substitution and will underestimate the cost of living. A Fisher index is therefore to be recommended.

In practice, current weights, necessary for the calculation of a Fisher index, are not available for the calculation of the monthly index which is published with a very short delay. One could imagine calculating a revised index when the weights are made available. However users are not prepared to such revisions. One could also imagine to automatically correct the quantities of products which price are relatively increasing. This is implicitely what is going to be done at the micro-index level with the geometric mean. However, it does not seem reasonable to generalize such a treatment at higher levels of aggregation. With no pratical solution to this other positive bias, the adjustment described in this note is all the more important.

References

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Appendix 1: $W_i^{'n} = f\ (W_i^n, I_i^{n-1/0})$

	Annual change in prices, in %, December to December $\frac{D_n - D_{n-1}}{D_{n-1}} x100$				Cumulated changes, from December 1980 $\frac{D_n - D_{80}}{D_{80}}\ x\ 100$			
	Official Index	**Adjusted Index**	**Difference**	**(Incoming excluded)**	**Official**	**Adjusted**	**Cumulated Difference**	
1981	13.976	//	-		13.976	//	-	
1982	9.689	9.656	0.033	(0.035)	25.019	24.982	0.037	(0.040)
1983	9.246	9.204	0.042	(0.043)	36.578	36.485	0.093	(0.097)
1984	6.692	6.665	0.027	(0.030)	45.718	45.582	0.136	(0.144)
1985	4.732	4.720	0.012	(0.013)	52.614	52.453	0.161	(0.170)
1986	2.131	2.123	0.008	(0.011)	55.866	55.690	0.176	(0.192)
1987	3.078	3.062	0.016	(0.013)	60.663	60.457	0.206	(0.238)
1988	3.061	3.050	0.011	(0.020)	65.581	65.351	0.230	(0.268)
1989	3.591	3.562	0.029	(0.028)	71.527	71.240	0.287	(0.324)
1990	3.382	3.386	- 0.004	(- 0.004)	77.328	77.038	0.290	(0.328)
1991	3.089	3.125	- 0.036	(- 0.030)	82.806	82.571	0.235	(0.285)
1992	2.018	2.058	- 0.040	(- 0.017)	86.495	86.328	0.167	(0.258)

On the whole, over 12 years, the cumulated difference is only 0.167 %, i.e. 0.014 % per year.

Calculations conducted on the new index (base year 1990)

	Annual				**Cumulated**			
	Official[(1)]	**Adjusted**	**Difference**	**(Incoming excluded)**	**Official**	**Adjusted**	**Difference**	
1992	2.197				2.197			
1993	2.092	2.082	0.010	(0.020)	4.335	4.325	0.010	(0.021)
1994	1.630	1.623	0.007	(0.013)	6.036	6.018	0.018	(0.034)
1995	2.045	2.034	0.011	(0.017)	8.204	8.174	0.030	(0.054)
1996	1.201	1.195	0.006	(0.007)	9.504	9.467	0.037	(0.062)

[(1)] For practical reasons, the study has been made on the overall index without fresh products. This is why the data of this column may differ from the official overall index. The exclusion of fresh products doesn't affect the conclusion of the paper.

Appendix 2 : $W_i^{'n} = f\ (W_i^{'n-1}, I_i^{n-1/n-2})$

	Annual change (%)		**Cumulated changes, from December 1980**	
	Adjusted index	**Difference**	**Adjusted index**	**Cumulated Difference**
1982	+ 9.661	0.028	+ 24.987	0.032
1983	9.204	0.042	36.490	0.088
1984	6.673	0.019	45.598	0.120
1985	4.730	0.002	52.485	0.129
1986	2.134	- 0.003	55.739	0.127
1987	3.070	0.008	60.520	0.143
1988	3.081	- 0.020	65.466	0.115
1989	3.566	0.025	71.366	0.161
1990	3.396	- 0.014	77.186	0.142
1991	3.170	- 0.081	82.803	0.003
1992	2.070	- 0.052	86.587	- 0.092

Appendix 3

The main paper has showed that, when there is negative price correlation (i.e. bouncing), one has to correct the weights in order to avoid to underestimate the relative decrease of price subsequent to its relative increase in the precedent period. This underestimation can lead to an overall positive bias.

