

Bernhard Goldhammer, Lukas Henkel, Malgorzata Osiewicz: Bias related to the Bridged-overlap- and Link-to-Show-No-Price-Change Method (with input from Raffaella Traverso)

Quality Adjustment Methods

- Quality adjustment: splitting the nominal price difference Δnp between two products („varieties“, IMF 2019) into a price component Δp and a quality component Δqu : $\Delta np = \Delta p + \Delta qu$
- Distinction between explicit and implicit methods for quality adjustment (FSO Germany 2009, Eurostat 2018):
 - Explicit methods: Explicit estimation of the value of the quality difference; e.g.
 - Hedonic methods
 - Supported judgement
 - Option pricing
 - Implicit methods: quality valuation regardless of the product characteristics.
- Most important methods:
 - Direct price comparison (DPC): $\Delta np = \Delta p$; $\Delta qu = 0$
 - Link-to-show-no-price-change (LNP): $\Delta np = 0$; $\Delta p = \Delta qu$
 - Bridged overlap (BO): the price difference equals the average percentage price change of all observed products in the sample, the remainder is quality difference

The problem

- Implicit methods can be problematic under certain circumstances:
 - LNP:
 - price changes with the introduction of replacements are not tackled (FSO Germany 2009)
 - „In no case shall a quality change be estimated as the whole of the difference in price between the two product-offers, unless this can be justified as appropriate“ (EU regulation 1749/1996, Art. 5 No. 5)
 - If prices of products decrease over their life cycle, downward drift of the index can happen (Keating/Murtagh 2018)
 - Bridged overlap:
 - Market with „regular price – sales price – replacement“ pattern: „If... a bridged overlap is applied in these cases, ... this would lead to a devastating downward bias in the index.“ (Dalén/Tarassiouk 2013, p. 11)
 - Prerequisite to be fulfilled: price development of the observed models has to reflect the price development coming with the introduction of the replacement model (FSO Germany 2009) => otherwise, method should not be applied
- The use of these methods in inappropriate situations may be one piece of explanation of the currently low inflation rates

Theoretical considerations and research question

- Theoretical considerations for the **bridged overlap** method.
 - The size of the bias also depends on the elementary (unweighted) index used in the calculation.
 - $\Omega_t = \{ \text{all products available both in } t \text{ and } t-1 \}$, $m = |\Omega_t|$, $\Psi_t = \{ \text{all products to be replaced in } t \}$, $n = |\Omega_t \cup \Psi_t|$, p_{it} price of product i in period t
 - Dutot-Index for all products including replacements:

$$\frac{I_{D,t}}{100} = \frac{\sum_{i \in \Omega_t} p_{it} + \sum_{j \in \Psi_t} p_{jt}}{\sum_{i \in \Omega_t} p_{it-1} + \sum_{j \in \Psi_t} p_{jt-1}} = \frac{\sum_{i \in \Omega_t} p_{it}}{\sum_{i \in \Omega_t} p_{it-1}} + \frac{\sum_{j \in \Psi_t} p_{jt}}{\sum_{j \in \Psi_t} p_{jt-1}}$$
 - Jevons-Index for all products including replacements:

$$\frac{I_{J,t}}{100} = \left(\prod_{i \in \Omega_t} \frac{p_{it}}{p_{it-1}} \prod_{j \in \Psi_t} \frac{p_{jt}}{p_{jt-1}} \right)^{\frac{1}{n}} = \left(\prod_{i \in \Omega_t} \frac{p_{it}}{p_{it-1}} \right)^{\frac{m}{n}} \left(\prod_{j \in \Psi_t} \frac{p_{jt}}{p_{jt-1}} \right)^{\frac{1}{n}}$$
- ⇒ Can the bias be replicated?
⇒ How large is the influence of missing replacement price differences with real data?

