

# **29<sup>th</sup> Voorburg Group Meeting on Services Statistics**

Dublin, Ireland  
September 22<sup>th</sup> - 26<sup>th</sup>, 2014

## **Cross Cutting Topics – Part 3** **“Chain Linking and Annual Update of Weights for Producer Price Indices for Services in Italy”**

Cristina Cecconi, Istat, Italy  
Francesco Santangelo, Istat, Italy  
Adele Vendetti, Istat, Italy

version of 5th September 2014

## Introduction<sup>1</sup>

Services Producer Price Indices (SPPIs) or Output Price Indices for Services measure quarterly changes in the prices of services purchased by enterprises and Government. This means the SPPIs cover what are commonly known as business to business transactions, thus leaving out sales to households.

According to the *Methodological guide for development producer price indices for services*<sup>2</sup>, SPPIs have two main goals: (a) to provide a short-term indicator of the business cycle; (b) to provide a suitable deflator for value developments, mainly for national accounts. Therefore it is very important for SPPIs to be representative, to be unbiased and to be able, as much as possible, to accurately reflect price changes over time.

Usually indices are built because they are expected to provide a more accurate measurement of the theoretical dimension than any single variable can do alone. Hence, all the variables included in an index should measure different aspects of the same phenomenon. For instance, in a price index this important role is played by prices and weights referring to a basket of services and a sample of units. Prices, weights, basket and respondent units contribute to the closeness of estimate (the index) to the true value of the phenomenon and therefore to the representativeness of the measurement.

### 1 How can a price index maintain its representativeness?<sup>3</sup>

The representativeness of a price index relies on the following elements: index formula; basket of services (and sample of items); sample of units (enterprises); weights. For the same index formula and aggregation structure, the frequency of updating the basket of services, the sample of units and the weights, is crucial for index accuracy. Annual chain-linking of an index helps to reach this scope because it is simply a way of improving the fixed base methodology taking more information into account so to provide a more accurate measure, minimizing the potential bias of the estimate.

Annual chain linking can imply annual updating of:

– *The basket of services*

Prices are collected for a list of services, fixed every year. Annual basket updating can help to reduce bias due to both: (i) the entry of new services in the market against the disappearance of others; (ii) the treatment of quality differences.

---

<sup>1</sup> Attributions to the authors: to C. Cecconi paragraphs 1 and 2; to F. Santangelo paragraph 3; to A. Vendetti paragraph 4. The views expressed in this paper are those of the authors only and do not necessarily represent the position of Istat.

<sup>2</sup> OECD, Eurostat. 2005. *Methodological guide for developing producer price indices*. 2005 Edition. Luxembourg: Office for Official Publications of the European Communities

<sup>3</sup> Some parts of this paragraph refer to International Monetary Fund et al. 2004. *Producer Price Index Manual - Theory and Practice*. Washington, D.C.

In the first case (i), a basket fixed for  $n$  years ( $n > 1$ ), for instance in a fixed base price index, risks to lose representativeness especially for very dynamic markets. Therefore an annual updated basket would be more realistic and reliable.

In the second case (ii), in a dynamic world the same service may change in quality from one observation to another, even though it retains the same general specification, and this is in contrast with the main goal of a price index, i.e. making price comparisons between two periods solely in terms of services that are identical in both periods. Undoubtedly, frequent changes in the basket composition, for example annual renewals, limit this problem to only one year - the current collection year - even if it cannot completely solve it. Basket updating should only exclude those services that are no more representative and not services that have quality changes (since, if one systematically deletes services that change in quality, the price index will tend to be biased upward if quality is improving on the price average; downward on the contrary). During the collection year, observed changes in prices that represents changes in quality can be treated with different implicit or explicit methods (e.g. among the implicit ones the overlap method is very common).

– *The sample of units*

Prices of the services included in the basket are collected from yearly selected units (enterprises).

In price surveys data are collected from the same enterprise many times (panel surveys). In long term, the general problem with such surveys is that the panel of enterprises becomes impoverished and no more representative of the market: some units exit from the market, others are created according to the dynamism of the economic system. The list becomes increasingly unrepresentative as time passes, besides the universe changes and some units may suffer the burden of responding and leave the panel or provide poor-quality data. All these problems cause bias especially when the sample of units is updated every  $n$  year ( $n > 1$ ).

A commonly used method to handle some of these problems is to limit the length of time in which units take part in the sample, by using panel rotation. Obviously, sample rotation has a cost since new panel members need to be recruited. Besides the statistician should decide in advance both the rotation rate and the rotation level (by industry, product group, etc.). Rotation and, therefore, sample revision fit best in a chain-linked index in which the product structure and weights can be updated each year. Given that, annual weights update is not a requirement for sample rotations rather it simply makes the process easier because weights are already updated at most levels of the index. On the contrary, when there isn't an annual weights update, sample rotation usually requires fixed weights at higher levels of index aggregation and separate periodically updated weights for low level indices.

– *The weights*

Weights can be updated every year in order to follow market dynamics.

