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Indirect and direct seasonal adjustment: an application to the wholesale trade time series[1]

Barbara Guardabascio[2], Barbara Iaconelli[3], Roberto Iannaccone[4]

Sommario

In questo articolo verranno studiate le differenze tra l'approccio indiretto e diretto per la destagionalizzazione delle serie trimestrali del fatturato del commercio all'ingrosso. Se sia più opportuno utilizzare un approccio diretto o indiretto per la destagionalizzazione è ancora un problema aperto, come sottolineato negli orientamenti suggeriti dalle linee guida di Eurostat. Lo scopo di questo lavoro è analizzare le differenze soprattutto in presenza di valori anomali o di break stagionali che caratterizzano in modo particolare le serie di fatturato del commercio all'ingrosso. In questa analisi considereremo un set di statistiche descrittive sulla qualità dell'approccio indiretto e diretto nonché alcune misure basate sul triangolo delle revisioni atte a controllare la dimensione delle revisioni che si ottengono utilizzando ciascuno dei due approcci.

Parole chiave: destagionalizzazione con approccio diretto/indiretto, break stagionale, triangolo delle revisioni.

Abstract

This paper investigates the differences between the indirect and direct approaches for seasonal adjustment in wholesale trade quarterly turnover series. Whether it is more appropriate to use a direct or an indirect seasonal adjustment is still an open issue, as underlined in Eurostat Guidelines on Seasonal Adjustment. The aim of this work is to analyse differences especially in presence of seasonal level shift outliers charactering wholesale quarterly turnover series. The analysis will consider usual descriptive statistics on the quality of indirect and direct seasonally adjusted series together with some measures to control the size of the revisions obtained by using the revision triangle approach.

Keywords: seasonal adjustment indirect/direct approach, seasonal break, revision triangle.

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1. Introduction

Seasonally adjusted time series data (aggregates) which are the result of a sum of other time series (components) can be estimated in two different ways: either directly by applying the seasonal adjustment procedure to the aggregate data, or indirectly by summing the seasonally adjusted component series to get an indirect adjustment for the aggregate series. Under most circumstances, the direct and indirect adjustments for an aggregate series are relevant in different cases. Whether it is more appropriate to use a direct or an indirect seasonal adjustment is still an open issue (Eurostat Guidelines on Seasonal Adjustment, 2009). This paper discusses these aspects for wholesale trade turnover series. The series is the result of the aggregation of eight component time series. Moreover, in the most recent estimation of the model two seasonal outliers have been introduced to take into account the presence of a seasonal break. Particular attention therefore has been focused on a deeper analysis of component time series in order to investigate the characteristic of the seasonal break looking at the differences in the seasonal adjustment using a direct or an indirect strategy (Ladiray and Mazzi, 2003). In general the direct approach is preferred for transparency and accuracy and especially when component series show similar seasonal patterns. On the other hand the indirect approach is preferred when the component series have quite distinct seasonal patterns. For a choice between the two approaches different statistics have been proposed (Hood and Findley, 2003 Otranto and Triacca, 2002). In this paper two specific statistical tests have been considered: the usual descriptive statistics on quality of indirect and direct seasonally adjusted estimates as the smoothness of the component time series and residual seasonality tests. Together with these some other measures have been implemented in order to control the size of revisions using the in revision triangle approach (Di Fonzo, 2005).

In the following section the direct vs indirect problem is presented, in section 3 a description of the criteria and the diagnostics used to assess the seasonal adjustment quality is provided, while section 4 concerns the practice of seasonal adjustment used in ISTAT. An empirical application with the results of the comparison between the wholesale trade seasonal adjustment obtained with the two alternative approaches is shown in section 5. Finally section 6 reports the conclusions.

2. Methodology

2.1 Direct and indirect seasonal adjustment

All the seasonal adjustment methods are founded on the assumption that each series Xt can be decomposed in three different unobserved components: the trend-cycle component (TC), which represents the long-run movement of the series (like those associated to the business cycle). The irregular component (I), which defines short term fluctuations that are not systematic and in some instances not predictable, e.g. uncharacteristic weather patterns. However some irregular effects can be expected in advance, e.g. changes in value added tax. Finally, there is the seasonal component (S), which represents the intra-year (monthly, quarterly) fluctuations that are stable over years to timing, direction and magnitude. In general, variations of the seasonal component recur every year to the same extent, e.g. weather fluctuations that are representative of the season, length of months, Christmas effect, tax deadline, expectations, institutional arrangements, social, religious or cultural events.

