Calendar and Seasonal adjustment of the LCI: direct versus indirect approach. The Italian experience

Anna Ciammola and Donatella Tuzi

This work focuses on the calendar and seasonal adjustment of the LCI. The direct and indirect approaches are compared, evidencing main advantages and drawbacks. Since aggregation of chain linked indices requires dealing with non-additive issues, methodological approaches and practical solutions are presented.

1. Introduction

The hourly Labour Cost Index sets out to be a system of indices, where elementary components are the indices for both wages and other costs by NACE section and aggregates are: i) the total labour cost indices by NACE section and ii) the indices of wages, other costs and total labour cost referred to the NACE aggregates. In such a system, good practice is to preserve internal coherence between components and aggregates. This accounting identity is always fulfilled in the compilation of unadjusted data, while in the production of calendar and seasonally adjusted data the outcome depends on both the approach used and the number of series treated. In these contexts, calendar and seasonal adjustment could be carried out through two possible strategies: on the one hand, the independent treatment of each series, i.e. components and aggregates (direct approach); on the other hand, the treatment of components and then their aggregation according to the same rules and weights utilized for unadjusted data (indirect approach). The issue of whether adjustment should be direct or indirect is still an open question and neither theoretical nor empirical evidence uniformly favours one approach over the other. The direct approach could be preferred for transparency, accuracy and replicability, especially when the ARIMA model-based method is used, while the indirect approach could be preferred for dissemination purposes as it ensures a perfect coherence between components and aggregates. As far as this latter matter is concerned, it is worth stressing that incoherencies may easily emerge using the direct approach when the aggregate derives from only few components (especially in the comparison of growth rates). This case fits the LCI system well. The indirect approach represents a good alternative, but it requires the aggregation of chain linked Laspeyres indices for which the additivity is not fulfilled. This paper deals with the aggregation of chain linked indices and shows, exemplifying with the Italian LCI, that calendar and seasonally adjusted chained indices can be aggregated using a weighting system suitably derived from the weighting system used to aggregate previous year based indices (i.e. indices to be chain linked afterwards and, therefore, additive). Paragraph 2 reminds EC requirements and recommendations on working day and seasonal adjustment of the LCI; in paragraph 3 sources and methods for the compilation of the Italian LCI are briefly described. Paragraph 4 motivates the transition from direct to indirect approach in the adjustment of the Italian LCI. A methodological description of the new system of weighs is the object of paragraph 5. Direct and indirect approaches are compared in paragraph 6 taking into account several quality indicators. Paragraph 7 concludes.

2. Seasonal and working day adjustment of the LCI: Eurostat requirements and recommendations by the Regulation

The EC Regulation No 450/2003 requires Member States comparable labour cost indices (LCI) at quarterly frequency. The three labour cost components, namely total labour costs, wages and salaries and other labour costs, to be expressed in terms of hours worked, must be provided separately, according to a fixed structure of economic activity at Nace Rev. 2 section level. Indices at section level have to be expressed as simple indices while the aggregates are Laspeyres indices chain linked annually. All indices must refer to a fix base, at the moment settled to 2008.
Article 1 of Commission Regulation (EC) No 1216/2003, implementing the EC-R No 450/2003, states that Labour Cost Index figures have to be transmitted in non-seasonally adjusted (UNADJ), working-day adjusted (CA) and working-day and seasonally adjusted form (SA). This Regulation does not explicitly state

whether working day/seasonal adjustments have to made using the direct or the indirect approach[1] or which software or method to apply, addressing member states to refer to the European Statistical System (ESS) Guidelines on Seasonal Adjustment and report on the national metadata the solutions adopted. The ESS Guidelines recommend to consider both statistical criteria to assess the quality of the adjustment (smoothness of aggregates, presence of residual seasonality, stability of the model and measures of revisions) and user demand (consistent and coherent outputs) when selecting the adjustment method (Eurostat, 2009). More in depth, direct approach should be preferred for clarity, especially when component series show similar patterns. In this case the production of consistent seasonally adjusted data and the use of coherent seasonal adjustment parameters should be monitored. The indirect approach should be preferred where component series show significantly different patterns. The presence of residual seasonality and calendar effects should be monitored. In case of direct approach, discrepancies should be removed through benchmarking techniques, but aiming at consistency between lower and higher level aggregates (users requirements) is not to be considered the main objective when selecting the approach.
When time series to be treated are expressed in the form of chain-linked measures the Guidelines on Seasonal Adjustment (Mazzi, 2014) recommend to work by unchaining the seasonal adjusted component series and deriving totals from unchained series and then chain-linking the aggregates when the indirect approach is used. In case of direct seasonal adjustment on each individual chain linked series, attention must be paid on the presence of residual seasonality. To be avoided is the seasonal adjustment of unchained series followed by the imposition of temporal constraints on chain linked seasonal adjusted series.
In the LCI domain Eurostat uses the direct method to aggregate the European figures. National working-day adjusted data is aggregated to European aggregates and subsequently seasonally adjusted. National data that are already adjusted are not further treated by Eurostat (at least the yearly mean is restored to 100). Seasonal adjustment is performed trough TRAMO-SEATS in combination with Demetra. Once a year all the series are processed individually using Demetra interface to TRAMO-SEATS and, after finding a preferable set of options and parameters, they are stored to be used later in the production database of the LCI. Every quarter when updating new LCI data to the production database, the raw series are processed automatically in TRAMO-SEATS by using the parameters created in the annual Demetra session (see: Eurostat/D1/LCI/6/04 and Eurostat/E1/Sal/14/02). If needed, a more detailed Demetra process can be executed at any time to ensure that the resulting seasonally adjusted series are of good quality. European aggregates are adjusted starting from the aggregated WDA series. Seasonal and working day adjusted data delivered by all Member States are systematically checked by Eurostat to verify the coherence of the total index and its sub-components by Nace section, introducing a policy of publishing only the total index, hiding the components if they differ by more than 2 basis points from the total (see: F3 Report 2014 from the Commission to the European Parliament and the Council on the implementation of Regulation (EC) No 450/2003 concerning the LCI).

3. The Italian LCI

A unique source of data for the compilation of the Italian LCI does not exist, implying the exploitation of several sources, involving business surveys and National Accounts data and requiring methodological solutions aimed at integration (Istat, 2014). Indices of the business economy sectors (sections from B to N) are compiled using data from three coherent and harmonized sources: the census monthly survey on large enterprises (LES)[2], the quarterly sample survey on job vacancies and hours worked (VELA)[3] and a survey on employment, wages and labour cost (OROS) mainly based on Social Security data[4]. These three sources outline a system of unified processes (in terms of definitions, collection of micro data, processing phases and target outputs) aimed at producing harmonized short terms indicators on labour input and labour costs at Istat (Baldi et al, 2011). In the system i) OROS-LES is used both as the current quarter population frame and