The calculation of a price index implies the use of weights to represent the different importance of the services (or units), according to the aggregation structure that characterised the index. However, it is a delicate matter combining prices for different services: first of all, different weights must be assigned to different services because not all the services are of equal importance; secondly, the relative importance of services changes over time, some services disappear while new ones enter the market. So it is clear that the weights structure can be accurate in only one of the periods for which the price index is produced. The greater the lapse of time between two weights structures referring to two different periods, the less meaningful the prices comparisons become. Under these conditions it is easy to understand that a price index can give more accurate measures of price changes only for periods close in time. Consequently, annual updating of weights can help to solve these problems.

The most important advantages of annual chain-linking are:

- regular updating of the sample of units maintains the representativeness of the sample itself;
- regular updating of the basket of services allows to follow market trends;
- using the most recent weights better reflects current users behaviors;
- the bias of the estimate (the index) is just limited to the current collection year;
- each year is a chain-link year, therefore the need to subjectively choose when to rebase is avoided;
- introducing new methodologies for the calculation of the index is easier;
- time series revisions, due to rebasing, are not needed.

On the contrary, the well-known shortcomings of the method are:

- the ‘non additivity’ problem: chain-linked index can’t be calculated as weighted mean of the sub-groups indices that compose it;
- it requires a systematic and time-consuming annual work to update the basket, the sample of units and weights.

## 2. The Producer Price Indices for Services in Italy<sup>4</sup>

In order to present the structure of the Italian SPPIs it can be helpful to summarize some basic concepts concerning the construction of a chain-linked price index. Briefly:

- *base period*: it is the base of the price ratios being weighted together at the elementary level of aggregation (e.g. period 0 is the base for the price ratio  $p_{i,y}/p_{i,0}$ , where  $y$  is the current year,  $i$  is the item);
- *weight reference period*: it is the period from which the weights are taken. An index is said to be annually chain-linked if its weights structure is annually updated;
- *reference period*: it is the period for which the index series is expressed as equal to 100. For a chain-linked index changing the reference period simply consists in a “rescaling practice”;
- *chain linking*: it means constructing long-term price measures by cumulating movements in short-term indices with different base periods. In fact chain-linked indices do not have a particular base or weight period. Each link (part of the series of short term indices) of the chain-linked index has a base period and a weight period both changing from link to link. The reference period can be chosen freely without altering the rates of changes in the series.

The main characteristics of the Italian SPPIs are described afterwards.

Firstly, it should be said that they are quarterly indices: data collection, as well as, index calculation and dissemination, take place quarterly.

### 2.1 Method applied

The Italian SPPIs are calculated using a chained Laspeyres formula in which the basket of services, the sample of units (enterprises) and the weights are annually updated.

In an annually chain-linked index, annual update could be limited only to weights. Nevertheless, the wish of better reflecting structural changes of economy as soon as possible, especially in case of dynamic markets (for example: telecommunication, IT activities, etc.), leads to the implementation of an index in which annual updating is extended also to the services and the sample of units.

### 2.2 Chaining method and levels

The chaining method consists in a quarterly overlap: the index is calculated as a series of chained Laspeyres indices linked in correspondence of the fourth quarter of each year.

Chain-linking is operated at each level of the index aggregation: from the elementary index up to the national one. Chaining short term quarterly indices allows to compute

---

<sup>4</sup> Some parts of this paragraph refer to:

- Bloem A. M., Dippelsman R., Mæhle N. Ø. 2001. *Quarterly National Accounts Manual Concepts, Data Sources, and Compilation*. International Monetary Fund
- Eurostat. 2012. *Final report. Task Force Chain-Linking in STS*
- OECD, Eurostat. 2005. *Methodological guide for developing producer price indices*. 2005 Edition. Luxembourg: Office for Official Publications of the European Communities

long time series (at every level of the classification tree of the basket of services), that enables the statistician to analyse consistent series expressed on a fixed reference period.

### **2.3 Base period**

The base period of the index of year  $y$  is the fourth quarter of the previous year  $y-1$ .

### **2.4 Basket of services**

The identification of the services to be included in the basket is a fundamental task in SPPI compilation.

First of all, it aims at identifying those service characteristics that are price-relevant and at distinguishing between apparently similar services. This task tends to be more complex for services than for goods and, in particular, for services provided to enterprises. Full information is often not available because services are typically based on unique contracts between service providers and clients. Besides, it is important that the selection of the services included in the basket follows market dynamics, with the inclusion of new services and the exclusion of the waning ones.

For these reasons, for the Italian SPPIs the basket of services is annually reviewed, and if necessary renewed, for each industry.

### **2.5 Sample of units**

Prices of services are collected from enterprises. Various samples of enterprises give data for calculating different industry SPPIs. Samples are annually drawn from Istat archive of enterprises in which units are classified by their main activity. The archive refers to year  $y-3$ , so it is recommended that statisticians check this information with others sources (i.e. trading associations, websites, information gathered from the price survey itself, etc.) before starting the current survey in order to better update old samples with the new ones.

