Conference on
# Remuneration Statistics
eurostat

## Structure

**Title** 100 years of theory: why a fixed-basket approach is less appropriate for international cost–of–living comparisons

**Author** Ian Dennis

**Expertise** Senior Expert

**Affiliation** Eurostat

**Abstract** This article briefly highlights a key conceptual criterion which underpins the calculation of Eurostat correction coefficients and allows to distinguish their quality from other approaches

**Luxembourg**
**9-10**
December 2019
European Convention Center
Luxembourg

# Introduction

Eurostat "correction coefficients" are indices which aim to provide a high–quality measure of price level differences between distinct geographical locations. They are used to adjust remuneration to equilibrate purchasing power in target location of salary values established in reference location. Note that this is not necessarily the same objective as maintaining local purchasing power in the comparison location. In addition to these bilateral figures, separate multilateral purchasing power parities are established to deflate Gross Domestic Product expenditure into comparable volume terms. Eurostat has been producing correction coefficients and purchasing power parities since the 1970s for Intra–EU locations, and since the 1990s for Extra–EU locations. Such spatial indices share many conceptual similarities with temporal "inflation" indices which measure changes in price levels between distinct points in time.

Alongside the figures calculated and published by Eurostat, there is an ever–growing number of alternative indices available from commercial and other sources which purport to achieve similar objectives. This paper focuses on a key conceptual criterion which allows to distinguish the Eurostat "gold standard" correction coefficient from other measures.

Price index number theory has advanced significantly since its origins[1], and there is now a vast academic literature discussing the appropriate choice of formulae for such calculations and establishing desirable axiomatic criteria and tests for their evaluation.

Of course, if all prices in the economy changed at the same rate, there would be no need to establish multiple temporal indices: one would suffice. Similarly, if all price ratios between geographical locations are constant, there is no need to establish multiple spatial ratios and summarise them using some measure of central tendency. In practice of course that is not the case, there may be millions of distinct goods and services available to consumers, and the prices of the same item may vary according to outlet type and location. A way must be found to combine (aggregate) all the differences into a reasonable measure of overall price change. That index needs to take into account the relative proportions of total household expenditure which are spent on each component item.

There is a necessary practical constraint: index calculations in practice generally reflect an average consumption pattern and average price level: neither of which may match the particular circumstances of a given individual[2].

# Fixed–basket approaches

In essence there is a choice between a fixed–basket approach and a cost–of–living approach. The standard fixed–basket approach examines the cost of the basket of goods and services bought by consumers in the reference location, and establishes a cost ratio using market prices paid for those goods and services in both the reference location and the comparison location.

In classic parlance, this can be considered as a "Laspeyres–type" index (or "Lowe–type" index). The statistical formula below expresses the aggregate index as an arithmetical weighted mean of the price ratio ("price relatives") between the two geographic locations for each item in the basket, weighted using proportions of household income spent on each item in the reference location "0":

$$I_L = \frac{\sum_i^n \frac{P^i{}_1}{P^i{}_0} \times W^i{}_0}{\sum_i^n W^i{}_0}$$

[1] Some authors attribute this to William Fleetwood in the 17th century, with developments coming during the 19th century and in particular at the start of the 20th century.

[2] This paper does not address other aspects such as the choice between "plutocratic" weights (average established by aggregating expenditure, thus richer households implicitly have greater influence) and "democratic" weights (average established by aggregating expenditure shares).

The exact opposite would be a "Paasche–type" index (or "Palgrave–type" index), which instead examines the situation from the perspective of the comparison location. The statistical formula below expresses the aggregate index as a harmonic weighted mean of the price ratio between the two geographic locations for each item in the basket, weighted using proportions of household income spent on each item in the comparison location "1":

$$I_P = \frac{\sum_i^n W^i{}_1}{\sum_i^n \frac{P^i{}_0}{P^i{}_1} \times W^i{}_1}$$

There is an important practical advantage in using the Laspeyres–type fixed basket index for temporal comparisons: the expenditure information is generally already available and there is no need to wait and establish the current consumption pattern required in order to compute a Paasche–type index. To a lesser degree, this may also be the case for a spatial index. The idea of continuously repricing a fixed basket has a simplistic appeal which is easy to explain to non–specialists. Depending on the number of comparison locations, it may also be significantly less costly to implement. However, this approach suffers from a major conceptual flaw when applied for cost–of–living measurement purposes.