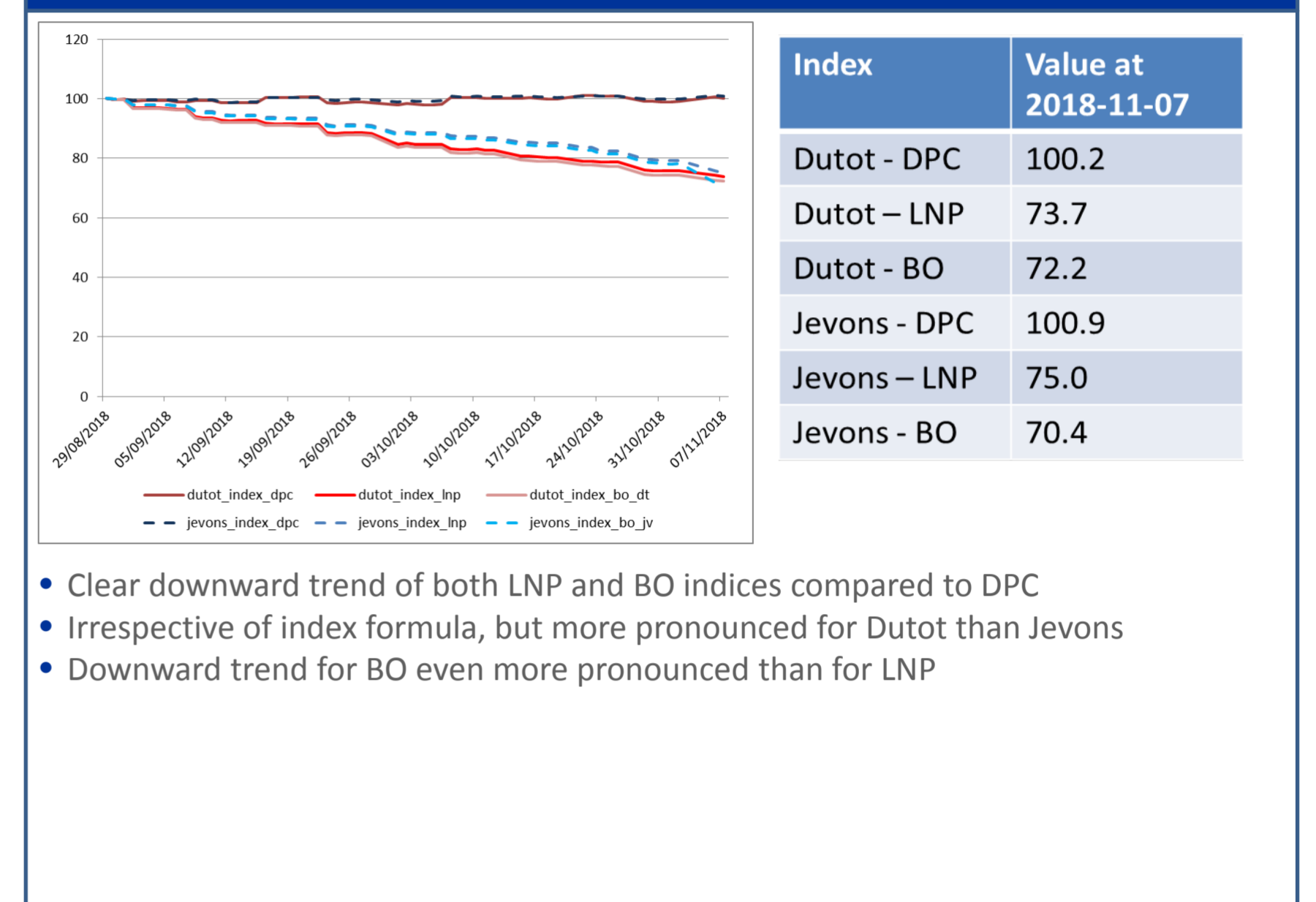
The web scraping process and the data

- Automated web scraping of two German online supermarkets:
 - pure online retailer, delivering goods Germany-wide
 - retailer with sales online and in brick and mortar stores => localised prices (location fixed in data collection)
- Inventory: mainly fast-moving consumer goods => around 8.000/110.000 different individual products
- Price collection by daily scraping of the online shop websites, always at the same time
- Information on all available products is collected
- IT infrastructure:
 - Scraping: Python implementation of Scrapy
 - Parsing from the raw HTML files : BeautifulSoup
 - Structured (SQL) database for storing the full history of all days and all products
 - Data collected: product price, product name, quantity (or volume), retailer-specific category of the product, product description, discount flag
- For this study: 28,698 price quotations for beer (cans, bottles, boxes) were used, scraped from 2018-08-29 to 2018-11-07 (60 days), including 1,888 discount quotations (6.6%). The price quotations belong to 629 beer product offers. 209 had less than 50 observations and were deleted. 24,149 price observations remained, with 1,662 discounts.