### **2.6 Weights**

The calculation of producer price indices for services at industry level (2 digit Nace Rev. 2) foresees the use of weights at different levels of aggregation. It is important to highlight some factors:

- Sources of weights:
  - (i) enterprises included in the sample provide data to be used both at enterprise index level to weight elementary indices, according to the classification tree of services, and at national index level to weight enterprise indices;
  - (ii) Istat archive of enterprises (containing the reference universe for each industry) gives weights to aggregate indices at higher levels;
  - (iii) external sources provides data used for weighting subsectors indices at 3 digit Nace level.
- Year of weights:
  - (i) weights at enterprise level are available for year  $y-1$ ;

- (ii) full version of the Istat archive, containing different variables (e.g. enterprise turnover ) refers to year  $y-3$ , meanwhile its short version refers to  $y-2$  (e.g. turnover is grouped by classes);
  - (iii) external sources data refer to year  $y-1$ .
- Weights reference period is year  $y-1$ .

It means that weights are annually updated. For points (i) and (iii), as said, weights already refer to previous year  $y-1$ ; instead, for point (ii) values have to be updated to the same period by using price changes. In particular, for each industry, they are updated with SPPI changes.

## 2.7 Industry based indices

As far as a price index is concerned, there are two common methods for aggregating in a price index data collected from a sample of units to calculate a particular SPPI: (i) the aggregation based on service products provided by any industry either as principal or secondary production (“product based index”); (ii) for each unit, the aggregation of data to calculate enterprise price indices, that are then aggregated in the national index to cover the whole service industry (“industry based index”).

In detail, the Italian SPPIs are industry based indices: they are computed by the aggregation of enterprise indices. The advantage of this method is that the enterprises can use their own familiar service classification, so that the potential classification bias that can derive from a product based index can be reduced. Unfortunately, a shortcoming of an industry SPPI is that the method is unable to provide information about price development of individual services. This could be problematic if the service industry in question includes a large number of different service groups.

## 2.8 Calculation of indices

SPPIs are calculated in two steps: in the first step, elementary price indices are computed; in the second step, higher level indices are calculated by averaging the elementary indices in order to obtain indices up to 2 digit Nace Rev. 2 level.

### 2.8.1 Calculation of elementary indices

#### AT ENTERPRISE LEVEL

The lowest level price index is the ratio between the individual price of a representative service item of the current quarter and the corresponding price of the fourth quarter of the previous year (base period).

Introducing the convention that the fourth quarter of year  $y-1$ , as base period for the link of year  $y$ , is denoted as quarter 0 of year  $y$ ; referring to quarter  $t$  ( $t=1,..,4$ ) of year  $y$  ( $y \neq B$ , where  $B$  is the reference period), at enterprise level, the described ratio is:

$$P_{y,0;j,k}^{y,t} = \frac{P_{y,t;j,k}}{P_{y,0;j,k}} \quad (1)$$

where  $j$  ( $j=1,..,J$ ) is the specific item of the representative service  $k$  ( $k=1,..,K$ ).

## 2.8.2 Calculation of higher level indices

### AT ENTERPRISE LEVEL

For each representative service  $k$ , elementary indices (1) are aggregated by geometric mean:

$$I_{y,0;k}^{y,t} = \left( \prod_{j \in k} P_{y,0;j,k}^{y,t} \right)^{1/J} \quad (2)$$

Then, an higher level index, for service-class  $c$  ( $c=1, \dots, C$ ), is obtained aggregating indices at level (2) by using Laspeyres formula and base period weights:

$$I_{y,0;c}^{y,t} = \sum_{k \in c} I_{y,0;k}^{y,t} \times w_{y-1;k}, \quad (3)$$

where the sum of weights is  $\sum_k w_{y-1;k} = 1$

According to the levels in the classification tree of the basket of services, indices (3) are further aggregated by weighted arithmetic means and base period weights, up to obtain each enterprise index. Services business to business turnovers are used as weights.

### AT INDUSTRY NATIONAL LEVEL

At this stage of the index calculation process, the enterprise indices are combined to subsector-level ( $s=1, \dots, S$ ) indices  $I_{y,0;s}^{y,t}$ , by weighted arithmetic mean (3 digit, Nace Rev. 2). They are weighted using base period business to business enterprises turnovers.

At the last step, subsector-level indices are aggregated to obtain a national-level ( $N$ ) index (2 digit, Nace Rev. 2) using base period business to business subsectors turnovers:

$$I_{y,0;N}^{y,t} = \sum_{s \in S} I_{y,0;s}^{y,t} \times W_{y-1;s} \quad (6)$$

where the sum of weights is  $\sum_s W_{y-1;s} = 1$

Finally the industry national-level index (6) is chained to obtained the corresponding index in the reference period, year  $y=B$ :

$$I_{B;N}^{y,t} = I_{B;N}^{B,4} \times \prod_{n=1}^{y-1} I_{n,0;N}^{n,4} \times I_{y,0;N}^{y,t} \quad (7)$$

## 3 The SPPIs annual updating process

As already described in paragraph 2, the Italian SPPIs are annually chain-linked indices and their updating process includes the updating of: the basket of services, the sample of units, the weights. With reference to year  $y$  (one of the link of index time series), *Figure 1* shows the updating activities tree and *Figure 2* places the same activities on the time line.