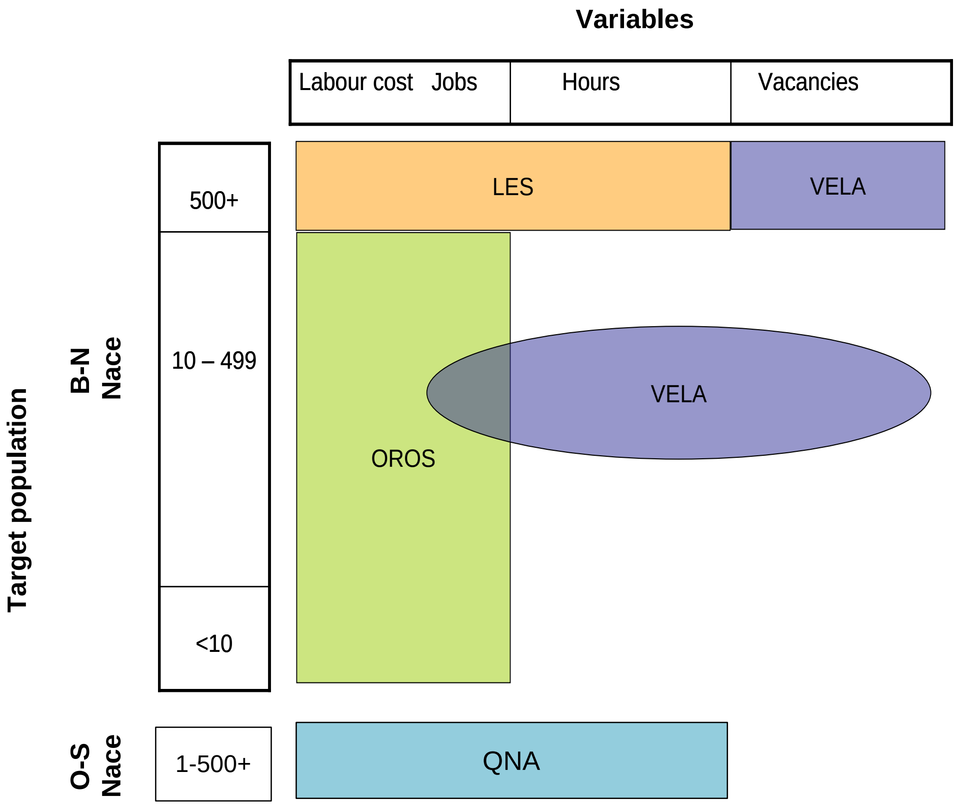
[1] Indirect adjustment implies that the adjustment is made only on the basic series, which are then used to construct higher-level aggregates. Direct adjustment implies that every single series, including higher-level aggregates, are adjusted individually.
[2] For more details about LES refer to the Information System for Survey documentation and Quality Control (Siqual), available on Istat's Internet website: http://siqual.istat.it/SIQual/lang.do?language=UK.
[3] Further details on VELA can be found in the Siqual link: http://siqual.istat.it/SIQual/lang.do?language=UK.
[4] For a brief description of the OROS survey see Rapiti et al. (2010) and at the Siqual link: http://siqual.istat.it/SIQual/lang.do?language=UK.

as the census based source of information for average quarterly jobs, wages and other labour costs variables; ii) VELA-LES is used as the sample based source of information for jobs at the end of the quarter, job vacancies and hours worked. At the basis of the system a very strict scheduling of the processing time, in order to guarantee the accomplishment of the various deadlines. The LCI is one of the final outputs of this system, where all the three sources are integrated.
The following formula, expresses how each component of the quarterly per hour labour cost ($hTLC^t$) is calculated into the system, clearly showing the high integration level that characterizes the system:

$$hTLC^t = \frac{TLC^t}{THW^t} = \frac{{}_jTLC^t_{OROS+LES} \cdot {}_jJ^t_{OROS+LES}}{{}_jTHW^t_{VELA+LES} \cdot {}_jJ^t_{OROS+LES}} \qquad [1]$$

Where ${}_jTLC^t_{OROS+LES}$ is the per-capita indicator on total labour cost and ${}_jTHW^t_{VELA+LES}$ is the per-capita indicator on hours actually worked. The three sources reconciliation passes through the number of jobs ${}_jJ^t_{OROS+LES}$ calculate in the OROS-LES subsystem.

Figure 1: The Italian LCI: sources, variables and coverage.



The VELA-LES source produces hours worked time series starting from Q1:2000 with the exception of section L, available since Q4:2014 for which an extrapolation of past data is used. Data collected by VELA and LES Surveys refers only to businesses. Administrative data at the basis of OROS only partially represents public administration, therefore these three sources are inadequate to compile LCI figures on the O to S aggregates, for which data are extracted from Quarterly National Accounts figures and calculated through an ad-hoc procedure, aimed at providing harmonized indicators.

4. Seasonal and working day adjustment of the Italian LCI: from direct towards indirect approach

The structure of the LCI system is quite complicate, being characterized by 3 variables (wages, other costs and total costs) by 18 sections to be expressed as simple indices (54 time series) and 8 sectorial aggregates as

chain linked Laspeyres (24 time series). In total, 78 time series have to be treated to remove working day and seasonal effects.
Since the delivery of June 2009, the Italian practice follows the indirect approach, overcoming the previous direct treatment procedure. The new procedure implies the adjustment of the totals to be dependent from the treatment of the components: the total labour cost aggregate by section, as well as the totals of each labour cost component are derived by summing up the related adjusted component series.
The transition to the new seasonal adjustment approach has been stimulated by several drawbacks produced by the direct approach. This latter was, at a first stage, chosen to afford some of the complexities of the LCI system of time series. Firstly, the volatility of the hours worked at the denominator, that would have significantly benefited by the independent adjustment of the single time series. Furthermore, to prevent the aggregates by *spurious* seasonality due to the low quality of the ARIMA models estimated for some of the components, particularly the other costs series by definition more volatile than wages (Ciammola et al., 2009). On the other hand, the direct approach does not guarantees *consistency* between the adjusted aggregate and its components In the case of the Italian LCI indices, this problem was particularly noticeable in relation to the total labour cost aggregate, because of the number of the composing variables (only two) and the fact that although highly correlated, the components may be affected by different exogenous interventions (changes in regulations that involve only the other costs, occasional payments not subjected to social security contribution, etc.).
In order to reduce this inconvenience several expedients have been undertaken along the time. Firstly, the ARIMA models for the sectorial totals were approximated to the ones chosen for the leading variable in the aggregate (i.e. wages that represent about 2/3 of the total cost). Same strategy for the most irregular time series of the other labour cost component whose ARIMA models, approximated to those of the corresponding wages, implied a reduced number of inconsistencies but a higher propensity to revision when new observations were available for the estimation. In order to show the severity of the consistency implication, table 1 in the appendix reports the percentage number of inconsistencies, on the total number of observations, in terms of q-on-q changes calculated from a simulated direct seasonal adjustment of the Italian LCI series[5]. The period ranging from I quarter 2000 to IV quarter 2014 is considered for a total of 60 observations (59 q-on-q changes).
Table a.1 in the Appendix shows as sectorial incoherencies are quite absent in the largest aggregates, affecting those totals where the number of components is low. A different situation distinguishes the compliance of the sectorial coherence between the total labor cost and its 2 components: here the number of inconsistencies is not negligible. In such a situation the adoption of an indirect approach aimed at restoring coherence was seriously considered.
The adoption of the indirect approach requires the existence of an additive relation between aggregates and related components. In the LCI system this relation is easily obtainable for the total labour cost index by section, that can be expressed as linear combination of the simple indices of the two components, wages and other costs (see Ciammola and Tuzi, 2010). As far as the aggregation over the economic sectors the question entails some more complications due to the chain linking. In fact, this passage inhibits the additive property that characterizes the Laspeyres index. As a result the indices for the totals cannot be compiled by simply aggregating the sectorial elementary indices through the original weighting system: the weights used to compute the total unadjusted indices, that are indices not chained yet, are inadequate to calculate indirectly the adjusted series, that must include the chaining.
In order to re-establish additivity in the Italian LCI system the unchaining approach suggested by the ESS guidelines (§2) has been discarded in favour of a more articulated but consistent solution: a new weighting system has been derived, where the new weights are obtained by applying a correction to the original weights that implicitly incorporates the chain links. The methodological description of the new structure of weights is the objective of next section.

