# 10 Price indices (Module 10)

## 10.1 Session I. Introduction to Price Index

## **Contents**

* Introduction – purpose and use of Price Index
	+ *What is Price Index?*
	+ *Main uses*
	+ *Common price indices*
* What is an Index number
	+ *Simple price index*
	+ *Types of simple price index*
* Aggregate index

## 10.2 Introduction: Purpose and Use of Price Index

A price is an amount of money paid by the buyer to the seller of a good or service as agreed upon in a transaction. These transactions can be of any types of products and can involve consumers, retailers, wholesalers, producers or government. The products transacted may be industrial goods, different kinds of services or agricultural products, as well as labour inputs.

***Price*** of a commodity – whether goods or services – is simply defined as the monetary value of one unit of that good or service.

When we say ‘monetary value’, we mean the value expressed in terms of the currency that is in use in the economy [this is also called ‘fiat’ money, which is the legal instrument of all transactions by Government order], such as Taka, Nepalese/ Pakistani/ Sri Lakan/ Indian Rupee, Rupiah, Kyat, Won, Lao Kip, Yen, Yuan etc.. Note that

* Prices are observable only in monetary transactions, i.e. transfer of ownership of a good or service in exchange of money.
* Prices are generally determined on a market.
* Wage rates are also considered as ‘prices’. They are prices for the factor[[1]](#footnote-1) service ‘labour’.
* The price of each good or service is made up of several cost factors.

Of all the index numbers, price indices are the most important and are commonly used in various economic and business contexts.

### 10.2.1 What is Price Index?

*Price index* is a measure of rate of change of prices, expressed using a percentage scale.

Price index compares the prices of a group of commodities (goods and services) at a certain time or place with prices of the base period (or place), respectively. The following discussion deals only with price index over time.

A price index is usually compiled by selecting a specified group of commodities purchased or sold by a specified type of buyers or sellers. The prices of the commodities in the current period are compared with those in a given year in the past (the base year). If the prices of the selected commodities in the current period show a rise by, for example, 3% as compared to the base year, the index number for the current period is 103. A fall in price of one per cent is shown by an index number of 99.

Price index measures price changes or price differentials rather than price levels. Usually, price level increases over time due to inflation. In most of the countries, the increasing price level is tracked by Consumer Price Index (CPI). The Government agency responsible for tracking changes in price level collects data on prices of a predetermined set of goods and services at regular intervals. For CPI compilation, the predetermined set of goods and services is called the ‘commodity basket’ and is assumed to represent what an average resident of the economy buys for consumption purposes. The price index is calculated from the price data thus collected.

Note that as the price level goes up, the value of money goes down. The value of money refers to what a unit of money can buy, whereas the price level refers to the average of all of the prices of the predetermined set of goods and services. Thus, the main purpose of compiling a price index is to measure the change in purchasing power of the economy’s currency with respect to the specified group of goods and services purchased or sold by a specified type of purchasers or sellers. For measuring the value of money, it is the general price index which is used.

### 10.2.2 Main uses

Index numbers are used for a variety of purposes. By comparing the index numbers of several years in succession, we can find out whether the price level is rising or falling and the degree of change. This helps the government to take appropriate measures. Main uses of price indices are as follows:

* *Measurement of inflation – changes in general level of prices over time*.

A good understanding of the inflation rate is important for every individual and household, as well as the government for formulating and adopting appropriate economic policies. Price index numbers measure changes in prices of commodities used for different purposes, products, exports& imports and changes in wages, etc. By comparing the index numbers of these for different periods, the government can know the present trend of economic activity and accordingly adopt price policy, foreign trade policy and general economic policies. Index numbers also serve as a guide to business­men.

* *Calculation of real values – National Accounts Statistics at constant prices[[2]](#footnote-2)*

The rate of growth of Gross Domestic Product (GDP) at constant prices is the most commonly used indicator of economic growth. The growth rate of GDP at current prices does not reflect the ‘real’ growth of an economy, since it comprises the effect of rise (or fall) in general price level. To eliminate the effects of inflation, a number of price indices are used for compilation of GDP (and other SNA aggregates)[[3]](#footnote-3) at constant prices.

* *Calculation of indexed values – adjustment of wages & salaries*.

Most economies face positive rates of inflation year after year. If the inflation rate is positive and an individual’s income remains constant, his or her real standard of living will fall since the individual’s income will be worth less and less in successive periods. Thus, labour unions often use the CPI in bargaining for wage increases. Also, most government pensions, including the level of Social Security benefits, are indexed to the consumer price index. The adjusted values such as these are called indexed values.

* *Contract escalation*.

Business contracts often include adjustment clause for contract price or cost for inflation/deflation. When price/cost changes are particularly unstable, contracting parties need to include an economic price adjustment clause in the contract. The use of index numbers is one of the most popular methods used to identify and define price changes for economic price adjustment.

* *Determination of foreign exchange rates and for International studies*.

Index numbers of wholesale price of two countries are often used to determine (foreign) exchange rate of their currencies. They are the basis of the purchasing power parity theory which determines the exchange rate between two countries. An index number facilitates international compari­sons of economic variables. For instance, for comparisons in living standards between different nations, we construct real per capita incomes of different nations on the basis of price index numbers. Thus, index numbers measure the rate of development of different countries.

### Common Price Indices

There are different kinds of price indexes. These are used to measure the rate of inflation in the economy from different viewpoints. There are some key price indexes that are routinely calculated and published by government agencies. These differ with respect to

* items they take into account. For example
	+ Consumer Price Index (CPI) is based on prices of only the goods and services consumed by the households.
	+ Producers Price Index-output (PPI-output) covers all goods and services produced in the economy.
	+ Producers Price Index-input (PPI-input) covers all goods and services used by the pro
	+ Wholesale price index (WPI)
	+ Export Price Index (XPI) takes into account the goods and services exported by the residents of the economy.
	+ Import Price Index (MPI) takes into account the goods and services imported by the residents of the economy.

* buyers or sellers involved in the transactions. For example
	+ CPI is based on prices paid by the households to the retailers
	+ PPI-output is based on prices received by the producers from the wholesalers
	+ WPI is based on prices charged by the wholesalers.
	+ XPI is based on the prices received by the exporters.
* periodicity, i.e. whether the prices are observed weekly or monthly or yearly.

*Points to note*

* Price of a commodity is the value of one unit of the commodity expressed in *fiat* money of the economy.
* Prices are observable only in monetary transactions.
* In economies where more than one currency is commonly used in transactions, prices expressed in only one of them (desirably the fiat money of the economy) should be used for price index compilation.
* A price index shows percentage change in prices with respect to the base year.
* Price indices do not indicate the level of prices.
* All price indices are compiled for a fixed set of commodities or factor services.
* Value of money is gauged by its purchasing power.
* Reciprocal of a price index is a measure of change of purchasing power of money (with respect to the commodity basket of the index).
* Index numbers can be used for a variety of purposes.
* Price indices are useful to
	+ the government for policy formulation and monitoring
	+ businesses in assessing future returns and making contracts
	+ individuals for negotiating wages / other benefits with the employers.
* The most commonly used price indices are CPI, (output) PPI, (input) PPI, WPI, XPI, MPI and wage rate index.
* The price data used for compiling each of these is different from those of others.

Before discussing these measures, it is worthwhile to explain why an index is needed to calculate the rate of inflation.

We will start with the basic ideas as to why do we need index numbers and how are they defined.

## 10.3 What is an index number?

In simple terms, an index (or index number) is a number showing the level of a variable relative to its level (set equal to 100) in a given base period.

Index numbers are of much practical importance in measuring all types of quantitative changes in the agricultural, industrial, and commercial fields, as also in such economic magnitudes as income, employment, exports, imports, prices, etc. Besides the price indices, which are used to measure changes in the value of money, there are other important indices, such as

* Index numbers of industrial production (IIP) measure increase or decrease in industrial production in a given year as compared to the base year. These reflect the actual condition of different industries, as an industrial index number measures changes in the quantity of production.
* The export and import indices indicate the foreign trade position of a country. These show whether the external trade of the country is increasing or decreasing.
* Index numbers are also compiled for representing growth of human and livestock population.

The indices may pertain to a single commodity/ product or a combination of many. For a single commodity/ product, we use simple index number and for the other we use aggregate indices. Types of indices

* Simple index number
* Simple aggregate index
* Weighted aggregate index.

We begin by considering the simplest form of index numbers, “simple indices”. In the context of price index, the elementary indices are called ‘*price relatives*’.

### 10.3.1 Simple indices

A *simple index* – ***It*** – of a variable ***Y*** is defined as

 $I\_{t}= \left(\frac{y\_{t}}{y\_{0}}\right)×100$

where *It* : index in the current period of the item

 *yt* : value in the period *t*

 *y0* : value in the base period.

The variable could be population size, GDP at constant prices or current prices, prices, exchange rates, industrial or agricultural production, area under a crop etc..

Compiling simple indices is an unavoidable step in compilation of all indices. The aggregate indices are compiled by simply combining the simple indices of its constituents. There are different methods of combining the simple indices.

For example, consider an economy that produces three metals, such as steel, copper and aluminium. We can separately compile annual/ monthly simple index of steel, copper and aluminium production for the economy. But, for compiling a single index of metal production of the economy, we have to combine all the three separate simple indices into one aggregate index.

### 10.3.2 Types of simple indices

The following examples are very simple (elementary) forms of index numbers. They refer to a single variable, such as the population, the exchange rate or the value of something in money terms. These relatives do not involve “weights”. There are three main types of simple index numbers:

* Value indices (indicating relative values of anything measured in terms of money)
* Volume or quantity indices (indicating relative quantities of something)
* Price indices (indicating the relative prices of a specific item)

For a single variety of rice, elementary value index (eVIt), quantity index (eQIt) and price index (ePIt) would be respectively the ratios of values of production, quantities produced and prices in the current year to that in the base year.

***Example 10.1*:** The population of Zambia each year may be converted into index numbers with the year 2000 as a base year like this.

|  |  |  |
| --- | --- | --- |
| **Year** | **Population** | **Index 2000=100**Note that $102.1=100× \frac{10089492}{9885591}$ $$108.7=100×\frac{10744380}{9885591}$$Similarly compute the index for 2007. |
| 2000 | 9,885,591 | 100.0 |
| 2001 | 10,089,492 | 102.1 |
| 2002 | 10,409,441 | 105.3 |
| 2003 | 10,744,380 | 108.7 |
| 2004 | 11,089,691 | 112.2 |
| 2005 | 11,441,461 | 115.7 |
| 2006 | 11,798,678 | 119.4 |
| 2007 | 12,160,516 | **?** |

***Example 10.2*:** The average exchange rate of Tanzanian shillings (TShs) to US dollars (US$) for each year is converted into index numbers with the year 2000 as a base year as follows:

|  |  |  |
| --- | --- | --- |
| **Year** | **TShs per US$** | **Index 2000=100**Again, note that $109.5=100 × \frac{876.4}{800.7}$ $129.7=100 ×\frac{1038.6}{800.7}$Similarly, calculate the value of the index for 2005 |
| 2000 | 800.7 | 100.0 |
| 2001 | 876.4 | 109.5 |
| 2002 | 966.6 | 120.7 |
| 2003 | 1038.6 | 129.7 |
| 2004 | 1089.3 | 136.0 |
| 2005 | 1128.8 | **?** |
|

***Example 10. 3*:** The average price (in a local currency)of tea leaves (of a particular kind) for each year is given in the following table. These when converted to index numbers with the year 2010 as a base year are the ‘elementary indices’ or ‘price relatives’:

|  |  |  |
| --- | --- | --- |
| **Year** | **Price of tea leaves per Kg.** | **Elementary Index or price relative(2010=100)**Calculate the value for 2015, following the method shown in Examples 1 & 2. |
| 2010 | 1500 | 100.0 |
| 2011 | 1550 | 103.3 |
| 2012 | 1620 | 108.0 |
| 2013 | 1710 | 114.0 |
| 2014 | 1850 | 123.3 |
| 2015 | 2000 | **?** |

***Example 10. 4*:** The quantity and value of production and average price of tea leaves (of a particular kind) for each year is given in the following table. The simple price, quantity and value indices with base year 2010 are as follows:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Price of tea leaves (Taka per Kg.)** | **Quantity produced (1000 Kgs.)** | **Value of production (‘000 Taka)** | **Elementary Price Index (2010=100)** | **Elementary Quantity Index (2010=100)** | **Elementary Value Index (2010=100)** |
| 2010 | 1500 | 123 | 184500 | 100.0 | 100.0 | 100.0 |
| 2011 | 1550 | 137 | 212350 | 103.3 | 111.4 | 115.1 |
| 2012 | 1620 | 140 | 226800 | 108.0 | 113.8 | 122.9 |
| 2013 | 1710 | 152 | 259920 | 114.0 | 123.6 | 140.9 |
| 2014 | 1850 | 138 | 255300 | 123.3 | 112.2 | 138.4 |
| 2015 | 2000 | 130 | 260000 | 133.3 | 105.7 | 140.9 |

Verify that, for all the years, value index = quantity index \* price index / 100.

*Points to note*

* An index number compares value of a variable in current period with respect to that in the base period.
* In addition to price indices, there are index numbers for different kinds of production, value of exports & imports, GDP, employment, population, etc...
* Two broad types of index number – simple and aggregate.
* The aggregate index numbers are compiled by aggregating simple index numbers. The aggregation may be weighted or unweighted.
* Simple price indices are also called *price relatives*.
* Simple price indices do not involve weights.
* There are three main types of elementary indices – value index (*eVIt*), quantity index (*eQIt*) and price index (*ePIt*).
* $eVI\_{t}= \frac{1}{100}×eQI\_{t}×ePI\_{t}$.

## 10.4 Aggregate Index

### 10.4.1 Why index numbers?

Indices of the elementary kind have little value in themselves. But they can be used to compile more complex “composite” indices, involving many different goods and services. In economic statistics, the term “index numbers” is usually reserved for these more complex “composite” indices. Index numbers become essential when measuring the change in price of a whole variety of products, the prices of which may be varying in different ways.

### 10.4.2 Change in value

Change in value of a group of products can be measured by the aggregate index.

$$V\_{0t}= \frac{\sum\_{i=1}^{n}q\_{ti}p\_{ti}}{\sum\_{i=1}^{n}q\_{0i }p\_{0i}} ×100    $$

 where

*n* represents the number of products

*qti* represents quantity of *i*th product in *t*th period

 *pti* represents price of *i*th product in *t*th period

 *q0i* represents quantity of *i*th product in base period

 *p0i* represents price of *i*th product in *base* period

This is the ratio between the total (money) value in the current period (*t*th) and that in the base period. In the rest of this note this is called *value index*.

But, price indices are required to measure change in prices alone. The question is how to separate out the change in value between changes in price and changes in quantity?

One can always measure the relative value of a variety of things, as in the turnover of the manufacturing industry (for example) in different periods. But a problem arises when you want to separate out the change in value between changes in price and changes in quantity. This leads to what is known as the *Index Number Problem* – defined as follows:

**The “index number problem”**

|  |
| --- |
| The problem is how to combine the relative changes in the prices and quantities of various products into (i) a single measure of the relative change of the overall price level and (ii) a single measure of the relative change of the overall quantity level. Or, conversely, how a value ratio pertaining to two periods of time can be decomposed in a component that measures the overall change in prices between the two periods—that is, the price index— and a component that measures the overall change in quantities between the two periods—that is, the quantity index.There is no unique way to achieve this.Source: *Producer price index manual: Theory and practice* IMF, Washington DC, 2004 |

Constructing composite Index numbers becomes essential for measuring separately the change in prices or that in quantity (or volume).

### 10.4.3 Types of composite indices

*Value index* is a simple ratio of expenditure of the current to that in the base period. It comprises effects of changes in both prices and quantities. How to decompose the value index into measures of change in quantity and prices is what the index number problem essentially addresses.

The decomposed measures of price and quantity changes are no longer be simple ratios, but a combination of simple ratios of prices or quantities. Combination of simple ratios into measures of price or quantity changes is a *composite* or *aggregate index*.

There are only two types of composite indices, (because “value” indices are always simple relatives or ratios of value). They are

* Price indices
* Quantity (or volume) indices

Quantity and volume are synonyms here. In economic statistics, changes in quality is considered as changes in quantity and included with them.

Although price indices and quantity indices are very similar in theoretical construction, it is very important to understand the difference between them. There is also a fundamental difference when it comes to measuring them.

Changes in the price of an item are far easier to measure than changes in quantity (or value).The quantities (or values) of items sold in different outlets may vary enormously, depending on many factors including the size and location of the outlets. Prices, by comparison, do not vary so much from outlet to outlet.

It is also much easier to find out the price of an item, than the quantity that may have been sold during a month. Observations on price movements in a few outlets give a fairly good idea of the average overall movement. Moreover, there is mostly a tendency for the price of similar items to change in a similar way. On the other hand, with some exceptions, quantities may vary widely and may be difficult to define. Knowing quantities (or values) from a few outlets or producers may not be a very good guide to the total.

*Price (quantity) index*

|  |
| --- |
| A price (quantity) index is a measure reflecting the average of the proportionate changes in the prices (quantities) of the specified set of goods and services between two periods of time. Usually the index is assigned a value of 100 in some selected base period, and the values of the index for other periods are intended to indicate the average percentage change in prices compared with the base period. Source: IMF PPI manual |

There are different methods of compiling aggregate price indices. Compilation of aggregate price indices, methods and the underlying concepts are discussed in greater detail in the following sessions.

*Points to note*

* Aggregate price indices are necessary to track price movements of a specified group of products of wide variety.
* Aggregate value indices are simple ratios of values (of production, consumption, exports, imports etc.) in two periods – current period and the base period.
* Aggregate price (or quantity) indices cannot be obtained as a simple ratio of prices (or quantities).
* *Index number problem* addresses the issues involved in decomposing value index into price and quantity indices.
* There is no unique solution to the problem of index numbers.
* There are different methods of aggregation of elementary price (or quantity) indices for obtaining an aggregate price (or quantity) index.
* Quantities sold in different outlets or produced by different producers tend to vary enormously in most cases. Thus, estimating the total quantity based on a sample of limited number of observations reliably is very difficult.
* Prices do not vary much from outlet-to-outlet or from producer-to-producer. A small number of sample observations are mostly found adequate to estimate average price of a product over short duration of time.

**Module 10, Session – I: Introduction**

**Test Your Knowledge**

**Exercise – 10.1: Purpose and Uses of Price Index Numbers**

1. State whether the following statements are true [T] or false [F].
2. Prices are observable only in monetary transactions.
3. In Lebanon, both Lebanese Pounds (*fiat* money in Lebanon) and US Dollars are commonly used in the market. For price index compilation, all prices quoted in US Dollars should be converted to prices in Lebanese Pounds using official exchange rate.
4. Price indices indicate the levels of prices.
5. All price indices are compiled for a set of commodities purchased or sold by a specified group of purchasers or sellers.
6. If price index increases the value of money also increases.
7. Index numbers are used only for policy formulation and monitoring.
8. Same set of price data are used for compiling CPI and output PPI.
9. Wage rate indices are required for tracking real income of employees. An index number compares value of variables, such as prices, production, value of exports & imports, GDP, employment, population, etc., in current period with respect to that in the base period.
10. Compilation of elementary indices always involves weights
11. An elementary value index (*eVIt*) can be decomposed into elementary price index (*ePIt*) and quantity indices (*eQIt*) as $eVI\_{t}= \frac{1}{100}×eQI\_{t}×ePI\_{t}$.
12. Sum of elementary price indices gives the aggregate price index.
13. Aggregate price (or quantity) indices can be obtained as a simple ratio of prices (or quantities).
14. Aggregate value indices are simple ratios of values (of production, consumption, exports, imports etc.) in two periods – current period and the base period.
15. An elementary value index (*eVIt*) can be decomposed into elementary price index (*ePIt*) and quantity indices (*eQIt*) as $eVI\_{t}= \frac{1}{100}×eQI\_{t}×ePI\_{t}$.
16. Sum of elementary price indices gives the aggregate price index.
17. Aggregate price (or quantity) indices can be obtained as a simple ratio of prices (or quantities).
18. Aggregate value indices are simple ratios of values (of production, consumption, exports, imports etc.) in two periods – current period and the base period.
19. .
20. There is a unique method of decomposing aggregate value index into aggregate price and quantity indices.
21. Generally speaking, variation in prices of goods and services produced (or sold) by a producer (or seller) is much less as compared to quantities of these goods and services.
22. An aggregate price index reflects the average of the proportionate changes (%) in the prices of a specified set of goods and services between two periods of time.
23. Aggregate price indices are usually obtained from elementary price indices.
24. Answer the following questions, with brief justifications.
25. The price index of a product A is 120 in the current period and that of B is 150. Can we conclude price of B is higher than A in the current period?
26. If the CPI for a year is 200, how and by how much the value of money with the consumers must have changed since the base year of the CPI?
27. If the current year CPI and wage rate index are respectively 120 and 110, would you say the real wages have increased, decreased or have remained the same?
28. Name three commonly used price indices.
29. Who are the buyers (producers / traders / households / government) paying the prices based on which CPI is compiled?
30. Following are prices of a coarse variety of rice for three years:

|  |  |  |
| --- | --- | --- |
| **Year** | **Price per Kg.** | **Elementary price Index (2010=100)** |
| 2010 | 100 |  |
| 2011 | 150 |  |
| 2012 | 120 |  |

Calculate the elementary price index for 2011 and 2012.

1. The elementary price and quantity indices of a coarse variety of rice are respectively 120 and 90 for the current period. What will be the elementary value index of coarse rice for the current period?
2. Following are the prices and quantities for two products A and B?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Price of A** | **Price of B** | **Quantity of A** | **Quantity of B** | **Value** | **Value index** |
| 2010 | 1710 | 150 | 260 | 1000 |  |  |
| 2011 | 1850 | 165 | 280 | 1200 |  |  |
| 2012 | 2000 | 160 | 300 | 1100 |  |  |

Calculate the total values of the two products and then the value indices with 2010 as the base year.

References:

 i) Producer price index manual: Theory and practice. IMF, Washington DC, 2004.

 ii) IMF PPI manual.

## 10.5 Session II. Composite Price Index

## **Contents**

* Composite Price Index
	+ Unweighted composite index
	+ Weighted composite index
* Important terms
	+ Base period (year): *price reference period*,

*weight reference period* and

*index reference period*

* + *Elementary aggregates*
	+ *(Expenditure) weights*
	+ *Consumption basket*
	+ *Price relatives and relative prices*
	+ *Price updating*

## 10.5.1 Composite Price Index

Composite Price Index or aggregate index numbers calculate price changes for a specified group of items and buyers or sellers over time. As we have already seen, we can find out elementary price indices for all the items in the group separately. But, this does not help tracking the price movement of the entire group of items taken together. Aggregate indexes permit analysis of price changes for the group of products, such as all that are required for making a cup of tea at home – tea leaves, sugar and cream.

Suppose you have a habit of taking tea in the morning and price of tea leaves (your preferred variety) is **1.2** times in the current month (in 2012) as compared to its average price in 2010. As compared to the average of 2010, how much does your morning cup of tea cost you in the current month?

The answer is simple if you drink black tea, i.e. tea without cream and sugar. We can readily say that your cup of morning tea costs 1.2 times in the current month as compared to that in 2010. [Note that we ignore the cost of fuel and water that are also required for making the cup of tea.] But, difficulty arises if you drink tea with sugar and cream. We cannot answer the question, unless we have more information.

