Addressing the Formula Effect – the Case for Change

Purpose

This paper summarises the key findings from work by ONS to address the formula effect gap between the Consumer Prices Index (CPI) and Retail Prices Index (RPI). On the basis of these findings a number of recommendations are presented that will remove the formula effect gap and improve the construction of these indices at their lowest level of aggregation (ie the elementary aggregate (EA) level) where suitable expenditure data are not available.

This paper is not concerned with and does not make any recommendations concerning the construction of the CPI and RPI above EA level – ie where expenditure data are available. Both the CPI and RPI are calculated using weighted, arithmetic averages indices above the EA level. This is in line with common practice for the construction of consumer price indices by National Statistics Institutes. The absence of expenditure data to calculate weights means that economic theory regarding consumer substitution is not relevant at the EA level. On the same basis, arguments regarding the most appropriate choice of aggregation method being determined by the primary use (or purpose) of a consumer price index are not relevant at the EA level. Whilst the compilers of price statistics in the UK and abroad have previously used economic theory and arguments of index purpose (without practical evidence to test them) in choosing EA formulae, ONS believes (based on its recent research – see finding 2 below) that this is no longer a justifiable approach. As a result, ONS believes that the choice of appropriate EA formulae in the CPI and RPI should be based on statistical considerations and empirical evidence alone.

Recommendations

Based on the findings set out in section 1 below, ONS recommend:

- the use of the Carli formula in the RPI be stopped at the earliest possible opportunity (the 2013 RPI basket update) and replaced with Jevons
- the formulae used in the CPI and RPI be fully aligned to Jevons at the point the use of the Carli formula is stopped
- an ongoing programme of work is launched to ensure that, as statistical thinking evolves and new expenditure data becomes available, the aggregation methods used in the CPI and RPI continue to reflect best practice for consumer price statistics

These points are discussed in detail in section 2 below.
Mr Robert Chote  
Chairman  
Office for Budget Responsibility  
20 Victoria Street  
London  
SW1H 0NF

17 September 2012

Dear Robert

CONSULTATION ON RETAIL PRICES INDEX (RPI)

As you will be aware, the Office for National Statistics (ONS) has been working to understand differences between the RPI and the Consumer Prices Index (CPI).

Tomorrow I shall be announcing in a statement on the ONS website my intention to open a public consultation on a number of possible options for improving the RPI. The consultation period will begin on 8 October 2012 and close on 30 November 2012.

I attach a copy of the statement at Annex A, which will be released at 11.00am tomorrow morning at the same time as the publication of papers from the Consumer Prices Advisory Committee on 13 September 2012.

There is likely to be considerable interest in this announcement and I would welcome the opportunity to discuss the issue with you. I will ask my office to contact yours to arrange.

Yours sincerely

Jil Matheson

Jil Matheson National Statistician | Ystadegydd Gwladol
Dear Nick

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I attach a copy of the statement at Annex A, which will be released at 11.00am tomorrow morning at the same time as the publication of papers from the Consumer Prices Advisory Committee on 13 September 2012.

There is likely to be considerable interest in this announcement and I am therefore copying to Wednesday Morning Colleagues, many of whose departments are key users of consumer price statistics. Should any department require further information, please contact my office, or contact Derek Bird, ONS Deputy Director – Prices Division (derek.bird@ons.gsi.gov.uk).

Yours sincerely

Jil Matheson

Jil Matheson
National Statistician | Ystadegydd Gwladol

Sir Nicholas Macpherson KCB
Permanent Secretary
HM Treasury
1 Horse Guards Road
London
SW1A 2HQ

17 September 2012
Mr C Bean
Deputy Governor, Monetary Policy
Bank of England
Threadneedle Street
London
EC2R 8AH

17 September 2012

Dear Charlie

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Yours sincerely

Jil Matheson

Jil Matheson
National Statistician | Ystadegydd Gwladol
From: Stephen Penneck/NSPD/ASRG/LONDON/ONS
To: Spencer.Dale@bankofengland.gsi.gov.uk, Dave.Ramsden@hmtreasury.gsi.gov.uk
CC: National Statistician, Caron Walker/OFD/BSG/NEWPORT/ONS, Derek Bird/EEPD/BSG/NEWPORT/ONS, Ainslie Restieaux/NEWPORT/ONS
Date Sent: 31/08/2012 15:00:02
Subject: [PROTECT] - CPI / RPI meeting 3 September

Spencer, Dave

We are meeting at 2pm at the Bank to discuss how we can take forward work on the formula effect for the RPI. I attach some papers that we can talk through at the meeting. They set out the statistical arguments for change, some of the history of these issues and a note which summarises the legal advice we have had on consultation.

These notes were essentially written for Monday's meeting and to brief Authority members in the course of next week. They are not designed for a wider audience and not intended for CPAC.

I look forward to the meeting on Monday

Steve

succinct paper summarising the statistical arguments for change 120630 MFE rec paper v11.docx
A summary of the key decisions taken over the past 30 years which show why we are where we are - incl a more detailed timeline MFE what happened when v4.docx
A summary of the legal and governance arguments that affect how this should be handled
Legal Position v4.docx
A scenario and timetable showing what will happen over the six months from Sept and how CPAC will be involved AFE handling schedule v5.docx
Dear colleague

Please see the attached letter from Jil Matheson to Nick Macpherson.

The letter is copied to Wednesday Morning Colleagues.

Please note that the letter and annex are RESTRICTED (market sensitive) until 11:00 on 18 September 2012.

Kind regards

Alex Elton-Wall
Private Secretary to the National Statistician
UK Statistics Authority
Tel: 01633 455306
E-mail: alex.elton-wall@statistics.gsi.gov.uk

Letter from Jil Matheson to Nick Macpherson - Consultation on RPI.pdf  Annex A - statement - restricted - market sensitive.pdf
Mail 3

From: Alex Elton-Wall/NSPD/ASRG/LONDON/ONS
To: robert.chote@obr.gsi.gov.uk
CC: 
Date Sent: 17/09/2012 18:46:52
Subject: [RESTRICTED] - Letter from Jil Matheson to Robert Chote - Consultation on the Retail Prices Index

Dear Robert,

Please see the attached letter from Jil Matheson.

Please note that the letter and annex are RESTRICTED (market sensitive) until 11:00 on 18 September 2012.

Kind regards

Alex Elton-Wall
Private Secretary to the National Statistician
UK Statistics Authority
Tel: 01633 455306
E-mail: alex.elton-wall@statistics.gsi.gov.uk
Okay. I have passed these to our legal department. And they will have some further comments. But, so far...

+ Both the note of the meeting and the statement need to remove the references to the Governor of the Bank of England. UKSA is not obliged to consult with the Governor, or any individual, the duty falls on the Bank as an organisation and not on any individuals.

On the statement...