5. A small insight into the methods to aggregate CA and SA LCI indices

From a definitional point of view, the main variables contributing to the calculation of the LCI draws a two-way classified system of indicators that should satisfy two cross-sectional aggregation constraints, the one

[5] Referring to coherence in terms of q-on-q growth rates, inconsistency between an aggregate and its components is intended when q-on-q growth rates are not included in the range of the q-on-q growth rates calculated for the components.

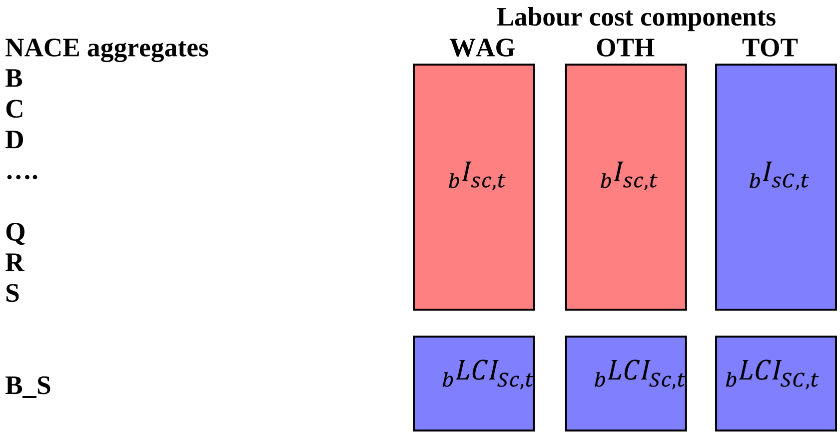
involving the sectorial aggregation, the other concerning the total labour cost as aggregation of wages and other labour costs.
Let S be the set of cross-sectional aggregation constraints over the three labour cost components in each sector s, and C the set of labour cost components cross-sectional aggregation constraints over the sectors in each Labour cost component c. These set of constraints can be written (following Dagum and Cholette, 2006) as:

$$Y_{sC,t} = \sum_{c=1}^{C-1} Y_{sc,t} \quad \forall\, s \tag{2}$$

$$Y_{Sc,t} = \sum_{s=1}^{S-1} Y_{sc,t} \quad \forall\, c \tag{3}$$

where $Y_{sc,t}$, $Y_{Sc,t}$ and $Y_{sC,t}$ represent the interest variables observed at quarter t and referred, respectively, to the sectorial component (sc), to the sectorial total cost (sC) and to the total component (Sc).
Let us imagine the system organized in a two-way table whose rows and columns are, respectively, the NACE sections and the labor cost components.

Figure 2: A two-way table representing part of the LCI system (only aggregate B-S is reported).



In the system, for each quarter, there are S constraints linking the components series to the "row" marginal totals $Y_{sC,t}$ and C constraints linking the component series to the "column" marginal totals $Y_{Sc,t}$. When CA and SA are performed, the fulfillment of these constraints (implying a perfect coherence in the system) is strictly dependent on the chosen approach.
As far as the UNADJ indices is concerned, LCI-R and Eurostat recommendations suggest different formulas to compile hourly indices of the three labor cost components referred to the NACE sections B to S (and to other aggregates, namely B to E, B to F, B to N, G to J, K to N, G to N, O to S and B to N). The former are elementary indices and the latter are chain-linked Laspeyres indices. As a consequence, the indices of the total labor cost by NACE section can be easily derived as weighted average of the indices referred to the two components (wages and other costs), while the indices of the NACE sectorial aggregates cannot be aggregated since the chain linking destroys their additivity.
This issue has a crucial implication in the choice of the approach to be used for the SA of the aggregates: the weights used to compute the total unadjusted indices, that are indices not chained yet, are inadequate to calculate indirectly the SA series that must include the chaining. Two approaches can be considered to deal with the aggregation of non-additive indices:
1. the approach suggested by the new ESS guidelines on SA based on three steps: i) unchaining of the chain-linked SA components to express them as indices in the previous year base; ii) aggregation of the unchained SA components to derive the unchained aggregate; iii) chain-linking of the SA aggregate;

2. the approach based on the direct aggregation of chain-linked SA components deriving a new convenient set of weights from the original set of weights used to aggregate unchained NSA components (for details see Ciammola and Tuzi, 2010)[6].
The main drawback of the first approach is that, when calendar effects are statistically significant and CA chain linked indices are compiled, the annual weights to be used to aggregate CA and SA unchained indices should be adjusted to remove calendar effects[7]. This requires a procedure for the CA of the annual weights and, therefore, the handling of a double set of weights (the one for UNADJ indices and the other for CA and SA indices). Table 1 explains why annual weights should be adjusted for calendar effects. In the example reported, both the UNADJ and CA aggregate, A, are obtained aggregating the UNADJ and CA components, C1 (whose calendar effects are assumed to be null) and C2 with the same weights. Growth rates referred to *base year*+2 and *base year*+3 show how the aggregation of unchained CA indices using the original weights does not consider that calendar adjustment is null for component C1, while it is positive for component C2.

Table 1: Aggregation of UNADJ and CA indices using the same weighting system.

Year	Weights		Unadjusted indices							Calendar adjusted indices						
			Unchained			Chain linked			% growth	Chain linked		Unchained			Chain linked	% growth
	C1	C2	C1	C2	A	C1	C2	A	rates of A	C1	C2	C1	C2	A	A	rates of A
Base year+1	7.00	3.00	101.0	101.0	101.0	101.0	101.0	101.0		101.0	105.0	101.0	105.0	102.2	102.2	
Base year+2	7.07	3.03	114.3	133.3	120.0	115.4	134.7	121.2	20.0	115.4	140.0	114.3	133.3	120.0	122.6	20.0
Base year+3	8.08	4.04	112.5	125.0	116.7	129.9	168.3	141.4	16.7	129.9	175.0	112.5	125.0	116.7	143.1	16.7
Base year+4	9.09	5.05	111.1	120.0	114.3	144.3	202.0	161.6	14.3	144.3	190.0	111.1	108.6	110.2	157.7	10.2