Figure 1 - The Italian SPPIs annual updating process: the updating activities tree

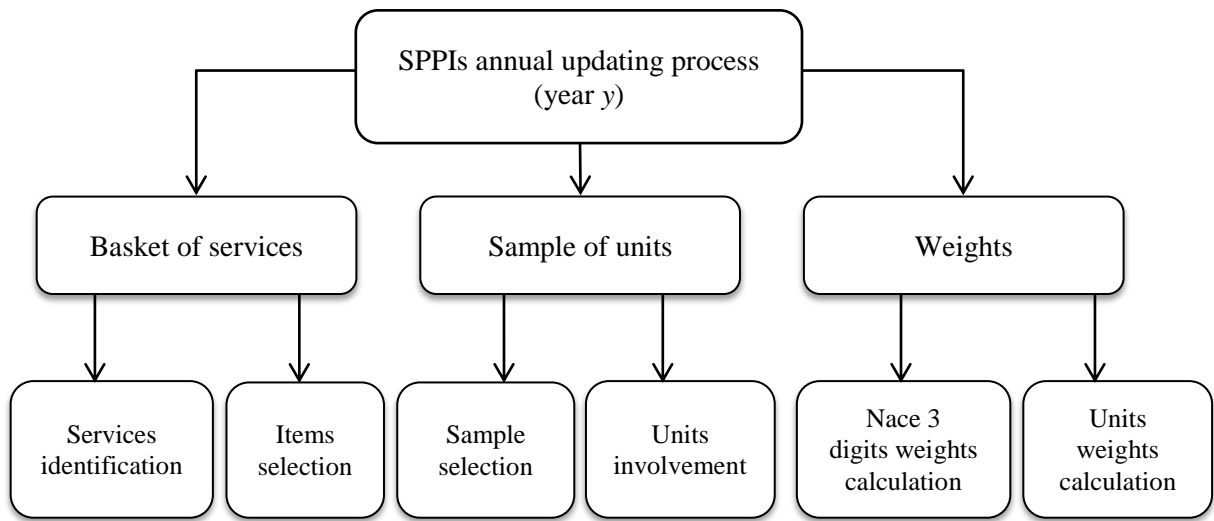
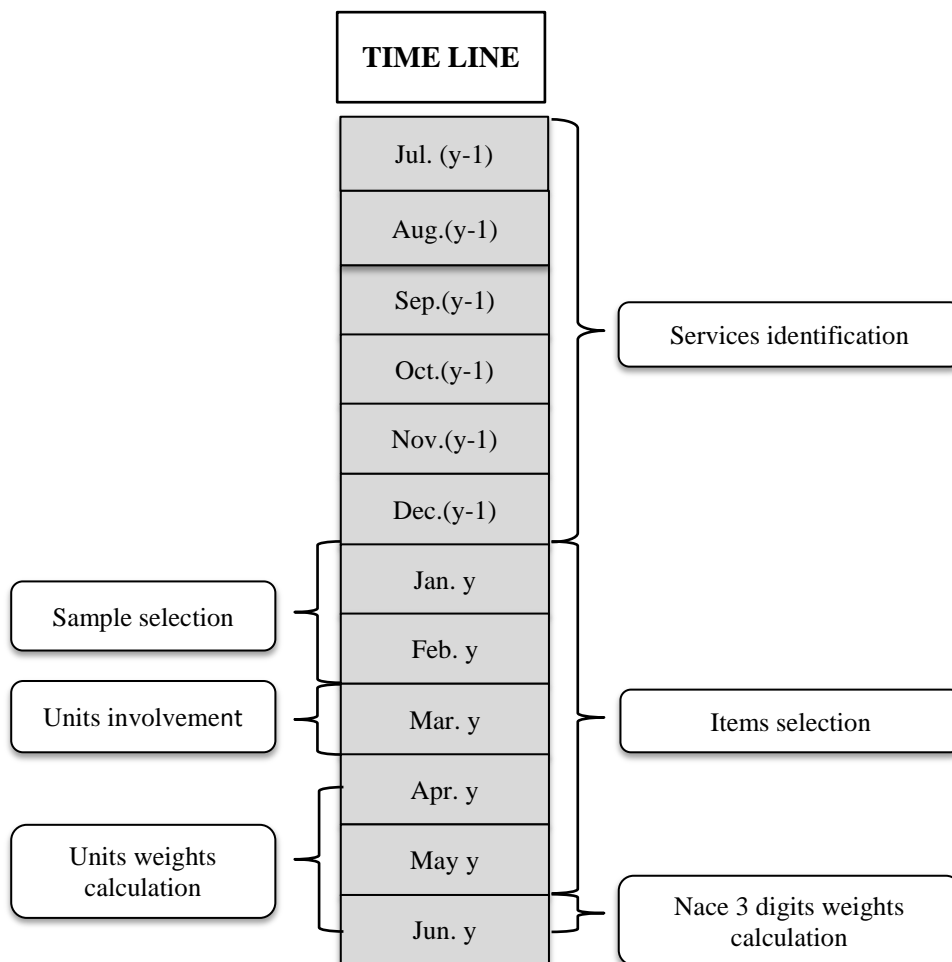


Figure 2 - The Italian SPPIs annual updating process: the updating activities placed on the time line



Detailed information about the lowest activities of the index updating process is described by *Figure 3*, *Figure 4* and *Figure 5*.