### Unweighted composite price index

If we have information on prices of sugar and cream in 2010 and the current month, we may attempt to answer the question by taking average of prices of tea, sugar and cream in 2010 and in the current month. The ratio of average of prices of the three commodities in question in the current month to that in 2010 is a possible answer[[4]](#footnote-4). But what meaning can we attach to the average of prices paid for as different commodities as tea, sugar and cream?

The other alternative could be working out the rate of price change separately for tea, sugar and cream, followed by taking average of the rates of price change[[5]](#footnote-5). Note that in this method we attach equal importance to all the three commodities. In fact, each of these unweighted aggregation methods gives us an unweighted composite index.

### Weighted composite price index

But, in reality we know that the shares of these three commodities in the total cost of a cup of tea could be very different. Thus, the rates of price change of these are expected to affect the rate of change in the cost of the cup of tea quite differently. Instead, if we have the information on those given below

1. the quantities of tea, cream and sugar you use for your cup of morning tea,
2. ratios of average prices of cream and sugar with respect to average price of tea leaves in 2010 and
3. ratios of prices of cream and sugar in the current month as compared to corresponding average prices in 2010,

we can work out how much costlier or cheaper is your cup of tea in the current month as compared to the average cost of 2010. First, let’s illustrate how we can calculate this from observed prices and quantities.

From the data on prices and quantities of tea, sugar and cream, given in Example 10.5 in the next page, workout the individual commodities’ costs and the total costs in the current month and the in 2010.

|  |
| --- |
| ***Example 10.5: Change in cost – with fixed quantities*** |
| **quantity (gms.) / price / cost** | **Commodities ( *i* )** | **total** |
| **tea leaves** | **sugar** | **cream** |
| quantity (gms.) for one cup – *qi* | 1.0 | 2.5 | 0.5 |  |
| average price (per gm.) in 2010 – *pi0* | 15 | 4 | 10 |
| price (per gm.) in current month - *pit* | 20 | 6 | 20 |
| cost in 2010 – *qi.pi0* |  |  |  |  |
| cost in current month – *qi.pit* |  |  |  |  |

We see that as compared to the average of 2010, the cup of morning tea cost you **1.5** times in the current month. In other words, if it was 100 in 2010, in the current month it is 150.

We say, the **price index** (*base year*: 2010), taking together all the ingredients of your morning tea, is 150 in the current month.

This is, in fact, an index that attaches weights to the price relatives[[6]](#footnote-6) of items whose collective price movement we are interested in. The weights we have used are the shares of each of the commodities in total expenditure for the cup of tea in 2010. We have thus combined the price relatives of tea, sugar and cream by assigning different weights to them as they do not have the same importance so far as a cup of tea is concerned. Algebraically, we can write the index (without multiplying by 100) as follows:

 $I\_{0t}= \frac{\sum\_{i}^{}p\_{it}q\_{i}}{\sum\_{i}^{}p\_{i0}q\_{i}}= \sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}\left(\frac{p\_{i0}q\_{i}}{\sum\_{i}^{}p\_{i0}q\_{i}}\right)= \sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i}$

 where $w\_{i}= \frac{p\_{i0}q\_{i}}{\sum\_{i}^{}p\_{i0}q\_{i}}$ are the weights.

A more difficult problem arises in combining the price relatives when the relative importance of commodities changes over time. Under these conditions, the pattern of weights selected can be accurate in only one of the periods for which the index numbers have been calculated. We get different values of the index by changing the weighting pattern, as illustrated in Example 10.6 below.

From the data on prices and quantities of tea, sugar and cream, given Example 6 in the next page, workout the individual commodities’ costs and the total costs in the current month and in the 2010.

|  |
| --- |
| **Example 10.6: Change in cost – with changing quantities** |
| **quantity (gms.) / price / cost** | **Commodities (*i*)** | **total** |
| **tea leaves** | **sugar** | **cream** |
| quantity (gms.) per cup in 2010 – *qi0* | 0.9 | 3.0 | 0.6 |  |
| quantity (gms.) per cup in 2011 – *qib* | 1.0 | 2.5 | 0.5 |
| quantity (gms.) per cup in current month - *qit* | 1.2 | 2.0 | 0.4 |
| average price per gm. in 2010 – *pi0* | 15 | 4 | 10 |
| price (per gm.) in current month - *pit* | 20 | 6 | 20 |
| cost in 2010 for 2010 quantities – *qi0.pi0* |  |  |  |  |
| cost in current month for 2010 quantities – *qi0.pit* |  |  |  |  |

We see, the cup of tea in the current month is costlier than 2010 by

48 / 31.5 = 1.52 times.

That is, as compared to the average of 2010, the morning cup of tea cost you 1.52 times in the current month. But, note that this rise in cost is not just for price rise. The change in the quantities of the ingredients required per cup is also responsible.

Thus, to get a measure of change in prices, we must keep the quantities constant. But, the question is which time period’s quantities should we consider for that purpose – quantities of 2010 or those of 2011 or the quantities of the current period?

If we take the fixed quantities weights of 2011 for the index calculation, as in Example 10.7 below, we get a different value of the price index. With the same data as in Example 6, workout the individual commodities’ costs and the total costs in the current month and the in 2010, with 2011 quantities.

We see, the cup of tea, with 2011 quantities, in the current month is costlier than 2010 by

 45 / 30 = 1.50 times,

which is different from that obtained with 2010 quantities (1.52).

|  |
| --- |
| **Example 10.7: Change in cost – with fixed quantities (of 2011)** |
| **quantity (gms.) / price / cost** | **commodities** | **total** |
| **tea leaves** | **sugar** | **cream** |
| quantity (gms.) per cup in 2010 – *qi0* | 0.9 | 3.0 | 0.6 |  |
| quantity (gms.) per cup in 2011 – *qib* | 1.0 | 2.5 | 0.5 |
| quantity (gms.) per cup in current month - *qit* | 1.2 | 2.0 | 0.4 |
| average price per gm. in 2010 – *pi0* | 15 | 4 | 10 |
| price (per gm.) in current month - *pit* | 20 | 6 | 20 |
| cost in 2010 for 2011 quantities– *qib.pi0* |  |  |  |  |
| cost in current month for 2011 quantities– *qib.pit* |  |  |  |  |

Using **fixed** (2011) **quantities**, the ratio of total costs in the current month in 2012 and 2010 is given by

 $=100× \frac{total cost in the current month in 2012 }{total cost in 2010}$

 =

This gives us a different measure of price change.

In fact, this is the general expression of the most commonly used measure of price index.

Algebraically, (without multiplying by 100)

 $I\_{0t}= \frac{\sum\_{i}^{}p\_{it}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$

where *qib* represents quantity of *i*th product in *b*th period

 *pit* represents price of *i*th product in *t*th period

 *pi0* represents price of *i*th product in *base* period

This is a *Lowe price index*. In this type of price index the quantities are fixed and predetermined. Many of the price indices produced by statistical agencies are *Lowe* indices. This will be discussed in greater detail in the next session.

*Points to note*

* Composite indices may be weighted or unweighted aggregation of price relatives.
* Aggregate indexes permit analysis of price changes for the group of products.
* The ratio of average of prices of two time points and average of the rates of price change are NOT the same.

i.e. $\frac{\sum\_{}^{}p\_{ti}}{\sum\_{}^{}p\_{0i}}$ ≠$ \frac{1}{n}\sum\_{}^{}\frac{p\_{ti}}{p\_{0i}}$

* *Consumption pattern* of a population or the product mix of resident producers keeps changing over time. Thus, the weights used for a price index usually refer to a single reference period (called *weight reference period* – discussed later).
* For a given set of price relatives, the value of price index is likely to change, if the weighting is changed.
* In a Lowe index, the quantities considered may be of a different period than the base period of the index.

## 10.5.2 Important terms

Conceptually, *CPI* is similar to the price index for a cup of tea. The differences are:

* + *CPI* is compiled for all the residents of an economy or a well-defined segment of it [not a single person as in the example];
	+ the set of products for consumption is very large – including all goods and services consumed by residents or a segment of them, and
	+ average of prices collected from a sample of sellers of the product is used for compilation of the index.

Thus, the quantities and costs considered do not pertain to just consumption of one person, but the aggregate consumption of the population under consideration.

To understand the basic ideas of index calculation and the formulae used, it is important to get familiar with certain terms and definitions commonly used to describe the alternative procedures. The following are some of the important terms:

* + Basket or Consumption basket
	+ Base period (year): *price reference period*, *weight reference period* and *index reference period*
	+ Price relatives and relative prices
	+ (Expenditure) weights
	+ Elementary aggregates and Elementary Price Index
	+ Price updating

*Basket* or *Consumption basket*:

The aim of a price index is to measure the change in the expenditure or costs or value of production, across space or time, which is solely due to changes in prices. The set of goods or services used to base the calculation of the price change is known as the ‘basket of goods and services’.

For CPI, the basket is called the ‘consumption basket’. It is a very large set of products. Each individual product has a share in the total value of consumption expenditure, which is the *expenditure weight* of the product.

*Consumption Basket* is the set of goods and services for which a CPI is constructed, along with their *expenditure weights*.

Depending on the kind of the price index, the basket must be representative of the goods and services acquired or consumed or produced. In our example of cost of a cup of tea, the consumption basket consists of just three commodities – tea leaves, sugar and cream, along with their respective weights 0.5, 0.33& 0.17.

*Base period*

The base period is usually understood to mean the period with which all the other periods are compared. The term may, however, have different meanings in different contexts. Three types of base period may be distinguished:

* The *price reference period* – the period that provides the prices to which the prices in other periods are compared. The prices of the price reference period appear in the denominators of the price relatives, or price ratios, used to calculate the index. The price reference period is typically designated as period 0;
* The *weight reference period* – the period, usually one or more years, of which the expenditures serve as weights for the index. When the expenditures are hybrid (i.e., the quantities of one period are valued at the prices of some other period), the weight reference period is the period to which the quantities refer. The weight reference period is typically designated as period b in this manual;
* The *index reference period* – the period for which the value of the index is set equal to 100.

The three reference periods may coincide but frequently do not in practice.

|  |
| --- |
| **Example 10.8: With three different base periods** |
| **Weights / price** | **commodities** | **total** |
| **tea leaves** | **sugar** | **cream** |
| weights in 2009 – *wi09* | 0.5 | 0.3 | 0.2 | 1.0 |
| average price per gm. in 2010 – *pi10* | 15 | 4 | 10 |  |
| average price per gm. in 2011 – *pi11* | 17 | 5 | 15 |  |
| price (per gm.) in current month - *pit* | 20 | 6 | 20 |  |
| (weights in 2009)\*(price relatives in 2010)– *wi09*\**pi10/ pi11* |  |  |  |  |
| (weights in 2009)\*(price relatives in current month) – *wi09*\**pit/ pi11* |  |  |  |  |
| Index reference period – 2010; Weight reference period – 2009 and Price reference period - 2011 |

The ratio

100\*$\frac{(weights in 2009)\*(price relatives in current month) }{(weights in 2009)\*(price relatives in 2010) }$

gives the required price index.

In practice, the duration of the weight reference period for a CPI is typically a year, or even two or more years, whereas the CPI is calculated monthly or quarterly, the duration of the price reference period being a month or quarter. Thus, the weight and price reference periods seldom coincide in practice, at least when a CPI is first calculated. However, the price and index reference periods frequently coincide.

*Relative price*

The ratios of prices of products (like tea, cream and sugar in 2010) is called ***relative prices****.*

*Relative Price* of ***i***th commodity w.r.t. ***j***th commodity at ***t***th time point:

$$^{p\_{it}}/\_{p\_{jt}}$$

Relative prices are often used for study of price structure, but are hardly used for compilation of price indices.

*Price relative*

Price relative is the ratio of the price of an individual product in one period to the price of that same product in some other period. This is the simplest kind of price index.

***Price relative*** of ***i***th commodity between base period and the ***t***th time point $^{p\_{it}}/\_{p\_{i0}}$

*(Expenditure) Weights*

A set of numbers, between zero and one, that sum to 1 and that is used to calculate averages. Value shares sum to 1 by definition and are used to weight price relatives, or elementary price indices (discussed later).The weights are used to obtain price indices or higher level indices by averaging the elementary price indices.

Weights (*wi*) of all the goods and services included in the basket should add up to 1. That is

 $\sum\_{i}^{}w\_{i}=1.$

As in Example 8, the weights add up to 1 and are used for combining the price relatives. Thus, it follows that

* items specified to be included in the basket should be mutually exclusive and
* should cover all the goods and services for which the price index is compiled.

In a CPI context, the weights are generally actual or hybrid expenditure shares that sum to unity by definition. They are used to average price relatives, or elementary price indices.

Although quantities are frequently described as weights, they cannot serve as weights for the prices of different types of products whose quantities are not commensurate and use different units of quantity that are not additive. The term “quantity weights” is generally used loosely to refer to the quantities that make up the basket of goods and services covered by an index and included in the value weights.

*Elementary aggregates* and *Elementary Price Index*

The lowest levels of aggregation for which value data are available and used in the calculation of a price index are called *elementary aggregates*. In our example of ‘a cup of tea’, each of the three items – tea leaves sugar and cream – are elementary aggregates. Elementary aggregates consist of relatively homogeneous sets of goods or services. Each elementary aggregate is assigned a weight, which is used for averaging the elementary price indices associated with them to obtain indices for higher-level aggregates.

An *elementary price index* is a price index for an elementary aggregate. In practice, for each elementary aggregate there are a number of varieties and number of sellers or producers, and the prices are not the same. Thus, a number of price observations on different varieties and from different sellers are taken and the *elementary price index* is calculated from individual price observations without using weights. Three examples of index number formulae used for computing elementary price index are the *Carli*, the *Dutot* and the *Jevons*. [Discussed later]

*Price updating*

A procedure whereby the quantities in the weight reference period are revalued at the prices of a later period that serves as the price reference period, typically the period preceding the current period. The resulting expenditure estimates therefore represent hybrid expenditures.

Usually, the weight reference period precedes the price reference period.



In other words, it is revaluing the weights in order to ensure that they are effectively based on the underlying quantities or volumes of the price reference period. The revaluing is achieved by multiplying the expenditure on each product in the weight reference period by the cumulative price change for that product between the weight reference period and the price reference period. This is also known as “value updating”.

As we will later on see, CPI weights are obtained from results of a household consumption expenditure survey (HCES). In Example 10.9 below, the HCES is conducted with 2008 as the reference period, while the index reference period is 2010.

|  |
| --- |
| **Example 9: Price updating of weights** |
| **weight / cost** | **products** | **total** |
| **A** | **B** | **C** |
| Weight (***wi08***) in 2008 | 0.5 | 0.3 | 0.2 | **1.0** |
| Prices (***pi08***) in 2008 | 13 | 4 | 11 |    |
| Prices (***pi10***) in 2010 | 15 | 5 | 10 |
| Price relatives 2008*→*2010 (***pr***) | 1.15 | 1.25 | 0.91 |
| ***pr*\* *wi08*** |  |  |  |  |
| Updated weights (***wi***) for 2010 |  |  |  |  |

In Example 9, first calculate price-updated shares in the last-but-one row. Divide each of them by their total in the last column to get the price updated weights, and verify that they add up to 1.

*Points to note*

* The set of goods and services used for calculation of the price change is known as the ‘basket of goods and service’.
* For CPI, the basket is called the ‘consumption basket’.
* The basket should cover all the goods and services for which the price index is compiled.
* It is a very large set of products. Each individual product has a share in the total value of consumption expenditure, which is the *expenditure weight* of the product.
* Depending on the kind of the price index, the basket must be representative of the goods and services acquired or consumed or produced.
* A Price index number may use three different base periods –*weight reference period*, price *reference period* and *index reference period*.
* Weights (*wi*) of all the goods and services included in the basket should add up to 1.
* Items specified to be included in the basket should be mutually exclusive.
* The lowest level of aggregation for which value data are available and used in the calculation of a price index are called *elementary aggregates*.
* It is desirable to have homogeneous elementary aggregates. But in practice an elementary aggregate represents items of different variety, which are sold/ produced by different kind of sellers/ producers.
* An *elementary price index* is a price index for an elementary aggregate.
* An *elementary price index* is calculated from individual price observations on products included in the elementary aggregate, without using weights.
* Price updating is carried out to have the same price and weight reference periods.

**Module 10, Session – II: Composite Price Index**

**Test Your Knowledge**

**Exercise – 10.2: Composite Price Index**

1. State whether the following statements are true [T] or false [F].
2. Composite indices are always weighted aggregation of price relatives.
3. If the price index for a group of products **A** is 120 and for another group **B** is 140, then the relative price of group **A** with respect to group **B** must have declined since the base period.
4. The ratio of average of prices of two time points and average of the rates of price change are always the same.
5. The weights used for a price index usually refer to a single reference period, called *weight reference period*.
6. In a Lowe index, the quantities considered may be of a different period than the base period of the index.
7. For CPI, the basket includes all goods produced in the economy.
8. All goods and services produced in an economy are included in the basket for output-PPI.
9. The lowest levels of aggregation for which value data are available and used in the calculation of a price index are called *elementary aggregates*.
10. A consumption basket for CPI may include rice and cereals as separate *elementary aggregates*.
11. Each *elementary aggregate* included in the basket for a price index is assigned a weight greater than 0 but less than 1.
12. For a price index the *weight reference period*, *price reference period* and *index reference period* should necessarily be different.
13. The sum of weights (*wi*) of all the elementary aggregate included in the basket of a price index may be less than 1.
14. An *elementary price index* is a price index for an elementary aggregate.
15. A price index is obtained as the weighted average of all the *elementary price indices*.
16. Price updating is carried out to have the same price and weight reference periods.
17. **Answer the following questions.**
18. If the price index for a period for the food division of the consumption basket be 120 and that of the non-food division be 130. If the overall price index be 135, what is the sum of weights of all the elementary aggregates falling in the food division?
19. A consumption basket has three divisions – A, B and C. The price indices for divisions A, B and C are respectively 120, 130 and 125, and their weights are respectively 0.4, 0.4 and 0.2. What is the overall price index?
20. Calculate the weights of tea leaves, sugar and cream for a price index for a ‘cup of tea’, of *weight reference period* using the following data on quantities consumed for making tea and prices of 2010.

|  |  |
| --- | --- |
| **quantity (000 Kgs) / price / cost** | **commodities** |
| **tea leaves** | **sugar** | **cream** |
| quantity (1000 kgs.) in 2010  | 90 | 110 | 60 |
| average price per 1000 Kg. in 2010  | 15,000 | 4,000 | 10,000 |
| value in 2010 |  |  |  |  |
| weights |  |  |  |  |

1. In Lowe price index, $I\_{0t}= \frac{\sum\_{i}^{}p\_{it}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$ , which two of the three reference periods – weight reference period, price reference period and index reference period – are the same?
2. The Lowe index for two time points, *s* and *t*, are respectively $I\_{0s}= \frac{\sum\_{i}^{}p\_{is}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$ and $I\_{0t}= \frac{\sum\_{i}^{}p\_{it}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$ . How will you interpret the ratio $^{I\_{0t}}/\_{I\_{0s}}$ ?

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## 10.6 Index Number Formula

## **Contents**

* Index number formula
	+ Simple index: *Price relatives*
	+ Simple aggregate index: *Dutot*, *Carli* and *Jevon*
	+ Weighted aggregate index: *Lowe*, *Laspeyres* and *Paashe’s*.

## **Price Index Formula**

Recall that there are three types of index numbers, viz.

* Simple index number or *price relative*
* Simple aggregate index
* Weighted aggregate index.

Simple price index or price relative is the simplest type is defined as

 $pr\_{i}= ^{p\_{it}}/\_{p\_{i0}}$

for the ***i***th product between the base period (*0*) and the current period (*t*).

A price relative is computed for a single commodity. For an exactly-specified commodity, price relatives measure “pure” price change. On the other hand, when a consumption item, say rice, has different varieties with varying price, say coarse, medium and fine, price relative of the item (rice) as such is not defined.

Even if we collect data on value and quantity of the entire consumption / production of rice, the ratio of the derived prices (total value/total quantity) of two different periods is not a measure of “pure” price change. The composition of the entire consumption/ production in terms of coarse, medium and fine rice of the two periods is likely to be different. Thus, the value of such a ratio will be affected by both the change in composition as well as change in prices.

For a group of related commodities, therefore, we have to adopt a method of aggregation. The methods of aggregation are referred to by algebraic formulas used. Each of the formula again is named after the index number pioneer who first proposed it. We will later see that these are used at different stages of index number compilation, such as *elementary* price index calculation and higher-level price index compilation.

Depending upon whether or not the aggregation method uses weight for the commodities or commodity-groups involved, the aggregate index numbers are broadly divided into two types, viz.:

* *Simple aggregate index* based on unweighted aggregation
* *Weighted aggregate index* based on weighted aggregation.

*Points to note*

* *Price relatives* are suitable price index numbers for homogenous individual goods and services, such as ‘coarse rice’, ‘T-shirts’, ‘male hair-cut’ etc..
* For an elementary aggregate like ‘rice’, comprised of different varieties such as coarse, medium and fine, an *unweighted aggregate index* is usually used, since the composition of ‘rice’ by the value of consumption/ production of its varieties is usually not known.
* *Weighted aggregate index* numbers are usually used for compiling higher level index numbers by aggregating elementary price indices.
* There are different formulas for aggregation – both weighted and unweighted.

## **Simple aggregate index**

A simple aggregate index is calculated from individual price observations without using weights. These are used for obtaining elementary price indices from observed price data. Three examples of most commonly used simple aggregate index number formulae are the Dutot, the Carli and the Jevons.

*Dutot Price Index formula*

A price index defined as the ratio of the unweighted arithmetic average of the prices in the current period (*t*) to the unweighted arithmetic average of the prices in the base period (*0*). It is an elementary index.

Algebraic formula: $\frac{\frac{1}{n}\sum\_{i}^{}p\_{it}}{\frac{1}{n}\sum\_{i}^{}p\_{i0}}$ or simply $\frac{\sum\_{i}^{}p\_{it}}{\sum\_{i}^{}p\_{i0}}$

This is the most widely used elementary index number formula and is attributed to the French economist *Dutot* (1738). The *Dutot* price index is equal to the arithmetic average of the *t*-period prices of ***n*** items divided by the arithmetic average of the base-period prices of the same ***n*** items.

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| --- |
| **Example 10: A family weekly diet in July 2005 and July 2010 – *Dutot* Index** |
| Item | July 2005 | July 2010 |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 | 6.0 | 1.0 |
| Beef | 10.0 | 6.0 | 11.0 | 3.0 |
| Pork  | 7.0 | 0.0 | 7.0 | 1.0 |
| Chicken | 5.0 | 0.0 | 5.8 | 3.0 |
| Sum of prices | 27.5 |  | 29.8 |  |

Calculate the *Dutot* index for July 2010 with base July 2005.

 Sum of price in 2005 =

 Sum of price in 2010 =

 *Dutot* index = 100\*(Sum of price in 2010) / (Sum of price in 2005)

=

Limitations of *Dutot* index:

* 1. The prices of various commodities may be quoted in different units,
		+ e.g., price of cereals may be quoted in Taka per quintal, liquids like milk, petrol, kerosene may be quoted in Taka per liter; cloth may be quoted in Taka per meter and so on.

Thus, the index is influenced very much by the units in which commodities are quoted and accordingly some of the commodities may get more than their due importance.

* 1. In this method the commodities get weighted according to the magnitudes of their prices
		+ Thus highly priced commodities exert greater influence on the value of the index.
	2. The relative importance in use of various commodities is not taken into consideration.