## Cost–of–living approaches

In economic utility theory, rational consumers will seek to maximise the satisfaction they receive from the purchase of goods and services within the constraints of their household budgets. In practice the choices of consumers identified through representative expenditure surveys can be assumed to reveal their utility preferences. The cost–of–living approach can be summarised as follows:

$$COLI(P_1, P_0) = \frac{C(U_t, P_1)}{C(U_t, P_0)}$$

Even after discounting the typical differences in expenditure patterns which are due to household size and composition, age, gender, marital status, tenancy status, contractual status, occupational grade, cultural origin, education, political orientation, *etc.*, economic theory recognises that consumers will adapt their expenditure patterns in response to changes in prices (the "substitution effect" and "income effect"). Of course the "elasticity" with which consumers are able to adjust their spending behaviour will vary for different items (shelter and healthcare are obvious candidates for special consideration). Nevertheless, the dynamic interaction of supply and demand which determines the availability and price of goods and services in one location or at one point in time may well result in a different availability and price of goods and services in another location or at a different point in time. It is widely accepted that assuming elasticity of substitution applies is preferable to assuming no elasticity at all.

The cost–of–living approach requires consideration not of the cost of a basket of goods and services, but comparing different baskets and saying when they yield the same standard of living. Of course, this economic approach ignores other elements of well–being, such as health or happiness, but is the standardised proxy for "satisfaction". If the same bundle of items is purchased at the same cost then it is assumed that utility is maintained. However, there may also be alternative bundles that are equally acceptable to the consumer, which cost the same originally but are now cheaper overall than the original basket, or are more expensive.

Since it is always possible to reach the original standard of living by purchasing the original basket, the Laspeyres–type index sets a boundary on the movement in the cost–of–living index compared to the starting point. Similarly, the Paasche–type index sets another boundary on the movement in the cost–of–living index (what would it have cost in the reference location to achieve the current standard of living in the comparison location?). The Laspeyres–type index assumes zero substitution. The Paasche type index assumes full substitution. Unless circumstances and behaviours are identical in the comparison and reference locations, these two boundaries are unlikely to coincide in practice. Homothetic preference theory suggests that consumers will rank baskets of goods and services in similar manner whatever their income level – however there is more than a century of empirical evidence dating back to Ernst Engel showing that the proportion of income spent on staple goods (*eg.* food) decreases as income rises, even if absolute spending on them increases, whilst the proportion spent on discretionary luxury goods increases as income rises.

## Superlative indices

In between these two fixed–basket index boundaries, there are a potentially infinite number of other index values reflecting other living patterns/standards. Axiomatic criteria and tests can then be applied to identify the index which is the most appropriate approximation to a genuine cost–of–living index. Diewert and others have shown that where there is substitution in response to relative price change, the true cost of living can be approximated using a number of "superlative" indices. All of these require information about how consumption spending patterns are modified between the reference location and comparison location.

The most widely known proposal is Fisher's ideal index which is the geometric mean (square root) of the Laspeyres–type and Paasche–type indices:

$$I_F = \sqrt{(I_L \times I_P)}$$

Other candidates include an arithmetic average of the Paasche and Laspeyres indices (Sidgwick–Bowley); weighted arithmetic mean using arithmetic average of the weighting structures themselves (Marshall–Edgeworth); weighted arithmetic mean using geometric average of the weighting structures (Walsh)[3]; weighted geometric mean using arithmetic average of the weighting structures (Törnqvist–Theil), and a host of alternative index formulations.