Although based on the original weights, the second approach allows overcoming the problem described in the above table because it is based on the direct aggregation of chain-linked CA and SA components. Consequently, there is no need to adjust annual weights for calendar effects. Moreover, the use of a modified weighting system reduces the aggregation of chain-linked indices to a simple weighted average.
The main drawback in the use of a modified weighting system is the lack of additivity (in a sense the problem is shifted from indices to weights). The following example can illustrate the problem.
Let *c1*, *c1* and *c3* be three components and *a1* and *a2* two aggregates derived, for a year *y*, as:

$$a1=f_y(c1,c2)$$

$$a2=g_y(c1,c2,c3).$$

When the three components are unchained indices, their weights can be used to derive both aggregates *a1* and *a2*. On the contrary, if they are chain-linked indices and the modified weights are used, components *c1* and *c2* will have one weight to derive *a1* and a different weight to derive *a2*. In order to avoid the computation of many weights (five weights in this example), a more efficient solution is to derive *a2* as

$$a2= h_y(a1,c3)$$

requiring only one weight for *a1* and another one for *c3* (a total di four weights).
Figure 3 shows how the proposed approach, requiring different sets of weights to be applied *hierarchically*, can be performed for the CA and SA of the LCI domain. All the indices can be obtained through the following steps:

1. CA and SA is applied of the elementary indices of wages and other labor costs by NACE section;
2. total cost by section is calculated from indices obtained in step 1.;
3. wages, others costs and total cost referred to the aggregates B-E, G-J, K-N and O-S are computed aggregating indices derived in step 1 and 2;

[6] Two routines have been implemented in SAS and R by the authors of this document. They are available upon request.
[7] Adjustment of annual figures to remove calendar effects is not novel in the domain of short-term economic indicators, as it is currently performed for quarterly national accounts.

4. wages, others costs and total cost referred to the aggregate B-F are computed using indices derived in steps 1. and 2. (for section F) and 3. (for the aggregate B-E), while those referred to the aggregate G-N using indices derived in step 3.;
5. wages, others costs and total cost referred to the aggregate B-N are computed using indices derived in steps 4.;
6. wages, others costs and total cost referred to the aggregate B-S are computed using indices derived in steps 3. (for the aggregate O-S) and step 5. (for the aggregate B-N).

This hierarchical path assures the calculation, the handling and the storing of the minimum number of weights.

Figure 3: The flow of the Italian LCI WDA and SA procedure(*).

NACE aggregates	**Labour cost components** WAG	OTH	TOT
B C D …. Q R S	**Step 1** $_{b}I_{sc,t}$		**Step 2** $_{b}I_{sC,t}$
B-E, G-J, K-N, O-S	**Step 3** $_{b}LCI_{Sc,t}$		
G-N (G-J+K-N), B-F (B-E +F)	**Step 4** aggregation of $_{b}LCI_{Sc,t}$ and $_{b}LCI_{Sc,t}$ + $_{b}I_{sc,t}$		
B-N (B-F+G-N)	**Step 5** aggregation of $_{b}LCI_{Sc,t}$		
B-S (B-N+O-S)	**Step 6** aggregation of $_{b}LCI_{Sc,t}$		

(*) In the figure above, *b* stands for the base year, *s* for the Nace section and *S* for the related (sub) aggregates, *c* is the generic labour cost component (*C* is the TLC), *I* is the simple index and *LCI* the Laspeyres chain index, *t* is the quarter.

6. The Italian experience in the SA of LCI indices: direct and indirect adjustment

The adjustment of the Italian LCI time series is performed through a Reg-ARIMA model-based approach using, at a first stage, JDemetra+ (version 2.0.0) to identify models and, at a second stage, TRAMO-SEATS (Linux version, 2010) to estimate parameters and to derive adjusted series. Before the adjustment for seasonality, the series are pre-treated for calendar effects according to the ESS Guidelines on Seasonal Adjustment (Eurostat, 2009). This pre-treatment is performed only for those series showing significant and plausible effects through a unique regression variable built from a country specific calendar. Since calendar effects are not null over the years, the calendar adjustment does not ensure that the average of the CA data is 100 for the reference base year. The CA series are then rebased.[8]
The seasonal adjustment strategy is based on a *partial concurrent* adjustment approach that implies models, filters, outliers and calendar regression variables to be re-identified once a year, while the respective

[8] When the indirect approach is used to adjust the indices for the calendar effects, such rescaling should be performed after the aggregation, especially for European aggregates. In fact they are generated aggregating national CA indices that reflect the features of different national calendars.

parameters and factors re-estimated every time a new or revised data becomes available. The choice of this approach is aimed at minimising the size of revisions and guaranteeing seasonally adjusted data as accurate as possible at any given time point. The identification of the new models is normally performed with the first quarter release, when most of the interventions implying revision on raw data are concentrated. Each quarter, the appropriateness of the identified models and the results of the seasonal adjustment process are evaluated analysing the quality measures and diagnostics provided by TRAMO-SEATS. More in depth analysis on revisions and stability of the estimates are considered when models are re-identified once a year. In this step the diagnostic facilities available on JDemetra+ are also used. Once a year indirectly seasonally adjusted series are tested to check the presence of residual seasonality. Two procedures are used: firstly, series already adjusted are further submitted to adjustment through JDemetra+ to verify the absence of any seasonal component. Secondly, the same series are submitted to the automatic test for seasonality available in JDemetra+[9]. The choice of the indirect approach to seasonally adjust aggregates is the results of a comparison based both on the consistency between SA components and SA aggregates (as already said in § 4) and on the stability of SA data over time (occurring when the revisions to the past estimates are small as new data are added into the estimation procedure). In order to provide a measure of stability of the seasonally adjusted LCI an exercise reproducing the revisions history implemented in X12/X13 (US Census Bureau, 2014) is implemented.
This technique compares the revisions on the seasonally adjusted data produced by the RegArima model estimated for the original time series with the adjusted data from the same model with parameters re-estimated on a decreasing number of observations. Several revision measures can be used for revision analysis. In this exercise we refer to the concurrent target that is the estimate of the adjusted data for t when $t < T$ that is the most recent observation of the time series. This gives a measure of the change in the seasonal adjustment when more data are added in the time series.
In this exercise revisions have been calculated omitting 12 quarters from the initial time series and gradually adding 1 observation for a new estimate. Revisions have been evaluated comparing the seasonal adjustment of each quarter t (belonging to the range of the omitted data) with the estimates obtained adding 1, ..., 4, 8 and 12 observations to the truncated time series. Both SA data and q-on-q growth rates have been considered on the following aggregates: total labour cost by NACE section and wages, others costs and total cost referred to all the NACE sectorial aggregation required by Eurostat. Results are reported in the tables a.2, a.3 and a.4 of the appendix only for wages, others costs and total cost referred to the latter aggregates.
Results confirm the stability of the seasonally adjusted data produced by both the approaches (apart from G-N and O-S aggregates). Nevertheless, a slight superiority of the indirect approach emerges implying almost always smaller revisions.

7. Conclusions

This paper deals with seasonal and calendar adjustment of the LCI, reporting the Italian experience on the direct and indirect approaches. The direct approach was, at a first stage, chosen to afford some of the complexities of the LCI time series, above all the volatility of the hours worked and the low stability of the other costs component, affecting quality of the ARIMA models and implying spurious seasonality effects on the aggregates. However, the direct approach posed severe inconsistency problems between adjusted aggregates and their components stimulating the transition to the indirect approach. Recommendations by Eurostat and specialized literature do not favour definitively one approach or the other; furthermore no clear indications are given by the LCI Regulation. Direct approach is generally suggested especially when model-based procedures are used to decompose time series, since it better reflects the features of time series to be handled. In turn, the indirect is favoured when the fulfilment of the aggregation constraints is a priority, keeping in mind the importance of checking residual seasonality. In the case of the LCI, the preference towards the indirect approach must cope with the problem of the non-additivity property of the chain linked indices.