*Carli Price Index formula*

The second widely used elementary index number formula is attributable to the Italian economist Carli (1764):

The *Carli* price index is defined as the unweighted arithmetic average of the current to base period price relatives. That is,

 $\frac{1}{n}\sum\_{}^{}\frac{p\_{it}}{p\_{io}}$

It is used for obtaining elementary index.

First the *price relatives* of each commodity of the group are computed. The price relatives are then combined to make an elementary indexfor the group by taking their simple average.

|  |
| --- |
| **Example 11: A family weekly diet in July 2005 and July 2010 – Carli Index** |
| Item | July 2005 | July 2010 | Price relatives |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 | 6.0 | 1.0 |  |
| Beef | 10.0 | 6.0 | 11.0 | 3.0 |  |
| Pork  | 7.0 | 0.0 | 7.0 | 1.0 |  |
| Chicken | 5.0 | 0.0 | 5.8 | 3.0 |  |
|  Arithmetic mean of price relatives: |  |

*Carli* price index = 100\*(average of price relatives) =

*Carli* price index is not affected by the units in which the prices are quoted. It gives equal weights to all the items. When the items should be given equal weights and their prices vary randomly in a given period, Carli index is the best measure for common inflation rate. However, by economic approach, it has an upward bias.

*Jevon Price Index formula*

The third widely used elementary index number formula is attributable to the English economist Jevons (1863):

*Jevon* price index is defined as the unweighted geometric average of the current to base period price relatives. That is,

 $\left(\prod\_{i=1}^{n}\frac{p\_{it}}{p\_{i0}}\right)^{^{1}/\_{n}}$

|  |
| --- |
| **Example 10.12: A family weekly diet in July 2005 and July 2010 – Jevon Index** |
| Item | July 2005 | July 2010 | Price relatives |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 | 6.0 | 1.0 |  |
| Beef | 10.0 | 6.0 | 11.0 | 3.0 |  |
| Pork  | 7.0 | 0.0 | 7.0 | 1.0 |  |
| Chicken | 5.0 | 0.0 | 5.8 | 3.0 |  |
| Geometric mean of price relatives: |  |

None of the unweighted elementary indices is really satisfactory. The *Carli* and *Jevon* index weights each observation equally, while the *Dutot* index weights each observation according to its relative price in the base period. A much more satisfactory approach would be to collect quantity or value information along with price information, and adopt a method of using some kind of weights based on money value shares of the items involved.

*Points to note*

* *Dutot* price index is the ratio of average prices of two time periods.
* *Carli* price index is the arithmetic average of ratio of prices, i.e. price relatives, of two time points.
* *Jevon* price index is the geometric average of ratio of prices, i.e. price relatives, of two time points.
* *Dutot*  price index is affected by the choice of units in which the prices are quoted.
* Highly-priced, rather than highly-used, commodities get greater importance in a *Dutot* index.
* *Carli* and *Jevon* price index are not affected by the units in which the prices are quoted.
* *Carli* and *Jevon* price index give equal weights to all the items.
* Judged by economic approach, *Carli* index has an upward bias.

## **Weighted aggregate index**

The idea underlying calculation of price is to gauge how much the price level of a basket of goods in a certain period differs from the price level of the same basket in another period. But the basket consists of goods and services of varying worth in money terms. Thus, in order to aggregate, that is to add up the price change measured for each product in the basket, each price change must be given its relative importance of the products taking account of the total sum of money spent in the index base period.

*Lowe Index*

In the weighted aggregate index formula, price changes are ‘weighted’ according to the relative importance of the products included in the basket. One very wide, and popular, class of price indices is obtained by defining the index as the percentage change between the periods compared in the total cost of producing a fixed set of quantities, generally described as a “basket”. In principle, any set of goods and services could serve as the basket. The basket does *not* have to be restricted to the basket actually produced or used in one or the other of the two periods compared.

In a general form, a weighted aggregate index number formula can be written as

 $I\_{0t}=100× \frac{\sum\_{i}^{}p\_{it}.v\_{i}}{\sum\_{i}^{}p\_{i0}.v\_{i}}$ where ***vi*** is the weight attached to *i*th commodity.

This is called the ***Lowe Index*** after the English economist, Joseph Lowe, who suggested this type of index in 1823. For a *Lowe price index*, the quantity weights are fixed and predetermined but need not pertain to either of the time periods for which prices are being compared. There are many ways in which the reference quantities or weights (*vi*) might be specified for a Lowe index.

Let there be *n* commodities in the basket with prices *pi* and quantities *qi*. Let periods 0 and *t* be the two periods whose prices are being compared.

The weights *vi* in the above formula can be the quantities of a period *b*, different from both the periods *0* and *t*. Then the Lowe index takes the form

 $I\_{0t}=100× \frac{\sum\_{i}^{}p\_{it}.q\_{ib}}{\sum\_{i}^{}p\_{i0}.q\_{ib}}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.\frac{p\_{i0}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i}^{(b)}$

 where $w\_{i}^{(b)}= \frac{p\_{i0}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$

These are often described as *hybrid weights* because the prices and quantities used for calculating the weights are of two different time periods, 0 and *b*, respectively.

In the context of *CPI*, a *Lowe* index is defined as a fixed basket index where the commodity basket is constructed based on household consumption patterns in a particular year (when a household consumption expenditure survey is conducted). This basket is priced using current month prices in the numerator and base period prices in the denominator of the index.

Thus, a *Lowe* index has two separate bases – one for the commodity basket (*weight reference period*) and the other for the prices as well as the index (*price reference period* and *index reference period*). The base period for the basket mostly precedes the base period for the index. Most *CPI*s are actually Lowe indexes.

Any set of quantities could be used in a Lowe index, but there are two special cases that are most important in theory as well as in practice. They are *Laspeyres* and *Paasche* index numbers. The following is a more detailed discussion on these two price indices, their properties and the relationship between them.

*Laspeyres price Index*

When the quantities are those of the first of the two periods whose prices are being compared, that is when *b =* 0, the Lowe is equivalent to the *Laspeyres price index*.

The formula for the *Laspeyres* price index, *LP*, is as follows

$$L\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$$

It is simply the ratio of the values of the basket of goods and services consumed / produced / traded in period 0 when valued at the prices of periods *t* and 0, respectively.

The above formula can also be written as

 $L\_{p}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}. \frac{p\_{i0}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i0}$

 where $w\_{i0}= \frac{p\_{i0}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$

This is a weighted arithmetic average of the ratios of the individual prices in periods *t* and *0* using the shares in total value of goods and services consumed / produced / traded of period *0* as weights. Thus, it is also known as a “base-weighted index”.

**Example 10.13: Calculating the *Laspeyres* price index from the following data.**

|  |
| --- |
| A family weekly expenditure on meat and fish in July 2005 and July 2010 **– *Laspeyres* Price Index –** without using price relatives |
| Item | July 2005 | July 2010 | *p0.q0* | *p1.q0* |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 | 6.0 | 1.0 |  |  |
| Beef | 10.0 | 6.0 | 11.0 | 3.0 |  |  |
| Pork  | 7.0 | 0.0 | 7.0 | 1.0 |  |  |
| Chicken | 5.0 | 0.0 | 5.8 | 3.0 |  |  |
| Total: |  |  |

$L\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$ =

|  |
| --- |
| A family weekly expenditure on meat and fish in July 2005 and July 2010 **– *Laspeyres* Price Index –** using price relatives |
| Item | July 2005 | July 2010 | *price relatives pt/p0* | $w\_{0}$\**pt/p0* |
| Price (*p0*) | Quantity (*q0*) | $$w\_{0}$$ | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 |  | 6.0 | 1.0 |  |  |
| Beef | 10.0 | 6.0 |  | 11.0 | 3.0 |  |  |
| Pork  | 7.0 | 0.0 |  | 7.0 | 1.0 |  |  |
| Chicken | 5.0 | 0.0 |  | 5.8 | 3.0 |  |  |
| Weighted arithmetic mean of price relatives: |  |

*Lp* = 100\*(weighted arithmetic mean of price relatives) =

Note that we get the same values of the *Laspeyres* price index from both the methods of calculation.

*Paasche price Index*

When the quantities are those of the current period or the latter of the two periods whose prices are being compared, that is when *b = t*, the Lowe is equivalent to the *Paasche price index*.

The formula for the *Paasche* price index, *PP*, is as follows

 $P\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}$

It is simply the ratio of the values of the basket of goods and services consumed / produced / traded in period *t* when valued at the prices of period’s *t* and 0, respectively.

The above formula can also be written in two different ways:

1. As weighted arithmetic average of price relatives

$$P\_{p}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}. \frac{p\_{i0}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i}$$

 where $w\_{i}= \frac{p\_{i0}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}$

The weights (*wi*) are hybrid weights – share of the *i*th commodity in total hypothetical expenditure / value of *t*-period quantities valued at base period prices.

1. As weighted harmonic average of price relatives

$$P\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}= \left[\sum\_{i}^{}\left(\frac{p\_{i0}}{p\_{it}}\right)\frac{p\_{it}q\_{it}}{\sum\_{i}^{}p\_{it}q\_{it}}\right]^{-1}$$

$$= \left[\sum\_{i}^{}\frac{p\_{0}}{p\_{t}}.w\_{it}\right]^{-1}= \left[\sum\_{i}^{}\left(\frac{p\_{it}}{p\_{i0}}\right)^{-1}w\_{it}\right]^{-1}$$

 where $w\_{it}=\frac{p\_{it}q\_{it}}{\sum\_{i}^{}p\_{it}q\_{it}}$

**Example 10.14: Calculating the *Paasche*** **price index from the following data.**

|  |
| --- |
| A family weekly expenditure on meat and fish in July 2005 and July 2010 **– *Paasche* Price Index –** without using price relatives |
| Item | July 2005 | July 2010 | *p0.qt* | *p1.qt* |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) |
| Fish | 5.5 | 2.0 | 6.0 | 1.0 |  |  |
| Beef | 10.0 | 6.0 | 11.0 | 3.0 |  |  |
| Pork  | 7.0 | 0.0 | 7.0 | 1.0 |  |  |
| Chicken | 5.0 | 0.0 | 5.8 | 3.0 |  |  |
| Total: |  |  |

$P\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$ =

|  |
| --- |
| A family weekly expenditure on meat and fish in July 2005 and July 2010 **– *Paasche* Price Index –**using price relatives |
| Item | July 2005 | July 2010 | *price relatives**pt/p0* | $w\_{t}$\*(*pt/p0*)-1 |
| Price (*p0*) | Quantity (*q0*) | Price (*p1*) | Quantity (*q1*) | $$w\_{t}$$ |
| Fish | 5.5 | 2.0 |  | 6.0 | 1.0 |  |  |
| Beef | 10.0 | 6.0 |  | 11.0 | 3.0 |  |  |
| Pork  | 7.0 | 0.0 |  | 7.0 | 1.0 |  |  |
| Chicken | 5.0 | 0.0 |  | 5.8 | 3.0 |  |  |
|  Weighted sum of reciprocals of price relatives: |  |

*Pp* = 100\*(weighted sum of reciprocals of price relatives)-1

 = 100\*(weighted harmonic mean of price relatives) =

Note that we get the same values of the *Paasche* price index from both the methods of calculation.

*Laspeyres vs. Paasche*

Points to note about Laspeyeres’ and Paashe’s methods:

1. *Laspeyres* method is generally expected to overestimate change in prices or to have an upward bias.
	* This is because in case of price increase there is usually a reduction in the consumption of those items for which the increase has been the most pronounced. Thus, by using base year quantities, we give higher weights to the prices that have increased the most. The numerator of the Laspeyres index will, therefore, tend to be too large.
	* On the other hand, when the prices go down, consumers often shift their preference to those items which have declined the most. Thus, by using base period weights in the numerator of the Laspeyres index, we give sufficient weight to the prices that have gone down the most. The numerator will again be too large.
2. *Paashe’s* method generally leads to underestimate, i.e., show a downward bias.
	* This is because people tend to spend less on goods when their prices are rising. The use of Paashe’s or current weighting produces an index which tends to underestimate the rise in prices, i.e., it has a downward bias.
3. But the above arguments do not imply that Laspeyres index must necessarily be larger than the Paashe’s.

*Fisher’s Price Index*

This price index uses both the baskets from the base and the current periods. It is defined as the (geometric) average of the Laspeyres price index and the Paasche price index.

FP01=( LaP01 \*PaP01)1/2 =(Σp1q0/Σp0q0 \* Σp1q1/Σp0q1)1/2 \*100

Fisher’s Price Index number is known as ‘Ideal’ due to the following reasons:-

* + It is free from bias, since the upward bias of Laspeyres’ index number is balanced to a great extent by the downward bias of Paasche’s index number.
	+ It is based on the geometric mean, theoretically which is considered to be the best average for constructing index numbers.
	+ It conforms to certain tests of consistency.
	+ This formula takes into account the influence of the current as well as the base year.

The choice of the index formula to use often depends on the availability of data. The *Laspeyres* formula does not require information on the basket of the current period, while the other formulae do. Therefore, the Laspeyres formula is very often used in practice in price statistics, which are often compiled and released rapidly - before consumption or production information for the current period has been collected.

*Points to note*

* Weights should be based on relative importance of the goods and services included in the basket.
* For an elementary aggregate, most statistical agencies use a weight that is based on its share in
	+ the total value of consumption expenditure as the weights for compiling *CPI*.
	+ the total value of production (*gross value added*) for compiling output-*PPI*.
	+ the total value of exports for compiling XPI.
* The weights used for *Lowe* index are ‘hybrid’ weights; they do not pertain to a single time period.
* The Lowe index takes the form

$$I\_{0t}==100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i}^{(b)}$$

where $w\_{i}^{(b)}= \frac{p\_{i0}q\_{ib}}{\sum\_{i}^{}p\_{i0}q\_{ib}}$

* When the weight reference period is made the same as the *index reference period,* i.e. when *b =* 0, the Lowe index is equivalent to the *Laspeyres price index, LP,*

$$L\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$$

* When the weight reference period is made the same as the *current period,* i.e. when *b = t*, the *Lowe* index is equivalent to the *Paasche price index, PP,*

$$P\_{p}=100×\frac{\sum\_{i}^{}p\_{it}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}$$

* *Laspeyres* formula can also be written as

 $L\_{p}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}. \frac{p\_{i0}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}=100×\sum\_{i}^{}\frac{p\_{it}}{p\_{i0}}.w\_{i0}$

 where $w\_{i0}= \frac{p\_{i0}q\_{i0}}{\sum\_{i}^{}p\_{i0}q\_{i0}}$

LP is a weighted arithmetic average of the price relatives.

* *Paasche* formula can also be written in two alternative ways
	+ as a weighted arithmetic average of price relatives, with weights as

$$w\_{i}= \frac{p\_{i0}q\_{it}}{\sum\_{i}^{}p\_{i0}q\_{it}}$$

* + as a weighted harmonic average of price relatives, with weights as

$$w\_{it}=\frac{p\_{it}q\_{it}}{\sum\_{i}^{}p\_{it}q\_{it}}$$

* Laspeyres method is generally expected to overestimate or to have an upward bias.
* *Paasche’s* method generally leads to underestimate, i.e., show a downward bias.
* Fisher’s price index is the geometric mean of Laspeyres price index and the Paasche price index.
* For compiling *Laspeyres* price index, data on current quantities are not required.

**Module 10, Session – III: Composite Price Index**

**Test Your Knowledge**

**Exercise – 10.3: Price Index Formula**

1. State whether the following statements are true [T] or false [F].
2. *Price relatives* are suitable price index numbers for heterogeneous groups of commodities.
3. Composite indices are always weighted aggregation of price relatives.
4. Unweighted aggregates index are suitable for compiling higher-level indices.
5. *Dutot* price index is the ratio of average prices of two time periods.
6. *Jevon* price index is the ratio of geometric average of prices of two time points.
7. Highly-used commodities get greater importance in a *Dutot* index.
8. *Carli* and *Jevon* price index are not affected by the units in which the prices are quoted.
9. *Lowe* price index is a weighted arithmetic average of the price relatives.
10. *Laspeyres* price index is a weighted arithmetic average of the price relatives.
11. *Paasche* price index is a weighted harmonic average of the price relatives, with weights defined as the shares in total money value of consumption/ production/ trade in the current period.
12. *Paasche* price index is a weighted arithmetic average of the price relatives, with hybrid weights based on prices of the base period and quantities of the current period.
13. *Laspeyres* index must necessarily be larger than the *Paasche’s*.
14. *Laspeyres* price index is most commonly used by statistical agencies, because data on quantities are required to be collected once in the base year.
15. Fisher’s price index always lies between *Laspeyres* price index and *Paasche* price index.
16. For compiling Fisher’s price index, data on current-period quantities are not required.
17. Answer the following questions.

The data set given below is for a basket of food grains, consisting of rice, wheat, sorghum, millets and pulses. Quantity figures are the totals for the entire economy and are given thousand quintals. Prices are in *Taka* per Kg.

|  |  |  |  |
| --- | --- | --- | --- |
| Items | 2009 | 2010 | 2015 |
| price | quantity | price | quantity | price | quantity |
| Rice | 15 | 250 | 16 | 255 | 18 | 270 |
| Wheat | 17 | 145 | 17 | 148 | 21 | 150 |
| Sorghum | 12 | 94 | 14 | 92 | 17 | 90 |
| Millets | 12 | 32 | 12 | 30 | 16 | 30 |
| Pulses | 21 | 155 | 22 | 154 | 30 | 160 |

Make appropriate tables (on separate sheet) and calculate the following

price index for food grains:

1. *Laspeyres* price index in 2015 with 2010 as the base year.
2. *Paasche* price index in 2015 with 2010 as the base year.
3. *Fisher’s* price index in 2015 with 2010 as the base year.
4. *Lowe* price index in 2015 with 2010 as the base year, using quantities of 2009 for calculation of weights.
5. Compare the values of price index obtained by different formulas and comment.

# 10.6 Construction of Price Index – Issues, Purpose and Frequency

## Contents

* Issues involved
* Purpose –Scope and coverage
	+ *Price Index – as a Measure of Inflation*
	+ *Price index relating to standard of living*
	+ *Purpose served by a price index*
	+ *Scope and coverage of Price Index*
* Periodicity and timeliness
	+ *Reference period and reference time point*
	+ *Timeliness*

### 10.6.1 Issues involved in construction of a Price Index

We have seen that Price Index is a useful way of expressing change in prices of a group of goods and services. Different kinds of price indices are used to measure price changes by policy makers, businesses and analysts for different purposes. But, their actual usefulness for analytical and predictive purposes depends on how well the choice of method and actual compilation are made. The following are the main compilation issues involved in designing a price index:

1. Defining Purpose – specifying scope and coverage
2. Frequency – periodicity and timeliness
3. Choice of Base period
4. Assigning Weights
5. Selection of items
6. Choice of data collection method
7. Choice of method of calculation.

In this session, we will take up the first two issues. The rest will be discussed in the following sessions.

### 10.6.2 Purpose, Scope and Coverage

A wide variety of indices is used to measure price changes taking place in an economy. As we have seen earlier, these serve a variety of purposes, such asmeasuring inflation, index linking salaries and social benefits, contract escalation and in compilation of national accounts for measuring real growth rates. Which sets of prices should be covered by a price index depends largely on the purposes the index is likely to serve. This has a direct bearing on what kind of transactions the index is designed to cover. Distinct price indices thus relate to different sets of goods and services involved in a specific kind of transaction, such as household consumption, production, investment, and foreign trade flows.

### 10.6.3 Price Index – as a Measure of Inflation

One of the main uses of most price indexes is measuring inflation for the specific set of goods & services in the specific kinds of transactions covered by the respective price indexes. In general terms, inflation is defined as the rise in the general level of prices over time. To understand, what does general level of prices really mean, let us take a closer look at the simplest measure of price change – *price relative*.

Recall that *price relative* of ***i***th commodity between *base period* and the ***t***th time point is defined as $^{p\_{it}}/\_{p\_{i0}}$where $p\_{it}$ and $p\_{i0}$ are respectively the prices of unit quantity of the ***i***th commodity in the current and base periods.

The *price relative* can be decomposed into two factors:

1. Change in the *general price level* and
2. Change in *price structure*, i.e. change in relative prices

Price indices are measures of the *general price level*, but each of them is a partial measure.

Example 15 illustrates what are ‘changes in price level’ and ‘price structure’.

It demonstrates three different hypothetical situations. In Case 1 there is a rise in *general price level*, with no change in *price structure*; in Case 2 there is no change in *general price level*, but change in *price structure*; and in Case 3 there is a rise in *general price level*, with change in *price structure*.

| **Example 10.15: Decomposition of Price relatives** |
| --- |
| **product** | ***p*0** | **Relative price** | **product** | ***pt*** | **Price relative** | **Relative price** |
| *Base period* | **Case 1** – *current period* |
| **A** | 10 | 1.0 | **A** | 12 | 1.2 | 1.0 |
| **B** | 20 | 2.0 | **B** | 24 | 1.2 | 2.0 |
| **C** | 15 | 1.5 | **C** | 18 | 1.2 | 1.5 |
| *p0*: price in base period*pt*: price in current periodPrice relative = *pt*/ *p0*Relative price : (price of the product) / price of **A**)  | **Case 2** – *current period* |
| **A** | 10 | 1.0 | 1.0 |
| **B** | 16 | 0.8 | 1.6 |
| **C** | 18 | 1.2 | 1.8 |
| For uniform weights of 1/3 of all the products, calculate the rise in *general price level* in | **Case 3** – *current period* |
| Case 1:  | **A** | 13 | 1.3 | 1.0 |
| Case 2: | **B** | 22 | 1.1 | 1.7 |
| Case 3: | **C** | 18 | 1.2 | 1.4 |

We see that in

**Case 1**: there is rise in *general price level*, with no change in *price structure*.

**Case 2**: there is no change in *general price level*, but change in *price structure*.

**Case 3**: there is rise in *general price level*, with change in *price structure*.

In real life, we invariably find price changes of the Case-3 kind. Generally, an overall increase in the *price level* is accompanied by a change in the structure of relative prices, but it is only the overall [average] prices increase, not the relative price change, that constitutes *inflation*. A price index for measuring inflation should therefore represent change in average prices of the goods and services covered by the index, segregated from changes in the *relative prices* of individual goods and services.

Only an economy-wide price index covering all money transactions occurring during the time period may be able to represent the *general price level* in an economy with respect to a specified base year. Such a price index should measure the increase in *average prices* of all goods and services transacted in an economy.

In a *market transaction approach*, only the transactions relevant for such a measure of *general price level* or *inflation* are only the monetary transactions, i.e. transaction of goods and services in exchange of money (*g&s* ↔ *M*). The domains of price indices meant for measuring inflation ought to be thus confined only to market transactions. The non-market transactions and own-use transactions ought to be excluded since they do not involve money transactions. The monetary market transactions can be classified as follows:



There is no single price index to cover all monetary market transactions in an economy. The only indicator of change in *general price level* of almost all monetary and non-monetary transactions available in official statistics is from national accounts statistics. It is called the *implicit GDP deflator* and is defined as

 $Implicit GDP deflator= \frac{GDP at current prices}{GDP at constnt prices} ×100$

This is an index that measures the average price level of an economy’s output relative to the base year. Percentage change in the GDP deflator, in a way, measures the rate of overall price increase for all goods and services produced in the economy, except that it does not cover purchase and sale of existing assets and properties. Moreover, it does not serve the purposes that are served by the specific price indexes compiled by the official statistical agencies.

