

ECONOMIC STATISTICS

Docente:	MARIA GIOVANNA GONANO
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Module 2	Price Indices and Measuring Inflation
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CONSUMER PRICE INDEX

The Price Index Numbers

Purpose

The Price Index Numbers are of great importance in the economic field. They are useful for example for:

- evaluate price changes (measurement of inflation);
- evaluate to what extent the variation in an economic aggregate (for example consumption, production, trade, etc.) is partly attributable to the variation in quantities and partly to the variation in prices of goods and services that compose them;
- estimate a “cost-of-living” indicator;
- obtain a revaluation coefficient (index number) in order to adjust the nominal value of a monetary sum to the current cost of living.

A Composite Index Number (or Aggregate Index Number)

It is a particular ratio (or index number) that simultaneously and synthetically measures the variations of a set of quantities observed in two different circumstances (different times and/or places). For example, the variation in prices referring to several goods and services; the variation in production referring to several goods and services of different sectors of activity.

The components of a composite index number are all of the same type and result in a synthetic index number that measures simultaneously the variation in the quantities considered. For example, the consumer price index measures the variation in the general price level for a category of goods and services intended for consumption.

In general, aggregate index numbers are used for temporal (or spatial) comparisons of prices, quantities (produced, consumed, imported, etc.) or, finally, monetary values. In general terms, such measures refer to a distinct set of goods and services.”

The Index Numbers

Elements to be considered for their construction

- 1) **Choice of goods and services:** can be sample or exhaustive. In the first case a representative index is obtained, in the second a complete index.

It depends:

- From the knowledge objectives to be pursued
- From the possibility of finding the necessary information
- A price index is appropriate for its purposes the greater the number of goods on which it is calculated
- It is impossible to consider all goods/services; it is necessary to select only a few «more representative» goods, that is, those whose prices can provide with their variations a «true» indication of the variations in all goods traded on the market.

2) Choice of the base-period: The base-period is identified with the denominator of the statistical ratio.

It can be:

- fixed, if all variations are calculated with respect to the same denominator
- mobile, if each term of the series is related to the previous one
- In prices time series the choice of base usually refers to a time period in which the quantities considered take on fairly normal values (not particularly high or low)
- It is possible to make base changes a) from fixed to mobile b) from mobile to fixed if the price index respects the reversibility property of the bases.
- Fixed-base indices tend to wear out and lose their meaning as the time interval during which the same reference system continues to be adopted is prolonged.
- The problem is solved by changing the base and weighting system, and then periodically renewing the reference basket
- An alternative solution is the construction of Chained Index Numbers.

- 3) **Choice of mean (aggregation criterion):** two solutions are possible
- Use a weighted average of ratios (or elementary indices)
 - Use a ratio of aggregates (= averages)
 - Usually, the arithmetic mean, the harmonic mean and the geometric mean are used.
 - In the case of geometric mean as a synthesis of price indices it allows to
 - have a base shift (reversibility of the bases).
 - Moreover, in the case of an index constructed by a geometric mean it is possible to calculate the reciprocal of the price index as a measure of changes in the purchasing power of money.
- 4) **Choice of weighting system:** depends on the purpose of the analysis. The weighting system distinguishes the type of index and depends on the purpose for which the indices themselves are calculated. Weights can be:
- fixed or variable
 - with or without chaining.
 - In the case of price indices, usually it is used the weighting system reflects the importance of the individual goods on the market.
 - Weights can be the quantities produced, consumed or imported.
 - In the case of fixed weights, the indices lose representativeness due to changes in quantities.

- The formulas most frequently used in the construction of price and quantity index numbers have been proposed by two German researchers, E. Laspeyres and H. Paasche, who deal with fixed-weighted and variable-weighted formulas respectively.
- Limits of the Laspeyres and Paasche formulas: it is not possible to use these indices for comparisons between two or more current time periods, both price and quantity indices depend not only on prices, but also on quantities (and vice versa), which are different across each of the two current time period.
- Only for a limited number of aggregates do statistical surveys provide price and quantity series that allow the calculation of the corresponding average values. Consequently, the analysis is restricted to the construction of index numbers using the Laspeyres formula, which has the advantage of applying constant quantities to prices observed in different periods.