[9] JDemetra+ performs the following tests to check for residual seasonality: tests on autocorrelations at seasonal lags; the non parametric Friedman test, based on the rank of the observations in each year; the non parametric (Kruskal-Wallis) test, based on the rank of the observations; identification of seasonal peaks in a Tukey periodogram and in an auto-regressive spectrum; periodogram; test on the sum of the values of a periodogram at seasonal frequencies; tests on regression with fixed seasonal dummies (see: JDemetra+ User Manual, 2013).

In this work we show how the seasonally adjusted indices, expressed in fixed base can be aggregated to produce seasonally adjusted chain linked indices. The problem has been tackled starting from the original weighting system, utilized to aggregate indices expressed in the previous year base, and deriving a new weighting system that allows to aggregate indices already linked and therefore not additive. The direct and the indirect approaches are then compared. Results are very similar and the discrepancies between the two approaches are negligible. The indirect approach slightly outperforms the direct one in terms of revision size. As a consequence the fulfilment of the internal coherence becomes the crucial element to prefer the indirect seasonal adjustment of the LCI. This quality prerequisite seems to assume a great importance at Eurostat in the debate on the opportunity of publishing in the news release SA data.
More in general, the methodological solution proposed in this paper to aggregate chain linked indices can be easily extended to other similar domains (e.g. SA Quarterly National Accounts) deeply simplifying the more traditional and complex procedures of SA that pass through the unchaining and chaining practices.

References

Baldi C., Bellisai D., Ceccato F., Pacini S., Serbassi L., Sorrentino M., Tuzi D. (2011a), "The system of short term business statistics on labour in Italy. The challenges of data integration". Paper presented at the ESSnet Data Integration Workshop in Madrid 24-25 November 2011 (http://www.ine.es/e/essnetdi_ws2011/ppts/Baldi_et_al.pdf).

Istat (2014), "Labour Cost Index - Quality Report 2013". Link: http://ec.europa.eu/eurostat/cache/metadata/EN/lci_esqrs_it.htm.

Ciammola A., Ceccato F., Congia M.C., Pacini S., Rapiti F., Tuzi D. (2009), "The Italian Labour Cost Index (LCI): Sources and Methods". *Contributi* n.8, Istat, Rome. Link: http://www.istat.it/dati/pubbsci/contributi/Contributi/contr_2009/08_2009.pdf.

Ciammola A. and Tuzi D. (2010), "Internal Coherence in Seasonally Adjusted Chain Laspeyres Indices: an Application to the Italian Hourly Labour Cost Indicators". Paper presented at the European Conference on Quality in Official Statistics, Q2010. Helsinki 4-6 May 2010. Link: http://q2010.stat.fi/sessions/session-5/.

Congia M.C., Pacini S., Tuzi D. (2008a), "Quality Challenges in Processing Administrative Data to Produce Short-Term Labour Cost Statistics", Proceedings of Q2008 European Conference on Quality in Official Statistics, Rome. Link: http://www.istat.it/istat/eventi/q2008/sessions/paper/29Congia.pdf.

Congia M.C., Pacini S., Tuzi D. (2008b), "The Editing Process in the Italian Short-Term Survey on Labour Cost based on Administrative Data", paper presented to the UNECE - Conference of European Statisticians,Work Session on Statistical Data Editing, 21 – 23 April, Wien. Link: http://www.unece.org/stats/documents/2008/04/sde/wp.8.e.pdf.

Dagum, E. and Cholette, P. (2006), "Benchmarking, Temporal Distribution, and Reconciliation Methods for Time Series". Springer-Verlag.

Eurostat (2009), "ESS Guidelines on Seasonal Adjustment". Eurostat Methodologies and Working papers. Link: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-006/EN/KS-RA-09-006-EN.PDF.

Eurostat (2014), "Revised ESS Guidelines on Seasonal Adjustment" Recent Developments on Seasonal Adjustment, Rome 11 September 2014, Gian Luigi Mazzi.

Istat (2013), "Il sistema degli indicatori congiunturali sulla domanda di lavoro e le retribuzioni in Ateco 2007 e base 2005". Metodi. Link: http://www.istat.it/it/archivio/97314.

Maravall, A. (2006), "An application of the automatic procedure of Tramo and Seats. Direct versus indirect adjustment". Computational Statistics and Data Analysis, 50:2167–2190.

Rapiti F.M., Ceccato F., Congia M.C., Pacini S. and Tuzi D. (2010), "What have we learned in almost 10-years experience in dealing with administrative data for short term employment and wages indicators?", ESSnet Project, Seminar "Using administrative data in the production of business statistics", Rome, 18-19 March 2010. Link: http://www.ine.pt/filme_inst/essnet/papers/Session2/Paper2.4.pdf.

US Census Bureau (2014), X-13ARIMA-SEATS Reference Manual. US Census Bureau.

APPENDIX

Table a.1: Incoherencies between variables (total labour cost versus wages and other costs) and sectors (aggregates versus sectorial components). *Percentages on the total number of q-on-quarter changes.*

Aggregate		Number of components	3 decimals	1 decimal
Nace Rev. 2 sections and aggregates – Total labour cost vs wages and other costs				
B – Mining and Quarrying		2	26.7	30.0
C - Manufacturing		2	1.7	8.3
D - Electricity, Gas, Stream and Air Conditioning Supply		2	1.7	3.3
E - Water Supply; Sewerage, Waste Management, ...		2	1.7	6.7
F - Construction		2	5.0	15.0
G - Wholesale and retail trade		2	1.7	6.7
H - Transport		2	0.0	5.0
I - Accommodation and food service activities		2	0.0	1.7
J - Information and communication		2	8.3	15.0
K - Financial and insurance activities		2	0.0	3.3
L - Real estate activities		2	0.0	3.3
M - Scientific and technical activities		2	0.0	5.0
N - Administrative and support service activities		2	0.0	1.7
O - Public administration and defence; compulsory Social Security		2	20.0	23.3
P - Education		2	15.0	15.0
Q - Human health and social work activities		2	0.0	0.0
R – Arts, entertainment and recreation		2	1.7	3.3
S – Other service activities		2	1.7	6.7
B-S – Whole economy		18	1.7	6.7
B-N - Business economy		13	0.0	16.7
B-E – Industry (except construction)		4	0.0	6.7
B-F - Industry and construction		5	0.0	3.3
G-N - Services		8	1.7	6.7
G-J - Wholesale and retail trade; transport; accommodation and food service activities; information and communication		4	0.0	1.7
K-N - Financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities		4	0.0	3.3
O-S – Mainly non-business economy		5	8.3	13.3
Labour cost components – Nace Rev. 2 aggregates vs sections				
B-S – Whole economy	Wages	18	0.0	0.0
	Other costs	18	0.0	0.0
	Total costs	18	0.0	0.0
B-N - Business economy	Wages	13	0.0	0.0
	Other costs	13	0.0	0.0
	Total costs	13	0.0	0.0
B-E - Industry (except construction)	Wages	4	0.0	0.0
	Other costs	4	3.3	1.7
	Total costs	4	1.7	0
B-F – Industry and construction	Wages	5	0.0	0.0
	Other costs	5	1.7	1.7
	Total costs	5	1.7	1.7
G-N - Services	Wages	8	0.0	0.0
	Other costs	8	0.0	0.0
	Total costs	8	0.0	0.0
G-J - Wholesale and retail trade; transport; accommodation and food service activities; information and communication	Wages	4	3.3	3.3
	Other costs	4	6.7	3.3
	Total costs	4	1.7	1.7
K-N - Financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities	Wages	4	1.7	1.7
	Other costs	4	3.3	3.3
	Total costs	4	3.3	1.7
O-S – Mainly non-business economy	Wages	5	1.7	1.7
	Other costs	5	0.0	0.0
	Total costs	5	0.0	0.0
Labour cost components – Nace Rev. 2 aggregates vs subaggregates				
B-S – Whole economy (B-N + O-S)	Wages	2	5.0	5.0
	Other costs	2	11.7	6.7
	Total costs	2	13.3	10
B-N - Business economy (B-F + G-N)	Wages	2	16.7	7.0
	Other costs	2	5.0	1.7
	Total costs	2	8.3	5.0
B-F – Industry and construction (B-E + F)	Wages	2	8.3	3.3
	Other costs	2	8.3	5.0
	Total costs	2	6.7	3.3
G-N - Services (G-J +K-N)	Wages	2	15.0	8.3
	Other costs	2	3.3	0.0
	Total costs	2	10.0	5.0