In national statistical systems, inflation or the rise in the *general level of prices* over time is measured using a combination of different indices. For assessing inflation faced by private households, the most suitable index is the consumer price index (CPI). For assessing inflation from the point of view of producers or importers of goods, the producer price index (PPI) can be the most suitable measure of inflation for certain purposes. As for building construction and housing, construction cost index may provide the most relevant picture of price trends in these industries.

### 10.6.4 Price index relating to standard of living

There is another associated concept of price change –*Cost of Living Index* (COLI) – which relates to welfare (also known as well-being, utility, standard of living) of the consumers. A COLI is defined as the measure of change in the minimum cost of maintaining a given level of welfare.

Note that the welfare of a household depends not only on the utility derived from the goods and services it consumes, but on the social, political and physical environment in which the household resides. A COLI designed to capture the change in minimum cost in response to environmental factors (*unconditional* COLI), strictly speaking, is not a price index. A COLI (*conditional* COLI) that qualifies as a price index is based on the change in the minimum cost of maintaining a given level of welfare resulting from only the changes in consumer prices, holding the environmental factors constant.

Evidently, the two approaches of measuring price change from the viewpoint of inflation and (*conditional*) COLI are closely linked. The main difference between the two approaches is that a COLI reflects results of changing prices and changing expenditure patterns, while inflation in its broadest sense is concerned only with changing prices. In very general terms, a COLI is a more appropriate tool for negotiating income changes, and an inflation index might be preferred for macro-economic policy analysis.

The term PPI is also used to cover a number of different concepts, and these are used in a number of ways. Most commonly, the term PPI is used to refer to *output PPI*s. Maintaining consistency with the national accounts definition of output, an *output PPI* reflects changes in ex-factory/ ex-farm gate prices valued at basic prices. In other words, they are the prices received by the producer at the first stage of commercialisation. An *input PPI*, on the other hand, reflects changes in prices paid by producers for raw materials and intermediate goods. Again, to maintain consistency with the national accounts definition of intermediate consumption, they are valued at purchasers’ prices.

### 10.6.5 Purpose served by a price index

In practice, CPIs are designed to measure changes over time in average retail prices of a fixed basket of goods and services taken as representing the consumption habits of households. These are used widely by the government and businesses for index linking salaries and social benefits.The purpose of output PPI is to provide measures of average movements of prices received by the producers of commodities. Similarly, a major use of XMPIs is as an escalator for price adjustments to long-term contracts.

Evidently, the first and the foremost problem in the construction of index numbers relate to specifying the purpose for which they are required. As we have seen, there is no all-purpose price index as every price index has its own particular uses and limitations. For example, a cost of living index will have different set of commodities, price quotations and weights compared with the general wholesale price index. Again the cost of living index for workers in an industrial town will have different requirements compared with one for agricultural workers.

### 10.6.6 Scope and coverage of Price Index

There is no all-purpose index number. Every index number has its own particular uses and limitations.The scope, or domain, of an index is the set of products or economic activities and kind of transactions that the index is intended to cover. It is determined by what is intended or believed to be its main use. What exactly should be within the scope of an index depends on the ‘intended’ main use. However, it should be borne in mind that the index may also be used as a proxy for a general price index and used for purposes other than those for which it is intended.

Often the scope these indexes go beyond that specified by the market transaction approach. Thus, there is no single, precise definition of what a CPI should measure. In practice, the price indexes are designed to cover parts of non-market and own-use transactions as well. Depending upon the purpose, there can be different concepts of consumption, which can be interpreted in several different ways. Each of these leads to a different CPI. For example, the interpretation of a CPI designed to measure changes in prices for ‘actual consumption’ (as defined in the SNA) would be quite different from that designed for consumption expenditure of the households.

The question that immediately crops up is: if the price of an item of ‘own-produce’ consumption, such as services of owner-occupied dwellings, is not observable, how is its price included in calculation of price index? This is dealt with by taking imputed prices or by appropriate weight adjustment of the rented dwellings, assuming parallel movement of price of housing services of both the categories of dwellings. We will discuss these issues in greater detail in the following sessions.

The ‘intended’ main use could be measuring changes in standard of living. Besides price change, a number of factors affect standard of living, such as availability of free education and health services provided by the government and NPISHs, law and order situation, and climatic conditions. But, the defined scope of CPIs constructed for measuring standard of living by the statistical offices is usually restricted to the market prices of goods and services purchased by households for purposes of consumption. For example, it may exclude publicly provided free goods and services, self-consumption of goods & services out of own production and consumption of banking and insurance services Thus, CPI serves as a measure of changing prices for standard of living with the factors outside the scope held constant.

It is also necessary to decide whether the index is meant to cover all consumers, i.e., all households, or just a particular group of households. The coverage of a CPI is inevitably influenced by what is intended, or believed, to be the main use of the index. The coverage of a CPI is specified by the reference population in terms of

* *Geographical coverage*: for example rural & urban areas.
* *Types of households*: Rural labour, industrial, two or more members’ households etc.
* *Socio-economic groups*: native population, non-rich population, etc.

Compilers also need to remember that the index may be used as proxy for a general price index and used for purposes other than those for which it is intended.

Similarly, the ‘intended’ main use of an Output-PPI is to measure changes in the prices of goods and services produced in the economy. The scope of PPIs varies. They generally reflect the changes in prices received by a definable industry such as manufacturing, agriculture or mining. Besides price changes, factors affecting producers’ income are many, such as tax regulations and labour laws, availability of infrastructure and environmental conditions. In practice, PPI’s scope is restricted to a set of market products with the factors outside the scope held constant.

The PPIs may also have very different coverages. Most often the coverage is restricted to non-agricultural market producers. It may be more restrictive and exclude the government market producers like departmental and non-departmental enterprises. In practice, the defence production units are left out of the coverage for the obvious reason that their products are not sold in the market. The coverage of a PPI is specified in the following terms:

* whether the index covers output prices or input prices (or both),
* whether the index is meant to cover all production, i.e., all economic activities and/or products, or just particular industries and/or product groups,
* for the economic activities included, whether the index should cover just market activities, and
* determine the geographic boundary in which the defined production is included.

In calculation of price index, comprehensive inclusion of all products in the coverage of the index is ensured by allocating appropriate weights to each of them. The weights are so allocated to all the individual goods and services in the coverage of the index that their sum is equal to 1. When prices of a group of products (say group X) are not observable, then observed prices of related products is applied on the weight allocated to group X to work out its contribution to the index. The role of weights in calculation of price index is discussed in greater detail in the following sessions of this module.

*Points to note*

* The purpose of a price index determines the set of prices that should be covered by it.
* The purpose also determines the kind of transactions, such as household consumption, production, investment, and foreign trade flows, the index should cover.
* A price relative can be decomposed into two factors:
1. Change in the *general price level* and
2. Change in *price structure*, i.e. change in relative prices
* Generally, an overall increase in the *price level* is accompanied by a change in the structure of relative prices.
* The overall [average] prices increase, not the relative price change, constitutes *inflation*.
* A price index for measuring inflation should therefore represent change in average prices of the goods and services covered in the index, segregated from changes in the *relative prices* of individual goods and services.
* Only the prices of monetary transactions form the basis of an index compiled in a *market transaction approach*.
* The price indices meant for measuring inflation are based only on monetary market transactions.
* *Implicit GDP deflator* measures the average price level of an economy’s output relative to the base year.
* Percentage change in the *implicit GDP deflator*, in a way, measures the rate of overall price increase for all goods and services produced in the economy.
* *Implicit GDP deflator* does not cover purchase and sale of existing assets and properties.
* A COLI is defined as the measure of change in the minimum cost of maintaining a given level of welfare.
* A COLI reflects results of changing prices and changing expenditure patterns.
* A COLI is a more appropriate tool for negotiating income changes
* A price index for measuring inflation in its broadest sense is concerned only with changing prices.
* An inflation index is more suitable for macro-economic policy analysis.
* An *output PPI* reflects changes in ex-factory/ ex-farm gate prices valued at basic prices.
* An *input PPI*, is based on prices of intermediate consumption, valued at purchasers’ prices.
* There is no all-purpose price index.
* The scope of a CPI is the set of products for household final consumption that the index is intended to cover.
* The scope, an output PPI is the set of products or economic activities that the index is intended to cover.
* Coverage of a CPI is defined in terms of geographical coverage, types of household by occupational class or level of living and socio-economic groups.
* Coverage of a PPI specifies the industries (economic activities) – only market output or also non-market output – as well as geographic areas to be included.

### 10.6.7 Periodicity and Timeliness

Frequency and timeliness of compiling a price index also depends on the purpose it is designed to serve. A price index used for monitoring inflation should be compiled with a short periodicity (high frequency) say a week or a month. On the other hand, a price index for other purposes, such as index linking salaries and social benefits and contract escalation, are required with a longer periodicity of say a month or a quarter or even annual.

### 10.6.8 Reference period and reference time point

Price indexes are designed to refer to a time point or a period of time. A price index is said to have a *reference time point*, if it is based on prices collected on a particular day of the week or the month. As against this, an index is said to have a *period reference*, when average prices during the reference period are considered for calculation of the price index. An index number series is generally smoother for *period reference* than *reference time point*.

For example, a WPI published weekly may refer to the prices prevailing on a particular day of the week. In such a case, the price index is said to have a reference time point. An index is said to have a period reference, when average prices during the reference period are considered for calculation of the price index.

A high-frequency index is usually compiled for a reference time point or a short reference time period. High-frequency indexes are compiled for those with a limited scope. Since collecting all the required data in a short period of time is difficult, high-frequency indexes are compiled for those with a limited scope, such as price index for crude oil or transport fuel. An index number series with reference time point is likely to be highly volatile in short-term. In a rapid inflation situation, monitoring authorities require *price index* with shorter reference period.

The price indexes with broader scope usually have a longer reference time period. If intended to be used for deflating income, expenditure or sales, the index should relate to the period of time. For example, CPI, which is based on prices of a very large set of goods and services, usually has a longer time period. Most of the countries compile CPI on a monthly basis.

### 10.6.9 Timeliness

The required timeliness of publishing a price index is closely linked to its frequency of compilation. The high frequency price indexes demand smaller gap between the reference period and date of publication of results. A minimum amount of time is required for calculation of index from the price data collected. The price indexes used for monitoring purposes should be so designed that the index for a reference period is made available soon after the reference period is over.

*Points to note*

* If a price index for monitoring inflation, it should be compiled with short periodicity.
* If a price index intended to be used for deflating income, expenditure or sales, the index usually have longer periodicity.
* The index number series is smoother for *period* reference than reference time point.
* An index number series with reference time point is likely to be highly volatile in short-term.
* Price indexes with broader scope usually have a longer reference time period.
* In a rapid inflation situation, monitoring authorities require *price index* with shorter reference period.
* But, all the required prices cannot be collected in a very short time period.

**Module 10, Session – IV: Construction of Price Index – 1**

**Test Your Knowledge**

**Exercise – 10.4: Purpose, scope & coverage and Periodicity & Timeliness**

1. State whether the following statements are true [T] or false [F].
2. The set of prices collected for a price index is largely determined by the purposes the index is likely to serve.
3. Prices on a fixed set of products are collected for CPI, irrespective of the purpose for which it is designed.
4. The purpose determines the kind of transactions, such as household consumption, production, investment, and foreign trade flows, the index should cover.
5. Generally, an overall increase in the *price level* is accompanied by a change in the structure of relative prices.
6. A price index for measuring inflation represents only the change in average prices of the goods and services covered in the index, segregated from changes in the *relative prices* of individual goods and services.
7. A price index for measuring inflation represents the change in average prices and the changes in the *relative prices* of individual goods and services.
8. Only the prices of monetary transactions form the basis of an index compiled in a *market transaction approach*.
9. The price indices meant for measuring inflation should be based only on monetary market transactions.
10. GDP deflator measures the average price level of only monetary transactions relative to the base year.
11. A COLI is defined as the measure of change in the minimum cost of maintaining a given level of welfare.
12. An inflation index reflects results of changing prices and changing expenditure patterns.
13. A COLI is concerned only with changing prices.
14. An *output PPI* reflects changes in producers prices.
15. An *input PPI*, is based on prices of intermediate consumption, valued at purchasers’ prices.
16. There is no all-purpose price index.
17. The scope of a CPI can only be the set of products purchased by the household.
18. The scope, an output PPI is the set of products or economic activities that the index is intended to cover.
19. Coverage of a CPI is defined in terms of geographical coverage, types of household by occupational class or level of living and socio-economic groups.
20. If intended to be used for deflating income, expenditure or sales, the index should relate to the period of time.
21. The index number series is more volatile for *period* reference than reference *time point*.
22. Answer the following questions.
23. In the island of the Jarawas in Andaman’s in the 19th century exchanges took place without use of money. Could you have devised (i) price relatives and (ii) relative prices for their common sea food items? Give reasons.
24. The table below gives prices of 6 products in 2011-12 and 2012-13. For this group of products, calculate the relative prices of products B to F with respect to (wrt) product A for both the years. Also calculate the price relatives of products A to F in 2012-13 with respect to 2011-12. Make your observations on the change in price structure and price relatives. Give reasons.

|  |  |  |  |
| --- | --- | --- | --- |
| Product | price per unit | relative prices wrt A | price relatives |
| 2011-12 | 2012-13 | 2011-12 | 2012-13 |
| **A** | 1502 | 1682 |  |  |  |
| **B** | 261 | 292 |  |  |  |
| **C** | 1410 | 1579 |  |  |  |
| **D** | 187 | 209 |  |  |  |
| **E** | 777 | 871 |  |  |  |
| **F** | 884 | 990 |  |  |  |

1. Calculate the implicit GDP deflators and the annual inflation rates for 2012-13 to 2014-15 from the GDP estimates at current and constant prices in the following table

|  |  |  |  |
| --- | --- | --- | --- |
| Year | GDP at | Implicit GDP deflator | Annual inflation rate (%) |
| current prices | 2011-12 prices |
| **2011-12** | 8106656 | 8106656 | 100.0 | --  |
| **2012-13** | 9210023 | 8546552 |  |   |
| **2013-14** | 10380813 | 9084369 |  |   |
| **2014-15** | 11472409 | 9727490 |  |   |

# 10.7 Session V. Construction of Price Index – Index Aggregation and Choice of Base Period

## **Contents**

* General Procedure of Index Aggregation
	+ *Computation of price relatives*
	+ *Computation of elementary price index – elementary aggregation*
	+ *Computation of higher level price index – aggregating elementary price indices*
* Choice of base period
	+ *Desirable qualities of all the reference periods*
	+ *Rebasing – how frequently?*

### 10.7.1 General Procedure of Price Index Aggregation

Price indices are compiled step-by-step. In stepwise compilation procedure, at every step the lower-level indices are aggregated to obtain the higher levels ones, up to the overall index.

*First step*: The first step is calculation of price relatives. Recall that, in each period, price data on specified products are collected from a fixed set of ‘outlets’ and that the price of a particular product obtained from an outlet is called a ‘quotation’. Price relative is calculated for each quotation as the ratio between the quoted current-period price (numerator) and the base-period price (denominator).

*Second step*: In the second step, price relatives are aggregated to obtain the *elementary price index* (or *elementary product index* in the PPI context). Recall that an elementary aggregate is the lowest level of aggregation for which value data are available and used in the calculation of a price index and the price index for an elementary aggregate is called an *elementary price index*.

*Third step*: In the third and final step, the elementary price indices are aggregated as weighted averages (typically as a Laspeyres-type index) to provide a set of synthetic indices up to the overall index.

This technique is consistent in aggregation. That is to say that this procedure produces the same value of the overall index as the one obtained by compiling the overall index in one step.

### 10.7.2 Computation of price relatives

Once collected, price quotations (or simply prices) are first converted to ratios or price relatives, by dividing each current price by a common denominator – index-base price. While designing a price index, the number of price quotations to be collected in each period and the outlets from where these are to be collected are decided. Thus, generally speaking, for each period there is a fixed number of pre-specified outlets from where price quotations for a group of specified products constituting an elementary aggregate are collected. For each specified product, the price relatives are calculated for each price as the ratio between the current period’s price and the base-period price.

[The special cases of seasonal products and new products are discussed later]

For example, consider the elementary aggregate representing ‘rice’ in compilation of CPI. Rice has a number of varieties, say ‘course’, ‘medium’ and ‘fine’. We usually have consumption expenditure data for rice but not for its varieties. Thus, the group of products, viz. ‘coarse rice, ‘medium rice’ and ‘fine rice’, is defined to constitute the elementary aggregate ‘rice’. The data collection scheme designed for CPI specifies the outlets from which prices are to be collected for each variety of rice. Once the price quotations of rice for the current period are collected from all the specified outlets, price relatives are calculated for each quotation.

### 10.7.3 Computation of elementary price index – elementary aggregation

The price relatives for each specified group of products constituting an elementary aggregate are then aggregated to obtain the elementary price index. The price index for an elementary aggregate is called an *elementary price index*. In our example of ‘rice’, all the price relatives for quotations collected for rice are combined, or aggregated, to obtain the elementary price index for rice. Likewise, for PPI, prices for different types of transactions for a product are collected from an establishment, and the derived price relatives are combined together to produce the index for the product from that establishment.

Recall that an elementary aggregate is the lowest level of aggregation for which value data are available and used in the calculation of a price index at higher levels.

For PPI compilation, weights are usually not available for these individual transactions and the establishment’s product index is thus computed as an unweighted average of the prices collected for the various transactions.

The elementary price index or an establishment’s product index can be compiled in several ways, depending on how the information on reporting units and representative products is actually managed. Mainly, two methods can be distinguished: the weighted and the unweighted mean of price relatives. We will first discuss only the applications that do not use explicit weights.

There are several methods for combining price relatives to obtain *elementary price indices*. Recall the price index formula of *Dutot*, *Carli* and *Jevon* discussed earlier. Usually one of these is used for obtaining an *elementary price index*. We have examined the theoretical properties of these index number formulas in the third session. Now, let’s look at the practical implications of using these formulas.

• The ratio of averages: *Dutot* – the average price of a sample of observations in the current period is compared to the average price of the same sample in the previous (or base) period. Note that, *Dutot*’s index can be also expressed as weighted averages of price relatives. Since,

 $\frac{\sum\_{i}^{}p\_{it}}{\sum\_{i}^{}p\_{i0}}= \sum\_{i}^{}\left(\frac{p\_{it}}{p\_{i0}}\right).\frac{p\_{i0}}{\sum\_{i}^{}p\_{i0}}$ where$ \frac{p\_{i0}}{\sum\_{i}^{}p\_{i0}}$is the weight for *i*th quotation.

Also note that $\sum\_{i}^{}\frac{p\_{i0}}{\sum\_{i}^{}p\_{i0}}=1$ as the sum of weights should be.

Thus, the Dutot index gives each price relative the weight equal to the share of its price in the sum of the prices in the initial base period of the comparison.

In order to obtain a correct result, it is vital that the samples of varieties are the same in both the periods (matched samples). If a price quotation is missing in the current period and no action is taken, i.e. the corresponding price relative is taken to be zero, the index will be downward biased. Instead, if the value of the price relative is taken as the same as for the earlier period in a rising-price situation, again the price index will be downward biased.

Moreover, *Dutot*’s index is not suitable if the spread of prices being aggregated is too large, i.e. the prices are heterogeneous. In most cases, we will end up assigning unduly high weights to varieties with high relative prices, while their market shares are expected to be lower than the varieties with low relative prices.

• The average of relatives: *Carli* – is based on comparing each individual price with its corresponding price in the previous (or base) period to give a price relative for each observation. Recall the formula for the *Carli*’s index:

 $\frac{1}{n}\sum\_{i}^{}\left(\frac{p\_{it}}{p\_{i0}}\right)$

*Carli*’s index gives equal weights to all the quotations and thus to all the varieties. For CPI compilation, it is subjected to upward bias under rising-price situation, as the consumers are likely to shift to varieties with low relative prices. The equal weights of 1/*n* assigned to all the varieties will no longer be valid.

If a price is missing in the current period, then its price relative cannot be calculated. The elementary price should in such cases be based only on the observed price relatives, i.e. average of only the observed price relatives should be the elementary price index.

• The geometric mean: *Jevon* – is being introduced by more and more countries. The approach is to calculate a geometric mean of prices in both periods and then derive the price relative or, alternatively, calculate a geometric average of the price relatives – both calculations will yield the same results.

The Jevon index gives each price relative the same (multiplicative) weights. The problem of missing observations is still the same as in the previous two cases. The sample of observations used from each period must have the same number of observations for computing the geometric mean of prices in order to avoid a biased measure of price change.

### 10.7.4 Computation of higher-level price index – aggregating elementary price indices

The elementary aggregates obtained above are combined to produce the sub-group and group indices, and eventually the overall, using some kind of index number formula and weights based on expenditure or population (for CPI) value of production (for PPI).

Generally, the *Laspeyres* type index is used by statistical offices for higher-level indices. This uses a weighted arithmetic mean of elementary price indices. As some elementary aggregates (product or product group) have greater value of consumption or production or sales than others, each of them is given a “weight” to represent its importance in total consumption or output or sales during the reference (base) period for the weights. To arrive at the aggregate index figure the elementary price indices are multiplied by their respective “weights” to derive a weighted average aggregate index.

Note that at the elementary level of aggregation, there is no role of explicit weights, while weights have a determining role in the higher levels of aggregation.

**Example 16: Process of Aggregation**

Consider a hypothetical situation where the overall price index is compiled from just three broad groups of products – cereals, other food and non-food – with weights 20%, 45% and 35% respectively. The broad group cereal consists of only products (elementary aggregates) – rice and flour. For rice, 8 quotations are collected every month and for flour 6 quotations. The following table shows the price quotations for rice and flour.

|  |  |  |  |
| --- | --- | --- | --- |
| Elementary aggregate - Cereals | Period / price relative | Quotation no. | elementary price index (Jevon's) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Rice | base year | 25 | 27 | 25 | 26 | 22 | 23 | 25 | 24 |   |
| current month | 33 | 32 | 36 | 34 | 30 | 31 | 35 | 32 |   |
| price relative |  |  |  |  |  |  |  |  |  |
| Flour | base year | 42 | 40 | 43 | 39 | 37 | 44 | x | x |   |
| current month | 51 | 55 | 58 | 49 | 53 | 50 | x | x |   |
| price relative |  |  |  |  |  |  |  |  |  |

First, the price relatives for each of the quotations are obtained as the ratio of current-period price to that of the base period. This is the first step.

Calculate the price relatives and enter them in the above table.

Next – the second step – the elementary price indices for rice and flour are calculated as unweighted geometric mean of the price relatives.

The third step usually consists of different stages of aggregation to obtain higher level price indices. Once the elementary price index for rice and flour are obtained, we can calculate the price index for the ‘Cereals’ broad group as follows (with the given weights of 60% and 40% for rice and flour respectively):

|  |  |  |
| --- | --- | --- |
| Elementary aggregate in ‘Cereals’ broad group | weights(%) within the ‘Cereals’ group | elementary index |
|
| Rice  | 60 |  |
| Flour | 40 |  |
|  | Price index of cereals: |  |

Calculate the value of index obtained as weighted arithmetic average of elementary price indices of rice and flour and enter it in the table above.

Now, let’s assume the price index for the broad groups ‘other food’ and ‘non-food’ are similarly obtained as 135.3 and 145.2. Finally, all the group price indices are combined, using the assigned weights of 20%, 45% and 35% respectively for ‘cereals’, ‘other food’ and ‘non-food’, to obtain the overall price index as follows:

|  |  |  |
| --- | --- | --- |
| broad group | Weights(%) | Broad group index |
| Cereals | 20 |  |
| Other food | 45 | 135.3 |
| Non-food | 35 | 145.2 |
| Overall price index: |  |

Calculate the value of overall price index as obtained as weighted arithmetic average of group-level price indices of ‘cereals’, ‘food’ and ‘non-food’.