The Fisher index has the advantage of being transparent and easy to calculate once the two fixed–basket indices have been established. It is evident that the consumption basket in the Laspeyres–type index is equally valid to the consumption basket in the Paasche–type index, thus an even–handed treatment is intuitive. This seems particularly appropriate when circumstances are quite different in the two locations. The Fisher index also satisfies a long number of statistical tests and axioms.

Diewert found that the Fisher index satisfies 21 tests (several more than the closest rival) and is uniquely characterised by a subset of them. On an axiomatic basis, the Fisher index clearly dominates other alternatives, which provides a very strong justification for its use. The tests are listed below:

- T1. Positivity: The price index and its constituent vectors of prices and quantities should be positive.
- T2. Continuity: The price index is a function of its components.
- T3. Constant prices (Identity): If the price of every item is identical in both locations then the price index should equal 1, no matter what the quantity vectors are.
- T4. Constant quantities: If the quantities of every item are identical in both locations, then the price index does not change.
- T5, T6. Proportionality: If all prices are different by X %, the price index should also be different by X %.
- T7, T8. Quantity proportionality: If all quantities are different by X %, the price index does not change.
- T9. Order invariance: The ordering of prices and associated quantities should not affect the price index.
- T10. Commensurability: Invariance to the unit of measure (e.g. whether both sets of prices are measured in dollars or in pesos, the index should show the same development).

[3] The United Nations International Civil Service Commission uses a Walsh index for the in–area component of its Post Adjustment Indices (the equivalent of Eurostat correction coefficients). Test calculations have suggested that the Walsh and Fisher formulae can give quite similar results in practice, especially where there is similarity in consumption structures.

- **T11. Reversibility**: If prices between locations are reversed, then the second index should be the reciprocal of the first index.
- T12: Quantity reversibility: If quantities between locations are reversed, the price index is invariant.
- T13: If prices between locations are reversed, then the quantity index is unchanged.
- T14: Mean value test: The price index lies between the highest and the lowest price relatives.
- T15: Mean value test for quantities: The quantity index lies between the highest and the lowest quantity relatives.
- T16. Paasche/Laspeyres boundary: The price index should lie between the Paasche and Laspeyres indices.
- T17, T18. Monotonicity: If one or more prices are higher, and none are lower, then the price index should increase.
- T19, T20. Monotonicity of quantities: If one or more quantities are higher, then the quantity index should increase.
- **T21. Factor Reversibility**: A price index multiplied by a corresponding quantity index should equal the ratio of the values for the two comparison locations.

One test which the Fisher index does not fully satisfy is "additivity". Computing an index for intermediate groups (*eg*. 12 main COICOP groups) from an underlying set of data (*eg.* the 80 basic headings in the Eurostat A64 classification), does not then allow subsequent calculation of an overall aggregate directly from those intermediate groups: the computation should start again from the underlying data. However, for the purposes of computing an overall correction coefficient like the one which Eurostat applies to adjust remuneration, the intermediate values are used primarily for analytical purposes, so this is not considered a genuine limitation in practice[4].

Another test which the Fisher index does not satisfy is "transitivity" or "circularity". Thus, multiplying the price index from 0 to 1 (*eg.* Brussels and Paris), by the price index from 1 to 2 (*eg.* Paris and Madrid) may not equal the price index from 0 to 2 (*ie.* Brussels to Madrid). Instead, a direct comparison should be made. For Eurostat correction coefficient purposes, this is not a practical limitation: the information is generally available simultaneously[5].

[4] Reinsdorf, Diewert & Ehemann have described techniques for decomposing the impact of component differences on the overall difference.