APPENDIX

Table a.2 – Revision indicators computed on SA data of wages and salaries (green cells point out a better performance of the indirect approach over the direct approach).

	Approach	Steps	B_E			G_J			K_N			O_S			B_F			G_N			B_N			B_S		
			MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR
Q-on-q growth rates	Direct	1	-0.017	0.104	0.124	-0.027	0.059	0.076	-0.048	0.079	0.171	-0.032	0.061	0.077	-0.003	0.091	0.112	-0.015	0.038	0.051	-0.03	0.054	0.068	0.009	0.039	0.051
		2	-0.017	0.112	0.142	-0.056	0.08	0.109	-0.102	0.135	0.23	-0.06	0.084	0.12	-0.014	0.083	0.111	-0.034	0.062	0.082	-0.047	0.071	0.084	-0.003	0.053	0.073
		3	-0.042	0.116	0.136	-0.144	0.245	0.301	-0.226	0.408	0.503	-0.267	0.342	0.436	-0.06	0.095	0.117	-0.088	0.158	0.201	-0.112	0.143	0.185	-0.031	0.09	0.118
		4	0	0.318	0.389	-0.016	0.282	0.364	-0.04	0.618	0.817	-0.065	0.522	0.644	0.007	0.284	0.338	-0.011	0.231	0.278	-0.033	0.227	0.28	-0.007	0.158	0.199
		8	-0.035	0.412	0.461	-0.04	0.286	0.367	-0.1	1.033	1.299	-0.152	0.933	1.109	-0.023	0.42	0.48	-0.036	0.298	0.332	-0.071	0.292	0.33	-0.036	0.24	0.307
		12	-0.038	0.457	0.538	-0.095	0.405	0.463	-0.106	1.026	1.189	-0.165	1.145	1.353	-0.021	0.486	0.572	-0.066	0.365	0.403	-0.117	0.338	0.376	-0.046	0.316	0.379
	Indirect	1	-0.017	0.102	0.119	-0.048	0.155	0.195	-0.026	0.067	0.09	-0.009	0.06	0.079	-0.018	0.089	0.1	-0.041	0.101	0.121	-0.03	0.08	0.099	-0.023	0.051	0.064
		2	-0.03	0.122	0.168	-0.055	0.162	0.213	-0.049	0.103	0.136	-0.053	0.095	0.133	-0.035	0.099	0.131	-0.053	0.109	0.137	-0.045	0.089	0.117	-0.048	0.073	0.106
		3	-0.036	0.147	0.171	-0.094	0.201	0.243	-0.216	0.334	0.415	-0.27	0.31	0.419	-0.053	0.142	0.163	-0.135	0.183	0.249	-0.098	0.14	0.179	-0.156	0.166	0.204
		4	-0.003	0.312	0.384	-0.031	0.168	0.216	-0.054	0.508	0.595	-0.071	0.464	0.608	-0.001	0.292	0.344	-0.039	0.183	0.235	-0.022	0.179	0.237	-0.037	0.181	0.218
		8	-0.04	0.375	0.43	-0.043	0.198	0.281	-0.128	0.704	0.811	-0.183	0.793	0.989	-0.035	0.398	0.42	-0.072	0.226	0.293	-0.055	0.244	0.29	-0.096	0.23	0.295
		12	-0.044	0.455	0.507	-0.08	0.224	0.312	-0.154	0.731	0.811	-0.225	0.991	1.207	-0.052	0.448	0.468	-0.105	0.233	0.32	-0.081	0.264	0.314	-0.127	0.273	0.345
SA data	Direct	1	-0.033	0.165	0.197	-0.067	0.138	0.18	-0.084	0.137	0.258	-0.092	0.15	0.2	-0.027	0.139	0.163	-0.032	0.091	0.125	-0.056	0.101	0.131	-0.009	0.06	0.073
		2	-0.038	0.149	0.187	-0.104	0.166	0.223	-0.138	0.181	0.321	-0.155	0.196	0.234	-0.044	0.132	0.149	-0.054	0.118	0.154	-0.08	0.122	0.147	-0.025	0.064	0.098
		3	-0.038	0.144	0.191	-0.105	0.171	0.227	-0.138	0.195	0.333	-0.198	0.238	0.275	-0.047	0.133	0.152	-0.053	0.126	0.164	-0.085	0.122	0.147	-0.032	0.069	0.109
		4	-0.027	0.229	0.271	-0.007	0.205	0.246	-0.006	0.409	0.582	-0.065	0.324	0.385	-0.01	0.185	0.219	0.014	0.189	0.214	-0.032	0.169	0.197	-0.018	0.112	0.156
		8	-0.067	0.322	0.373	-0.043	0.213	0.245	-0.04	0.732	0.954	-0.159	0.574	0.644	-0.042	0.306	0.345	0.01	0.23	0.26	-0.058	0.225	0.254	-0.061	0.189	0.251
		12	-0.093	0.389	0.453	-0.108	0.235	0.262	-0.079	0.715	0.887	-0.202	0.751	0.816	-0.057	0.366	0.427	-0.008	0.241	0.29	-0.109	0.225	0.258	-0.093	0.269	0.307
	Indirect	1	-0.037	0.159	0.191	-0.058	0.191	0.248	-0.062	0.178	0.219	-0.084	0.164	0.229	-0.04	0.141	0.161	-0.06	0.14	0.168	-0.051	0.112	0.137	-0.063	0.095	0.115
		2	-0.045	0.152	0.196	-0.062	0.205	0.265	-0.12	0.218	0.283	-0.164	0.213	0.269	-0.051	0.133	0.16	-0.082	0.155	0.195	-0.068	0.114	0.147	-0.102	0.122	0.159
		3	-0.034	0.15	0.202	-0.056	0.206	0.268	-0.158	0.214	0.278	-0.201	0.23	0.285	-0.04	0.128	0.16	-0.091	0.16	0.207	-0.068	0.111	0.153	-0.114	0.12	0.169
		4	-0.034	0.217	0.271	-0.009	0.157	0.224	-0.023	0.409	0.51	-0.068	0.312	0.376	-0.024	0.185	0.23	-0.014	0.183	0.217	-0.018	0.143	0.176	-0.037	0.128	0.169
		8	-0.072	0.282	0.346	-0.033	0.186	0.257	-0.059	0.647	0.743	-0.178	0.521	0.583	-0.048	0.258	0.297	-0.043	0.23	0.262	-0.045	0.176	0.221	-0.093	0.19	0.226
		12	-0.099	0.347	0.413	-0.082	0.191	0.258	-0.1	0.662	0.764	-0.242	0.682	0.726	-0.077	0.285	0.329	-0.089	0.204	0.235	-0.084	0.161	0.209	-0.141	0.243	0.26

Legend: MR - Mean of revisions; **MAR** - mean of absolute revisions; **RMSR** - root mean squared revisions.