*Points to note*

* Price indices are compiled step-by-step.
* There are three main steps:
	+ *First step*: calculation of price relatives.
	+ *Second step*: price relatives are aggregated to obtain the *elementary price index (or elementary product index in the PPI context).*
	+ *Third step*: elementary price indices are aggregated as weighted averages to obtain higher-level indices, including the overall index.
* Price relatives are obtained from the price quotations collected in different time periods by dividing each current price by a common denominator or index base – the base-period price.
* Weights are usually not available for outlets from which the price quotations are collected for CPI. Nor are they available for individual transactions of an establishment from which prices are collected PPI.
* *Elementary price indices* are unweighted arithmetic or geometric means of price relatives (*Carli* and *Jevon*) or ratio of unweighted averages of current-period prices and the base-period prices (*Dutot*).
* In fact, *Dutot*’s index is a weighted average of price relatives.
* For compilation of elementary price index, *Dutot*’s index is not suitable if the prices are heterogeneous.
* For CPI compilation, *Carli*’s index is subjected to upward bias under rising-price situation.
* Generally, the *Laspeyres* type index is used by statistical offices for higher-level indices.
* The elementary aggregates are combined to produce higher-level indices, using weighted averages of elementary price indices.
* This technique of aggregation used for price index compilation is consistent in aggregation.
* No explicit weights are used for aggregation at the elementary index level.
* Weights have a determining role in the higher levels of aggregation.

### 10.7.5 Choice of base period

A price index is a measure of the change in the prices of many commodities from one situation (a time period or place) to another situation. More specifically, the period from which the change is measured is called the *base period*. Typically, this period relates to a specific calendar year, but may also be a conventional time interval such as an agricultural / financial year, a month, etc.

The following consideration is kept in mind while selecting a base period.

1. Base period should be a period of normal and stable economic conditions, i.e., it should be free from all sorts of abnormalities and random or irregular fluctuations like earthquakes, wars, floods, famines, labour strikes, lockouts, economic boom or depression.

For instance, if the base period is taken as a period of economic boom wherein the prices of various goods and commodities are very high, the index will be understated, while the base period is a period of depression or economic instability, wherein the prices of consumption goods are abnormally low, the index will be overstated.

But a period which is normal in one respect may be abnormal in some other respects. Accordingly, sometimes an average of two or more years is taken as base period and the average price and quantity of the commodities consumed in these years is taken as base year price or quantity.

1. The base period should not be too distant from the given period. A distant period makes the index number irrelevant for short period comparisons. This is because, among other things, the habits, tastes, fashions, undergo a change and should be reflected by a change in the commodity composition and the weights assigned to various commodities.

Thus, an index number series is up-dated by “rebasing”.

1. Sometimes a year of some economic importance for the country is also taken as base, e.g., the year 1951 being the first year of the planning process, is taken for purposes of plan assessment.

Recall that there are three kinds of reference periods are involved in construction of a price index:

* *Index reference period*: for which the index is set to 100. This is called the base year of an index.
* *Weight reference period*: The period covered by the expenditure statistics used to calculate the weights. Usually, the weight reference period is a year.
* *Price reference period*: The period for which prices are used as denominators in the index calculation.

The three periods are generally different. For example, a CPI might have 1998 as the weight reference year, December 2002 as the price reference month and the year 2000 as the index reference period.

Thus, when we say ‘choice of base year’ in the context of a price index, we mean choice of all the three reference periods. The expression ‘base period’ can mean any of the three reference periods, thus it should be used only by clearly stating exactly which period is referred to.

### 10.7.6 Desirable qualities of all the reference periods:

Generally speaking, all the reference periods used for construction of a price index should desirably

* be long enough to cover a seasonal cycle, which is normally a year.
* have economic conditions that can be considered to be reasonably normal or stable
* not be too distant from each other.

To achieve this, it may be necessary to adjust some of the values to normalize them and overcome any irregularities in the data for the particular period that constitutes the source of the information.

The index reference period is often a year; but it could be a month or some other time unit as well. An index series (with base say 2005) may also be re-referenced to another period (say 2010) by simply dividing the series by the value of the index in that period (2010), without changing the rate of change of the index.

**Example 10.17: Re-referencing a Price Index**

Consider the following price index series with index reference period as the year 2005.

|  |  |
| --- | --- |
| Base year / re-referenced base year | Price index |
| 2005  | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| 2005 | 100.0 | 102.4 | 108.3 | 115.0 | 119.7 | 125.0 | 130.2 | 138.5 |
| 2010 |  |  |  |  |  |  |  |  |

Calculate the series with base year re-referenced to 2010. One has to divide the values of price index with base year 2005 by the value of price index of 2010 (125.0) and multiply by 100.

The weights typically refer to a whole year, or even two or three years (in high-inflation situations), whereas the periods for which prices are compared are typically months or quarters. The weights, particularly for CPI, are usually estimated for on the basis of an expenditure survey that was conducted some time before the price reference period. For these reasons, the weight reference period and the price reference period are invariably separate periods in practice.

### 10.7.7 Rebasing – how frequently?

Rebasing may have different meanings in different contexts. It may mean:

* changing the weights used for a series of indices; or
* changing the price reference period used for a series of indices; or
* changing the index reference period for a series of indices.

The weights reference period, price reference period and index reference period may be changed separately or at the same time.

Let’s start with a closer look at the necessity of rebasing. In a changing world, it does not take very long before an index becomes out-of-date. There are two main reasons for index becoming out-of-date. They are:

* + new products come on to the market that did not exist before
	+ the weights no longer reflect the patterns of expenditure, output or trade.

The index ceases to represent the present-day price change.

Thus, the two main reasons that necessitate periodic rebasing are (i) updating the product coverage and (ii) capturing the changing consumption (or production) pattern of the economy in the weighting structure.

For each elementary aggregate, prices are collected on a set of selected specific products that is assumed to capture the price movement of the entire elementary aggregate. But, products become obsolete and new products come to the market. This introduces bias in the elementary indices, particularly when the price movement of the “new” products is very different from the ones already in the basket of goods or services of the elementary aggregate in question.

Example 10.18 illustrates the bias in elementary index caused by “new” product coming to the market.

|  |
| --- |
| **Example 10.18: Bias in elementary index due to “new” product coming to the market** |
| **Price** | **Products** | **Elementary index (Jevon’s)** |
| **A** | **B** | **C** |
| In 2008 ($p\_{i}^{08}$) | 13 | 4 | -- |  |
| In 2018 ($p\_{i}^{18}$) | 15 | 5 | 10 |  |
| Price relatives 2008 → 2018 (*pr*) | 1.15 | 1.25 | -- |  |

Calculate the elementary index.

The introduction of Product C in an elementary aggregate with two product specification, after the 2008 (base period), is not reflected in the elementary index.

Usually, while rebasing a price index series, an entirely new set of units or outlets are selected for price collection. Most countries use a fixed-weight index and do not change the selected set of outlets or units till the next rebasing is done. This leads to progressively increasing biases in the index numbers. A fixed-base index number formula, like that of Laspeyere’s or Lowe’s, the price index becomes more and more biased as the actual consumption pattern (or distribution of goods & services produced over product classes and sub-classes) shifts away from base year weighting structure.

Example 10.19 illustrates how the CPI gets biased if the consumption pattern changes from the base year pattern. In the example, the weights in the base period (2008) and the current period (2018) are very different. It is seen that the for a product group with just three elementary aggregates, the group indices based on the two weighting structures are very different, even if the price and index reference periods are held constant.

|  |
| --- |
| **Example 10.19: Changes in group index with changes in weighting structure** |
| Weights / prices / price relatives | Elementary aggregates | **Product-group weights / indices** |
| **A** | **B** | **C** |
| Weight (***wi08***) in 2008 | 0.5 | 0.4 | 0.1 | **1.0** |
| Prices (***pi08***) in 2008 | 13 | 4 | 5 |   |
| Weight (***wi18***) in 2018 | 0.3 | 0.3 | 0.4 | **1.0** |
| Prices (***pi18***) in 2018 | 15 | 5 | 10 |  |
| Price relatives 2008*→*2018 (***pr***) | 1.15 | 1.25 | 2.00 |
| ***pr*\* *wi08*** |  |  |  |  |
| ***pr*\* *wi18*** |  |  |  |  |

One way of minimizing this bias is to revise the weights and the price and index reference periods as frequently as possible. The other alternative is to revise the weights annually. This is called ‘chaining’. Annual chaining eliminates the need to choose a base period, as the weight reference period is always the previous year, or possibly the preceding year.

Since weights are required only at the third step, i.e. aggregating elementary price indices to higher-level indices, chaining or revising the weights does not take care of changing universe of products. New products are incorporated in the index only at the time of rebasing the index. Frequent rebasing allows for the early introduction of new products.

*Points to note*

* Base period should be a period of normal and stable economic conditions.
* If prices are very high in the base period, the price index tends to understate price rise.
* If prices of consumption goods are abnormally low in the base period, the price index tends to overstate price rise.
* Often, the mid-period of two or more years is taken as the index reference period and the average prices and quantities are taken as the base-year prices and quantities.
* A distant base period makes the index number irrelevant for short period comparisons.
* The *weight reference period*, *price reference period* and *index reference period* are generally different. Choice of base period refers to all the three reference periods.
* Reference periods should be long enough to cover seasonal cycles.
* Reference periods should desirably be periods of normal or stable economic conditions.
* Reference periods should not be too distant from each other.
* Usually, the specific products for which prices would be collected are decided while “rebasing” a price index series.
* “Weights” are revised during rebasing to capture changes in habits, tastes, fashions and technology.
* The index reference period is most often a year. It could be a month or some other time unit.
* The weights typically refer to a whole year, or even two or three years (in high-inflation situations).
* The periods for which prices are compared are typically months or quarters.
* The price movement of “new” products coming to the market is not reflected in a price index.
* Frequent revision of weights and price reference periods can minimise the bias in index numbers, but does not necessarily include effects of price changes of a “new” product.
* In annually chained price index, the weights are revised every year; weight reference period is the previous year or possibly the preceding year.
* Chaining or revising the weights does not take care of changing universe of products.

**Module 10, Session – V: Construction of Price Index II**

**Test Your Knowledge**

**Exercise – 10.5: Choice of base period and weights**

1. State whether the following statements are true [T] or false [F].
2. Price indices are compiled step-by-step.
3. Price relatives, for each quotation, are obtained by dividing current price by the base-period price.
4. Weights are available for outlets from which the price quotations are collected for CPI.
5. *Dutot*’s index is a (implicitly) weighted average of price relatives.
6. For compilation of elementary price index, *Dutot*’s index is the suitable one even if prices are heterogeneous.
7. For CPI compilation, *Carli*’s index is subjected to upward bias under rising-price situation.
8. The elementary aggregates are combined to produce higher-level indices, using weighted averages of elementary price indices.
9. No explicit weights are used for aggregation at the elementary index level.
10. Weights have a determining role in the higher levels of aggregation.
11. A chain-based price index always captures the price movement of a “new” product.
12. If owner-occupied dwellings are within the scope of an index, its weight is added to that for rented dwellings and assigned to the heading ‘rent of dwellings’.
13. For CPI, the aggregation process always uses weights derived from either the HES.
14. Annual chaining of a CPI minimises bias due to backdated weighing structure.
15. A price index is compiled with weighting structured as follows:

There are 6 major heads– A, B, C, D, E, and F.

The major head D is divided into 5 classes –D.1, D.2, D.3, D.4 and D.5.

The class D.2 has 4 sub-classes or elementary aggregates – D.2.1, D.2.2, D.2.3 and D.2.4. Varying number of quotations is collected for the elementary aggregates, as indicated in the tables below:

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | Prices in the base year(2010) of item specifications | Number of quotations |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| D.2.1 | 11.0 | 10.3 | 10.8 | 12.1 | 11.7 | 12.2 | x | x | 6 |
| D.2.2 | 44.1 | 42.5 | 46.7 | 39.6 | 40.2 | 41.8 | 43.5 | x | 7 |
| D.2.3 | 23.6 | 26.0 | 29.6 | 30.0 | 25.7 | 28.7 | 29.0 | 29.0 | 8 |
| D.2.4 | 127.3 | 115.7 | 128.8 | 96.7 | 104.2 | x | x | x | 5 |

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | Prices in the current month of item specifications | Number of quotations |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| D.2.1 | 26.0 | 21.2 | 25.8 | 19.3 | 18.7 | 27.6 | x | x | 6 |
| D.2.2 | 80.6 | 77.3 | 76.1 | 69.8 | 72.8 | 77.9 | 104.6 | x | 7 |
| D.2.3 | 52.6 | 39.6 | 65.9 | 66.5 | 63.1 | 69.4 | 49.1 | 47.7 | 8 |
| D.2.4 | 293.9 | 188.5 | 266.1 | 200.0 | 178.9 | x | x | x | 5 |

1. Calculate the price relatives and the Jevon’s index for the elementary aggregates in the table below:

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | Price relatives in the current month of item specifications | Jevon’s index |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| D.2.1 |  |  |  |  |  |  |  |  |  |
| D.2.2 |  |  |  |  |  |  |  |  |  |
| D.2.3 |  |  |  |  |  |  |  |  |  |
| D.2.4 |  |  |  |  |  |  |  |  |  |

The weighting structure for the Index (with details for class D) is as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| Major head | Class | Elementary aggregate (Sub-class) | Weights in overall index (=1000) |
| (1) |  |  | (3) |
| A | all | all | 120 |
| B | all | all | 145 |
| C | all | all | 165 |
| D | all | all | 200 |
|  | D.1 | all | 30 |
|  | D.2 | all | 60 |
|  |  | D.2.1 | 17 |
|  |  | D.2.2 | 15 |
|  |  | D.2.3 | 19 |
|  |  | D.2.4 | 9 |
|  | D.3 | all | 20 |
|  | D.4 | all | 50 |
|  | D.5 | all | 40 |
| E | all | all | 150 |
| F | all | all | 220 |

1. From the weights of the elementary indices of the class D.2, calculate the price index of D.2.

|  |  |  |  |
| --- | --- | --- | --- |
| Elementary aggregate | Jevon’s index | Weights in overall index (=1000) | col(2) \* col(3) |
| (1) | (2) | (3) | (4) |
| D.2.1 |  | 17 |  |
| D.2.2 |  | 15 |  |
| D.2.3 |  | 19 |  |
| D.2.4 |  | 9 |  |
| **D.2** | **total** | **60** |  |

Price index of the class D.2

= 100\*[sum of col(4)] / [sum of weights] =

1. From the class weights and the given value of sub-class indices for D.1, D.3, D.4 and D.5, find out the price index for class D.

|  |  |  |  |
| --- | --- | --- | --- |
| class | class index | Weights in overall index (=1000) | col(2) \* col(3) |
| (1) | (2) | (3) | (4) |
| D.1 | 160.2 |  30 |  |
| D.2 |  |  60 |  |
| D.3 | 187.6 |  20 |  |
| D.4 | 210.2 |  50 |  |
| D.5 | 198.5 |  40 |  |
| **D** | **total** | **200** |  |

Put the value of the index for class D.2 in the table and find out the

Price index of major head D = [sum of col (4)] / [sum of weights] =

1. From the major head weights and the given value of major head indices for A, B, C, E and F, find out the overall price index.

|  |  |  |  |
| --- | --- | --- | --- |
| major head |  index | Weights in overall index (=1000) | col(2) \* col(3) |
| (1) | (2) | (3) | (4) |
| A | 211.0 | 120 |  |
| B | 162.5 | 145 |  |
| C | 189.2 | 165 |  |
| D |  | 200 |  |
| E | 188.5 | 150 |  |
| F | 175.3 | 220 |  |
| **overall** | **total** | **1000** |  |

Put the value of the index for major head D in the table and find out the overall Price index

= [sum of col(4)] / [sum of weights] =

## 10.8 Session VI. Construction of Price Index – Defining Basket, Weighting Structure and Classification

## Contents

* Basket and its structure
	+ use of standard classifications
* Weighting structure
	+ *source of data,*
	+ *price and other updating of weights*
* Classifications

## 10.8.1 Basket and its structure

The term ‘basket’ is commonly used for the list of goods and services, together with their relative values (of consumption or output or input or imports or exports), serving as weights, for which a sample of prices is collected for the purpose of compiling a price index. It may also consist of specific quantities of goods and services, instead of values. For example, the basket for a CPI may comprise the actual quantities of consumption goods or services acquired or used by households in some period, or may even be made up of hypothetical quantities.

Decisions on the composition of the basket and the weights follow directly from the scope and coverage of the index. Conceptually, the basket for a CPI represents total household consumption of the specified domain of the index – defined in terms of scope and coverage. Similarly, the basket for an Output-PPI represents total production of its domain.

The goods and services within the scope of an index are invariably very large in number. Collecting prices or the data required for determining the weighting structure for all these items is simply not feasible. Thus, the quantity / value data are collected separately for item-groups rather than for individual items and the price data are collected for selected items of an item-group.

Identification of the items to be included in the basket depends on their relative shares in the total. For a fixed-basket index, the composition of the basket is kept unchanged during the life of a series. This is one of the conditions for the index to measure pure price changes. Thus, during a weighting revision exercise, some items are dropped from the basket and other items that have become more important are included.

The goods and services included in the basket are usually arranged in a hierarchical structure, using standard classifications. The individual products of the basket – often called ‘basket items’ – are kept at the lowest level of the hierarchy. The prices are actually collected for these ‘basket’ items. These are grouped into sub-classes, classes and groups following standard classifications, such as COICOP, ISIC, CPC and Standard International Trade Classification (SITC). The sub-classes (also called ‘product headings’) are the most detailed level (i.e. lowest level) of these classifications. The price index series is normally published for each ‘sub-class’. Normally, the sub-classes are the ‘elementary aggregates’ used for compilation of the index and thus are the lowest level at which index weights are attached.

The sub-classes are intended to be homogenous in respect of

*Purpose*.  The products within a sub-class have a broadly similar purpose or use, such as final consumption, intermediate consumption, capital formation etc. Adopting standard classifications like COICOP (which itself is a purpose classification), CPC and SITC assists in ensuring this.

*Prices*. The products within a sub-class are selected in such a way that the price movements and to the extent possible the price levels are likely to be reasonably similar.

*Substitutability*.  The products included within a sub-class are expected to be, to a certain degree, substitutable in response to a change in relative prices. That is, a consumer or an importer or a producer or an exporter is expected to make a choice of a product in place of another in the sub-class if their relative prices change.

**Example 20: Selecting basket items in an elementary aggregate**

Suppose there are 7 brands of body soap available in the market. Of these, three – A, B & C – are low priced and between them are known to have a market share of about 70 per cent. Three other – D, E & F – are of similar quality and between them have a share of about 20 per cent. The seventh brand – G – is a high-priced imported variety with high price fluctuations. Which of these should be included in the basket?

Owing to their high market shares all the three low-priced soaps – A, B & C – should be included in the basket. However, if one of these, say B, is found to be much less popular than the other two, B can be dropped from the basket.

The imported variety, G, should also be included, since it has a considerable market share and price movement not comparable with the other varieties.

Of the remaining three – D, E & F – just one can be selected in the basket to represent the category.

*Use of standard classifications*

The standard classification systems provide organizing structures for price indices. It forms the index structure and help in defining the *basket* in terms of products and industries, as well as their aggregate levels. Generally, International standard classification systems are used to group the products and economic activities. The international classifications are often augmented by national statistical offices to make them suitable for national conditions and needs.

In the context of price index, the main uses of these classifications are in:

* organizing collection and compilation of price data
* aggregating and disaggregating of price data sets meaningfully for purposes of analysis
* presenting price data and indices.

Recall that a price Index is compiled in stages. First, *elementary price indices* are calculated, which are then aggregated to higher-level price index. Usually, the elementary level aggregates are set as the lowest level of the standard classification used for a price index. The delineation of higher level price indices is also made following the standard classification. Since, a price Index is compiled from data on prices and quantity / value weights, both the data collection systems should follow the same classification system.

The standard classification system adopted forthe price index also determines its publication scheme. The use of these classifications provides meaningful series for policymaking and analysis, as well as facilitating international comparisons.

*Points to note*

* ‘Basket’ is a list of goods and for which data on prices is collected.
* It also consists of the weights of the goods & services – either in terms of value or quantity.
* Conceptually, the basket for a CPI represents total household consumption of the specified domain of the index – defined in terms of scope and coverage.
* The basket for an Output-PPI represents total production of its domain.
* The quantity / value data are collected separately for item-groups rather than for individual items
* The price data are collected for selected items of an item-group.
* The prices are actually collected for these ‘basket’ items.
* The elementary indices are combined, using weights, to produce individual product index.
* These are grouped into sub-classes, classes and groups following standard classifications, such as COICOP, ISIC, CPC and Standard International Trade Classification (SITC).
* The sub-classes are also called ‘product headings’.
* Normally, the sub-classes are the ‘elementary aggregates’ used for compilation of the index and thus are the lowest level at which index weights are attached.

## 10.8.2 Weighting Structure

Weights are key elements in the construction of a price index. They determine the impact that a particular price change will have on the overall index. Use of weights to combine price relatives maintains the fixed-quantity relationship that existed in the base period. That is, it provides the estimate of what it would cost at today’s prices the same quantities of products as in the price reference period.

In the construction of index numbers, all commodities included for pricing are not of equal importance. The system of weights and particularly the allocation of weights to different items is, therefore, of utmost importance. The weights are assigned to the various commodities in a manner deemed appropriate to bring out their economic importance.

Weighting is a top-down process. The total is divided between the highest-level headings of the classification system. [Classifications of goods and services used for price indices are discussed in the next session]. The resulting weight for each category is then divided between the classes, and the weight of each sub-category is divided between the sub-classes, and then to the elementary aggregates. The weight of an elementary aggregate represents the entire elementary aggregate and not just the weights of the items that have been chosen to represent it in price collection survey.

* Often, the elementary aggregate is the lowest level at which reliable weighting information is available.
* Thus, the price indices for elementary aggregates are calculated without the use of explicit weights – as unweighted averages.
* Ideally, however, weights – even if approximate – should be used to reflect the relative importance of the sampled items.
* For example, when the items are selected with PPS with size as, say, sales, value of output etc., weights are implicitly introduced by the sampling selection procedure.

The Index number formula(s) required to be used for a price index is determined by choice of system of assigning quantity or value weights (in the base or current year) and the kind of average – arithmetic or geometric means – used for aggregation at different levels.

The method of calculating a price index is generally specified by a combination of a method of unweighted aggregation of price relatives at the level of elementary aggregates and a method of weighted aggregation at the higher levels. Some of these are simple to use but lack scientific basis and others more sophisticated but are difficult to prepare. A compromise has often to be struck considering the purpose, availability of data and the resources at the disposal. The suitability of each method in a given context depends on the purpose with which the index numbers are constructed.

The item headings that have been identified act as proxy representatives for those items not identified. The weights of all the unidentified item headings that are included in a proxy representative are added to the latter’s weight. For example, if a COLI is designed to include housing services provided by all residential units of the economy, owner-occupied dwellings for which house rents are not actually paid, thus are not observable, are also included in the coverage. Changing house rents of rented dwellings act as proxies for change in (notional) house rents of owner-occupied dwellings. The weight for owner-occupied dwellings is added to that for rented dwellings and assigned to the heading ‘rent of dwellings’.