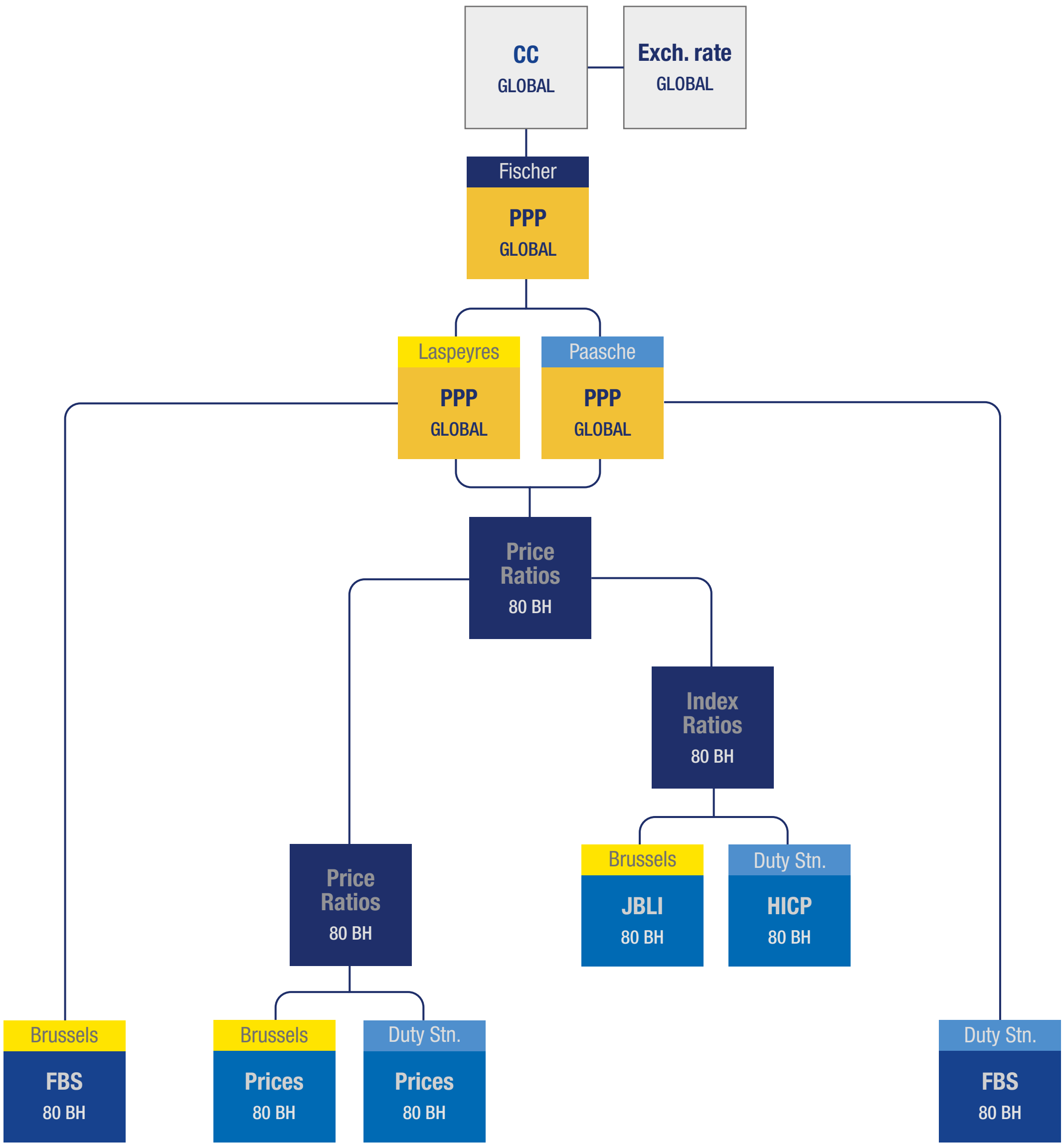
[5] There is a recognised (Gini–Eltetö–Kovacs–Szulc) methodology for converting a matrix of bilateral Fisher indices into a set of transitive indices. That method is used by Eurostat to establish multilateral PPP for GDP deflation purposes. It involves replacing the calculated Fisher–type PPP between each pair of countries by the geometric mean of itself squared and all the corresponding indirect Fisher–type PPPs between that pair obtained using the other countries as bridges. For example in a group of three countries 0, 1 and 2 this calculation would be the cubic root of 0:0*0:2, 0:2*2:2, 0:1*1:2. Test calculations on this basis were done in 2011 for Intra–EU correction coefficients at global level, which suggested the impact was low when applied for relatively homogenous locations, and the transparency loss did not justify the additional workload.