APPENDIX

Table a.3 – Revision indicators computed on SA data of other costs (green cells point out a better performance of the indirect approach over the direct approach).

	Approach	Steps	B_E			G_J			K_N			O_S			B_F			G_N			B_N			B_S		
			MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR
Q-on-q growth rates	Direct	1	-0.041	0.113	0.14	-0.008	0.053	0.061	-0.049	0.086	0.156	-0.014	0.071	0.099	-0.037	0.086	0.107	-0.009	0.038	0.057	-0.017	0.049	0.062	-0.001	0.065	0.091
		2	-0.04	0.141	0.184	-0.02	0.066	0.087	-0.045	0.11	0.171	-0.064	0.117	0.165	-0.065	0.107	0.131	-0.014	0.05	0.066	-0.042	0.075	0.091	-0.04	0.065	0.102
		3	-0.104	0.128	0.161	-0.05	0.186	0.225	-0.085	0.298	0.367	-0.277	0.293	0.375	-0.096	0.127	0.155	-0.028	0.138	0.165	-0.085	0.136	0.159	-0.096	0.11	0.138
		4	0.003	0.336	0.392	0.001	0.271	0.33	-0.024	0.494	0.639	0.024	0.387	0.449	-0.003	0.323	0.367	-0.008	0.197	0.245	-0.014	0.212	0.262	-0.008	0.175	0.221
		8	-0.037	0.363	0.438	-0.01	0.255	0.317	-0.074	0.884	1.07	-0.001	0.561	0.671	-0.054	0.406	0.472	-0.028	0.211	0.263	-0.049	0.246	0.309	-0.045	0.283	0.339
		12	-0.042	0.463	0.553	-0.04	0.313	0.359	-0.08	1.092	1.323	0.014	0.617	0.696	-0.077	0.526	0.595	-0.043	0.283	0.324	-0.078	0.367	0.401	-0.062	0.312	0.362
	Indirect	1	-0.039	0.102	0.122	-0.031	0.121	0.162	0.002	0.048	0.068	-0.017	0.06	0.085	-0.031	0.082	0.099	-0.02	0.079	0.101	-0.025	0.063	0.082	-0.023	0.044	0.054
		2	-0.058	0.112	0.15	-0.034	0.135	0.176	-0.016	0.079	0.108	-0.059	0.128	0.174	-0.048	0.091	0.123	-0.029	0.084	0.108	-0.038	0.067	0.092	-0.046	0.059	0.082
		3	-0.105	0.137	0.168	-0.044	0.188	0.225	-0.071	0.23	0.294	-0.258	0.286	0.369	-0.107	0.122	0.172	-0.053	0.137	0.196	-0.079	0.12	0.158	-0.145	0.149	0.192
		4	-0.007	0.337	0.39	-0.012	0.203	0.242	-0.032	0.39	0.469	0.015	0.402	0.477	0.008	0.289	0.321	-0.018	0.151	0.215	-0.006	0.181	0.214	0.002	0.177	0.215
		8	-0.052	0.366	0.431	-0.036	0.24	0.296	-0.097	0.577	0.641	-0.021	0.569	0.673	-0.035	0.3	0.351	-0.057	0.145	0.218	-0.046	0.171	0.213	-0.037	0.179	0.222
		12	-0.059	0.467	0.543	-0.062	0.243	0.315	-0.087	0.655	0.719	-0.007	0.609	0.655	-0.053	0.395	0.437	-0.071	0.19	0.276	-0.062	0.25	0.287	-0.042	0.117	0.131
SA data	Direct	1	-0.064	0.176	0.212	-0.025	0.121	0.148	-0.038	0.12	0.181	-0.077	0.126	0.175	-0.065	0.151	0.19	-0.012	0.077	0.108	-0.046	0.097	0.129	-0.038	0.07	0.1
		2	-0.084	0.172	0.219	-0.037	0.137	0.172	-0.042	0.131	0.194	-0.152	0.19	0.219	-0.078	0.145	0.178	-0.016	0.095	0.12	-0.069	0.112	0.143	-0.075	0.092	0.136
		3	-0.082	0.174	0.22	-0.032	0.134	0.172	-0.052	0.122	0.199	-0.179	0.214	0.246	-0.064	0.151	0.181	-0.015	0.101	0.128	-0.066	0.11	0.138	-0.077	0.092	0.128
		4	-0.039	0.225	0.271	0.012	0.178	0.214	-0.01	0.288	0.412	0.025	0.239	0.284	-0.03	0.204	0.247	0.01	0.135	0.172	-0.023	0.145	0.183	-0.02	0.119	0.154
		8	-0.093	0.335	0.391	-0.019	0.165	0.223	-0.036	0.515	0.701	0.005	0.335	0.387	-0.074	0.315	0.383	-0.002	0.139	0.168	-0.054	0.177	0.239	-0.061	0.202	0.261
		12	-0.129	0.437	0.5	-0.056	0.167	0.228	-0.049	0.641	0.845	0.006	0.402	0.437	-0.114	0.41	0.487	-0.015	0.166	0.193	-0.092	0.248	0.302	-0.093	0.262	0.324
	Indirect	1	-0.073	0.175	0.209	-0.036	0.157	0.203	-0.011	0.112	0.155	-0.071	0.127	0.175	-0.066	0.137	0.176	-0.028	0.104	0.129	-0.046	0.096	0.12	-0.056	0.078	0.092
		2	-0.088	0.161	0.208	-0.034	0.165	0.207	-0.043	0.147	0.198	-0.138	0.193	0.228	-0.082	0.14	0.172	-0.037	0.113	0.135	-0.059	0.095	0.122	-0.089	0.096	0.116
		3	-0.079	0.16	0.207	-0.023	0.165	0.209	-0.061	0.128	0.189	-0.168	0.201	0.241	-0.075	0.127	0.159	-0.036	0.119	0.146	-0.055	0.096	0.126	-0.097	0.101	0.124
		4	-0.046	0.221	0.264	0	0.141	0.188	-0.017	0.294	0.367	0.027	0.241	0.297	-0.023	0.185	0.215	-0.006	0.11	0.147	-0.014	0.117	0.139	0	0.093	0.119
		8	-0.095	0.323	0.375	-0.049	0.159	0.233	-0.046	0.467	0.545	0.009	0.312	0.36	-0.072	0.253	0.297	-0.049	0.126	0.154	-0.06	0.116	0.169	-0.035	0.115	0.139
		12	-0.13	0.42	0.482	-0.091	0.203	0.254	-0.038	0.551	0.628	0.013	0.355	0.376	-0.102	0.28	0.351	-0.075	0.143	0.165	-0.088	0.154	0.207	-0.051	0.096	0.106

Legend: MR - Mean of revisions; **MAR** - mean of absolute revisions; **RMSR** - root mean squared revisions.