Although series may be decomposed in different way, generally the following models are used:

- Additive model: $X_t = TC_t + S_t + I_t$;
- Multiplicative model: $X_t = TC_t \; S_t \; I_t$;
- Log-additive model: $X_t = log(TC_t) + log(S_t) + log(I_t)$;

According, for example to the additive model, applying a direct approach once removed the seasonal component, a seasonally adjusted series is obtained:

$$A_t = TC_t + I_t$$

However can be supposed that the X_t is an indicator computed by linear aggregation of a set of N component indicators. In this case each component series has a weight ωn to compose the aggregate index as follows:

$$X_{n,t} = TC_{n,t} + S_{n,t} + I_{n,t}$$

$$X_{n,t} = \sum_{n=1}^{N} \omega_n X_{n,t}$$

In this case the indirect approach is used, meaning that each elementary indicator $X_{n,t}$ is seasonally adjusted and the final seasonal adjusted series is then derived as the aggregation of the seasonally adjusted elementary indices with the following result:

$$A_t = \sum_{n=1}^{N} \omega_n A_{n,t}$$

2.2 Quality measures

Whether it is better the direct or the indirect adjustment for a given set of series depends on the set of series analysed. Generally speaking, when the component series have a quite distinct seasonal patterns and have adjustments of good quality, indirect seasonal adjustment should be of better quality than the direct one. However, when the component series are noisy but have similar seasonal patterns, then summing the series may result in noise cancellation, and the direct seasonal adjustment is usually of better quality than the indirect one. In other situations, it is not clear a priori which would be the best adjustment. For this reason in order to assess empirically the performance of the two different approaches, for the wholesale trade series seasonal adjustment some quality measures are used.

More in details, in order to check the differences between the seasonal adjusted series obtained through the application of the two approaches the following statistics are considered:

– **Mean Absolute Percentage Deviation**: $\frac{100}{N}\sum_{n=1}^{N}\left|\frac{A_t^D - A_t^I}{A_t^I}\right|$;

– **Max Absolute Percentage Deviation**: $100 Max\left|\frac{A_t^D - A_t^I}{A_t^I}\right|$;

both on the complete series and on the last three years.

Moreover a **growth rate series analysis** has been elaborated by computing some summary statistics like the mean and the range of the series of the growth rate differences and by checking inconsistencies, through the application of a sign analysis, between the two seasonal adjusted series.

More in details following items have been considered:

- The global percentage of sign concordance between the direct and indirect series;
- The percentage of concordance between the seasonally adjusted series and the components adjusted series. An inconsistency in the growth rates is detected when the aggregate does not respect the majority, in terms of weight, of the adjusted subseries.

In order to test the suitability of the approach used taking into account the particular structure of the series considered, a check for **idempotency** has been carried out, i.e. a seasonal adjustment method applied to a seasonally adjusted series should leave the SA series unchanged.

2.3 Revision Analysis

The stability of the seasonal adjustment process has been studied by analyzing the revision process. Indeed, the duration of the revision process is more or less stable depending on the seasonally component removed: modest revision errors are generally associated with the removal of a stable seasonal component. It means that the convergence process of the concurrent estimator of the final estimator is slower.

To test the revision process the following indices are computed:

– *Mean revision*:

$$MR = \frac{1}{n}\sum_{t=1}^{n}(L_t - P_t) = \frac{1}{n}\sum_{t=1}^{n} R_t$$

– *Mean absolute revision*:

$$MAR = \frac{1}{n}\sum_{t=1}^{n}\left|L_t - P_{t=}\right|\frac{1}{n}\sum_{t=1}^{n}\left|R_t\right|$$

– *Standard deviation of revision*:

$$SDR = \sqrt{\frac{1}{n}\sum_{t=1}^{n}\left(R_t - MR\right)^2}$$

– *Mean squared revision*:

$$MSR = \frac{1}{n}\sum_{t=1}^{n}\left(L_t - P_t\right)^2 = \frac{1}{n}\sum_{t=1}^{n} R_t^2$$

which represents the variance of the revision process.