# Conclusions

In the light of the foregoing, Eurostat remains satisfied that the Fisher index is an appropriate basis for the calculation of correction coefficients. This methodology is considered to have proved its worth over nearly 50 years of successful implementation.

At the same time, it can be argued that cost–of–living statistics which do not adequately reflect consumption behaviour in both the reference and comparison locations present an inferior picture of the situation.

The following diagram summarises the Eurostat approach to calculating correction coefficients using Fisher index. Prices are established for a basket including items representative for both the reference location and comparison location. Expenditure patterns are established for both the reference location and the comparison location.



# References


- Armknecht, Paul A & Silver, M (2014), “Post–Laspeyres: the case for a new formula for compiling consumer price indexes”, Review of income and wealth, 2014, 60(2), pp225–244
- Armstrong, Katharine G (2003), “Towards a cost–of–living index: progress and prospects”, Journal of economic perspectives, 2003, 17(1), pp45–58
- Balk, Bert M (1995), “Axiomatic price index theory: a survey”, International statistical review, 1995, 63(1), pp69–93
- Balk, Bert M (2001), “Aggregation methods in international comparison: what have we learned?”, Research in Management, Erasmus University Rotterdam, 2001
- Dennis, I (2016), “Methodology manual: Calculation of Intra–EU correction coefficients in accordance with the EU staff regulations”, Eurostat, docA6465/14/59rev3, 2016
- Dennis, I (2017), “Methodology manual: Calculation of Extra–EU correction coefficients in accordance with the EU staff regulations”, Eurostat, docA6465/14/60rev3, 2017
- Dennis, I (2011), “Summary of the Eurostat simulation studies and numeric examples of Commission orientations for reform”, Eurostat, doc.A65/11–B/03, 2011 – restricted, unpublished.
- Diewert, Erwin W (1976), “Exact and superlative index numbers”, Journal of econometrics, 1976, 4(2), pp115–45
- Diewert, Erwin W (1993), “The early history of price index research”, National Bureau of Economic Research, Working paper 2713, 1988, 68p
- Diewert, Erwin W (1999), “Axiomatic and economic approaches to international comparisons”, in Heston, Alan W & Lipsey, Robert E (1999) eds. “International and interarea comparisons of income, output and prices”, NBER studies in income and wealth, 1999, 61, pp13–87
- Eurostat (2012), “Methodological manual: Purchasing Power Parities”, Eurostat, KS–RA–12–023–EN–N
- Eurostat (2018), “Methodological manual: Harmonised Index of Consumer Prices”, Eurostat, KS–GQ–17–015–EN–C
- Fisher, Irving (1922), “The making of index numbers”, Houghton–Mifflin, 1922
- Hill, Robert J (1997) “A taxonomy of multilateral methods for making international comparisonof prices and quantities”, Review of Income and Wealth, 1997, 43(1), pp49–69
- Hill, Robert J (2004), “Price indices across space and time”, American Economic Review, 2004, 94(5), pp1379–1410
- Krijnse–Locker, Hugo & Faerber, Hans–Dieter (1984), “Space and time comparisons of purchasing power parities and real values”, Review of income and wealth, 1984, 30(1), pp53–83
- Reinsdorf, Marshall B, Diewert, Erwin W & Ehemann Christian (2002), “Additive decompositions for Fisher, Törnqvist ad geometric mean indexes”, Journal of economic and social measurement, 2002, 28, pp51–61
- Summers, Robert (1973), “International comparisons based upon incomplete data”, Review of income and wealth, 1973, 19(1), pp1–16