Research methodology

- The data was cleaned and edited (deletion of items with price >30, restriction to one observation per day, deletion of non-beer related beverages or wrongly classified items)
 - Simulation of replacements:
 - Assumption: end of discount period => beer leaves the market and is replaced
 - Replacement is the same, undiscounted beer
 - Calculation of replacement price using DPC, LNP, BO:
 - Use of Additive Adjustment Factor to determine the calculation price pc_{it} from the observed price: $pc_{it} = p_{oit} - AAF_{it}$
 - Calculation of AAF_{it} : $AAF_{it} = 0$;
 - if (discount_{it-1} = false or discount_{it} = true): $AAF_{it} = AAF_{it-1}$;
 - ELSE the following table applies for the calculation of AAF_{it} :
- | Method | Jevons index | Dutot index |
|--------|--|---|
| DPC | | 0 |
| LNP | | $p_{oit} - p_{oit-1}$ |
| BO | $p_{oit} - p_{oit-1} \cdot \sqrt[n]{\prod_{j \in \Psi_t} \frac{p_{jt}}{p_{jt-1}}}$ | $p_{oit} - p_{oit-1} \cdot \frac{\sum_{j \in \Psi_t} p_{jt}}{\sum_{j \in \Psi_t} p_{jt-1}}$ |
- Unweighted index calculation with Dutot and Jevons => 6 indices are calculated

Results



Discussion

- Disregarding price changes at replacements can lead to a downward drift in a price index.
- Therefore, link-to-show-no-price-change and bridged overlap as implicit methods for quality adjustments should be handled with care.
- Only employ them if the underlying assumptions are met:
 - Bridged overlap: „...the missing item and all the other items of the same group have undergone the same change or prices and ... the new (replacement) good B is “improved” to the extent to which the price of B (compared with the old good A) is rising higher than the average of the group of comparable goods...” (von der Lippe 2007, p. 282)
 - LNP: „... any difference in price level is assumed to be a measure of the quality difference. However, in practice there are many reasons to render the underlying assumptions ... invalid, as for example “strategic” setting of prices (e.g. discounting of old models... or “skimming” of market segments)...“ (von der Lippe 2007, pp. 282-283)
- Use of LNP and BO may explain a small piece of the “missing inflation” puzzle.
- BO and LNP are not suited for goods with downward moving prices over the product life cycle and price jumps in replacement situations.
- Further research should be devoted to the question whether methods under discussion for scanner data that rely on the assumption $\Delta p = \Delta qu$ are suitable.

Limitations, Proposal for further research

- Limitations:**
- Artificial example => only for illustrative purposes
 - Use of Additive Adjustment Factor instead of multiplicative one => leads to a stronger downward bias and potentially negative calculated prices (avoided by setting a 0.01€ threshold) => research to be replicated with MAF, but outcome unlikely to change
- Proposal for further research:**
- Replicate with MAF.
 - Can such biases be expected for scanner data indices with the assumption $\Delta p = \Delta qu$?
 - Empirical confirmation of the bias formula derived under „theoretical considerations“.
 - For Statistical Offices: provide clear guidelines when and when not to use BO and LNP.
 - Should the assumption by economic theory that, under perfect competition, price differences reflect quality differences be dropped?
 - A review of applied QA methods in the light of this research might be advisable.

Conclusion

- Be careful when considering Bridged Overlap and Link-to-show-no-price-change as implicit methods for quality adjustment!**
- Always consider whether the underlying assumptions are met in reality!**

References, Contact

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For further questions contact:
Bernhard Goldhammer
Economist-Statistician
European Central Bank

bernhard.goldhammer@ecb.europa.eu
Tel. +49-69-1344-95901



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