+ Might want to italicise “for a limited number of categories” and “for all categories that use it” in options 2 and 3, or it’s a bit hard to tell them apart.

+ The statement doesn’t really set out the timetable as it says it does – it doesn’t say when the authority would come to a decision, for example. The is really important: We need to be entirely happy with the timetable at our end so that we can commit to being able to deliver our assessment as dictated by the protocol. So can we clarify the precise timetable today, please.

+ I do not really understand the intention of the final paragraph in the ‘legal’ section, beginning “HM Treasury will provide good notice ...”

Our formal opinion on the proposed change is given to UKSA in January and then again in February if the actual change is made. The ONS announces the change in February also (it is unclear from the Protocol whether this is after our second formal opinion). HMT then publishes a notice to stockholders if redemption is necessary. I am not sure then what the final paragraph refers to when it says “HM Treasury will provide good notice of the date on which the opinion of the Bank of England, if sought, and, if required, the consent or otherwise of the Chancellor of the Exchequer to any change, would be published”. We do not publish our opinion. And the Protocol makes no mention of publication. Is the intention (for UKSA?) to publish the Bank’s second opinion or the first? Would it publish our opinion even if the Chancellor’s consent is not needed, the paragraph implies so? I assume you will agree this date with us.
May be more to follow....

From: Derek Bird [mailto:derek.bird@ons.gsi.gov.uk]  
Sent: Friday, September 14, 2012 10:40 AM  
To: Nicholas.Vaughan@hmtreasury.gsi.gov.uk; Bell, James  
Subject: [RESTRICTED] - Re: CPAC

*************************  
This email has reached the Bank via the Internet or an external network  
*************************

Nick/James
I attach a near final version of the note of yesterday's meeting. It has been cleared by Jil and so is unlikely to change much between now and next Tuesday.
I also attach a draft of the announcement Jil plans to make on the options. It will be released at 11:00 on 18 September 2012 alongside the CPAC papers. This has been seen by Jil but will be finalised on Monday.
Happy to receive any comments.  
regards
Derek

______________________________________________________________________________  
________________________________________  
Derek Bird | Deputy Director| Head of Prices Division | Office for National Statistics | Cardiff  
Road | Newport | Wales | NP10 8XG |  
Phone: +441 633 456 739 | Internal Extension: 6739 | Email: derek.bird@ons.gsi.gov.uk |  
http://www.statistics.gov.uk/  

For the latest data on the economy and society consult National Statistics at  
http://www.ons.gov.uk

******************************************************************************  
***
I tried calling you earlier to check that you were up to speed and comfortable with what we are doing following the CPAC meeting yesterday.

The meeting went quite well; CPAC was comfortable with our proposals on the consultation exercise and on the broad timings we had indicated. James was present, of course, and Derek Bird has been in touch with him since to share the draft statement that we plan to issue on Tuesday.

The plans are that at 11 am on Tuesday 18 September, which is the date and time pre-announced for release of the CPAC papers, Jil Matheson will issue a statement announcing a consultation. The announcement will include a brief explanation of the formula effect gap and of the 4 options considered to date. It also explains the statutory provisions around changes to the RPI, and the processes we would follow should there eventually be a decision to propose a change. The consultation will be launched on 8 October, and any recommendation for change would be published in January 2013. If appropriate, and subject to the views of the Chancellor, ONS would introduce any change with the annual update of the RPI when it is published on 19 March 2013.

We will continue to work closely with you to share our plans and ensure that we are all comfortable with the timetable.

I hope this is all OK with you. I would be happy to discuss any of it with you at any time. If you have any concerns or questions, please do not hesitate to get in touch. In the meantime, Derek will remain in close contact with James.

Caron
Dave

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Caron

| Caron Walker | Director of Collection & Production | Room 1.362 |
| 01633 456343 | Office for National Statistics | Government Buildings |
| Cardiff Road | Newport | South Wales | NP10 8XG |
Nick/James

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Happy to receive any comments.

regards

Derek
NATIONAL STATISTICIAN’S
CONSUMER PRICES ADVISORY COMMITTEE

Minutes

Thursday, 13 September 2012
Meeting Room 3, Office for National Statistics,
Drummond Gate, Pimlico,
London, SW1V 2QQ, 10:30-12:30

Present
National Statistician (Chair)
Mr James Bell (Bank of England)
Deputy Director, Prices Division (Office for National Statistics)
Dr Ian Crawford (University of Oxford)
Dr Gary Gillespie (Scottish Government)
Professor James Sefton (Imperial College London)
Mr Philip Turnbull (Independent statistical expert)
Deputy Director, Economics Group (H M Treasury attending for Mr David Ramsden)
Director, Collection and Production (Office for National Statistics)
Dr Martin Weale (Monetary Policy Committee)

Secretariat
Mr Zuhaib Khan (Office for National Statistics)
Head of Prices Development (Office for National Statistics)

Apologies
Mr Partha Dasgupta (Non-Executive member of the UK Statistics Authority)
Mr Chris Giles (Financial Times)
Professor Stephen Nickell (Office for Budget Responsibility)
Mr Duncan Weldon (Trades Union Congress)

Declarations of Interest
None
3. The Formula Effect Gap between the Retail Prices Index and the Consumer Prices Index - CPAC(12)24

3.1 Director, Collection and Production, ONS presented a paper on the formula effect gap between the RPI and the CPI and asked CPAC to consider the handling of this work. The paper presented to CPAC was an early draft and ONS thinking had moved on since the paper was distributed. Director, Collection and Production, ONS noted that the National Statistician will launch a consultation outlining the possible options to take the formula effect work forward in early October. The consultation will be announced on the same day that CPAC papers are published. CPAC will be asked to consider the responses, probably in January 2013, and members’ advice sought. Should CPAC advise that there is a need to change and the National Statistician develop a recommendation, then the appropriate governance arrangements would be followed with a possible implementation date of March 2013.

3.2 Director, Collection and Production, ONS asked CPAC to consider the questions and help form possible options for change. This approach was being taken as the issue is market sensitive and markets are already speculating on a possible change. Making a recommendation in January and taking the recommendation through the governance arrangements soon after the CPAC meeting would limit the time for uncertainty in the markets.

3.3 There was a discussion instigated by members of the Committee regarding markets pricing in possible changes to the formula around March 2013 and how market sensitive the issue is. One member stated that there is evidence to suggest that markets were already pricing in some change to the formula. It is important to have transparency in the governance arrangements and the timing of any changes and to ensure that everyone gets the information at the same time.

3.4 One member asked if it was appropriate for CPAC to have an opinion on the preferred change. The Chair said that it was clear from the evidence that Carli is out of date but there still needs to be a decision made on which formula should be used instead. The consultation will provide more evidence to help inform this decision. Deputy Director, Prices Division, ONS mentioned that the consultation needs to be conducted in such a way to ensure that it reflects the response of all users.