– *Relative mean absolute revision*:

$$RMAR = \frac{\sum_{t=1}^{n}\left|L_t - P_t\right|}{\sum_{t=1}^{n}\left|L_t\right|} = \frac{\sum_{t=1}^{n}\left|R_t\right|}{\sum_{t=1}^{n}\left|L_t\right|}$$

In order to evaluate the significance of the mean revision, a simple and robust approach based on the Heteroskedasticity Autocorrelation Consistent estimate`s variance proposed by Newey and West has been considered. In this case the standard t test is applied using a robust estimate of the variance of the mean revision as in Di Fonzo et al (2005). Indeed, this modified t-test corrects the value of the t-statistic by adjusting the estimate of the variability of the revisions to take into account the serial correlation, that is the extent of the association between successive revisions.

3. Major practices for seasonal adjustment in ISTAT (STS Indicators)

Taking into account the most important short term indicators produced by the Italian Institute of Statistics the approach (direct or indirect) used for the seasonal adjustment in each of them is presented. Table 1 presents a summary showing the absence of an uniform approach for the seasonal adjustment practices in ISTAT. Indeed, both the methods are almost equally used inside the Institute. For example, the direct approach is preferred for seasonal adjustment in *Industrial Production, Labour Cost* as well as some *Sentiment Indicators*, while the indirect one is used for *Industrial Turnover* and *New Orders series* and *Retail Trade*.

Table 1 – Approach for seasonal adjustment in ISTAT

INDICATOR	Direct	Indirect
INDUSTRIAL PRODUCTION	X	
INDUSTRIAL TURNOVER AND NEW ORDERS		X
PRODUCTION IN THE CONSTRUCTION SECTOR		X
FOREIGN TRADE		X
RETAIL TRADE		X
LABOUR COST	X	
TOURISM ARRIVALS AND PRESENCES		X
QUARTERLY TURNOVER IN SERVICES	X	
CONSUMER CONFIDENCE	X	
CONFIDENCE INDEX IN MANIFACTURING		X
CONFIDENCE INDEX IN CONSTRUCTION	X	
MARKET SERVICES CONFIDENCE INDEX	X	
RETAIL TRADE CONFIDENCE INDEX		X

In particular, in this paper the focus is on quarterly turnover service index in which only six economic sectors have seasonally adjusted time series. Indeed, the length of a great part of the other time series is too short for applying the seasonal adjustment. Among these six components for two series in particular the indirect approach can be applied given the presence of a set of subseries (*Information and Comunication Services* and *Wholesale Trade Index*). More in details, in the following empirical application the performance of the indirect approach for the *Wholesale Trade Index* which represents the 46% of the total *Services Turnover Index*[5] is evaluated.

4. Empirical Application

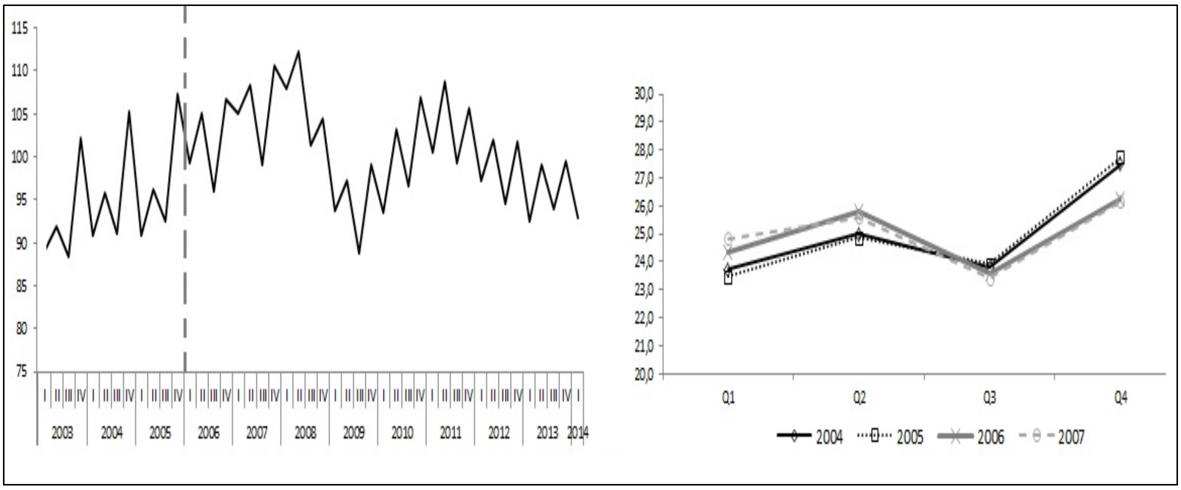
4.1 The wholesale trade turnover index

The *Wholesale Trade Turnover Index* is a quarterly time series whose time span considered goes from 2000:1 – 2014:1. It is characterized by the presence of a seasonal break from 2006, when the contribution to the yearly growth of the second quarter and partially of the first quarter becomes higher with respect to the fourth one that decreases. Moreover the series presents a structural break between 2008 and 2009.