*Figure 3* -The annual updating of the basket of services in detail

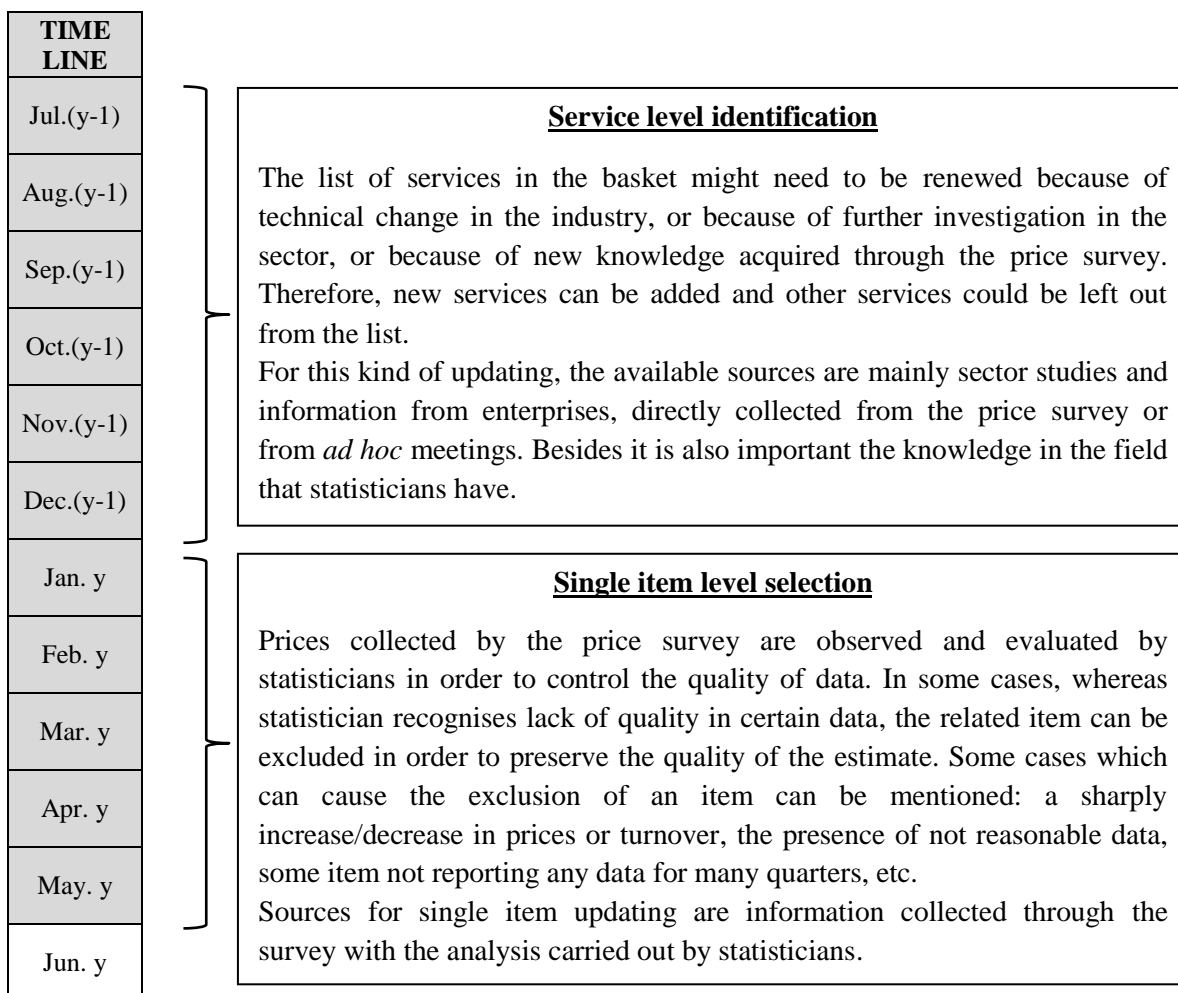


Figure 4 - The annual updating of the sample of units in detail

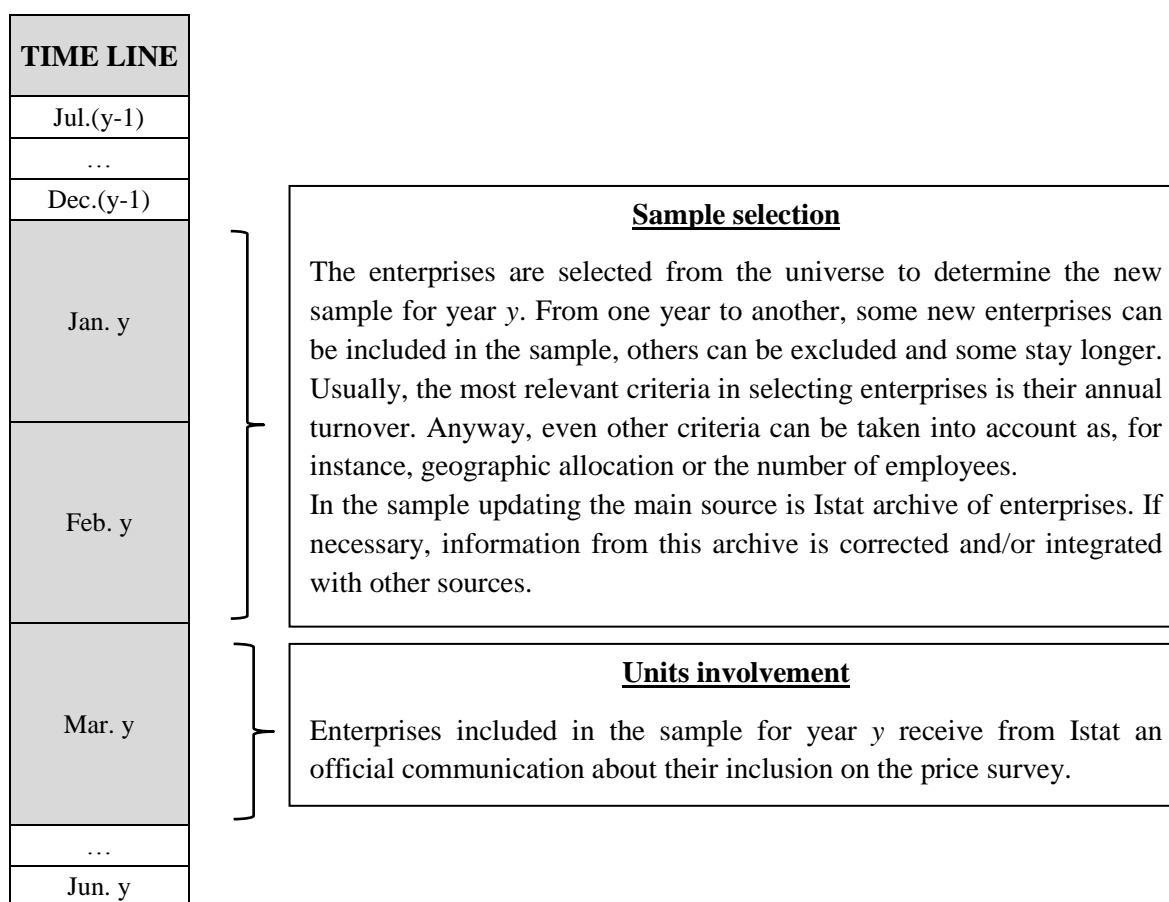
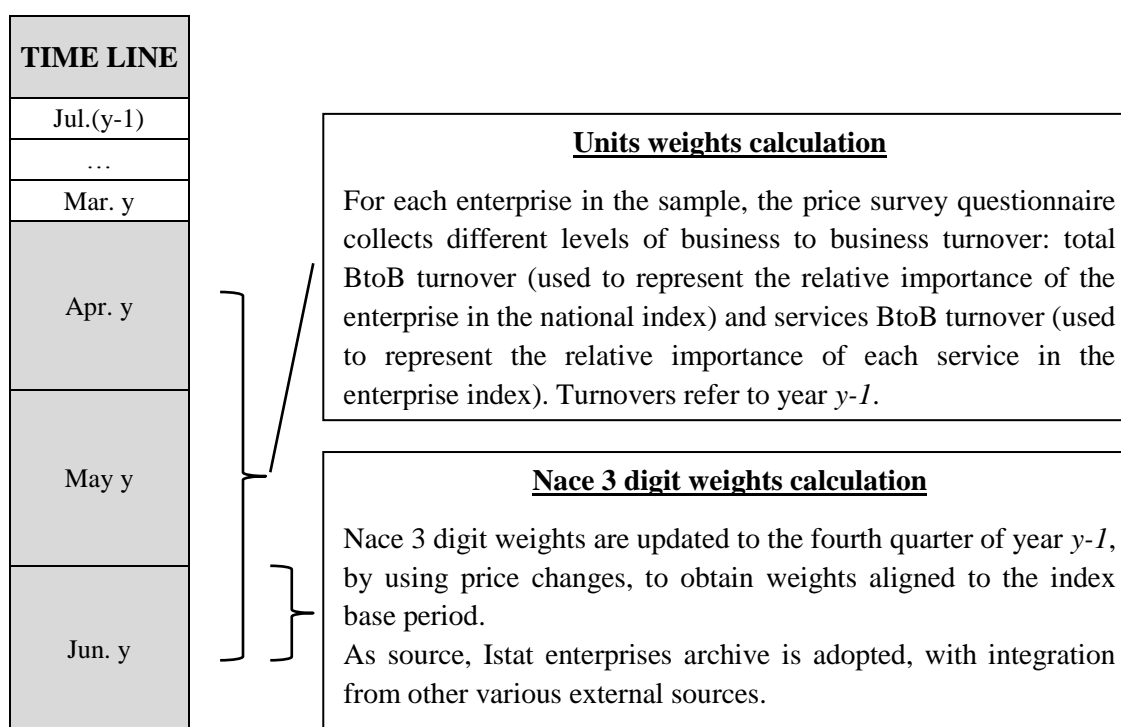


Figure 5 - The annual updating of weights in detail



#### 4 Chain linking versus fixed base approach: an example.

This section provides the results of an exercise carried out with the aim of analysing the effects of using different approaches in computing a price index. The analysis refers to actual data related to a specific industry, quarterly collected through the Italian service producer price survey. Referring to year  $y$ , three methods were applied, indicated respectively as chain-linked index, fixed base index and “mixed index”. All the three indices are price indices of Laspeyres type and their main features are specified in *Table 1* below:

*Table 1* - Features of the calculation methods applied in the example

Index	Base period	Reference period	Weights reference period
Chain-linked index	quarter 4, year (y-1)	2006=100	year (y-1)
Fixed base index	average of year 2006	2006=100	2006
Mixed index	average of year 2006	2006=100	year (y-1)

For all the three indices, the sample of units is the same for the entire period and the reference period is fixed to 2006, while the main differences are:

- (i) in the chain-linked index, both the base period and the weights reference period change yearly;
- (ii) in the fixed base index, the base period and the weights reference period agree with the reference one;
- (iii) in the mixed index, the base period coincides with the reference one and the weights reference period changes from one year to another.

The so-called mixed index was calculated in order to stress the importance of different index forms and above all to highlight how the main features, in particular base period and weights reference period, could affect the index.

Compared to the fixed-base index, the mixed index highlights the weights structure effects because the two indices have the same base period but differ from the weights (annually changing in the former, fixed in the latter). On the contrary, in comparison with the chain-linked index, it shows the contribution of different base periods, since they have the same weights structure.

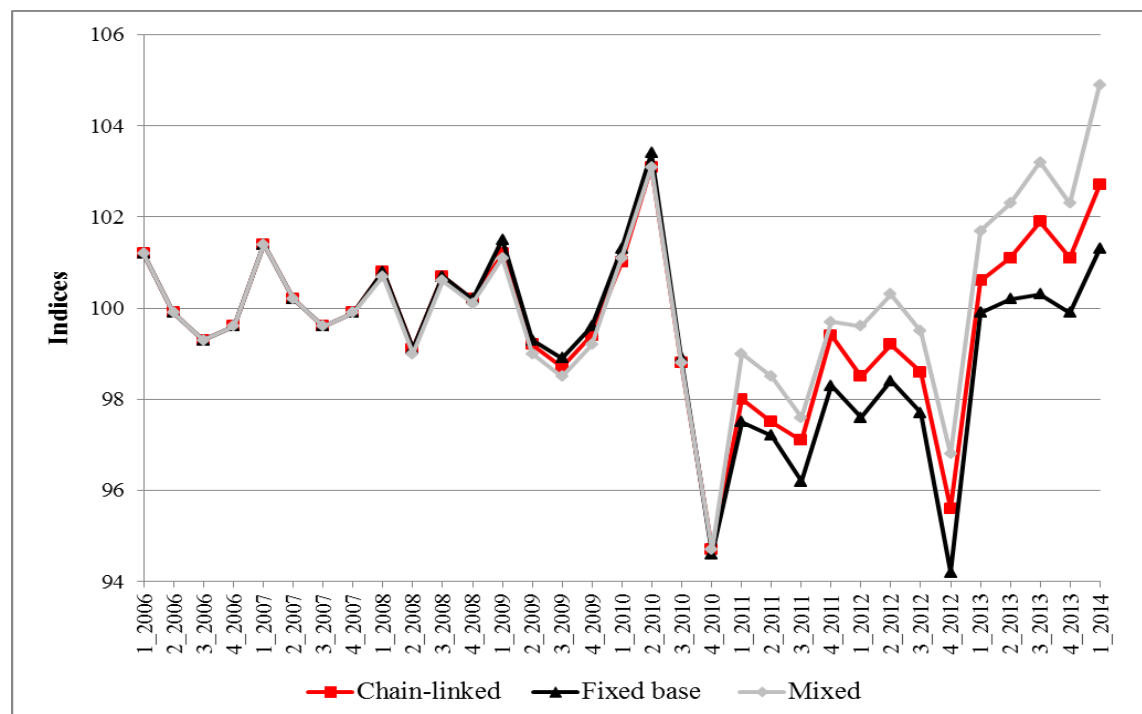
*Figure 6* shows the indices calculated with the methods described in *Table 1*.

Except for the first two years, where the weights structure is stable and the three indices coincide, from 2008 on the position of the chain-linked index is between the other two indices: it seems that, moving away from the reference period, it averages both the effects of yearly updated weights and chain-linked base.

Notably, both the chain-linked index and the mixed index show the effects of the annual change of weights; in particular, the relative movements in composition of weights; as can be seen their behaviour suggests a greater impact when there are significant shifts in the structure. It should be noted that from the beginning of 2012 onward “Service 6” isn’t in the basket because it doesn’t exist in the market anymore; it

means that while such service is still in the fixed base index (its price is repeated), it is excluded from the other two indices (*Table 2*).