3.5 A member questioned whether ONS had done the ground work on the formula effect. There was a concern regarding the clothing pilot study and what impact it would have on any change to the formula. Another member stated that the clothing pilot was not the issue and the public wants to see evidence of what is happening. The member argued that there needs to be interrogation of the data. The concern was whether there is enough evidence to be able to make a change.

3.6 There was a general discussion about the consultation document and what should be included. Deputy Director, Prices Division, ONS clarified that the intention was to include formula effect work and proposed changes to the private rental data as a minimum. The publication of the consultation document would be timed to coincide with the publication of Prof. Erwin Diewert’s report. There was agreement that ONS should make all the data it has available to the public in the consultation document.

3.7 There was a discussion about the economic approach to elementary aggregates and why it is important not to dismiss this theory but to explain why it is not appropriate to apply it at the elementary aggregate level. Deputy
Director, Prices Division, ONS informed the committee that Prof. Erwin Diewet regretted the phrasing used in the ILO CPI manual which may have caused international confusion on the issue.

3.8 A member asked whether further improving the homogeneity at the item level would be considered. There was a discussion about this and how it could be achieved, for example using post stratification. Deputy Director, Prices Division, ONS gave an example to demonstrate that even very tight item descriptions can still result in a wide range of prices. Tightly defining item descriptions will also reduce the number of price quotes collected so there is a need to reach a balance between tightly defined item descriptions and the number of price quotes collected.

3.9 The formula type split in the CPI and RPI was discussed based on a new table which had been revised in the paper. The suggestion to change just the Carli in the RPI was raised as an option (representing 27% of the index). Deputy Director, Prices Division, ONS outlined the likely impact on the formula effect gap if this change was implemented and added the likely impact on the formula effect gap if the Carli was only changed for clothing times.

3.10 Four options for changing the RPI were summarised by a member (do nothing, stop using Carli for clothing items, stop using Carli completely or fully align the RPI with the CPI) and the Chair asked if there were any other options which should be considered. The committee went on to discuss the merits of each option particularly questioning whether the ‘do nothing’ and ‘stop using the Carli for clothing items’ options were sensible. The characteristic that Carli could only be the same or worse than the other formulae was raised.

3.11 The Chair asked the committee whether changes to the RPI (including the clothing pilot) could be stored up and made together. There was a general consensus that it would be easier to understand any changes if they were implemented separately.

3.12 A member acknowledged the need to suggest options for change but again questioned whether ONS is in a position to do this. The Chair asked CPAC for views on this challenge. Deputy Director, Prices Division, ONS said that work on price dispersion was ongoing and that it should be available in the near future. A member reiterated that the Carli was old and hard to defend.

3.13 A member asked if there is ever a situation where Carli is better, would the advantages of using the Carli ever return. One member replied to say that Carli gives unbiased estimates on statistical grounds where the Jevons does not.

3.14 The Chair asked if there were any other points to raise and Deputy Director, Prices Division, ONS reiterated the options for change proposed by CPAC, which the National Statistician would take into consideration for the consultation document.

**Action 2:** National Statistician to launch a consultation on a number of potential options for improving the RPI.
National Statistician to seek users’ views on the Retail Prices Index

The National Statistician will consult on a number of possible options for improving the Retail Prices Index (RPI)

As a result of work to understand the reasons for the differences between the RPI and the Consumer Prices Index (CPI) estimates of inflation, the National Statistician is to invite users’ views on the way the RPI is constructed. The differences between the RPI and CPI under consideration are those caused when different formulae are used to calculate average prices where there is no information about precise expenditure\(^1\). This is known as the ‘formula effect gap’.

The National Statistician will publish a consultation document on 8 October 2012 to invite users’ views on a range of options for the way the RPI is calculated. The consideration of change is part of a programme of work to maintain the quality of the statistics. The consultation, which will close on 30 November 2012, will ask users to indicate which options they feel are most appropriate.

The options developed by the National Statistician are:

i. **No change** – the reasons for the formula effect gap have been identified, explained and understood.

ii. **Change one particular approach to averaging prices** – which calculates the average of price relatives (the amount a price changes) over time for the same type of item where there is no information about precise expenditure - **for a limited number of categories** (for example, clothing), with options of the method to be used in its place. This would reduce but not remove the formula effect gap as some difference between the RPI and CPI formulation would remain.

iii. **Change one particular approach to averaging prices** – which calculates the average of price relatives over time for the same type of item where there is no information about precise expenditure - **for all categories that use it**, with options of the method to be used in its place. This would reduce the formula effect gap to a minimum, although some difference between the RPI and CPI formulation would remain.

iv. **Change the RPI so that its formulae align fully with those used in the CPI** – this would remove the formula effect gap between the RPI and CPI, though there would remain differences in estimates because of the different coverage, weights, products\(^2\) etc used in each.

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1. For instance, £x is spent on canned fruit but there is no information on how much is spent on the different types of canned fruit.

Further detail on each of these options will be set out in the consultation document to be published on 8 October 2012.

The Consumer Prices Advisory Committee (CPAC)\(^3\), chaired by the National Statistician, will meet to consider the responses. The National Statistician may then put forward recommendations, which the UK Statistics Authority would be asked to consider. Any recommendations for change would be published in January 2013.

Changes to the RPI are required to follow governance arrangements (see the background note for further detail) set out in Section 21 of the Statistics and Registration Service Act 2007. Consequently, the Bank of England will be consulted on whether any proposal would be a fundamental change to basic calculation of the RPI that would be materially detrimental to the interests of holders of relevant\(^4\) index-linked gilts.

Only if the Bank considers a proposed change to the RPI constitutes a fundamental change that is materially detrimental to the holders of index-linked gilts, would the agreement of the Chancellor of the Exchequer be required before the change could be made.

If any change were proposed, and subject to the above, the Office for National Statistics (ONS) would introduce any change with the annual update of the RPI when it is published on 19 March 2013.

\(^3\)CPAC papers can be downloaded from the CPAC papers webpage: http://www.ons.gov.uk/ons/guide-method/development-programmes/other-development-work/prices-development-plan/consumer-prices-development-work.html

\(^4\) The prospectuses of five gilts in issue, with maturities ranging from 2013 to 2030, currently contain this redemption clause.
Notes for editors

Statutory provisions concerning changes to the Retail Prices Index

The Statistics and Registration Service Act 2007 established the UK Statistics Authority (referred to as the “Statistics Board” in the Act), as an independent body, at arm’s length from government, reporting directly to Parliament. The Authority is responsible for promoting and safeguarding the quality of official statistics.