The technique based on this weight adjustment is tantamount to recalculating a real Laspeyres index (i.e. « direct » Laspeyres) rather than the incorrect one that is implicitely obtained when chaining without adjusting weights. Then, if the weight adjusted index is lower than the non weight adjusted index (which is the case for the French CPI), this justifies a posteriori the correction because it shows that, on the whole, there is negative correlation. However, this overall result omits the fact that there are also numerous cases of positive correlation. One should better say that, on the whole there is more negative correlation than positive correlation.

Let's discuss about positive price correlation.

Lets take a simplistic example, as simplistic as the one that was presented for the bouncing case in the main text:

	Time	**0 (base)**	**1**	**2**	**3**	**4**
Prices	A	2	1	0.5	0.25	0.125
	B	1	2	4	8	16
Indices t/t-1	A		1/2	0.5/1	0.25/0.5	0.125/0.25
	B	-	2/1	4/2	8/4	16/8
	Arithmetic Mean.	-	1,25	1,25	1,25	1,25
Chained index (base = 0)		-	1,25	1.56= $(1,25)^2$	1.95= $(1,25)^3$	2.44= $(1,25)^4$

In this case, prices of A are always decreasing and prices of B are always increasing. In that sense, there is positive correlation in price changes in time. The resulting chained index is equal to 1.56 in period 2, up to 2.44 in period 4.

The same method which was used to obtain the corrected weights in the bouncing case will lead to the following corrected weights and the following adjusted index in this case:

time	**1**	**2**	**3**	**4**
A	(0.5)	(0.25)	(0,13)	(0,06)
B	(0.5)	(1.00)	(2.00)	(4.00)
Leading to the following t/t-1index	1.25	1.70	1.91	1.98
and the following weight adjusted chained index[9]	1.25	2.13	4.06	8.03

One sees that, here, rather than a downward correction, the weight adjustment leads to an upward correction, 8.03 at period 4 rather than 2.44 at the same period in the non corrected index.

This case is as extreme as the bouncing case presented in the main text. However, one can imagine that, in the real CPI, there are also numerous cases of that sort (positive correlation) along with cases of the first sort (negative correlation). In other words, even if the overall result shows a negative correlation, one could say that this is the result of some positive correlation which is slightly overwhelmed by negative correlation.

Now, is our weight adjustment correction fully justified in these cases of positive correlation ? One can think that it is not.

Indeed, the correction of weights is tantamount of assuming that the quantity weights are maintained fixed during the whole period (which is, once more, equivalent to a Laspeyres index). In our example, if we admit at least a minimum of substitution between good A and good B due to the explosively increasing price relative of B compared to A, than one can admit that the weight adjustment is not totally justified in that case because it implicitely assumes that there is no substitution at all.

One could therefore make a case that the weight adjustment is only relevant in the cases of negative correlation and not in the case of positive correlation. If this conclusion is admissible, then the overall bias is in fact much larger than the 0.167% over ten years (or 0.014% per year) that was admitted in the main text. Indeed, the 0.167% « bias » has been damped by the numerous high-side corrections that were implemented when there was positive correlation rather than negative correlation.

This sheds a quite different light on the result of the main text.

However, one must admit that it would not be very « ethical » to apply a weight correction in the bouncing cases and not to apply the same correction in the non bouncing cases. This would be equivalent to use a certain formula when the resulting index rises too high and another when it is not rising too low. Why not at this moment use a geometric mean? But both solutions do not seem to be applicable, specially when dealing with aggregates that are not micro-indices and are rather high in the aggregation level of the index. At this level of agregation, substitution is probably limited.

The only good solution is to frequently update the weights using fresh data, even at detailed levels of aggregation.

[9] Which is equal to the Laspeyres index.