The PPI is calculated from many prices collected from all types of establishments, covering the selected economic activities and products. For an establishment, the collected prices are first combined to arrive at the establishment’s elementary product index as an unweighted average of the prices collected for the various transactions. These are then combined, using weights, to produce individual product index, which in turn are combined into the sub-group and group indices, and eventually the all product index. Each product is given a “weight” to represent its importance in the economy-wide output or sales of the product during the reference (base) period for the weights.

### Source of Data

*Source for CPI*: The weights for CPI is mainly derived from the results of Household Expenditure Surveys (HES) – also called Household Budget Surveys. The household expenditure structure is used as the weighting pattern for CPIs. Such surveys are carried out on representative sample of households taking care of the factors having impact on household expenditure patterns, such as household size, income level, geographic location, socio-economic group etc. Usually, HES are conducted over a whole year to eliminate seasonal effects.

Expenditure on some kinds of services like those on households’ consumption of financial intermediation services (FISIM) is not observable in HES. The weights for such items are derived from national accounts statistics. For CPI with ‘actual’ consumption expenditure kept within the scope, the weights for consumption of education and health services provided free (or not at economically significant price) by the government and NPISHs are also derived from national accounts statistics.

The aggregation process may also involve the application of weights not derived from either the HES or the national accounts. For example, weights that relate to outlet type (derived from market research data) or regional weights (ideally derived from HES, but in some cases population is used) may be used.

*Data source for PPI*: The primary sources of weight information for the PPI are business- or establishment based censuses, annual industrial surveys, and business registers. The Output-PPI is an index of product prices weighted by their importance in output of the resident producers. The PPI is presented in the aggregate for the total economy, and also by product and by industry.

*Business census or Economic census*: The business census covers all establishments that have productive activity within the geographic borders of the country. A detailed accounting of annual output in value (at basic prices) and quantity terms by detailed product classification is typically obtained at the enterprise or establishment level. These data are used to derive the value weights by detailed product classification and establishment. This is an excellent source of weight data, assuming that the coverage of economic activity is essentially complete.

*Industrial / Enterprise surveys*: The results of periodic or annual industrial surveys and enterprise/ establishment surveys are also used for deriving weights of output-PPI. These are carried out on a sample of units. Thus, the data for deriving weights that are available from the surveys are generally for higher levels in the aggregation structure, such as product group and industry rather than detailed product and establishment. The use of these weights for the PPI depends on how the PPI aggregation structure has been designed.

*Business registers*: Many countries maintain a business register which provides a list of firms that are involved in productive activities. The business register could be an alternative source of weight information, particularly if business censuses are not conducted on a regular basis or if annual surveys do not provide sufficient information for establishing weights. The main shortcoming of use of business register is that it does not include the informal sector units, which have a significant share of output in developing countries.

*National accounts statistics*: In developing countries, there may be significant under coverage in annual industry surveys due to the exclusion of informal activities. Often data from informal (unorganised) sector surveys are conducted whose results are used for compilation of national accounts statistics. In such cases, the national accounts estimates on output by industry may prove to be a better source of weight information at the industry level than the business register or annual industrial / enterprise surveys data.

*Other source*: A wide variety of administrative data on production values may be available from public agencies charged with regulating or monitoring certain economic activities. For example, many public utility, communication, and transport activities are regulated by national, regional, or local governmental bodies.

*Data source for XMPI*: Customs records are the main source of information on exports and imports by products. If detailed customs records are maintained and available for statistical purposes, information on detailed products by shipping enterprise should be available and provide source data for deriving weights.

### Price and other updating of weights

One of the main tasks in dealing with price indices in practice consists of updating the weights. Weights refer to the structure at the beginning of the time series, but in practice these are updated periodically using different weights chained. In a broad sense, depending on the frequency of updating, price indices are distinguished between fixed base indices and chained indices. Fixed base indices are commonly updated every five years while chained indices are typically updated once a year.

The re-basing procedure, carried out every five years, involves simultaneously updating the selection and weights of products (at the elementary aggregate level), the list of reporting units and the set of representative products. This apart, the statistical offices usually carry out different kinds of weights updating at intermediate stages. Mainly, the following kinds of updating of weights are adopted by the statistical offices:

* Price updating of weights
* Introduction/ removal of new/ old products
* Weights updating without changing the set of products.

*Price updating of weights*: This has already been defined in Session II. The procedure consists of recalculating the weights from the values obtained by applying prices of a different period on the quantities of the weight reference period. For example, consider a CPI series with price and index reference period as 2005, for which the HES was conducted in 2004. To bring the weight reference period to 2005, the prices of 2005 are applied on the quantity estimates of HES. The values of products thus obtained are used for deriving their respective weights. This kind of updating is essential when the relative prices of the goods and services in the coverage of the index change rapidly. No change is required to be made in the lists of products and reporting units.

*Introduction/ removal of new/ old products*: In this case, re-weighting involves drawing a new sample of products and a new list of reporting units and a chained index is the result. It is characterised by an annual update of products (at the elementary aggregate level), reporting units and the representative products. This is a much more demanding exercise and requires continuous reorganisation of data collection schedules. This brings about changes in the compositions of elementary aggregates but need not necessarily involve change in weighting pattern for aggregation at higher levels.

The consumption habits change with time, in response to different relative price movements, changes in supply, changes in technology, new products being introduced, changes in tastes and fashions and changes in standards of living. Annual update of products helps capturing these changes and often requires revision of the weighting pattern. Whenever the composition and/or weighting pattern of the index is changed within a series, the new values of the index should be re-referenced to the index reference period to provide a continuous time series.

*Weights updating without changing the set of products*: This involves annual updating of the product weights, while the index base is fixed for a longer period, say every five years. In this way the indices are annually chained – weight reference period is the previous year while the index reference period (set to 100) remains unchanged.

*Points to note*

* Weights determine the impact that a particular price change will have on the overall index.
* Weighting is a top-down process.
* The items included for price collection act as proxy representatives for items not included.
* The weights of all the unidentified item headings that are included in a proxy representative are added to the latter’s weight.
* Thus, the weight of an elementary aggregate represents the entire elementary aggregate and not just the weights of the items that have been chosen to represent it in price collection survey.
* For PPI compilation, the prices collected from an establishment are first combined – as an unweighted average – to arrive at the establishment’s elementary product index.
* The elementary product indices are combined, using weights, to produce individual product index.
* For CPI, the household expenditure structure is used for assigning weights to elementary aggregates, which are mainly derived from the results of Household Expenditure Surveys (HES) – also called Household Budget Surveys.
* For this purpose, the HESs are conducted over a whole year to eliminate seasonal effects.
* For CPI, sometimes, the aggregation process also involves application of weights not derived from either the HES or the national accounts.
* The primary sources of weight information for the PPI are business- or establishment based censuses, annual industrial surveys, and business registers.
* The main data source for XMPI is the Customs records on exports and imports by products.
* *Price updating of weights* consists of recalculating the weights from the values obtained by applying prices of a different period on the quantities of the weight reference period.
* *Price updating of weights* is essential when the relative prices of the goods and services in the coverage of the index change rapidly.
* In *Price updating of weights*, no change is made in the lists of products and reporting units.
* Re-weighting done by drawing a new sample of products and a new list of reporting units is called *Introduction/ removal of new/ old products*, which results in a chained index.
* Annual chaining of an index involves annual updating of the product weights, while the index base is fixed for a longer period.

## 10.8.3 Classifications

The international standard classifications commonly used for compilation of price indices are as follows:

* For CPI: Classification of Individual Consumption according to Purpose(COICOP)
* For PPI: Central Product Classification (CPC) and International Standard Industrial Classification (ISIC)of economic activities
* For XMPI: Standard International Trade Classification (SITC)

All these classifications are of goods and services, except the ISIC. The CPC is closely linked to the ISIC and thus suitable for classifying outputs of production units. Both CPC and ISIC are therefore used for compilation of PPI.

*International Standard Industrial Classification* (ISIC).

ISIC is a coherent and consistent classification structure of economic activities. Itis intended to be a standard classification of economic activities for production of goods and services. But, it itself is not a classification of goods and services. While PPIs are compiled from price data on different products using CPC, the selection of production units from which price data are collected are made on the basis of industrial classification.

*Structure of ISIC*: Economic activities are subdivided in a hierarchical, four-level structure of mutually exclusive categories: section, division, group and class. For each category, the number of them in the structure is indicated below:

* + Section – 21
	+ Division – 88
	+ Group – 238
	+ Class – 419.

In most countries, ISIC is adapted by statistical offices. Usually, a national industrial classification based on ISIC, with further categorization of classes into sub-classes, is constructed.[[7]](#footnote-7)

*Central product classification* (CPC).

CPC is the international classification of products based on the physical characteristics of goods or on the nature of the services. Each type of goods and services distinguished in the CPC is defined in such a way that it normally corresponds to only one activity of ISIC.

Only from CPC, one cannot tell which industries produce the products. Identification of the industry producing the products is necessary for selection of production units producing them. Use of CPC for compilation of PPI helps in doing that, since it is designed to be integrated and correspond to ISIC. To identify product type by originating activity, the CPC codes (or those of the national product classification) of each product produced by a production unit of industrial classification is recorded in the enterprise or establishment surveys, which form the bases of weights allocation.

CPC groups products into somewhat homogeneous categories on the basis of physical properties and intrinsic nature, as well as the principle of industrial origin. The physical properties and intrinsic nature are characteristics include raw materials from which the goods are made, the stage of production and way in which the goods are produced or service rendered, the purpose or use of the products, and the prices at which they are sold. The product categories are exhaustive and mutually exclusive so that a product is included only in one category.

*Structure of CPC*: Products are categorised in a hierarchical, five-level structure of mutually exclusive categories:

* Section – 9,
* Division – 70,
* Group – 305,
* Class – 1.167 and
* Sub-classes – 2,092.

The sub-classes of products (coded into five-digits) can be aggregated to higher level groupings (four, three, two, and single digits).Each of the 2,092 CPC subclasses is integrated with ISIC to some extent by grouping sub-classes according to the ISIC activities for which they are the principal products. In general, each five-digit subclass of the CPC consists of goods and services that are predominantly produced in one specific four-digit class or classes of ISIC.

[Web reference: <http://unstats.un.org/unsd/class/default.asp>]

*Classification of Individual Consumption according to Purpose* (COICOP).

COICOP groups various expenditures of households according to the purposes or objectives of spending the funds available with them. It identifies and classifies “individual” consumption expenditures incurred by households according to the purposes, or objectives. The COICOP is designed by a *functional principle* rather than a *market grouping principle*. For example, insurance on cars is included under transport rather than in the insurance item. This is the most commonly used classification used for compilation of CPI and collection of product price data and the detailed household expenditure data in HES.

*Structure of COICOP*: The COICOP classification has the following hierarchical structure:

* Groups: there are 47 groups
* Classes: sub-divisions of the groups
* Sub-classes: the lowest-level categories that are weighted and usually the most detailed level of the structure for which index series are published – these are the expenditure components and weights that remain fixed when using a fixed weight index.

Sub-classes consist of individual products. The individual products – the lowest level of the CPI basket – are the individual goods and services for which prices are actually collected. This is the level at which the composition of the CPI basket can be adjusted between two major revisions of the weighting structure to reflect changes in product supply and consumer behaviour.

In deriving the weights, the detailed expenditure items identified in the HES must be mapped to the CPI expenditure classes. If necessary, the HES results must be transformed to match the CPI categories.

[Web reference: <http://unstats.un.org/unsd/class/default.asp>]

*Points to note*

* Mostly, COICOP is used for compilation of CPI.
* Both CPC and ISIC are used for compilation of PPI.
* Standard International Trade Classification (SITC) is used for compiling XMPI.
* The COICOP classification has a hierarchical structure consisting groups, subdivided into classes and sub-classes. Sub-classes are the lowest-level categories for which weights are assigned.
* In *ISIC*, economic activities are subdivided in a hierarchical, four-level structure of mutually exclusive categories: section, division, group and class.
* Each five-digit subclass of the CPC consists of goods and services that are predominantly produced in one specific four-digit class or classes of ISIC.

**Module 10, Session – VI: Construction of Price Index – 1**

**Test Your Knowledge**

**Exercise – 10.6:**

1. State whether the following statements are true [T] or false [F].
2. A CPI ‘Basket’ consists of all goods and services consumed by households.
3. The price data are collected for selected items of an item-group.
4. The ‘elementary aggregates’ are also called ‘product headings’.
5. Normally, ‘elementary indices’ are not attached with Index weights.
6. Weights determine the impact that a particular price change will have on the overall index.
7. Weighting is a top-down process.
8. The weight of an elementary aggregate represents the entire elementary aggregate and not just the weights of the items included in price collection survey.
9. For CPI, the main source of data for assigning weights to elementary aggregates is the Household Expenditure Surveys (HES).
10. The HESs for determining weighting structure of a CPI should be conducted over a month representing the base period.
11. The primary sources of weight information for the PPI are business- or establishment based censuses, annual industrial surveys, and business registers.
12. The main data source for XMPI is the Customs records on exports and imports by products.
13. *Price updating of weights* for CPI is not required if the consumption pattern of households do not change, even if the relative prices change rapidly.
14. In *Price updating of weights*, no change is made in the lists of products and reporting units.
15. *Introduction/ removal of new/ old products* results in a chained index.
16. COICOP is used for compilation of PPI.
17. Both CPC and ISIC are used for compilation of PPI.
18. Each five-digit subclass of the CPC consists of goods and services that are predominantly produced in one specific four-digit class or classes of ISIC.
19. For a product heading, 8 different items are identified and thus considered for inclusion in the basket. From consultations with retailers, their market shares (in value terms) are learnt to be as follows:

|  |  |  |
| --- | --- | --- |
| Item | Market share (%) | Other observations of retailers |
| A | 15 | Available in all shops |
| B | 33 | Available in all shops & market places |
| C | 2 | Very similar to D |
| D | 13 | Very similar to C |
| E | 4 | Very similar to F – preferred by ladies |
| F | 5 | Very similar to E |
| G | 19 | Available in low-income earners’ market |
| H | 9 | Similar to G, but available only in stores |

The resources permit collection of only 12 quotations for the product heading. Which of the items do you think should be included in the basket? Give reasons.

1. Clearly state the data sources normally used for determining the weights for
	1. CPI
	2. PPI and
	3. XPI and
	4. MPI

# 10.9 Session VII. Collection of Price Data

## **Contents**

* Designing price data collection
* Product and outlet selection
* Product specification
	+ *Initial choice*
* Organising data collection
	+ *Method of collection*
	+ *Frequency and timing*
* Dealing with missing price data
	+ *Seasonal products*
	+ *Product substitution & quality adjustment*

## 10.9.1 Designing price data collection

Designing a price data collection system involves:

* Product and Outlet selection
* Product Specification & setting norms of items substitution
* Determining Frequency and timing
* Method of data collection – centrally or locally
* Treatment of seasonal products
* Quality adjustment of products in market
* Dealing missing data – editing & imputation

All these, except the last, are discussed in this session. The topics ‘Treatment of seasonal products’ and ‘Quality adjustment of products in market’ are discussed under ‘Dealing with missing price data’ in this session and the editing and imputation is discussed in some detail in the next session.

Normally, a large variety of products are transacted in the market. Most of the sub-classes consist of innumerable varieties and transactions. It is virtually impossible to collect price data on all of them. Thus, a limited number of products and transactions are selected for pricing to represent a sub-class.

## **Product and outlet selection**

Recall that the weighting structure of a price index is designed by allocating weights to individual sub-classes. The sum of weights of individual sub-classes is equal to 1. Often the weights are expressed in parts of 1000 – with 1000 representing the entire universe. Once the weighting structure is established, the representative items for price data collection for each sub-class are selected. The identification of these items depends on their relative shares of expenditure or output in the respective sub-class.

For example, if there are 10 different varieties of a particular product sub-class, of which the 3 most popular varieties account for 90 per cent of the market share. Normally, the price data collection is restricted to the top three varieties, under the assumption that the other seven varieties will have similar price movement as the average of that of the top three.

*For CPI*

The methodology adopted for this purpose should result in selections that are as representative as possible. Despite practical problems of implementation, the guidelines favour use of probability sampling techniques in the belief that they will enhance the accuracy of the index and allow estimation of the sampling error. However, such techniques are rarely used in practice.

Varieties of items are either selected by the national statistical office, again using expenditure or market share data where possible, or varieties may be chosen by price collectors who are instructed to choose the most popular varieties based either on the advice of retailers or on the amount of shelf-space taken up.

For example, the HES usually give an estimate of rice consumption in the total household expenditure. But, normally there is a variety of rice available in the market, each of which has different price. In most cases, it is practically impossible to collect price data on all the available varieties of rice. Thus, a limited number of varieties are selected for price collection. The selection is done in such a way that the average price movement of the selected varieties represent the price of the sub-class ‘rice’.

It is recommended that random sampling techniques be used for item and outlet selection. But, in most countries, outlets as well as items are selected purposively. Sales data, if available, ought to be used for this purpose. But, in most of the developing countries, local expertise are used to select the most representative outlets, and the national statistical central office decides the quotas for major outlet types. The HES may be designed to provide data on the share of major outlet types from where the households purchase a product. The quota for different major outlet types, in that case, can be decided on the basis of HES data.

For example, suppose 80% of fruits and vegetables consumed in urban areas are known to be sold in local markets and the rest in shops. But, the sales data of different outlets are not available. Also, let’s assume that 400 price quotations on different varieties of plantains & bananas are planned to be collected from 20 outlets of an urban area every month. While selecting the outlets for this purpose, the central office would normally select 16 outlets from local markets and 4 shops, to ensure representative coverage of outlet types.

*For PPI*

As for PPI compilation, since CPC is a product classification, it cannot be used to uniquely identify the industry of a product’s origin: a given detailed CPC code may identify products originating from establishments classified in different ISIC activity categories. However, identification of product type by originating activity would be possible in principle merely by recording both the ISIC and CPC codes for each product record collected in the business surveys providing source data for weights calculation.

Prices are collected for products from establishments in particular industries. The sampling process involves multiple stages of selection. Once the industries to be covered are decided, the establishments within these industries are selected and sampled, and then individual (representative) products are selected or sampled. Finally, individual transactions that represent the sampled products in each sample establishment are selected. The procedures used for selecting the sample at each stage are important.

The representative sampling of establishments and products requires comprehensive and up-to-date sampling frames. Two separate frames are used for this purpose:

* listing the universe of establishments and
* listing the universe of products.

Examples of possible sampling frames for establishments are business registers, establishment censuses, and central or local government administrative records. Sampling frames for products are usually available from establishment or business censuses and may be supplemented by telephone or price survey visits.

However, most countries continue to rely heavily on the purposive selection of establishments and products because random sampling may be too difficult and too costly. Once the establishments for price collection are selected, the selection of the individual products to be priced within the selected establishments is also done purposively. The central office draws up lists of products that are deemed to be *representative* of the products within an elementary aggregate.

*Points to note*

* The identification of representative items depends on their relative shares of expenditure or output in the respective sub-class.

For CPI

* Use of random sampling techniques for item and outlet selection is recommended. But, in most countries, outlets as well as items are selected purposively.
* The quotations to be collected for each elementary aggregate are spread over major outlet types.
* The quota for different major outlet types is usually decided by the Central office.

For PPI

* For PPI compilation, prices are collected for products from establishments (outlets) in particular industries.
* Once the industries to be covered are decided,
	+ the establishments within these industries are selected
	+ the individual (representative) products are selected.
* Finally, individual transactions that represent the sampled products in each sample establishment are selected.
* The industries to be covered for a product is determined using data on originating activity collected in the business surveys providing source data for weights calculation.
* Random sampling requires two separate comprehensive and up-to-date sampling frames:
	+ listing the universe of establishments and
	+ listing the universe of products.
* But, most countries continue with purposive selection of establishments and products.

## 10.9.2 Product specifications

Usually, the varieties for pricing are selected by head office, with the price collectors being given a *detailed specification*, or the price collectors may select the variety. In the latter case, they are given a loose specification and record a *detailed specification* themselves. In either case, for the sake of continuity (comparability with the past) and to avoid quality change bias creeping into the index, it is necessary that price collectors work with detailed descriptions at all times.

For each item, it is important that the price-determining characteristics are identified and that these then become the headings for the detailed specification. The detailed written description of an item’s specification includes

* price-determining features
* features required for future identification and
* features representing quality.

Such detailed descriptions ensure collection of price of the same variety of item, even if the individual price collector is changed. This practice ensures that the same item is priced over time and helps in identification of quality change if replacements are made. When a variety is no longer available, it is replaced by a variety as similar as possible. At the time of replacement, the price collector must record the detailed description of the new variety.

### Initial choice

The main criteria for selecting the representative varieties and transaction types for pricing are that they:

* between them, account for significant proportion of sales,
* broadly represent other products of their respective sub-groups, and
* are expected to stay in market / production for a long period.

But, while carrying out price data collection, it is quite common to find that some selected products and transaction types are no longer available and it is necessary to select replacements. The information about all price-determining characteristics helps in identifying differences in *quality* between the old and replacement items, and so that adjustments can be made for quality change if necessary.

In measuring price changes, variations in *quality* must be avoided. It introduces bias into a price index. In this context, the term *quality* includes:

* + the size of package sold
	+ the time of day or day of the week of purchase;
	+ type of location of outlet and
	+ exact physical specifications.

Examples of such price-determining characteristics are as follows:

* Product characteristics (for CPI):
* type of product
* brand name or model number
* main price determining characteristics: size, weight, power, etc.
* Transaction characteristics (for PPI):
* type of buyer: exporter, wholesaler, retailer, manufacturer, government
* type of contract: single/multiple deliveries, orders, one year, agreed volume
* unit of measure: per unit, per meter, per tonne
* size of shipment
* delivery basis: free on board, sale with/without delivery to customer,
* type of price: average, list, free on board, net of discount
* type of discount: seasonal, volume, cash, competitive, trade.

All such item specification norms vary from being tightly (narrow) defined or generally (broad) defined. The set of items selected for pricing often consists of a mix of broadly and narrowly defined specifications.

Adopting narrow item descriptions are generally more effective for controlling sample representativeness and quality differences. As a result, narrow description reduces the variance of prices and price relatives, thus optimizing the use of some aggregation formulas. The index number formulas used for aggregation at the elementary aggregate levels, such as Dutot’s, Jevon’s and Carli’s, are unweighted. These are used with the underlying assumption of homogeneity within the elementary aggregates. Narrow item descriptions, however, can result in a smaller achieved sample, because of less flexibility of choosing an appropriate item in a particular outlet / establishment.

Use of broad item descriptions, on the other hand, can increase the size of the achieved sample. But, using broad item descriptions can prove to be more difficult in controlling sample representability and thus result in higher variances in prices collected.

When a price collector finds that a variety is no longer available in the market, a replacement with a similar product is made. Replacement of a product is made only when production or supply of the item is permanently discontinued or when the item is not be available in the same specification and its quality has changed to such an extent that it should be treated as “new” product. When an item is replaced by another, it is essential to record the detailed description of the “new” variety and make quality adjustments, if necessary, based on differences in characteristics of the ‘replaced’ and ‘replacement’.