The Authority is required to ensure the compilation and maintenance of the RPI and that it is published it every month. The National Statistician is the Authority’s principal adviser on statistical matters. The Office for National Statistics (ONS), as the Authority’s executive office, is responsible for the production and publication of price index statistics. Changes may be made to the coverage and the basic calculation of the RPI, although in certain circumstances, under section 21 of the Act changes may only be made with the consent of the Chancellor of the Exchequer following consultation with the Bank of England.

Section 21 of the Statistics and Registration Service Act 2007 states that:

“(2) Before making any change to the coverage or the basic calculation of the retail prices index, the [Statistics] Board must consult the Bank of England as to whether the change constitutes a fundamental change in the index which would be materially detrimental to the interests of the holders of relevant index-linked gilt-edged securities.

(3) If the Bank of England considers that the change constitutes a fundamental change in the index which would be materially detrimental to the interests of the holders of relevant index-linked gilt-edged securities, the Board may not make the change without the consent of the Chancellor of the Exchequer.”

The Explanatory Notes accompanying the Act explain that:

“This is because, among other things, the RPI is used to calculate returns on [index linked gilt-edged securities] ILGs, which are government securities issued by HM Treasury under its borrowing powers in section 12 of the National Loans Act 1968. The prospectuses of ILGs first issued before July 2002 provided as follows:

‘If any change should be made to the coverage or the basic calculation of the [Retail Prices] Index which, in the opinion of the Bank of England, constitutes a fundamental change in the Index which would be materially detrimental to the interests of the stock-holders, Her Majesty’s Treasury will publish a notice in the London Gazette immediately following the announcement to the relevant Government Department of the change, informing stockholders and offering them the right to require Her Majesty’s Treasury to redeem their Stock in advance of the revised index becoming effective …’.

The prospectuses of eight gilts with maturities ranging from 2009 to 2030 currently contain this redemption clause and the aggregate outstanding amount of these gilts is substantial5.

5 There are now five gilts in issue containing the clause, with maturities ranging from 2013 to 2030.
The rationale of the redemption clause was to protect holders against arbitrary changes in the nature of the RPI. However, depending on the nature of the change to the RPI and on market circumstances at the time, the triggering of the section could have a significant impact on financial markets and potentially on the public finances.

Subsection (3) provides that if, under subsection (2) the Bank of England considers the proposed change to constitute a fundamental change that would be materially detrimental to holders of ILGs, then the Board may not make the change without the consent of the Chancellor of the Exchequer.”

Therefore, in the event that the National Statistician was to recommend a change to the RPI that, in the opinion of the Bank of England, constitutes a fundamental change in the index that would be materially detrimental to the interests of the holders of relevant index-linked gilt-edged securities, and the Chancellor were to consent to such a change, then HM Treasury would publish a notice informing stockholders and offering them the right to require HM Treasury to redeem their Stock.

HM Treasury has informed ONS that it will provide advance notice, via its website, of the date the consent or otherwise, if required, of the Chancellor of the Exchequer to any change would be published in the event that the National Statistician recommends a change to the RPI. The Debt Management Office (DMO) will circulate this notice among market participants by way of a screen announcement.

Other uses of the RPI include setting wage increases, indexation of rail fares, for indexing some pensions and in contracts.

The forward timetable for this process is provided in this statement.
Formulae used in the RPI

There tends to be a lack of reliable expenditure data for products at the lowest level of price collection (for example, canned fruit), meaning it is not always possible or meaningful to derive weights in either quantity or value terms for individual products within tightly defined commodity groupings (for example, for tinned peaches or tinned pears). In these circumstances it is accepted practice to assign an equal weight to each price observed. In the RPI, price indices at the lowest level are predominately calculated using a simple arithmetic average.

The average of price relatives (also known as the Carli) is calculated as the arithmetic average of price changes.

The ratio of average prices (also known as the Dutot) is calculated by dividing the arithmetic average price in one period by the arithmetic average price in a reference period.

A description of these methods is available in section 9.3 of the Consumer Price Indices Technical Manual. Further information on these will be set out in the consultation document to be published on 8 October 2012.

Consumer Prices Index

The CPI uses a geometric approach (known as the Jevons) to average items where there is no information about precise expenditure. As with the RPI, further information on the geometric average is given the Consumer Price Indices Manual and will be included in the consultation document.

There are no proposals to change the way the CPI is calculated because of the very limited use of the arithmetic average formula for items at the lowest level of price collection.

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Consumer Prices Advisory Committee

As noted above, changes to the RPI require the approval of the Authority before being referred to the Bank of England. To facilitate this, the Authority established a body to advise it on proposals for change to the RPI. This body is called the Consumer Prices Advisory Committee and it has three distinct roles:

1. To advise the UK Statistics Authority on the implication for the RPI of the improvements to this index recommended by the ONS.
2. To provide the UK Statistics Authority with advice on methodological issues.
3. To advise the UK Statistics Authority on improvements to the Consumer Prices Index (CPI) recommended by ONS.


Media contact:

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    Emergency on-call 07867 906553
E-mail: press.office@ons.gsi.gov.uk

Statistical contact:

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E-mail: Ainslie.restieaux@ons.gsi.gov.uk

Website: www.ons.gov.uk

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Consideration by the ONS of elementary aggregate formulae in the Retail Prices Index: a short history

Although there were occasional official comparisons of food in the late 19th century and early 20th century, the Government first began a systematic, continuous check on the increase in the cost of living in 1914. The new index was accepted as a valuable aid towards protecting ordinary workers from what were initially expected to be temporary economic consequences of the First World War. The ‘cost of living index’, with unchanged weights, was produced throughout the 1920s and 1930s. Criticism mounted, especially in relation to its out-of-date weights. In 1936, the Ministry of Labour announced the introduction of a large-scale household expenditure inquiry to update the weights; this was carried out in 1937–8. However, by the time the results become available, war had broken out and further action on the revisions was deferred until the war had finished.

In 1946 a new committee, the Cost of Living Advisory Committee, was set up. An interim report in 1947 recommended the removal of the name ‘cost of living index’ and the associations it implied. This new index, the Interim Index of Retail Prices, started in June 1947.

The RPI as it is currently composed began in 1956. It was initiated as a costs of goods index (COGI) rather than a cost of living index (COLI). Governance was provided by the Cost of Living Advisory Committee, which became the RPI Advisory Committee (RPIAC) in an effort to move people away from the perception that the index was a COLI. Original decisions on the formulae to use for items at the elementary aggregate level (where no weights were available) were taken by the Technical Working Party of the RPIAC. From the outset the options appear to have been between the ratio of averages (Dutot) and average of price relatives (Carli) – see Box 1.

There is little record of any consideration within the Central Statistical Office (CSO) of the appropriateness of the respective arithmetic averages until 1977, when a problem with using the arithmetic mean of price relatives in elementary aggregates was recognized by RPIAC. However, little was done to remedy this issue since it “noted at the outset that the choice of elementary formula does not make a large difference to the index”.