Laspeyres' Price Index and Paasche's Price Index

a) Index Numbers as weighted averages

Laspeyres' Price Index

$$\frac{\sum_i \frac{p_{i,t}}{p_{i,0}} \cdot p_{i,0} \cdot q_{i,0}}{\sum_i p_{i,0} \cdot q_{i,0}} = \frac{\sum_i p_{i,t} \cdot q_{i,0}}{\sum_i p_{i,0} \cdot q_{i,0}} = {}^p_0 I_t^L$$

$$w_i = p_0 \cdot q_0$$

Paasche's Price Index

$$\frac{\sum_i \frac{p_{i,t}}{p_{i,0}} \cdot p_{i,0} \cdot q_{i,t}}{\sum_i p_{i,0} \cdot q_{i,t}} = \frac{\sum_i p_{i,t} \cdot q_{i,t}}{\sum_i p_{i,0} \cdot q_{i,t}} = {}^p_0 I_t^P$$

$$w_i = p_0 \cdot q_t$$

In the case of fixed-base series calculations, Laspeyres' formula requires a smaller amount of information

b) Index Numbers as the ratio of aggregate values

To measure the variation in expenditure due to price changes between period 0 and period t, we can compare expenditure levels in the two periods, while keeping purchased quantities constant.

Laspeyres' Index
quantity at time 0

$${}_0^p I_t^L = \frac{\sum_{i=1}^k p_{i,t} q_{i,0}}{\sum_{i=1}^k p_{i,0} q_{i,0}}$$

Paasche's Index
quantity at time t

$${}_0^p I_t^P = \frac{\sum_{i=1}^k p_{i,t} q_{i,t}}{\sum_{i=1}^k p_{i,0} q_{i,t}}$$

The two formulas (Laspeyres and Paasche), while capturing the same price dynamics, lead to different results.

Laspeyres: the consumer has a conservative behavior that is, in response to price changes, he does not change his consumption structure which in fact remains that of the base year.

Paasche: reflects a situation in which the consumer, in response to price changes, immediately changes his consumption by adjusting to the current year's consumption structure.

It is generally found that ${}_0^p I_t^L > {}_0^p I_t^P$ given the negative correlation between price changes and quantity changes

Fisher Ideal Price Index

The Fisher index is a geometric mean of the indices calculated according to the Laspeyres and Paasche formulas.

$${}_0^p I_t^F = \sqrt{{}_0^p I_t^L \cdot {}_0^p I_t^P}$$

It is also known as the 'ideal' formula because of the formal properties it satisfies.

Quantity Index Numbers

The Laspeyres, Paasche and Fisher formulas can also be used to calculate **synthetic quantity index numbers**.

$${}_0^q I_t^L = \frac{\sum \frac{q_t}{q_0} p_0 q_0}{\sum p_0 q_0} = \frac{\sum q_t p_0}{\sum q_0 p_0}$$

$${}_0^q I_t^P = \frac{\sum \frac{q_t}{q_0} p_t q_0}{\sum p_t q_0} = \frac{\sum q_t p_t}{\sum q_0 p_t}$$

$${}_0^q I_t^F = \sqrt{{}_0^q I_t^L \cdot {}_0^q I_t^P}$$

Quantity Index Numbers measure the relative changes in real terms of the monetary aggregates on which they are calculated.

Properties of simple index numbers

a) **Identity:**

If we compare one situation in a given period of time with itself, the index number equals 1:

$${}_tI_t = \frac{x_t}{x_t} = 1$$

b) **Commensurability:**

The index number does not vary if the unit of measurement of the quantities used to express the weighting system changes

c) **Determinacy:**

The index number does not cancel, it is not indeterminate if you cancel a term included in the formula.

d) **Proportionality:**

If all prices (or all quantities) vary in the same proportion when passing from one situation to another then the index number varies according to the same proportionality coefficient.