*[The issues of replacement are discussed in some more detail under ‘Dealing with missing price data’]*

*Points to note*

* Detailed specification (written description) of selected items for price collection is essential for
	+ continuity i.e. comparability with the past) and
	+ to avoid quality change bias creeping into the index.
* The detailed written description of an item’s specification includes
	+ price-determining features
	+ features required for future identification and
	+ features representing quality.
* In the context of price data collection, the term *quality* includes:
	+ the size of package sold
	+ the time of day or day of the week of purchase;
	+ type of location of outlet and
	+ exact physical specifications.
* A narrow item description is generally more effective for controlling sample representativeness and quality differences,
* Narrow descriptions reduce the variance of prices and price relatives, thus making unweighted formulae appropriate for elementary-level aggregation.
* Narrow descriptions can result in a smaller achieved sample, because of less flexibility of choosing an appropriate item in a particular shop.

## 10.9.3 Organising price data collection

There are two broad categories of respondents determining the basic method adopted in price data collection. Besides the large number of local shops, retailers and small producers, there are central offices of large enterprises and the government from whom the price data are collected. For example, fuel price of oil companies are collected from their central offices. The administered prices like those charged for public utilities, central or local government fees are revised and notified periodically.

Thus, there are two basic method of price data collection, viz.

* local collection and
* central collection.

The local collection method is used for a large majority of items. In this method, prices are obtained from *outlets* spread over the country. From each selected outlet, a number of price quotations are obtained normally by visiting the outlet, and sometimes by telephone.

Central collection is used for items where all the prices can be collected centrally with no field work. These prices can be further sub-divided into two categories, depending on their subsequent use:

* + *central shops,* where the prices are combined with prices obtained locally; and
	+ *central items,* where the prices are used on their own to construct centrally calculated indices.

We will mainly discuss issues relating to local collection method, but these are in most cases relevant for central collection method as well.

Once the product specifications and outlets / establishments are decided, the price data collection for CPI and PPI has much in common. Typically, a national statistical office compiles and publishes CPI at the national level as well as at the regional levels separately for the rural and urban areas. Price data collection is designed accordingly. The total number of price quotations on products of an elementary aggregate to be collected in a period (month) is allocated to the rural and urban areas of the regions, usually in proportion of their shares (as estimated in the HES used for weights) in total consumption expenditure on the product group representing the elementary aggregate.

The number of quotations allocated to a selected rural or urban location of a region is further allocated to the representative varieties (with given *item specifications*) constituting the elementary aggregate and the major outlet types where they are available. Usually, no data on quantity or value of the varieties and their place of purchase are available either from the HES or other sources. The allocation to varieties and outlet types is thus done on the basis of the judgement of experienced price data collectors, in accordance with the notional market shares of the varieties and the major outlet types.

The figure in Example 21 indicates how price data collection for an elementary aggregate of CPI is typically organised for an urban location. The scheme illustrated in the figure could be that for an elementary aggregate such as “rice”, consisting of three product specifications – Z, X & Y – respectively for three distinct varieties, say coarse, medium and fine. These are sold mainly in three types of outlets – local markets (A), shops (B) & departmental stores (C). Suppose the coarse variety is sold only in shops (B) and local markets (A); the medium variety in all the three types of outlets and the fine variety only in shops (B) and departmental stores (C).

**Example 10.21: Price Collection Plan for an Elementary Aggregate of CPI**

With, say, 100 price quotations to be collected each month from the urban area, 40 are allocated to the coarse, another 40 to the medium and 20 to the fine varieties, assuming that their respective market shares in 2:2:1 proportions. The allocated numbers are then assigned to major outlets types: local markets, shops & departmental stores, according to judgement of the price collection officials regarding their respective share in the total sales of the variety.

Though random sampling is recommended for selection of the outlets, usually these are selected purposively in most cases. The three sets of outlets thus selected for collection of prices of the three varieties are expected to have much in common. The time schedule for price data collection is framed in such a way that the prices of all the product specifications required to be collected from a selected outlet are recorded in a single visit.

The price data collection for PPI is organised in very much the same way. The units from which prices of specified products are collected, in case of PPI, are units (establishments) producing them. Further, for each specified product prices of a number of transactions are collected from the selected establishments.

In fact, in developing countries with large informal sector, a considerable part of data collection for the two indices should desirably be integrated. Particularly for the manufacturers who directly sell their products to households, the same price data should serve for compilation of both CPI and output-PPI.

### Method of price data collection

Prices are usually collected using a variety of methods, such as:

* personal visit to outlet, recording prices on paper or electronically,
* paper form sent by mail or fax.
* electronic form sent by e-mail or on floppy disk,
* telephone call to establishment.
* prices observed in catalogues/brochures,
* official price changes notified by other government departments or announced in the press.

In personal visit to outlet/ establishment, descriptions and prices are recorded on paper collection forms, or electronically using hand-held computers. This is by far the most commonly used method of price data collection for CPI. For PPI, however, this is rare although personal visits are strongly recommended during establishment and product/transaction selection.

In the method of sending paper forms, descriptions and prices are recorded on the forms. It has been the most common practice for price data collection for PPI. However, most countries are fast shifting towards electronic forms sent by the Internet. Whether paper or electronic version, it is essential that the form contains full product and transaction specifications each month and careful instructions to the respondent on how to proceed if any of the specifications change.

Making telephone calls to the data provider is quite a common practice to validate price data. Collecting prices from catalogues and brochures is also quite common, but it is not recommended since actual transaction prices should be recorded, not list prices. The best source for collecting data on changes in administered/ official prices is government notifications and announcements made in the press. Examples are petrol, electricity and telecommunication prices.

The price collection system are usually closely managed by an efficient communication network to keep collectors up to date with any special circumstances each month and remind them of seasonal goods appearing/disappearing from the market. The collectors are trained regularly and called for meetings with other collectors to discuss common problems (*e.g.*, selecting replacement varieties), to be taught about any new procedures, and to learn about new products and their characteristics.

### Frequency and timing

The aim of the price collection is to compile reliable indicators of period-to-period—say, monthly—price change. This involves collecting prices from businesses and retailers relating to particular products and time periods. Usually price collection is monthly and covers the entire month.

Different frequency of collection (monthly or quarterly) and the time period are covered for collecting prices (a single point in time, several times during the month, or a monthly average). For example, point-in-time (say the 15th of the month prices) may be the easiest to collect and commonly prove to be reliable indicators. But spreading the collection over the reference period helps making more observations with a given team of price collectors. Thus, it is more common to collect data over a period than on a point in time. For example, price data collection may be spread over three or four pricing points and different commodities priced on different days. However, resource considerations may limit collection to a single point in time.

For commodities with volatile prices, it is necessary to price them on several different days of the month. Alternatively, retailers and businesses can be asked to provide average monthly prices (derived as the value of sales divided by the quantity sold). The main problem with this method is that the respondents may include a ‘mix’ of different qualities while doing the calculation.

A fundamental decision about the frequency and timing of price collection is whether the index should relate to monthly average prices or prices for a specific point in time (for example, a single day or week in a month). This decision is related to a number of factors. They are as follows:

* *Uses of the index*: If used for deflating income, expenditure or sales, the index should relate to the period of time of these money flows. Moreover, when used in conjunction with other economic statistics, most of which relate to a period rather than to a point in time, the price index should also relate to the period of time.
* *Practicalities of carrying out price collections*: Not all price observations can be made within a single day. In practice, the observations are either spread over a few days to provide an approximation to a point-in-time estimate or spread over the whole month to provide an estimate for the average for that month.
* *Pattern of price movements*: The desired frequency of price collection may vary by commodity, depending on how frequently the prices to be observed change. For example, the official/ administered/ catalogue prices change annually or quarterly according to a known timetable. On the other hand, food prices – where shopkeepers may review and charge prices on a continuous basis to reflect market conditions and the prices charged by their suppliers. The prices of the former kind are collected annually or quarterly, according to the timetable of changes, while those of the later kind are collected more frequently.
* *Timing of index publication*: Another point to note is the timing of publication of the resulting price indices. There may be legal constraints on the timing of the publication of indices. In such cases, prices must be collected in time to allow quality assurance, processing and aggregation procedures to be completed before the deadline.

*Points to note*

* There are two basic method of price data collection, viz.
	+ local collection: more common and relatively more costly
	+ central collection: of restricted use and does not require field work.
* Having determined the total number of quotations to be collected for an elementary aggregate, it is allocated to rural and urban locations of regions in the country.
* The allocation for a rural or urban area of a region is assigned to
	+ the representative varieties (with given *item specifications*) constituting the *elementary aggregate* and
	+ the major outlet types, where the items are available.
* The higher the frequency of collection the lower is the spread over outlets.
* The higher the variation in price the higher should be the frequency of collection.
* When the price of an item fluctuates considerably quotations are taken for a number of days spread over the current period.
* An index used for deflating income, expenditure or sales, the index should relate to the period of time.

## 10.9.4 Dealing with missing price data

The main problem faced by price data collectors is when an item is no longer available in the outlet or establishment. In that case, the item’s price cannot be collected. This happens for a number of reasons, such as

* production or supply of the item is permanently discontinued,
* the item is not be available to the same specification – its quality has changed,
* it is a seasonal item like some fruits and vegetables and winter clothing.

It is necessary to distinguish between items that are permanently and temporarily missing. Items that are temporarily missing are items not available and not priced in the month in question, but that are priced in subsequent months.

A number of approaches are adopted for dealing with missing items. Those commonly used in practice are as follows:

1. An item is a seasonal product that regularly disappears and reappears in the market. For such items, the price collector is required to record prices of the item only when it is expected to be available in the market.
2. The item may be dropped altogether. Price collectors are not required to collect any additional information in such cases.

It is implicitly assumed that the aggregate price change of other items of the group (to which the missing item belonged) reflects change in the missing item. (This is an *implicit quality adjustment* to price).

1. A replacement item of comparable quality is selected to replace the missing item. The price collector, in such cases, has to record all the relevant information on price-determining characteristics required for detailed specification about the “new” item.

The underlying assumption is that the replacement item is comparable in quality to the missing item. The replacement item’s price in the current period and missing item’s price in the previous period are used for computing price relative.

1. A replacement item of non-comparable quality is selected to replace the missing item. In such cases, the price collector must collect price data of replacement item for the previous period, in addition to information required for detailed specification about the “new” item.

The prices of both the items available in the *overlap* period (the previous period) are used to estimate of quality difference and appropriate quality adjustment measures are taken. Example 22 illustrates how price relatives are calculated using overlap period. [This is discussed in some more detail in the next session]

|  |
| --- |
| **Example 10.22: Overlap method**The measurement of price change is switched from the ‘old’ item to the ‘new’ one. There is a period (March) of overlap; price relatives (with January as the base) are calculated as the price relatives of the “old” product A till March.Henceforth, it is calculated as the price relatives (PR) of the “new” product B, as follows: PR of April = (PR of A in March) \*(PR of B in Apr. with March as base).This method is in general called “*splicing*”.Calculate the price relatives using *overlap* method. |
| Item | price in |
| Jan. | Feb. | Mar. | Apr. | May |
| “old” specification A | 200 | 210 | 204 |   |   |
| “new” specification B |   |   | 153 | 162 | 159 |
| **Price relative** |  |  |  |  |  |

### Seasonal products

*Seasonal products* are products that regularly disappear and reappear in the market. The production and supply as well as prices of such products, mainly in the food and clothing groups, are subject to marked seasonal variations. They are broadly of the following two kinds:

* A product that is not available in the marketplace during certain seasons of the year. Such a product is called a *strongly seasonal commodity*.
* A product that is available throughout the year but there are regular fluctuations in prices or quantities that are synchronized with the season or the time of the year. Such a product is called a *weakly seasonal commodity*.

Unless appropriate adjustments are made, seasonal products can cause problems during index compilation.

The *strongly seasonal products* create the biggest problems for price statisticians in the context of producing a monthly or quarterly Price Index. If a product price is available for only one of the two periods being compared, it is not possible to calculate its price relatives.

Examples of important seasonal products are the following: many food items; alcoholic beverages; many clothing and footwear items; water, heating oil, electricity; flowers and garden supplies; vehicle purchases, vehicle operation; many entertainment and recreation expenditures; books; insurance expenditures; wedding expenditures; recreational equipment; toys and games; software; air travel, and tourism purchases.

[Treatment of seasonal products in compilation of price indices is discussed in some detail in the next session.]

### Product substitution & quality adjustment

The price quotations used in the computation of a price index are for precisely defined items, *i.e.*, those forming the index basket of goods and services. Ideally, the composition of the basket is kept unchanged during the life of a price index series. In practice, this ideal situation is not expected to prevail. A product initially chosen for inclusion in the basket may progressively become obsolete. It is then replaced by a suitable substitute. Again, a product may continue to be in the market, but may undergo *quality change* by way of minor alterations, such as change in design, quantity sold in standard package or colour mix or the replacement of a particular component. These changes bring about replacement and change in item specifications.

During price collection, it is critical to note whether there has been a quality change. For this, it is necessary to identify price-determining characteristic of an item and price collection forms are designed with provisions of recording information about these characteristics. This is done by consultation with producers, retailers, consumers, etc. or, for some commodities, by using hedonic regression techniques, which estimate values for individual characteristics bundled together to form a good or service.

The difference in quality between the original product and the one that replaces it may be so great that the new quality is better treated as a new good. Distinction is made between two kinds of substitution – by *evolutionary* and *revolutionary* “new goods and services”.

An *evolutionary* new good or service is one that meets existing needs in much more efficient, or new, ways. In practice, an *evolutionary* new good can be fitted into some subclass of the product or industry classification.

A *revolutionary* new good or service provides completely new kinds of services or benefits. Its inclusion requires some modification to the classification in order to accommodate it.

Both the kinds of substitution usually require adjustments in prices due to change in quality. It is difficult to measure the effect of a quality change on the price of a commodity. In practice, this is done by consultation with one of the following:

* very experienced price collectors or data analysts in the statistics office,
* consultation with retailers, who are knowledgeable about the quality characteristics of their goods or services, pricing policy and consumer behaviour;
* producers, who are able to estimate the effect of quality change on price, or the marginal cost of the new features,
* expert panels for valuation of any quality change.

Hedonic regression models are also used to estimate the contribution of each unit of each characteristic to the price.

*Points to note*

* There are two kinds of missing price data – *permanently* missing and *temporarily* missing.
* Dropping an item within an elementary aggregate does not require explicit re-weighting. It is an implicit quality adjustment.
* Quality change brings about replacement and change in item specifications.
* Replacement by an item of comparable quality does not require quality adjustment.
* Replacement by an item of non-comparable quality requires quality adjustment.

**Module 16, Session – VII: Collection of Price Data**

**Test Your Knowledge**

**Exercise – 10.7: Purpose, scope and coverage**

1. State whether the following statements are true [T] or false [F].
2. The identification of basket- items depends on their relative shares of expenditure or output in the respective sub-class.
3. For CPI, the quotations to be collected for basket-items of an elementary aggregate are collected from a single outlet.
4. The sample of quotations for an elementary aggregate of a CPI is spread over major outlet types.
5. For output-PPI compilation, prices are collected from retailers.
6. Most countries continue with purposive selection of establishments and products because complete list of establishments producing different products is not available.
7. Detailed specification of selected items for price collection is essential for comparability with the past.
8. A narrow item description is generally more effective for controlling sample representativeness and quality differences,
9. Narrow descriptions increases the variance of prices and price relatives
10. The unweighted formulae are appropriate for elementary-level aggregation, if the variance of prices and price relatives of the items within the elementary aggregate are very high.
11. Broad descriptions can result in a smaller achieved sample.
12. The entire price data used for CPI compilation are collected from local markets, shops and departmental stores.
13. For CPI, the price of petrol is collected from gas stations (petrol pumps).
14. The higher the frequency of collection the lower is the spread over outlets.
15. An item with high price variation should be priced with high frequency.
16. A CPI used for escalation of wages should relate to a period of time.
17. Dropping an item within an elementary aggregate amount to implicit quality adjustment.
18. For *strongly seasonal products*, calculating price relatives it is not possible for every month of a year. Inclusion of a *revolutionary* new good or service usually requires some modification to the classification.
19. Replacement by an item of non-comparable quality requires quality adjustment.
20. You are required to draw a monthly price collection plan for CPI compilation for a town. A total of 50 quotations are assigned to the COICOP class *Mineral waters, soft drinks, fruit and vegetable juices*. The elementary aggregates defined for this purpose are as follows:
21. Mineral or spring waters; all drinking water sold in containers;
22. Soft drinks such as sodas, lemonades and colas;
23. Bottled fruit and vegetable juices;
24. Fresh fruit and vegetable juices;
25. Syrups and concentrates for the preparation of beverages;
26. Local sherbet.

There are three major outlet types in the town selling these products:

1. Departmental stores
2. Shops
3. Street Vendors

The following table shows the number of item specifications selected for price collection under each elementary aggregate and their availability.

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | Availability (indicated by ) by Major outlet type | No. of item specifications |
| I | II | III |
| A |  |  |  | 2 |
| B |  |  |  | 3 |
| C |  |  |  | 2 |
| D |  |  |  | 4 |
| E |  |  |  | 2 |
| F |  |  |  | 1 |

Note that prices of the first two items are decided by the three companies which produce them.

Draw a plan for monthly price collection for the town with the allocated 50 quotations. Indicate clearly the item specification and the major outlet type from where the quotations would be collected. Also justify your answer in brief.

1. Which of the following should be included the detailed item’s specification for an electric fan? Give brief justifications.
	1. maximum retail price
	2. price-determining features
	3. expiry date
	4. date of manufacturing
	5. colour, size and weight
	6. speed, noisiness, and power consumption.

## **10.10 Session VIII. Calculation in practice**

## **Contents**

* Treatment of Missing Prices and other adjustments
	+ *Calculation of price relatives and elementary indices*
	+ *Index aggregation*
	+ *Alignment of expenditure and price reference base*
	+ *Chaining re-weighted indices*
* Adjustments for Seasonal products
* Adjustments for Quality changes
* Data editing

### 10.10.1 Treatment of Missing Prices and other adjustments

Recall that compilation of a price index involves three distinct stages, viz.

1. Calculation price relatives
2. Elementary aggregation and
3. Higher index aggregation.

The formulas used at different stages are already discussed in Session III. Here, we will review the formulas in respect of adjustments made in practice.

Besides, calculation of a price index may also require

* aligning weight and price reference periods with the index reference period and
* chaining re-weighted indices.

The basic principles followed for carrying out these calculations are the same for CPI and PPI. In practice, however, the countries follow different procedures in these regard.

In addition, calculation of an index also includes adjustments made for

* missing price observations
* seasonal items and
* quality change.

The treatment of these at the price collection stage is discussed earlier in Session VII. Here, we will discuss how these adjustments take effect in calculation of price index.

### 10.10.2 Calculation of price relatives and elementary indices

Price relative of an item or transaction (say *i*th) is defined as $\frac{p\_{it}}{p\_{i0}}$

where $p\_{it}$and $p\_{i0}$stands for the *i*th price quotation collected from a pre-specified outlet (establishment) for a pre-specified product (transaction) respectively for the current period (*t*)and the base period (*0*).

Normally, there is no problem in calculating the price relatives. Problem arises when the price for the current period becomes missing temporarily or permanently. Temporarily missing price quotation occurs for seasonal items, as well as for other reasons. For permanently missing price quotations, mainly caused by the product becoming obsolete, the product is substituted by a “new” product or just dropped.

The special cases of seasonal products and new products are discussed later in this session. Here, we will discuss how the temporarily missing price quotation of non-seasonal products and dropping of an obsolete product is adjusted for in calculation of index.

*Temporarily missing prices of non-seasonal products*: Items may be temporarily unavailable due to supply shortages caused by factors, such as the seller underestimating demand, strikes by factory or transportation employees, or supply problems with imported commodities. In these cases, a price observation is unavailable in the current period but it is known that it will be available in the future, although it may not be clear when.

The methods most frequently used to deal with such temporarily missing prices problem generally are as follows:

* taking no action;
* carrying forward the last available price;
* imputing prices.

If no action is taken to accommodate missing prices, the outcome will depend on the method used to compile the elementary aggregates:

* for *Dutot* formula the samples will no longer be matched and the index will reflect sample changes as well as price changes;
* for *Carli* formula computer error may occur, or the weights may be incorrectly distributed;
* for *Jevon* formula any of the problems stated above can occur.

If no imputation is done, it will be omitted from the calculations till a missing price returns. This means that any price rise during start of the missing period to the period before its reappearance is not reflected in the index. Thus, the index will suffer a systematic upward or downward bias, depending upon whether the price movement of the missing product is flatter or sharper than the rest of the items in the elementary aggregate. Thus, a better method is to use imputed prices for all the periods when observations cannot be made.

**Example 10.23: No Action taken for missing price data in elementary aggregation**

For an elementary price index with 4 quotations to be collected, the fourth quotation becomes missing for the periods 3 to 6. Taking no action amounts to calculating the elementary index with the available price quotations. Calculate the indices for the missing periods and observe how the indices behave.

|  |  |
| --- | --- |
| quotation number | prices in  |
| Base period | Current period |
| *1* | *2* | *3* | *4* | *5* | *6* | *7* |
| Jevon's | 108.0 | 114.3 |  |  |  |  | 177.6 |
| Carli's | 108.1 | 114.4 |  |  |  |  | 181.4 |
| Dutot's | 108.2 | 114.4 |  |  |  |  | 181.2 |
| 1 | 15.3 | 16.7 | 17.9 | 19.8 | 24.7 | 25.9 | 29.5 | 34.8 |
| 2 | 15.5 | 17.9 | 18.0 | 17.4 | 21.0 | 21.6 | 20.2 | 19.8 |
| 3 | 14.8 | 14.7 | 16.4 | 19.7 | 19.4 | 23.2 | 29.7 | 28.4 |
| 4 | 14.5 | 15.7 | 16.5 | n.a. | n.a. | n.a. | n.a. | 25.9 |

A common treatment of missing prices is carrying forward the last available price to the months when prices are not available. Evidently, this leads to biased indices for the months the price remains missing. As the price relatives in question will remain flat when prices are not available, the bias will be downwards in rising-price situations and the bias will be upwards in falling-price situations. There is also likely to be a large step-change in the index when the price becomes available again. Thus, this method is not recommended, particularly with high inflation or where short-period movements in the price index are used as a major indicator.

**Example 10.24: Carrying forward the last available price**

For the same data set used above in Example 10.23, the fourth quotation missing for the periods 3 to 6 are replaced by 16.5 – the price quotation available last. Calculate the indices for the missing periods and observe how the indices behave.

|  |  |
| --- | --- |
| quotation number | prices in  |
| Base period | Current period |
| *1* | *2* | *3* | *4* | *5* | *6* | *7* |
| Jevon's | 108.0 | 114.3 |  |  |  |  | 177.6 |
| Carli's | 108.1 | 114.4 |  |  |  |  | 181.4 |
| Dutot's | 108.2 | 114.4 |  |  |  |  | 181.2 |
| 1 | 16.7 | 17.9 | 17.9 | 19.8 | 24.7 | 25.9 | 29.5 | 34.8 |
| 2 | 17.9 | 18.0 | 18.0 | 17.4 | 21.0 | 21.6 | 20.2 | 19.8 |
| 3 | 14.7 | 16.4 | 16.4 | 19.7 | 19.4 | 23.2 | 29.7 | 28.4 |
| 4 | 15.7 | 16.5 | 16.5 | n.a. | n.a. | n.a. | n.a. | 25.9 |

In fact, the method of “carrying forward” should be avoided wherever possible. It is acceptable only for a very limited number of periods. While simple to apply, “carrying forward” biases the resulting index toward zero change. In general, carry forward is not an acceptable procedure or solution to the problem unless it is certain the price has not changed.