Suppose we want to measure inflation for apples and we collect prices in Sainsbury’s, Asda, Tesco, Morrison’s and Waitrose. For the Dutot we would look at how much we spend on apples in each period and calculate the rate of change. For the Carli, we would look at the price change in each store and then take the average of those changes.

Eg: p/kg apples (illustrative data only)

<table>
<thead>
<tr>
<th>Store</th>
<th>Last period</th>
<th>This period</th>
<th>Change (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sainsbury’s</td>
<td>298</td>
<td>305</td>
<td>2.3</td>
</tr>
<tr>
<td>Asda</td>
<td>295</td>
<td>295</td>
<td>0.0</td>
</tr>
<tr>
<td>Tesco</td>
<td>300</td>
<td>305</td>
<td>1.7</td>
</tr>
<tr>
<td>Morrison’s</td>
<td>292</td>
<td>294</td>
<td>0.7</td>
</tr>
<tr>
<td>Waitrose</td>
<td>320</td>
<td>330</td>
<td>3.1</td>
</tr>
<tr>
<td>Total expenditure</td>
<td>1505</td>
<td>1529</td>
<td>1.6</td>
</tr>
</tbody>
</table>

So the Carli is the average of the ratios highlighted yellow, which is 1.6%. The Dutot is the ratio of total expenditures, in green, also 1.6%. The prices and price movements are reasonably homogenous here, which is why we get similar outcomes from both Carli and Dutot. Let’s introduce a small, but feasible, degree of heterogeneity by allowing Asda to have a loss leader on apples in the first period:

<table>
<thead>
<tr>
<th>Store</th>
<th>Last period</th>
<th>This period</th>
<th>Change (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sainsbury’s</td>
<td>298</td>
<td>305</td>
<td>2.3</td>
</tr>
<tr>
<td>Asda</td>
<td>195</td>
<td>295</td>
<td>51.3</td>
</tr>
<tr>
<td>Tesco</td>
<td>300</td>
<td>305</td>
<td>1.7</td>
</tr>
<tr>
<td>Morrison’s</td>
<td>292</td>
<td>294</td>
<td>0.7</td>
</tr>
<tr>
<td>Waitrose</td>
<td>320</td>
<td>330</td>
<td>3.1</td>
</tr>
<tr>
<td>Total expenditure</td>
<td>1405</td>
<td>1529</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Here the large change in Asda’s prices impacts more on the price relatives than the total expenditures. The result is that the Carli provides a growth rate of 11.8% while the Dutot yields 8.8%.
By the early 1980s RPIAC had been reconvened to review the RPI, but did not (as far as we can tell) consider the elementary aggregate issue. The Wilson Report published in 1980 recommended that the UK government issues index linked gilts for pension funds and these were introduced in 1981. Later in the 1980s a report on “Methodological Issues affecting the Retail Prices Index” was published by RPIAC, but again did not consider the averaging formulae at the elementary level.

At the end of the 1980s responsibility for the RPI transferred from the Employment Department to the CSO, but importantly, responsibility for the scope and definition of the index remained under the control of Ministers (the Chancellor instead of the Secretary of State for Employment), not the Director of the CSO.

In 1994 RPIAC met for the last time and published a report relating to the house depreciation costs component of the RPI. In the same year, Bohdan Schultz, from Statistics Canada’s Prices Division submitted a paper to the first meeting of the Ottawa Group, a UN sponsored ‘city group’, highlighting the real problems that using the Carli can create in a consumer price index. The next year the European Union introduced regulations providing for the construction of a harmonised index of consumer prices, the development of which occupied NSIs around Europe (the HICP was first published in 1996). The regulation effectively bans the use of the Carli formula in the HICP and official documentation states “the decision to rule out its use was not taken on the grounds that it is generally accepted as wrong, but rather that it does not give results which are ‘comparable’ to those given by other formulae.” However, in a recent discussion with Erwin Diewert, he suggested that participants from Eurostat at the first meeting of the Ottawa group “took the advice to heart and banned the use of the Carli index in the HICP due to its built in upward bias.”

In 1996 the CSO morphed into ONS but again governance of the RPI remained unchanged, with scope and definition remaining with the Chancellor. At the same time, the US saw the publication of the Boskin Report. This increased debate internationally on measurement bias in consumer price statistics and reignited COGi or COLI arguments (Boskin favoured the latter). Given this, ONS published a couple of documents looking at the implications of Boskin for the UK’s RPI. These papers concluded that the US CPI aspires to be a COLI, and many methodological decisions are taken in a cost of living framework. By contrast, RPI advisory committees have recommended that the RPI should not be a cost of living index. The papers acknowledged that the argument over whether the geometric average (Jevons) formula is better than the arithmetic formulae (Carli and Dutot) is not clear cut and depends on consumer reaction to price changes. Boskin estimated a formula bias of 0.25 percentage points in the US CPI. ONS statisticians thought the effect of moving to Jevons in the UK was likely to be lower because the Dutot formula (rather than Carli) was used for a substantial number of items. Further research was proposed to investigate the true impact.

With the advent of the HICP the UK had two measures of inflation and began to see the consequences of that, in the shape of the formula effect. As a consequence, ONS began research looking at the factors driving the gap, with the main work starting towards the end of the 1990s. The status of the HICP increased at the start of 1999 when the HICP was used to meet the requirements of the Maastricht Treaty and subsequently for the measurement of price stability across the euro area by the ECB. The same year saw ONS setting out a three year work programme on the RPI methodology, with nine workstreams, one of which was to look at the formula to use at the elementary aggregate level.
In 2000 the Framework for National Statistics was published, but again, responsibility for RPI remained unchanged. That year, ONS produced an internal paper with a recommendation not to use the Carli, or at the very least to produce a statistical design that reduces the impact of its use, and started to look at issues around the substitution effect. Over the next couple of years ONS looked at the impact of switching the formula away from the Carli. The pervading governance arrangements for the RPI at that time are important, since they appear to have inhibited action on the Carli. That is because a switch from Carli to Jevons was deemed to be one that would change the nature of the index away from a COGI, (with the economic argument suggesting that Jevons compensated for substitution bias better than the Carli). As such, this was an issue for the Chancellor, and it appears that ONS did not consider pressing the argument for a change, and by 2002 ONS had concluded that the use of the Jevons should be ruled out because “taking into account substitution that takes place within an elementary aggregate within a chain is ‘alien to a fixed basket index’”. This was supplemented by some work with the IFS, by Ian Crawford and Bella Image (the latter from ONS), that concluded that the COLI approach could (but should not) be adopted as a conceptual basis for the UK RPI. A line was drawn in the sand when Image, a Prices methodologist, concluded that “there should be no more work on elementary aggregation until a decision has been reached on whether GM may be used. If so, it should be. If not, RA (Dutot) should be used”. In 2003 ONS switched the formula for 48 items, 47 of which were away from Carli to the ratio of averages.