In the following figure raw series for the period 2003-2014 are presented together with the quarterly profile for the year 2004-2007.

[5] Notice that the turnover services index does not include the retail trade.

Figure 1 – Wholesale Trade (G46) Raw Series and Quarterly Profile



The components of the wholesale trade turnover index include a set of economic activities, ranging from Wholesale on fee or contact basis to non-specialized wholesale trade and are aggregated with a set of weights coming from the turnover in Structural Business Statistics for the base year (2010). More in details the three series that give an higher contribution to the overall index are: G467 - Other specialized wholesale (0.344), G464 - Wholesale of household goods (0.225), G463 - Wholesale of food, beverages and tobacco (0.204). In particular a change in the seasonal pattern in the same period of the total series can be seen in all these three components. Moreover all of them show a change in the yearly contribution in favor of the first and second quarter against the fourth one.

Figure 2 – Other specialized wholesale (G467) Raw Series and Quarterly Profile

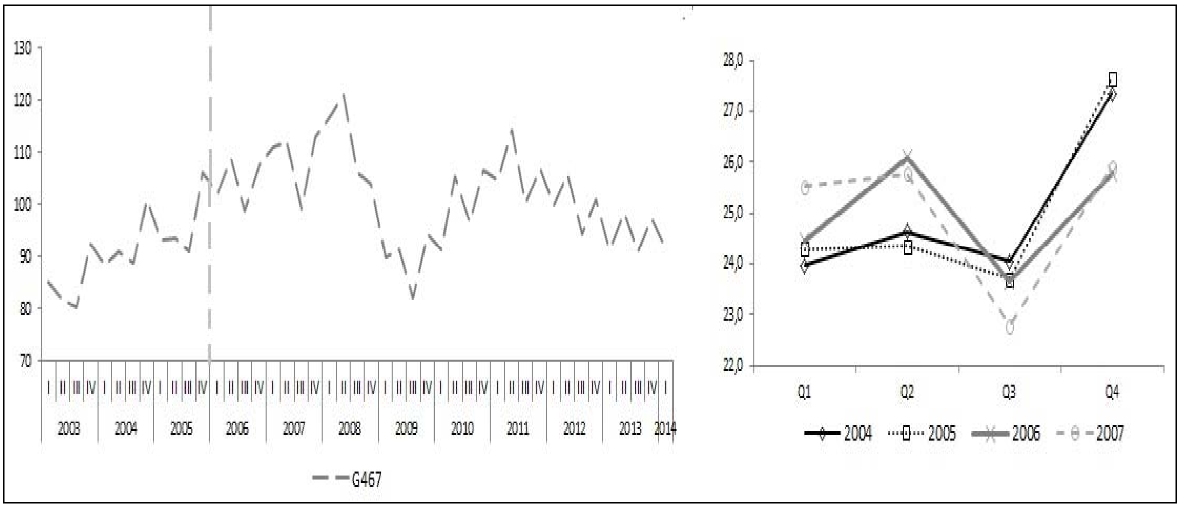


Figure 3 – Wholesale of household goods (G464) Raw Series and Quarterly Profile

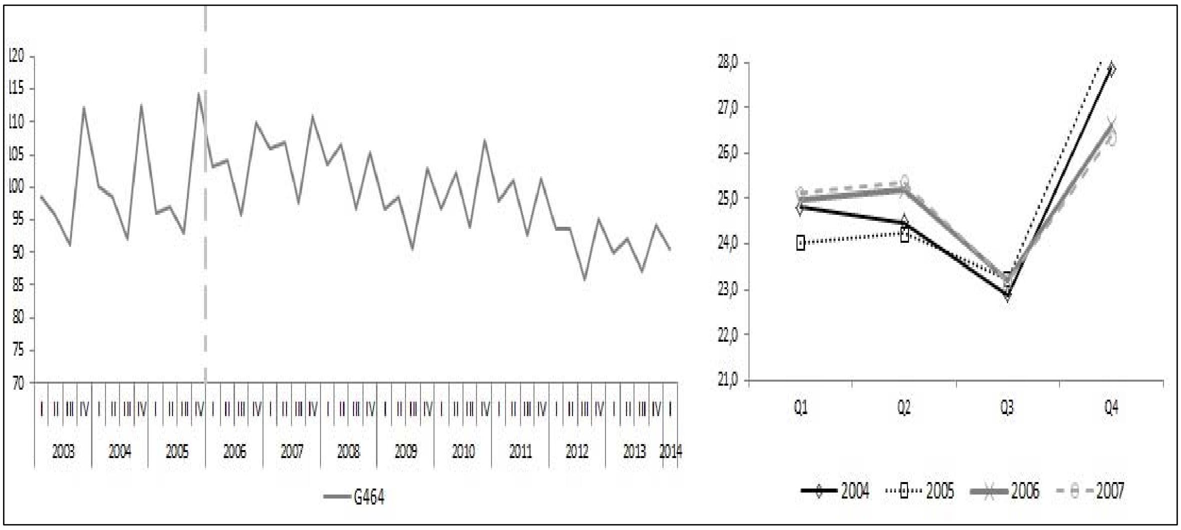
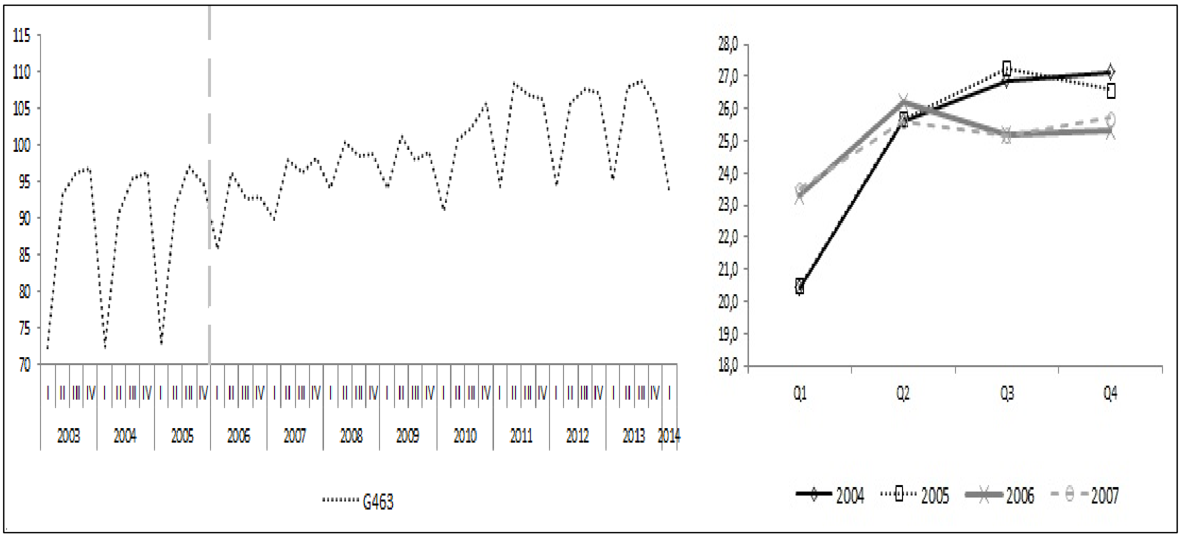


Figure 4 – Wholesale of food, beverages and tobacco (G463) Raw Series and Quarterly Profile



In order to assess empirically the quality of different approaches (indirect and direct seasonal adjustment) the best model for each component as well as for the aggregate index is chosen. In particular for each series the presence of calendar effects or outliers are checked and then, through the autocorrelation analysis and taking into account the Tramo-Seats and X12 diagnostics available from Demetra +, the best Arima model is selected. One of the aims of this analysis is to study in depth the presence of a seasonal break in aggregate index using the components time series. The following Table 2 reports the model chosen for each series (the series G46 is the aggregate time series).