By far the best solution for *missing prices of non-seasonal products* is imputing prices. Imputation can be done in two ways – *implicit* imputation elementary price index or *explicit* imputation of the missing price.

In *implicit* imputation the missing price relative and its weight are simply dropped or omitted from all calculations, resulting in the weight being automatically redistributed, proportionally, over the other items / transactions in the elementary aggregate. Thus, the elementary index is based only on those price relatives that are available and the missing price relative implicitly assumes the same value as the elementary index.

In *explicit* imputation, the missing price for the missing item is explicitly estimated and the elementary index is calculated using the imputed value. It is recommended that imputations should always be made explicitly.

Imputation – whether implicit or explicit – makes use of the best available information to provide an unbiased estimate of price movement. Imputation can be done using prices or elementary indices or higher level indices. Note that imputation of prices is necessarily explicit, whereas the imputation of indices can be implicit or explicit.

### 10.10.3 Index aggregation

We have seen how elementary indices are aggregated to obtain higher-level indices. Besides publishing the overall index, the statistical offices usually publish indices by COICOP groups or CPC or ISIC sections. The elementary aggregates obtained after making the required adjustments are combined using some kind of index number formula and weights based on expenditure or output or sales. All the adjustments for missing prices, seasonal goods & services and quality changes are usually made at the stage of calculating price relatives and elementary aggregation. For aggregation at higher levels, only the weights may have to be adjusted, as a result of changes in weights made for elementary indices.

Statistical offices also publish indices at local and regional levels. In such cases, first, local- or regional-level weights for elementary aggregates are used for obtaining directly local, regional indices. The national-level indices are then obtained by combining the regional-level indices for COICOP groups or CPC or ISIC sections as well as for overall index. Relatively few prices may be combined to give local item indices or a wider spread of prices may be combined to give regional indices. For combining the regional indices to national indices, usually the same weighting structure of expenditure or production or sales, estimated from the survey conducted for the purpose, is used.

Often, for obtaining the national CPI from the regional indices, population is used as weights. Even in such cases, aggregation of elementary indices to higher-level indices is done using the expenditure weights. Note that the national indices for individual COICOP group indices can be obtained either by combining the respective regional level COICOP group indices, or directly by aggregating the elementary indices at the national level.

If the regional indices and the national index are not built from a same weighting structure, the national level indices obtained by the two different ways are likely to differ. For example, if the usual expenditure weights are used for aggregating elementary indices to higher level indices, while the weights used for combining the regional indices to national indices be based on population, the national-level indices obtained by the two different methods are likely to differ.

### 10.10.4 Alignment of weight and price reference base

In practice, data generally are not available as required by the Laspeyres formula. While the index reference period is set to coincide with the price reference period, the weight reference period is usually different. Expenditure or production or sales weights are calculated using average prices for the weight reference period (mostly a year).

As we have seen earlier, weights are estimated by conducting a survey and the reference period of the survey usually predates the index reference period. The price reference period and index reference period are normally the same and is commonly either a whole year or a single month. Thus, the reference period for the weights is often different from that for the prices. In order to use price relatives based on a different period to their corresponding weights, link factors (or adjustment coefficients) are needed.

The linking is made by *price updating of weights*. This has already been defined and discussed in Sessions II & V. The procedure consists of recalculating the weights from the values obtained by applying prices of a different period on the quantities of the weight reference period.

### 10.10.5 Chaining re-weighted indices

A chain index consists of a series of successive indices, each linked (*spliced*) to its predecessor. Linking consists of multiplying the values of the successor index by the value of its predecessor in an overlap period (linking coefficients are calculated using values in the overlap period), so that the index base period of the successor becomes the same as for the predecessor index, *i.e.* the indices have a common reference base. Linked indices can be produced at any level, *i.e.* item, product, group, total CPI. However, it should be remembered that aggregating linked sub-indices will give a different result to linking aggregated indices. The recommendation is that aggregation should always be done before chain-linking, *i.e.* linking should always be the last stage in the process.

**Example 25: Annually Chained price index**

For a price index with index reference period 2005, annually chained weights are used. Col. (3) shows the initial weights, which are used for deriving the all-item price index for 2006. Cols(4) & (6) show the group-level price indices of respectively 2006 and May, 2007. The individual item group’s weights for 2007 are obtained as follows:

 $col.\left(5\right)=\frac{col.\left(3\right) × col.\left(4\right)}{col.\left(4\right), all items}$

|  |  |  |  |
| --- | --- | --- | --- |
| Item groups | Base index (2005) | 2006 | May, 2007 |
| (initial) weights | Index (average) | weights  | index |
| (1) | (2) | (3) | (4) | (5) | (6) |
|  **All Items**  | **100.0** | **100.0** | **113.1** | **100.0** | **120.2** |
|  Food  | 100.0 | 53.2 | 105.6 | 49.7 | 110.2 |
|  Beverage &Tobacco  | 100.0 | 6.5 | 123.7 | 7.1 | 122.4 |
|  Clothing & Footwear  | 100.0 | 4.1 | 108.3 | 3.9 | 122.7 |
|  Housing  | 100.0 | 18.0 | 126.7 | 20.2 | 136.9 |
|  Household operation  | 100.0 | 6.2 | 116.5 | 6.4 | 126.9 |
|  Transport  | 100.0 | 6.6 | 133.7 | 7.8 | 130.1 |
|  Miscellaneous  | 100.0 | 5.4 | 103.2 | 4.9 | 122.8 |

The chained-based index for 2007 is 120.2 while the value of fixed-weight index for May, 2007 is …….

[Chained index is not discussed further in this module.]

*Points to note*

* *Temporarily* missing price quotation occurs for seasonal items, as well as for other reasons.
* For *permanently* missing price quotations, mainly caused by the product becoming obsolete, the product is substituted by a “new” product or just dropped.
* For *temporarily missing prices of non-seasonal product* of an elementary aggregate, taking no action leads to upward bias if the price movement of the missing product is actually flatter than the rest of the items of the aggregate.
* The method of carrying forward leads to biased indices for the months the price remains missing, unless there is actually no change in its price level during the missing period.
* In *implicit* imputation the missing price relative and its weight are simply dropped or omitted from all calculations.
* *Implicit* imputation automatically redistributes, proportionally, the weight of the missing product or product-group to the rest of the products or product-groups of the immediately upper-level of aggregation.
* If an elementary index (using an unweighted formula) is based only on those price relatives that are available, the missing price relatives are implicitly imputed by the same value as the elementary index.
* When indices at local and regional levels are compiled, first, local- or regional-level weights for elementary aggregates are used for obtaining directly local, regional indices.
* The national-level indices are then obtained by combining the regional-level indices for elementary indices, product sub-groups and groups, as well as for overall index.
* *Price updating of weights* is required for aligning price and weight reference periods.
* In a chain index the weights of a particular year is updated by the price indices of the previous year.
* Annually chained indices have a common index reference base.

### 10.10.6 Adjustments for Seasonal Products

There is no panacea for seasonality. A consensus on what is best practice in this area has not yet been formed. There is a number of different ways in which the problems may be tackled. Here we will only outline different possibilities of dealing with seasonality, without going into details of how exactly the calculation are done; details are beyond the scope of this module.

In practice, the adjustments for seasonality are made in the form of:

1. *Excluding seasonal products*: One possibility is to exclude seasonal products from the index, but this is an unacceptable reduction in the scope of the index, as seasonal products can account for a significant proportion of total household consumption or domestic production.
2. *Month-to-month movement*: Another solution is to switch the focus from month-to-month movements of the index of seasonal products to changes between the same months in successive years. In some countries, it is common for the media and other users, such as central banks, to focus on the annual rate of inflation between the most recent month and the same month in the previous year. This year-on-year figure is much easier to interpret than month-to-month changes. While this kind of treatment is quite suitable for seasonal products, it poses serious problems of integrating year-on-year index with indices of month-to-month index of non-seasonal products.
3. *Imputation*: Adjustments by imputation consists of imputing prices of seasonal products for the months when their prices are not available. In adjustment by imputation, all items are made to retain their respective fixed weights. This avoids the problem of bias in monthly movements and results in a smaller step-change in the index when the new season starts.

[The details of imputation techniques are not discussed in this module.]

1. *Variable Weights*: This kind of adjustments requires using a system of variable weights. The seasonal items are assigned different weights indifferent months according to consumption or production or sales, but the weights for the corresponding group of items are kept fixed. Thus, zero weights are assigned to the items in the months when their prices are not available.

For example, in compilation of CPI, consider the COICOP group “fruits” consisting of say 20 different fruits. Of these, say 10 are available only in certain seasons. The weight (say 5 per cent) for the group “fruits” in the overall index is distributed over all the 20 fruits according to estimates of their consumption by the households obtained from the HES. For a particular period, the sum of weights of the seasonal fruits (say 3 per cent in the overall index) is redistributed to only those available during the current period, assigning zero weights to those not available. Thus, the weight for the COICOP group “fruits” remains fixed (at 5 per cent) in all the months of a year.

**Example 10.26: Seasonal Adjustment – Variable Weight**

A seasonal product (say mango, D2.2) is known to be available in specific months of the year – March to August. In the “fruit” group, mango has a weight of 33%.

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | weight (%) in group D.2 | elementary index in current period |
| *Jan.* | *Feb.* | *Mar.* | Apr. | *May* | *June* | *July* | *Aug* | *Sept.* |
| **D.2** | **100** |  |  | **127.9** | **130.8** | **124.8** | **133.6** | **137.8** | **140.8** |  |
| D.2.1 | 22 | 110.0 | 114.3 | 118.2 | 128.5 | 129.0 | 134.6 | 137.5 | 140.2 | 142.3 |
| D.2.2 | 33 | ***n.a.*** | ***n.a.*** | 148.2 | 145.2 | 120.9 | 139.4 | 146.4 | 150.0 | ***n.a.*** |
| D.2.3 | 25 | 111.9 | 114.5 | 117.1 | 123.8 | 125.1 | 128.9 | 132.2 | 135.3 | 138.6 |
| D.2.4 | 20 | 110.8 | 113.9 | 118.8 | 118.3 | 126.3 | 129.1 | 130.7 | 133.2 | 135.6 |

For the other months, the weight of mango is distributed proportionately to the other groups and the group index is calculated as follows:

|  |  |  |
| --- | --- | --- |
| Elementary aggregate | weight (%) in group D.2 | elementary index in current period |
| initial | adjusted | *Jan.* | *Feb.* | *Mar.* | Apr. | *May* | *June* | *July* | *Aug* | *Sept.* |
| **D.2** | **100** | **100** |  |  | **127.9** | **130.8** | **124.8** | **133.6** | **137.8** | **140.8** |  |
| D.2.1 | 22 |  | 110.0 | 114.3 | 118.2 | 128.5 | 129.0 | 134.6 | 137.5 | 140.2 | 142.3 |
| D.2.2 | 33 |  | n.a. | n.a. | 148.2 | 145.2 | 120.9 | 139.4 | 146.4 | 150.0 | n.a. |
| D.2.3 | 25 |  | 111.9 | 114.5 | 117.1 | 123.8 | 125.1 | 128.9 | 132.2 | 135.3 | 138.6 |
| D.2.4 | 20 |  | 110.8 | 113.9 | 118.8 | 118.3 | 126.3 | 129.1 | 130.7 | 133.2 | 135.6 |

Calculate the missing values.

### 11.10.7 Adjustments for Quality Changes

Ideally, the index should not be affected by changes in quality. But, since it is not always possible, we have to make appropriate adjustments for change in quality. That is, when we replace an “old” product by a “new” product of different quality, it is essential to make a quality adjustment to the replacement item’s price.

Quality adjustment of the replacement item’s price is done by multiplying the “new” product’s price by a coefficient (α). The reciprocal of this coefficient (1 / α) represents the part of the price change that results from quality difference between the “replaced” and replacement” items.

In practice, an estimate of the coefficient is obtained from data available. The two situations discussed below are most common:

1. The “old” and “new” products have been available simultaneously for some time in reasonable quantities. If the prices of both have been fairly stable, it is assumed that the price difference between the products is attributable to the difference in quality of the products.
2. The two products are not available at the same time or if their prices have been unstable. In such cases, the ratio of production costs of the two is used along with judgement based on other information provided by the manufacturer to separate the change in the price from the change in quality.

In situation (i), the new series is simply spliced to the old one. The procedure is illustrated in Example 27 below.

In situation (ii), when the price for the previous period is not available, one of three methods is applied for quality adjustment:

* direct comparison (that is, when there is no change in quality),
* indirect (implicit) quality adjustment [discussed earlier]
* direct (explicit) quality adjustment. [discussed in latter modules in some more detail]

**Example 27: Quality Adjustment – Assuming price difference is attributable to quality difference**

The “old” product is available in the market till June. The “new” product has been available since January. We calculate the relative prices of the two products and use the average relative price as the coefficient for price adjustment by dividing the prices of the “new” product in July, Aug. & Sept. by the coefficient.

|  |  |
| --- | --- |
| **Product** | prices in current period |
| *Jan.* | *Feb.* | *Mar.* | *Apr.* | *May* | *June* | *July* | *Aug* | *Sept.* |
| old | 14.5 | 14.7 | 15.5 | 15.5 | 15.7 | 16.0 | -- | -- | -- |
| new | 18.0 | 18.1 | 19.8 | 19.3 | 19.9 | 20.5 | 20.4 | 21.1 | 22.0 |
| relative price | 1.24 | 1.23 | 1.28 | 1.25 | 1.27 | 1.28 | -- | -- | -- |
| adjusted price | 14.5 | 14.7 | 15.5 | 15.5 | 15.7 | 16.0 |  |  |  |

If it is not possible to quantify the effect of a quality change, then one of the following alternatives is adopted:

1. All quality differences are ignored, *i.e.*, if there is any price difference it is treated as a genuine price movement.

In this case the price of the new variety can be compared directly with that of the old variety, and 100% of the price difference is reflected in the index. Obviously, if there is an improvement in quality, the index will be biased upwards. On the other hand, if there is a worsening of quality, the index will be biased downwards.

1. Assuming that the entire price difference is due to quality difference. There are several ways to remove the price difference due to quality.

First, by overlap imputation, discussed earlier. Underlying assumption is that the price difference is due to quality differences.

1. If there is no overlap period, it is necessary to create one by imputing a movement in the index for the time between the period when the old variety was last available and the period when the new variety is first available.

In this case, the difference between the imputed price for the old variety and the price of the new variety is assumed to be due to quality differences. The imputed movement could be the movement of the next higher level of index aggregation. This is called overall mean imputation.

*Points to note*

* Excluding seasonal products from the scope of the index is not recommended.
* The movement of index of seasonal products between the same months in successive years is a good way measuring its annual rate of inflation.
* The *variable-weight* method assigns zero weights to the items in the months when their prices are not available.
* Quality adjustment of the replacement item’s price is to multiply the “new” product’s price by a coefficient.
* Ignoring the quality difference may result in biased index.
* Overlap imputation assumes that the entire price difference is due to quality difference.
* Overall mean imputation is based on the assumption that the imputed price movement of the missing product is same as the movement of the next higher level of index aggregation.

## 10.11 Data editing

Editing and imputation is an integral part of compilation of price index. Like all survey data, the data of price collection surveys consist of errors. These errors creep in either at the data collection (recording) stage or at the stage of data (coding) capturing. With the use of CAPI, these two stages, however, are not distinguishable. Here we will discuss the data editing procedures applied to minimize both types of errors are discussed briefly.

Data editing is here meant to comprise two steps:

* detection of possible errors and outliers;
* verifying and correction of data.

Identification of errors is carried out by:

* non-statistical checking of input data;
* statistical checking of input data and output checking.

### Non-statistical checking of input data

Non-statistical checking is undertaken by manually checking of the survey data. This is particularly important when price data are collected in the traditional way by recording the data in paper forms. The manual checking is mainly undertaken to

* examine completeness of the data received – this is called checking the coverage,
* identifying some kind of errors relating to ID particulars and
* detecting a selected kind of errors in price quotations.

The checking of the first two kinds is essential at the manual checking stage. Coverage check helps in monitoring the field work as well as provides the basic information on how much of the required data have actually been collected. Wrong ID particulars create all kinds of problems at the data processing stage. Manual checking of ID particulars helps reducing such problems at the data collection stage. Detecting errors in price data by manual examination, however, is extremely time-consuming and does not ensure identification of all errors.

### Statistical checking and output checking

After the price data have been coded, the statistical system can be programmed to present the data in a comparable tabular form. For example, a table showing the percentage change for all reported prices from the previous to the current month may be produced and used for detection of possible errors suing statistical techniques.

Statistical checking of input data compares, for some time period, each price change with the change in prices in the same or a similar sample. The statistical techniques used for this purpose are based mainly on filtering of the following three broad kinds:

1. tests based on the median and quartiles of price changes
2. based on the log normal distribution of price changes.
3. checking by impact, or data output checking.

The first two are beyond the scope of this module. Here, we will briefly describe the third method.

Filtering by impact, or output editing, is based on calculating the impact that an individual price change has on an index to which it contributes. The index can be an elementary aggregate index, the total index, or some other aggregate index. A minimum value for this impact – the product of percentage change and effective weight – is set, so that all price changes that cause an impact greater than this change can be flagged for review.

### Dealing with errors

Some errors, such as data coding errors, can be identified and corrected easily. Dealing with other potential errors is more difficult. Some potential failures may only be resolved by checking the data with the respondent. The methods used in practice are briefly indicated below.

*Treatment of outliers*: We are here concerned with the extreme values that have been verified as being correct. The treatment, therefore, is to reduce the impact of the exceptional observation, though not to ignore it as, after all, it did occur. The outlier adjustment essentially consists of imputation based on comparable set of prices.

*Treatment of missing price observations*: It is likely that not all the requested data will have been received by the time the index needs to be calculated. Likewise, the respondent may not report the price owing to reasons like absence of stock or no transaction during the reporting period. Both these are the cases of *temporarily missing* price data. Again in some cases, the respondent may report that a price cannot be reported because neither the product, nor any similar substitute is being made any more. This is the case of *permanently missing* price data. Treatments of missing data have already been discussed earlier in this session.

*Points to note*

* Manual checking of the price data is essential for coverage checks and identifying wrong ID particulars.
* Records with mistaken ID particulars create problems at the data processing stage.
* Detection of errors in price data is done better by using computer programs.
* Filtering by impact helps detecting the quotations that have unduly high contribution in the index measuring change in price.
* Outliers, even if verified as being reported by the respondent, are treated like missing values while making adjustment.

**Module 10, Session – VIII: Calculation in Practice**

**Test Your Knowledge**

**Exercise – 10.8: Calculation in Practice**

1. State whether the following statements are true [T] or false [F].
2. Calculation of price relatives does not involve any weight.
3. Elementary level aggregation is mostly done without weight.
4. Higher level aggregation is always without weight.
5. If an elementary index is calculated using *Jevon*’s formula, a *temporarily* missing price quotation should be imputed by arithmetic mean of the available quotations.
6. *Temporarily* missing price quotation occurs only for seasonal items.
7. Products for which price quotations become *permanently* missing are substituted by a “new” product or just dropped.
8. Taking no action for a *temporarily missing* item always causes an upward bias.
9. The method of carrying forward, in most cases, leads to biased indices for the months the price remains missing.
10. If an elementary index is based only on those price relatives that are available, the missing price relatives are implicitly imputed by the same value as the elementary index.
11. The national-level indices are then obtained by combining the regional-level indices for elementary indices, product sub-groups and groups, as well as for overall index.
12. *Price updating of weights* is required for aligning price and weight reference periods.
13. In a chain index the weights of a particular year is updated by the price indices of the previous year.
14. Annually chained indices have a common index reference base.
15. The *variable-weight* method assigns zero weights to the items in the months when their prices are not available.
16. Quality adjustment of the replacement item’s price is done by multiplying the “new” product’s price by a coefficient.
17. Overlap imputation assumes that the entire price difference is due to quality difference.
18. Calculate the group price index for D.2 from the following price data. Note that the fourth price quotation of D.2.3 is missing for the month of May and D.2.2 is a seasonal product.

|  |  |  |  |
| --- | --- | --- | --- |
| Elementary aggregate | weight (%) in D.2 | quotation number | prices in  |
| Base period | Current period |
| *Jan.* | *Feb.* | *Mar.* | Apr. | *May* | *June* | *July* |
| **D.2** | **100** | **Group index** |  |  |  |  |  |  |  |
| D.2.1 | 15 | Jevon's |  |  |  |  |  |  |  |
|   |   | 1 | 841.5 | 918.5 | 984.5 | 1090.8 | 1360.8 | 1424.5 | 1620.7 | 1916.3 |
|   |   | 2 | 852.5 | 984.7 | 990.0 | 954.4 | 1156.2 | 1188.0 | 1109.4 | 1086.8 |
|   |   | 3 | 814.0 | 811.0 | 902.0 | 1080.8 | 1068.0 | 1275.5 | 1636.1 | 1562.2 |
|   |   | 4 | 797.5 | 863.5 | 905.4 | 962.5 | 1019.2 | 1063.6 | 1160.9 | 1422.1 |
| D.2.2 | 33 | Jevon's |  |  |  |  |  |  |  |
|   |   | 1 | 23.1 |  |  | 36.9 | 38.8 | 43.5 | 52.4 |  |
|   |   | 2 | 24.5 |  |  | 45.5 | 43.1 | 46.7 | 48.3 |  |
|   |   | 3 | 22.7 |  |  | 24.0 | 30.9 | 31.9 | 34.7 |  |
| D.2.3 | 25 | Jevon's |  |  |  |  |  |  |  |
|   |   | 1 | 7.3 | 9.4 | 11.4 | 13.4 | 13.3 | 16.4 | 20.7 | 20.8 |
|   |   | 2 | 7.9 | 8.2 | 9.7 | 11.0 | 12.8 | 13.5 | 16.5 | 15.4 |
|   |   | 3 | 6.3 | 6.0 | 5.9 | 6.9 | 8.5 | 9.4 | 10.4 | 12.3 |
|   |   | 4 | 5.6 | 5.1 | 4.7 | 4.7 | 5.0 | **N.A** | 6.4 | 7.6 |
|   |   | 5 | 6.6 | 6.9 | 8.5 | 9.4 | 11.4 | 14.6 | 14.2 | 15.2 |
| D.2.4 | 27 | Jevon's |  |  |  |  |  |  |  |
|   |   | 1 | 33.2 | 30.1 | 28.7 | 29.3 | 33.8 | 37.7 | 38.3 | 37.6 |
|   |   | 2 | 32.3 | 41.4 | 37.9 | 35.9 | 39.4 | 44.9 | 51.2 | 65.8 |
|   |   | 3 | 34.1 | 40.0 | 49.6 | 44.7 | 45.5 | 43.5 | 40.1 | 50.7 |

1. See modules 2&3 on National Accounts for definition of factors of production, factor services and factor compensation. [↑](#footnote-ref-1)
2. See Module 6 on National Accounts. [↑](#footnote-ref-2)
3. 3 ‘SNA aggregates’ stand for macro-economic aggregates in System of National Accounts (SNA). Please see Modules 3 & 4. [↑](#footnote-ref-3)
4. This is called a *Dutot* index, as we will see later. [↑](#footnote-ref-4)
5. This is called a *Carli* index. This will be discussed in the following sessions. [↑](#footnote-ref-5)
6. Price relative of an item is the ratio of its price in the current to that in 2010. We will discuss ‘price relatives’ in greater detail later. [↑](#footnote-ref-6)
7. <http://unstats.un.org/unsd/class/default.asp> [↑](#footnote-ref-7)