*Figure 6* - Comparison of different calculation methods for a SPPI



*Table 2* - Weights structure: percentage distribution by services and annual rates of change

Weights percentage distribution by services									
Services	year								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Service 1	36,8	36,8	34,8	35,1	36,1	37,4	40,6	40,3	32,9
Service 2	22,0	22,0	22,2	21,5	18,1	14,7	17,9	16,7	19,9
Service 3	13,2	13,2	13,0	13,4	16,0	17,8	19,8	20,6	22,8
Service 4	7,0	7,0	8,0	9,1	10,0	11,8	15,2	15,3	17,7
Service 5	12,1	12,1	12,8	12,0	11,5	8,8	6,6	7,0	6,6
Service 6	8,9	8,9	9,2	8,9	8,3	9,6	0,0	0,0	0,0
TOTAL	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Annual rate of change									
Service 1	-	0	-5,2	0,9	2,8	3,3	8,7	-0,7	-18,3
Service 2	-	0	0,7	-3,2	-15,7	-18,8	22,3	-6,9	18,9
Service 3	-	0	-1,8	2,8	20,1	10,7	11,3	4,5	10,7
Service 4	-	0	15	13,4	9,8	18,3	28,5	0,9	15,8
Service 5	-	0	6,2	-6,1	-4,6	-23,4	-25,5	7,3	-5,7
Service 6	-	0	2,5	-2,8	-7,1	16,3	-100	-	-

In general, the observed services present reasonable annual average price rate of changes (*Table 3*). This stems from the fact that the observed industry is characterised by low levels in the prices of services and by slow price movements from the base period. The last point implies negligible differences between the annual average rates of change of elementary indices in the chain-linked index and the same rates of change of elementary indices in the fixed base and mixed index (*Table 4*).

Conversely, in 2011 greater price variations of some services occur, in most cases characterised by important rates of change in relative weights as well, causing a clear difference in the annual average rate of change of the chain-linked and mixed indices respect to the fixed one (*Table 3* and *Table 4*). Afterwards, the chain-linked index tends to produce higher levels than the fixed base index due to the oscillatory behaviour of price and weights of the services investigated in successive periods.

*Table 3* - Annual average rates of change of elementary indices for different methods (different values are in bold)

Elementary indices annual average rate of change							
Services	year						
	2007	2008	2009	2010	2011	2012	2013
<b>CHAIN- LINKED</b>							
Service 1	0,555893	<b>0,823893</b>	<b>1,069009</b>	<b>2,043474</b>	-1,823664	0,039399	-0,695737
Service 2	-2,586131	<b>0,183124</b>	0,989806	<b>-1,224251</b>	0,622139	-0,269812	<b>15,691406</b>
Service 3	1,573291	<b>-0,042363</b>	<b>2,121419</b>	<b>1,561716</b>	<b>-0,268434</b>	-0,587157	<b>3,662990</b>
Service 4	-7,131884	-2,115481	<b>-6,056444</b>	1,063606	<b>14,194939</b>	-0,746755	<b>6,047091</b>
Service 5	5,822550	-0,695250	-7,468220	-8,528464	-24,177068	-1,025753	-11,553205
Service 6	2,607001	-1,991669	0,145625	<b>-0,323301</b>	1,229989	-	-
<b>FIXED BASE and MIXED INDEX</b>							
Service 1	0,555893	<b>0,823894</b>	<b>1,069008</b>	<b>2,043475</b>	-1,823664	<b>0,039400</b>	-0,695737
Service 2	-2,586131	<b>0,183125</b>	0,989806	<b>-1,22425</b>	0,622139	<b>-0,269811</b>	<b>15,691405</b>
Service 3	1,573291	<b>-0,04236</b>	<b>2,121418</b>	<b>1,561717</b>	<b>-0,268435</b>	-0,587157	<b>3,662989</b>
Service 4	-7,131884	-2,115481	<b>-6,05644</b>	1,063606	<b>14,194938</b>	-0,746755	<b>6,047092</b>
Service 5	5,822550	-0,695250	-7,468220	-8,528464	-24,177068	-1,025753	-11,553205
Service 6	2,607001	-1,991669	0,145625	<b>-0,323300</b>	1,229989	0	0

*Table 4* - Annual average rates of change for different calculation methods

Annual average rate of change							
	Year						
	2007	2008	2009	2010	2011	2012	2013
Chain-linked index	0,3	-0,1	-0,6	-0,2	-1,4	0,0	3,2
Fixed base index	0,3	-0,1	-0,4	-0,3	-2,3	-0,3	3,2
Mixed index	0,3	-0,2	-0,7	0,0	-0,7	0,3	3,4

## **Bibliography**

- Allen R.G.D. 1975. *Index numbers in theory and practice*. Macmillan Press
- Bloem A. M., Dippelsman R., Mæhle N. Ø. 2001. *Quarterly National Accounts Manual Concepts, Data Sources, and Compilation*. International Monetary Fund
- Eurostat. 2012. *Final report. Task Force Chain-Linking in STS*
- Forsyth F. G., Fowler R. F. 1981. The theory and practice of chain price index numbers. *Journal of Royal Statistical Society (2)* Vol. 144, 1981, 224-246
- Goodridge P. 2007. Index numbers. *Economic & Labour Market Review* Vol. 1, No 3, March 2007
- International Monetary Fund et al. 2004. *Producer Price Index Manual - Theory and Practice*. Washington, D.C.
- Istat. 2014. *Prezzi alla produzione dei servizi - Nota metodologica*
- OECD, Eurostat. 2005. *Methodological guide for developing producer price indices*. 2005 Edition. Luxembourg: Office for Official Publications of the European Communities
- Robjohns J. 2006. Methodological Notes: Annual chain-linking. *Economic Trends* 630, May 2006