Developments outside of ONS moved on, with the UK’s HICP being renamed the Consumer Prices Index (CPI) and the Chancellor of the Exchequer’s Pre-Budget Report 2003 announcing that the UK inflation target would in future be based on the CPI. Within ONS, work was focussed on improving item descriptions to mitigate some of the impacts of the use of the Carli and in developing hedonic approaches to quality adjustment for a range of items. Resources were allocated to work on the CPI, including participation in Eurostat led task forces.

The governance of RPI began to take a turn in 2004 when a Statistics Commission report recommended “that, in a revised Framework, the Chancellor should no longer be responsible for the scope and definition of the RPI but that these should instead be the responsibility of the National Statistician, along with methodology.” At the same time, ONS began to look in earnest at the causes of the gap between RPI and CPI, and in particular began investigating the contribution to the gap being made by clothing items. In 2005 an internal report revisited decisions and analyses set out in 2002, and again concluded that the Carli should not be used. It identified weaknesses in the criteria for assessing the use of the Carli and proposed new measures. It concluded that the formula effect was generating about 0.6 percentage points difference between the two. However, there are no documents that show that a switch away from the Carli was seriously considered. Outwardly, ONS reported on the conclusion of the three year work programme, begun 6 years earlier, but made little reference to the use of Carli.

Over the next couple of years work centred around the transfer of responsibilities for price statistics from London to Newport, and the expectation of a new computer system. This was coincident with the creation of the UK Statistics Authority and issues around RPI were focussed on policy and governance rather than methodology. The legal and policy issues were resolved in 2007 with the enactment of the Statistics and Registration Services Act, which established new arrangements for the governance of the RPI. These placed responsibility with the Board to compile and maintain the RPI and publish it each month. It also required that the Board consult the Bank of England and
ultimately the Chancellor before making any change to the coverage or the basic calculation of the index that was judged to be fundamental and materially detrimental to holders of index linked gilts. The relocation of the consumer prices work was completed in 2007 and the RPI was first published from the Newport office in December of that year.

Around a year later, in January 2009, ONS discussed options for change to the RPI and CPI, including a review of formulae at a meeting with the Bank and HMT. The minutes conclude that ONS’s “top priorities for change in the RPI and CPI in 2009” included the elementary aggregate formulae. “Discussions followed regarding the shortcoming of the RPI in its current form, and it was acknowledged that the current statistical methodology was out of date and in need of review. It was also noted that until RPI governance issues are resolved there would be barriers to change in the CPI.” The Bank “pointed out that the MPC may be concerned if resources were diverted from the CPI, to focus on updating the RPI and questioned the impact of introducing multiple changes to the RPI. “ The governance issues referred to previously were resolved in July 2009 with the formation of CPAC and in December 2009 CPAC considered the issues taken to the Tripartite meeting between ONS, HMT and the Bank at the start of the year. This is the first time CPAC were asked to consider work to address the formula effect in development plans for the CPI and RPI. However, including OOH in the CPI was seen as the top priority and addressing the formula differences between CPI and RPI was listed as an item for review in 2011 or later.

In early 2010 ONS implemented changes to the way prices for clothing were collected. These changes were not brought to CPAC for approval but were discussed at the Tripartite meeting in December 2009. The question of whether the change was fundamental was considered by the meeting, but it was accepted that as this was a change to collection guidelines it was not. The analysis of the impact of the change focussed on the CPI only, since the driver for the change was a compliance monitoring assessment by Eurostat in autumn 2008 and increasing concern from users for the continued and prolonged period during which inflation rates for clothing were negative. There was no assessment of the impact the change might have on the formula effect. After the changes to the collection guidelines were made, estimates of inflation in clothing in the CPI switched from negative to positive (so delivered the intended outcome) but the gap between CPI and RPI widened from around 0.5 percentage points to an average of 0.9 percentage points. In late April 2010 the Authority’s Assessment Team began an assessment of consumer price statistics and progress on this was reported to CPAC in July. At the same meeting, another update on the CPI and RPI development plans was considered but the formula issues had slipped off the list. CPAC accepted that a higher priority was attached to the need to continuously improve the CPI compared with the RPI. In part this probably reflected developments from the June Budget, where the Chancellor announced that the government would adopt the CPI for the indexation of benefits, tax credits and public service pensions.

In August 2010 the President of the RSS wrote to Sir Michael Scholar and expressed concerns around the widening formula effect. CPAC was updated on these developments and a programme of work instigated, though it did not feature in the programme set out in CPAC’s annual report that was published in November 2010. Indeed, CPAC first received a paper on the formula effect, though focussing on the clothing issues, at its meeting in May 2011, though development work within ONS was under way ahead of this date. At the end of 2010 the Authority’s assessment of consumer prices noted that it is not always clear whether the different approaches that have been adopted in the
past for the RPI remain appropriate today. For example, the use of the arithmetic mean to combine individual prices rather than the geometric mean. The focus of investigation by ONS, under the guidance of CPAC has been to look at the clothing collection guideline changes in 2010. However, that work was widened to look at the formulae used by other statistics offices, which showed that the UK was the only nation that retained the Carli. The focus of the development programme therefore changed, and on the back of a significant amount of new research and analysis a tentative position has been reached on the formulae that are best suited for consumer inflation purposes.

There are a number of reasons why the time is now right to consider a change in elementary aggregate formula. Strategies and tactics for pricing products have evolved over many years into various models which are now well documented in marketing literature. Examples include loss leader pricing, predatory pricing and limit pricing. In today’s supermarkets a range of items will be on offer at temporarily reduced price to attract customers, before returning to full price days, hours, or possibly minutes later. The clothing industry has changed dramatically since the RRI was first published in 1956. Ready-made clothing using synthetic and easy-care fabrics was a relatively new phenomenon in the 1950s. A large segment of the fashion industry now relies on mass market sales, catering for as many customers as possible. In order to save money and time, cheap fabrics and simpler production techniques are used which can easily be done by machine. The final product can therefore be sold much more cheaply. At the end of the season products are sold at dramatically reduced prices to make way for new stock. These conditions create an environment where a variety of products are available at a range of prices for any one item in the CPI or RPI basket, making the items and prices more heterogeneous over time. Products are frequently on and off sale, and in the case of clothing, items will need to be replaced by a comparable product if no longer available. This is the type of everyday pricing behaviour which fuels a significant upward bias in the Carli formula. It can be managed to a degree by refining item descriptions and comparability rules over time but is this not a means to an end.