The models selected require the introduction of a ramp regressor from the III quarter 2008 to the III quarter 2009 for a large number of series, a seasonal level shift in 2006 (SLS, Kayser and Maravall, 2001) for three of the eight component series (among them two are with greater weights in the overall index) but not always in the same quarters, and the calendar effects are significative only for two of the eight series components. Instead for the aggregate index the regressors for the calendar effects and the ramp are introduced together with two seasonal level shift outliers whose effects are related to the II and IV quarter 2006. The airline model is the best model in the direct approach and also for two of the eight series components. The constant is never significant but for the G463.

The following section shows in details both some quality measures and concordance analysis of growth rates (Ladiray and Mazzi, 2003) and then the statistics for the choice between the indirect and direct approach.

Table 2 – Main Future of the Seasonal adjustment for the wholesale trade series

GROUP \ DIVISION	Weight	Log	Model	Regressors	SLS Outlier
G46 – Total Wholesale trade	1.000	No	(0,1,1)(0,1,1)	TD ; I.V: IV 2008 - I 2009	Q2_06 Q4_06
G461 - Wholesale on a fee or contact basis	0.048	No	(1,0,0)(0,1,0)	I.V: III 2008 - III 2009	
G462 - Wholesale of agricultural raw materials and live animals	0.031	No	(0,1,1)(0,1,1)	I.V.: I 2008 - III 2009	Q1_06 Q3_06
G463 - Wholesale of food, beverages and tobacco	0.204	No	(1,0,0)(0,1,0)		Q1_06 Q2_06
G464 - Wholesale of household goods	0.225	Yes	(0,1,0)(0,1,1)	TD	Q4_06
G465 - Wholesale of information and communication	0.047	Yes	(1,0,0)(0,1,1)		
G466 - Wholesale of other machinery	0.062	Yes	(1,0,0)(0,1,0)	I.V: III 2008 - III 2009	
G467 - Other specialized wholesale	0.344	Yes	(0,1,0)(0,1,1)	I.V: III 2008 - III 2009	
G469 - Non Specialized wholesale trade	0.039	Yes	(0,1,1)(0,1,1)	TD ; I.V.:III 2008 - III 2009	

* TD: Trading Days Variable; I.V. : Intervention Variable

4.2 Quality Measures and concordance analysis of growth rates

Some measures to analyse the size of the differences both in the levels and in the growth rates of the two seasonal adjusted (SA) series have been computed with the aim to check if the direct and indirect approaches give similar results.

Table 3 – Absolute percentage deviation indicators

INDICATOR	Value
Mean APD (SA)	0.487
Max APD (SA)	1.748
Mean APD (SA), Last 3 years	0.069
Max APD (SA), Last 3 years	0.688

The indicator calculated in Table 3, the percentage difference between the two SA series, shows that the difference is lower when last three years are considered, both in terms of mean and of maximum value, with respect to the values calculated for the full period. In particular the mean decreases from 0.487 to 0.069. This is due to the fact that the main differences between the two approaches are in the way the seasonal level shift and the structural break are treated, respectively, in the year 2006 and 2009.

Moreover the mean, the variance, the maximum and minimum value and the variation range of the differences between the growth rates have been computed. From the results in Table 4 it is clear as there are not big differences between the two approaches.

Table 4 – Difference in growth rates (SA) between the two approaches

INDICATOR	Direct	Indirect
Mean	0,24	0,24
Minimum	-6,00	-5,60
Maximum	2,90	3,10
Variance	2,63	2,91
Range	8,90	8,70

One of the aim of our analysis is to study the effects on the SA series due to the different way in which the seasonal break is treated introducing seasonal level shift outliers in the two approaches. In the analysis of the differences between the growth rates the most significant ones have been identified. From Table 5 it results that these are concentrated in the period from 2006 to 2009. The results are in line with the models estimated for the component series and for the aggregate index already shown in Table 1. In particular both models and regressors introduced are different if the aggregate index and the two series with bigger weights in the overall index (G464 and G467) are considered.

Table 5 – Significant differences in growth rates (absolute value)

DATE	Direct
2005Q4	1,23
2006Q1	1,22
2007Q1	2,53
2007Q3	1,71
2008Q1	1,03
2008Q3	1,37
2009Q1	1,07
2009Q3	1,81
2009Q4	1,42

From the growth rates analysis in Table 6 it is quite evident as the main differences are induced by the different pattern in the series for G467 that has effects on the growth rate calculated for the SA series with the indirect approach.