APPENDIX

Table a.4 – Revision indicators computed on SA data of total cost (green cells point out a better performance of the indirect approach over the direct approach).

	Approach	Steps	B_E			G_J			K_N			O_S			B_F			G_N			B_N			B_S		
			MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR	MR	MAR	RMSR
Q-on-q growth rates	Direct	1	-0.021	0.102	0.123	-0.027	0.059	0.074	-0.035	0.08	0.164	-0.019	0.069	0.092	-0.009	0.088	0.114	-0.014	0.041	0.054	-0.028	0.053	0.067	0	0.038	0.054
		2	-0.024	0.109	0.149	-0.041	0.068	0.085	-0.08	0.121	0.2	-0.081	0.124	0.18	-0.031	0.097	0.128	-0.031	0.06	0.08	-0.05	0.075	0.088	-0.034	0.056	0.078
		3	-0.063	0.113	0.14	-0.124	0.231	0.28	-0.175	0.385	0.458	-0.285	0.313	0.394	-0.085	0.113	0.131	-0.079	0.157	0.19	-0.115	0.146	0.179	-0.067	0.103	0.126
		4	-0.001	0.317	0.388	-0.018	0.273	0.342	-0.032	0.586	0.776	-0.025	0.439	0.532	0.003	0.287	0.336	-0.013	0.219	0.266	-0.031	0.208	0.259	-0.01	0.167	0.202
		8	-0.034	0.406	0.461	-0.041	0.269	0.347	-0.085	0.995	1.263	-0.091	0.763	0.904	-0.033	0.422	0.475	-0.041	0.271	0.301	-0.072	0.27	0.305	-0.051	0.247	0.301
		12	-0.036	0.48	0.563	-0.088	0.381	0.435	-0.097	1.038	1.235	-0.097	0.847	1.05	-0.037	0.499	0.582	-0.072	0.342	0.383	-0.114	0.336	0.368	-0.068	0.287	0.35
	Indirect	1	-0.022	0.101	0.119	-0.043	0.142	0.184	-0.019	0.055	0.074	-0.011	0.049	0.06	-0.022	0.086	0.098	-0.035	0.092	0.114	-0.029	0.074	0.092	-0.023	0.051	0.066
		2	-0.035	0.115	0.164	-0.049	0.152	0.201	-0.038	0.093	0.123	-0.06	0.088	0.135	-0.037	0.09	0.125	-0.046	0.098	0.126	-0.042	0.077	0.105	-0.048	0.072	0.104
		3	-0.061	0.139	0.167	-0.078	0.196	0.233	-0.173	0.286	0.368	-0.283	0.301	0.378	-0.075	0.135	0.163	-0.11	0.16	0.227	-0.094	0.125	0.166	-0.16	0.164	0.194
		4	-0.004	0.305	0.381	-0.026	0.168	0.214	-0.046	0.473	0.546	-0.025	0.417	0.534	0.001	0.295	0.337	-0.033	0.163	0.218	-0.017	0.173	0.222	-0.018	0.169	0.189
		8	-0.042	0.37	0.426	-0.041	0.199	0.276	-0.116	0.665	0.758	-0.09	0.739	0.914	-0.034	0.388	0.407	-0.066	0.201	0.264	-0.051	0.232	0.265	-0.062	0.24	0.27
		12	-0.043	0.466	0.526	-0.075	0.223	0.308	-0.13	0.715	0.787	-0.088	0.853	1.098	-0.051	0.459	0.481	-0.094	0.219	0.304	-0.073	0.268	0.31	-0.075	0.29	0.33
SA data	Direct	1	-0.042	0.163	0.196	-0.059	0.139	0.175	-0.063	0.129	0.228	-0.093	0.134	0.171	-0.042	0.138	0.168	-0.029	0.088	0.126	-0.058	0.097	0.132	-0.027	0.061	0.085
		2	-0.052	0.146	0.19	-0.088	0.158	0.204	-0.108	0.161	0.277	-0.175	0.195	0.233	-0.066	0.141	0.161	-0.049	0.115	0.148	-0.085	0.119	0.148	-0.054	0.072	0.117
		3	-0.053	0.137	0.189	-0.095	0.176	0.21	-0.108	0.164	0.284	-0.199	0.228	0.259	-0.064	0.14	0.162	-0.049	0.124	0.155	-0.088	0.117	0.145	-0.053	0.075	0.118
		4	-0.03	0.222	0.268	-0.012	0.194	0.228	-0.003	0.374	0.536	-0.03	0.283	0.316	-0.017	0.185	0.22	0.008	0.174	0.204	-0.031	0.146	0.18	-0.023	0.114	0.153
		8	-0.074	0.321	0.378	-0.049	0.195	0.226	-0.033	0.662	0.893	-0.1	0.459	0.512	-0.059	0.308	0.356	0.001	0.21	0.234	-0.062	0.201	0.238	-0.073	0.19	0.245
		12	-0.101	0.417	0.478	-0.115	0.21	0.234	-0.069	0.673	0.882	-0.134	0.58	0.642	-0.084	0.389	0.452	-0.02	0.229	0.27	-0.114	0.224	0.262	-0.112	0.251	0.295
	Indirect	1	-0.048	0.159	0.191	-0.051	0.181	0.234	-0.047	0.156	0.194	-0.087	0.129	0.168	-0.048	0.135	0.159	-0.05	0.125	0.155	-0.049	0.102	0.128	-0.063	0.081	0.098
		2	-0.06	0.148	0.196	-0.053	0.199	0.248	-0.095	0.198	0.253	-0.169	0.184	0.227	-0.063	0.124	0.155	-0.067	0.138	0.176	-0.065	0.102	0.133	-0.102	0.11	0.142
		3	-0.053	0.147	0.197	-0.045	0.199	0.251	-0.128	0.188	0.245	-0.209	0.219	0.256	-0.057	0.118	0.15	-0.073	0.143	0.187	-0.066	0.099	0.137	-0.116	0.118	0.152
		4	-0.038	0.205	0.263	-0.005	0.144	0.208	-0.018	0.373	0.464	-0.028	0.271	0.321	-0.024	0.173	0.216	-0.01	0.161	0.191	-0.017	0.124	0.153	-0.021	0.106	0.138
		8	-0.079	0.278	0.347	-0.032	0.172	0.242	-0.051	0.593	0.687	-0.099	0.466	0.531	-0.051	0.244	0.289	-0.039	0.2	0.229	-0.045	0.157	0.196	-0.065	0.161	0.202
		12	-0.106	0.364	0.435	-0.077	0.183	0.247	-0.076	0.632	0.727	-0.128	0.622	0.678	-0.083	0.293	0.343	-0.078	0.186	0.213	-0.08	0.163	0.205	-0.099	0.23	0.256

Legend: MR - Mean of revisions; **MAR** - mean of absolute revisions; **RMSR** - root mean squared revisions.