In addition, Fisher's formula also satisfies the following properties:

e) **Base-reversal property:**

The index number between r and s is the inverse of the index number between s and r:

$${}_t I_s = \frac{1}{{}_s I_t} = \frac{1}{\frac{x_t}{x_s}} = \frac{x_s}{x_t}$$

f) **Decomposition of causes:**

The value (v) of the expense can be decomposed into the product of its elementary “components” price and quantity:

$$v_t = p_t \cdot q_t$$

Similarly, the monetary value index number can be decomposed into the product of a quantity index and a price index

$$\frac{v_t}{v_s} = \frac{p_t}{p_s} \cdot \frac{q_t}{q_s}$$

None of the three formulas satisfy the transitivity (or circularity) property:

g) **Transitivity property:**

The index between 0 (base-period) and r (current-period) can be obtained by chaining the indices between 0 and s, and between s and r:

$${}_0I_s \times {}_sI_r = {}_0I_r$$

Thanks to this property, it is possible to convert from mobile-base to fixed-base indices and vice versa.

Properties of Composite Index Numbers: synthesis

Property	Aggregate Index Numbers		
	Laspeyres	Paasche	Fisher
Identity	Yes	Yes	Yes
Base-reversality	No	No	Yes
Transitivity	No	No	No
Commensurability	Yes	Yes	Yes
Decomposition of causes	No	No	Yes
Determinacy	Yes	Yes	Yes
Proporzionalità	Yes	Yes	Yes

Chained Index Number

Chained Index Numbers are based on the assumptions that changes in price and quantity (or rather «volume») take into account not only the values assumed by the variables observed at two specific points in time (base period 0 and current period t), but also by movements of prices and quantities within the interval considered.

Over the period between 0 and t , numerous changes occur, for example in the range of products supplied (with new goods added and others disappeared), in their quality and distribution, and finally in consumer' preferences.

The Chained Index Number of period t with base 0 is obtained from the product of the subsequent indices referring to the sub-intervals $(0,1)$, $(1,2)$, ..., $(t-1,t)$, i.e

$${}_0I_1, {}_1I_2, \dots, {}_{t-1}I_t$$

$${}_0I_t = {}_0I_1 \cdot {}_1I_2 \cdot \dots \cdot {}_{t-1}I_t = \prod_{i=1}^t {}_{i-1}I_i$$

The main advantage of a chain representation of indices lies in the fact that it incorporates all the economic changes that occurred over the period under consideration. Chained Index generally refers to very short intervals, so the choice of the aggregation criterion (index formula) and the weighting system becomes less decisive.

Consumer Price Indices

A particular category of index numbers produced by ISTAT are those of consumer prices. The definition is given in the “Note informative”, ISTAT.

misurano le variazioni nel tempo dei prezzi di un paniere di beni e servizi destinati al consumo finale delle famiglie presenti sul territorio economico nazionale e acquistabili sul mercato attraverso transazioni monetarie (sono escluse quindi le transazioni a titolo gratuito, gli autoconsumi, i fitti figurativi, ecc.).

(Note Informative – Istat)

Consumer Price Indices

There are three Consumer Price Indices:

- National Consumer Price Index for the whole Nation (NIC)
- Consumer Price Index for Workers' and Employees' Households (FOI)
- Harmonised Consumer Price Index for the countries of the European Union (HICP)

In relation to these three composite indices we ask ourselves:

What does a consumer price index measure?

What prices and of what goods and services are considered?

What goods are the prices of?

How is price collection done?

How do you calculate a consumer price index?

How do you get the index for the distinct territorial aggregations?

The three indices (NIC, FOI and HICP) have the following elements in common

- *the collection of data*
- *the territorial basis*
- *the calculation methodology*
- *the classification of the basket*

The three indices differ in:

- *the weighting systems*
- *the concept of price*
- *the basket*

Istat produces three different consumer price indices

- ***National Consumer Prices Index for the Whole Nation (NIC)*** measures changes over time in the prices of goods and services actually consumed within national borders, it is used as a measure of inflation at the level of the whole economic system, in other words it regards the national collective as if it were one large consumer family, within which spending habits are obviously highly differentiated. .
- ***Consumer Price index for Workers' and Employees' Households (FOI)*** it is calculated in the same way of the previous one with the only difference that it considers as consumers households headed by a non-agricultural employee. The index is generally used to periodically adjust monetary values, expressed in current euros, such as rents or category wages.