The formula effect is now more important than ever before. The rate of inflation in the UK abated substantially in the 1990’s. As a result, a bias that might have contributed a fraction of the total annual change in prices is now a significant portion of the entire change. In response to the CPI being used for the indexation of benefits, tax credits and public sector pensions there has been an increased focus on the formula effect from the public and other users. Finally, empirical research by ONS has shown that economic theory cannot be used to justify the use of the arithmetic mean or geometric mean based on simple models of consumer behaviour. In addition, the theory is not applicable at the elementary aggregate level because, by their very definition, weighting information are not available at this level to test the theory. These key findings have helped ONS build recommendations for change.
Section 1 - Key Findings

Finding 1 - there is no ‘perfect’ EA formula, nor is there a single, internationally recognised method of determining the most appropriate formulae. The debate over the best approach to aggregating price change to the EA level has been going on amongst academics and National Statistics Institutes for many years. While progress has been made, a definitive answer has not been reached. Of the many formulae available, each has its strengths and weaknesses, its supporters and detractors. Three formulae, the Arithmetic Mean of Price Relatives (in price index literature this is referred to as the Carli), Ratio of Arithmetic Mean Prices (the Dutot), and the Geometric Mean (the Jevons) have, traditionally, been used in the construction of consumer price indices.

Finding 2 – there is no good reason not to use the same formulae for a given item in the CPI and RPI. For example, if we use the Jevons to calculate the price movement of men’s shirts in the CPI, then we should also use the Jevons to calculate the price movement of men’s shirts in the RPI. This finding is supported by ONS's review of EA formulae used in other countries, which demonstrated that Slovenia was the only other country found to use different formulae in different indices,¹ and is reinforced through the assessment of UK consumer price statistics conducted on behalf of ONS by Prof. Erwin Diewert².

Furthermore, where there is no clear justification for using different approaches in different measures, it is desirable to use the same elementary aggregate formula to promote comparability in line with the Code of Practice for Official Statistics³.

Finding 3 – the use of the Carli formula is no longer justifiable. One of the classical approaches to ranking index number formulas is the axiomatic or ‘test’ approach⁴. This approach identifies a range of desirable properties that index formulae should possess. The Carli fails the tests for two important properties - time reversal (if the price data for two periods are interchanged, then the resulting price index should be the reciprocal of the original index) and circularity (measuring the price change from period one to three doesn’t give the same result as measuring the combined price changes from period one to two then two to three).

The consequence of failing these tests are an upward bias in the Carli. This, together with the closely-linked phenomena of ‘price bouncing’⁵ and the Carli’s lack of comparability with other EA index formulae have been known for some time and are the reason why European regulations effectively prohibit the use of the Carli in the Harmonised Index of Consumer Prices (HICP – the UK CPI)⁶.

¹ See Evans B (2012).
² Erwin Diewert is a Professor Economics at the University of British Columbia, Canada and is one of the world’s leading experts on consumer price statistics. In early 2012, Prof. Diewert was contracted by ONS to conduct a review of the methods for constructing the CPI and RPI with a focus on the use of elementary aggregate formulae. Details of Prof. Diewert's career and publications can be found on his homepage (http://faculty.arts.ubc.ca/ediewert/hmpgdie.htm).
⁴ See ILO (2004), Section 20.58 onwards for a list of the axiomatic tests.
⁵ For a worked example of price bouncing see Annex B.
⁶ The use of the Carli is prohibited except in exceptional instances when it can be shown to produce comparable results to the Dutot and Jevons. See Commission Regulation (EC) No 1749/96 – Annex II.
The full extent to which the use of the Carli formula, rather than the Dutot or Jevons, is responsible for the formula effect has come to light through recent research by ONS. A review of the experience of countries that have changed their EA formulae showed that they experienced larger formula gaps between the old and new indices when switching from the Carli to Dutot or Carli to Jevons, compared with a switch from Dutot to Jevons\(^7\). Attempts to produce estimates of the CPI and RPI using different formulae at the EA level corroborates this finding (see figure 1 below) with the aggregated indices produced using Carli at the EA level producing markedly different results to comparable indices produced using Dutot and Jevons indices. The scale of the gap between an index calculated using the Carli and other EA formulae will be dependent on the variance of price changes from the base prices – the greater the degree of variance, the greater the gap.

**Figure 1 – Illustration of the estimated impact of using different elementary aggregate formulae in calculating the RPI**

![Graph showing RPI using different formulae](image)

(note: a number of assumptions have been made in calculating the series in the above chart. These should be treated as accurate, but illustrative, estimates of how the RPI would look if calculated using different formulae).

Another classical approach to determining the appropriate choice of EA formulae is through economic theory. Unlike other approaches, this doesn’t treat prices and quantities as independent. The approach recognises that quantities bought will be affected by changes in prices. Some commentators have used the economic theory for index numbers to justify the

\(^7\) There is no evidence of countries switching to the Carli or from the Jevons. For further information see pages 5-6 in Evans B (2012).
use of the Carli. Briefly, the theory states that if the cross-price elasticity of substitution\(^8\) for an item is closer to zero, then an arithmetic mean (Carli or Dutot) is more appropriate, whilst the Jevons is more appropriate when the elasticity of substitution is closer to one\(^9\). This only follows if a range of restrictive assumptions apply which may not be the case in practice.

Empirical research by ONS\(^10\) has estimated the elasticity of substitution for alcoholic drinks using economic and algebraic techniques. The work suggests that consumer behaviour in response to relative price change is too complex to be quantified using a simple model from economic theory. This in turn suggests that the economic approach to index number theory cannot be used to justify the use of the arithmetic mean or geometric mean. In addition, the theory is not applicable at the elementary aggregate level because, by their very definition, weighting information are not available at this level to test the theory. This was supported by Prof. Diewert in his report to ONS.

**Finding 4 – the Jevons is, on balance, the most appropriate elementary aggregate formula to use in the CPI and RPI.** As explained in finding 3 above, the use of the Carli is no longer viewed as appropriate for the CPI and RPI. The use of the Dutot is appropriate where there is a high degree of homogeneity amongst prices. Whilst ONS aims to achieve price homogeneity through well defined item descriptions and price collection guidelines, there are limits to the effectiveness of this approach. For example, the item description for red wine could be tightened to ‘Australian red wine, 750ml bottle, 13-14% abv, screw cap’ and prices for this item would still vary between approx £5 and £20 or more in a single shop. Tightening an item description also heightens the probability of the product being out of stock and having to be replaced by another product (which introduces other issues in the price index). This means that there are many items where the Dutot will not be suitable as, in cases where there is a wide range of prices, a Dutot index will be heavily influenced by the price movement of the more expensive goods in the sample, rather than reflecting the general price movement of all items. The Jevons does not have the flaws of the Carli, nor is it subject to the limitations of the Dutot, making it suitable for use in the vast majority of EA formulae. This view was supported by Prof. Diewert in his report to ONS and is reflected through the use of the Jevons by the majority of countries\(^11\).