- ***Harmonised Index of Consumer Prices (HICP)***: was developed to ensure a comparable measure of inflation at European level. In fact, it is taken as an indicator to verify the convergence of the economies of the member countries of the European Union. This index is calculated and published by ISTAT and sent to EUROSTAT monthly according to a fixed timetable. EUROSTAT, in turn, disseminates the harmonized indices of individual European countries and elaborates and disseminates the European synthetic index, calculated on the basis of the former.

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The criteria followed by Istat for the collection of basic data and the construction of the indices are illustrated in detail in the «Information note» with updates to the basket, the weighting structure and the survey.

With reference to the information note provided by ISTAT, we can highlight the common elements of the three indices (price survey, territorial base, basket classification (12 expenditure divisions), calculation methodology) as well as the different ones: weighting system, price concept, reference base.

Periodicity: monthly;

Series: Monthly index numbers are calculated with reference to the month of December of the previous year (fixed calculation basis in the year); they are then concatenated over the period chosen as the reference (2020 basis=100) to measure price dynamics over a longer period of time than one year (mobile basis over several years)

Data collection: sample survey and administrative data for the weighting system

Population: set of all possible products purchased by households for consumption according to the definition of a basket

Calculation method: Laspeyres type chain indices

Diffused information: general index and sub-indices by product type and territory.

- NIC and FOI are based on the same basket and refer to individual final consumption regardless of whether the expenditure is borne entirely by households or, to a partial or total extent, by the Public Administration or non-profit institutions.
- The weight given to each good or service, however, is different in the two indices, depending on the importance that the different products assume in the consumption of the reference population.
- For the NIC, the reference population is the entire population; for the FOI, it is the set of families headed by a worker or employee.

- The HICP has the reference population in common with the NIC, but differs from the other two indices since it refers to monetary final consumption expenditure borne exclusively by households. It also excludes, on the basis of Community regulations, certain products such as, for example, lotteries, lotto and prediction competitions.
- NIC and FOI always consider the price to be full of sale. The HICP, on the other hand, refers to the price actually paid by the consumer. For example, in the case of medicinal products, while for national indices the full price of the product is considered, for the harmonized one the reference price is represented by the share actually borne by households. In addition, the HICP also takes into account temporary price reductions (sales, discounts and promotions).
- The national indices NIC and FOI are also produced version that excludes tobaccos from the calculation.

Comparative table of price indices

Caratteristica -----	Indice dei Prezzi (CPI/NIC)	Indice Costo della Vita (COLI /FOI)
Paniere	Fisso (aggiornato periodicamente)	Variabile (basato sull'utilità)
Sostituzione	Non considerata (solitamente)	Considera il cambio di abitudini
Focus	Stabilità dei prezzi e inflazione	Benessere del consumatore
Uso Pratico	Politiche monetarie (BCE)	Adeguamento salari e affitti

The collection of prices

Price statistics include all indicators recording the evolution over time of the prices of goods and services produced and traded in a country.

In the case of consumer price indices (CPI), they are based solely on the **observed prices** (excluding imputed prices or other virtual values) of goods and services **purchased on the market** (excluding taxes, contributions or fees) and intended for household consumption within the domestic territory.

Features

- price
- sample of goods and services (basket)
- price collection at different stages of production and commercialization

The collection of individual prices takes place through four distinct channels:

- 1) Territorial survey carried out by the Municipal Statistical Offices (UCS) of 19 regional capitals and 59 provincial capitals – they collect data for a total of 44,000 retail stores and approximately 2,800 homes → approximately 385,000 prices observations are reached
- 2) Centralized Survey managed directly by ISTAT – monthly collection
- 3) Acquisition of scanner data provided by the Large Organized Distribution – covering packaged products, fruit and vegetable products – are based on approximately 12 million references for a total of 33 million processed price quotes.
- 4) Use of administrative sources (Customs and Monopolies Agency, Fuel Observatory, Real Estate Market Observatory).

Another important element concerns the so-called «basket», that is the list of products for which prices are collected, is updated every year and improved from period to period in relation to the index calculation process (Chained indices)

Finally, the weighting system - i.e. the weights with which individual products contribute to the measurement of consumer price indices - is reviewed every year. The sources used for quantities and expenditure aggregates are derived from National Accounts Estimates, the Household Expenditure Survey as well as other auxiliary sources, both internal and external to ISTAT.