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\(^8\) In the context of consumer price statistics, cross price elasticity is a measure of the responsiveness in consumer demand for a specific product in relation to a change in the price of a comparable product (eg the extent to which consumer demand for a particular brand of baked beans changes when a competing brand falls or rises in price).

\(^9\) See ILO(2004) and Silver & Heravi (2006) for theoretical examples of how this economic theory could be applied in constructing a consumer price index.

\(^10\) See Winton J, O’Neill R, Elliott D (2012). Since the publication of this paper, ONS has extended the time series and coverage of goods of the analysis in the paper. To date, the additional work has not altered the findings in the paper.

\(^11\) See Annex C for a list of elementary aggregates used by country.
Section 2 - Recommendations

Taking the four findings outlined above into account, there is a clear case to improve the calculation of UK consumer price statistics at the EA level. This section outlines the steps that should be taken to implement these improvements and to ensure that the CPI and RPI continue to be calculated in line with current best methodological practice for consumer price statistics.

Step 1 – stop the use of the Carli formula in the RPI at the earliest opportunity. As summarised in finding 3 above, there is now overwhelming evidence against the continued use of the Carli in consumer price indices. The Carli is used for approx 40 per cent (in terms of weight) of the RPI.

Step 2 – align the formulae used in the CPI and RPI at the point step 1 is implemented. Implementing step 1 will, by itself, probably remove most of the formula effect gap between the CPI and RPI\(^\text{12}\). However finding 2 demonstrates that there is no good reason to use different formulae for the same item in different indices. It is therefore expedient to align the EA formulae for all items in the RPI with the same items in the CPI at the same as the use of the Carli is stopped. Failure to do so will result in a continuation of the formula effect gap that is unjustifiable based on the evidence here and will not be in line with user expectations.

Fully aligning the EA formulae used in the CPI and RPI means that the difference between the two indices in the long run will be limited to differences in the coverage and classification of goods and services, and the different population coverage of the two indices.

Step 3 – implement an ongoing evidence gathering programme for the formula effect. As stated in finding 1 above, there is unlikely to ever be full consensus on the most appropriate EA formula(e) to use for consumer price statistics. New developments in price index theory and new sources of data (eg point of sale scanner data) will move rather than resolve on the debate about which formula(e) should be used.

It is worth noting that for approximately 30 per cent of the CPI and RPI by weight, some form of expenditure weighting data are used in constructing the item indices. In the medium term (the next couple of years), ONS should complete a review of the construction of all item indices – whether constructed using EA formulae, weighted indices – or a mixture of both. The purpose of this review will be to consider the most appropriate formulae (given the current evidence) are used for each item, and are implemented consistently using the best methodology. Once completed, this review process should be repeated on a regular basis to ensure new developments in evidence and methodology can be considered.

Through the work it has undertaken in the last year (particularly the work on consumer behaviour) ONS has demonstrated the ability to shape and advance consumer price index number theory. ONS should continue to do this, and to keep abreast of other developments, over the long term.

\(^{12}\) Based on calculations using historic data, the remaining formula effect gap is estimated to reduce to 0.1 percentage points. This tallies with the formula effect gap between Slovenia’s national CPI and HICP (Slovenia being the only other country found to use different EA formulae in its different consumer price indices).
Richard Campbell  
Prices Division, ONS  
August 2012

List of Annexes

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<tr>
<th>Annex</th>
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<tbody>
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<td>Annex A</td>
<td>Description of Elementary Aggregate Formulae</td>
</tr>
<tr>
<td>Annex B</td>
<td>Example of Price Bouncing</td>
</tr>
<tr>
<td>Annex C</td>
<td>International use of Elementary Aggregate Formulae</td>
</tr>
</tbody>
</table>

References


Annex A – Description of Elementary Aggregate Formulae

Dutot, or Ratio of Arithmetic Average Prices (RA) index

Ratio of average prices from the current and base periods.

\[ I_{RA}^{0:t} = \frac{1}{n} \sum_{i=1}^{n} \frac{p_i^t}{\frac{1}{n} \sum_{i=1}^{n} p_i^0} \times 100 \]

Where \( I = \) index, \( p = \) price, \( i = \) item and \( t = \) period

Carli, or Arithmetic Average of Price Relatives (AR) index

Average of price relatives for all items in the price basket.

\[ I_{AR}^{0:t} = \frac{1}{n} \sum_{i=1}^{n} \frac{p_i^t}{\frac{1}{n} \sum_{i=1}^{n} p_i^0} \times 100 \]

Where \( I = \) index, \( p = \) price, \( i = \) item and \( t = \) period
Jevons, or Geometric Mean (GM) price index

The geometric mean of price relatives for all items in the price basket is always equal to ratio of the geometric mean of current period prices to the geometric mean of base period prices.

\[
I_{GM}^{0:t} = \left( \prod_{i=1}^{n} \frac{p_i^t}{p_i^0} \right)^{\frac{1}{n}} \times 100
\]

\[
= \left( \frac{\prod_{i=1}^{n} p_i^t}{\prod_{i=1}^{n} p_i^0} \right)^{\frac{1}{n}} \times 100
\]

Where \( I = \) index, \( p = \) price, \( i = \) item and \( t = \) period
Annex B – Example of Price Bouncing

<table>
<thead>
<tr>
<th>Price (£)</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>1.15</td>
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<td>0.78</td>
<td>0.80</td>
<td>0.78</td>
</tr>
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<td>d</td>
<td>0.76</td>
<td>0.85</td>
<td>0.95</td>
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<td>1.10</td>
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<th>Price Relatives (period t/ period 0)</th>
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<td>Product</td>
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<td>Period 1</td>
<td>Period 2</td>
<td>Period 3</td>
<td>Period 4</td>
<td>Period 5</td>
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<td>0.90</td>
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<td>b</td>
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<td>0.88</td>
<td>0.92</td>
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<td>c</td>
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<th>Index (base = period 0)</th>
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<td>Dutot</td>
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<td>97.91</td>
<td>95.30</td>
<td>100.00</td>
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<td>85.64</td>
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<tr>
<td>Jevons</td>
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<td>95.27</td>
<td>100.00</td>
<td>94.47</td>
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The tables above show the hypothetical movements for four products and elementary aggregate indices produced for these using the methods used in the CPI and RPI. Note that in period 3 the total price of the goods returns to the original (period 0) total. The Dutot and Jevons indices for this period return to their values for the base period (100). However, the Carli index does not return to its original value. In other words, the use of the Carli suggests that prices have increased when they have, collectively, haven’t changed.
## Annex C – International use of Elementary Aggregate Formulae

<table>
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<tr>
<th>Country</th>
<th>National CPI EA formula</th>
<th>HICP EA formula</th>
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<td>Jevons</td>
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<tr>
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</table>

For further information see Evans B (2012).