Table 6 – Significant Differences in growth rates for some quarters

DATE	Direct	Indirect	G463	G464	G467
2005Q4	0,8	2,1	-1,0	1,2	4,7
2006Q1	2,2	1,0	0,6	1,8	0,6
2007Q1	0,6	3,1	1,9	0,2	6,2
2007Q3	1,0	-0,8	1,4	-0,5	-2,9
2008Q1	1,5	2,5	0,5	-0,7	6,4
2008Q3	-0,9	-2,3	0,7	-1,4	-4,1
2009Q1	-5,7	-4,7	0,6	-1,8	-9,3
2009Q3	0,0	-1,8	-1,2	-0,9	-1,6
2009Q4	1,3	2,7	0,1	1,0	6,0

Another quality measure on the two SA series can be carried out looking at the difference in the growth rate calculated on the annual averages for the raw and the indirect and direct SA series. Table 7 shows that the difference between the growth rate on the raw and the SA series are bigger for direct approach. More in details, it is clear that these differences are focused on the period 2004-2007 characterized by the presence of the seasonal break.

Table 7 – Annual growth rates

DATE	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raw	4,3	1,2	1,1	3,1	1,1	5,2	3,9	0,7	-11,1	5,7	3,4	-4,5	-2,6
Direct	3,7	1,3	1,5	2,3	1,8	6,5	2,4	0,7	-11,4	5,5	3,9	-4,4	-2,5
Indirect	4	1,3	1,3	3,1	1,5	5,7	3,4	0,5	-11,5	5,8	3,6	-4,5	-2,4

Another key point to be considered in the seasonal adjustment for short-term analysis is to control if there is any big discordance in signs of the growth rate calculated on SA series with the direct and indirect approach. As shown in Table 8 the two approaches lead to different signs only for three quarters and the biggest one is in the III quarter 2007 (+0.96 direct approach vs -0.76 for the indirect).

This result is confirmed also looking at the overall concordance rate (Table 9) that is quite high (94.64%).

Table 8 – Inconsistencies in growth rates

DATE	Direct	Indirect
2003Q4	-0,11	0,43
2006Q3	0,29	-0,58
2007Q3	0,96	-0,76

Table 9 – Concordance rates in (%)

INDICATORS	Rates
Direct and Indirect	94,64
Indirect vs G463	60,71
Indirect vs G464	78,57
Indirect vs G467	89,29
Direct vs G463	57,14
Direct vs G464	62,50
Direct vs G467	73,21

The analysis has been carried out also for the concordance rate between the indirect SA series and the SA series components and between the direct SA series and the SA series components. The highest concordance rate is recorded for the group G467 that is one with the biggest weight in the calculation of the general index G46.

5. Direct vs Indirect seasonal adjustment

5.1 Idempotency

Idempotency has been checked by running the TRAMO-SEATS procedure on the two SA series, testing that seasonal adjustment does not leave a significant residual seasonality. Before applying the automatic Arima selection procedure for the Final Seasonal Adjusted Series (Direct approach) the significance of regressors has been tested. The results suggest that the ones with a seasonal effect (Trading days and SLS) are not significant. In the following Table the results of the automatic Arima selection operated by Demetra+ are presented.

Table 10 – Idempotency results

Group \ Division	Regressors	Model Selected
G46 – Final Seasonal Adjusted (Direct approach)	I.V: IV 2008 - I 2009	(1,1,0)(1,0,0)
G46 – Stochastic Seasonal Adjusted (Direct approach)		(1,1,0)(0,0,1)
G46 – Final Seasonal Adjusted (Indirect approach)		(1,1,0)(0,0,0)

For the direct approach, the test provides some complex results to read. Indeed, running it on both stochastic and final series (including the deterministic effects) an Arima model is obtained with a seasonal parameter. However, the two model selected are not admissible for SEATS, who cannot decompose it and find a different model without the seasonal component. Taking into account what before, we apply the X12 ARIMA test included in JDEMETRA+ for checking the presence of residual seasonality. The results suggest the absence of seasonality in the direct seasonal adjusted series. Differently, the idempotency test applied on the indirect seasonal adjusted series is hold immediately.

5. 2 Revisions Analysis

A set of measure of quality coming from the revisions analysis for three different horizons (h = 1, 2, 4) has been computed.

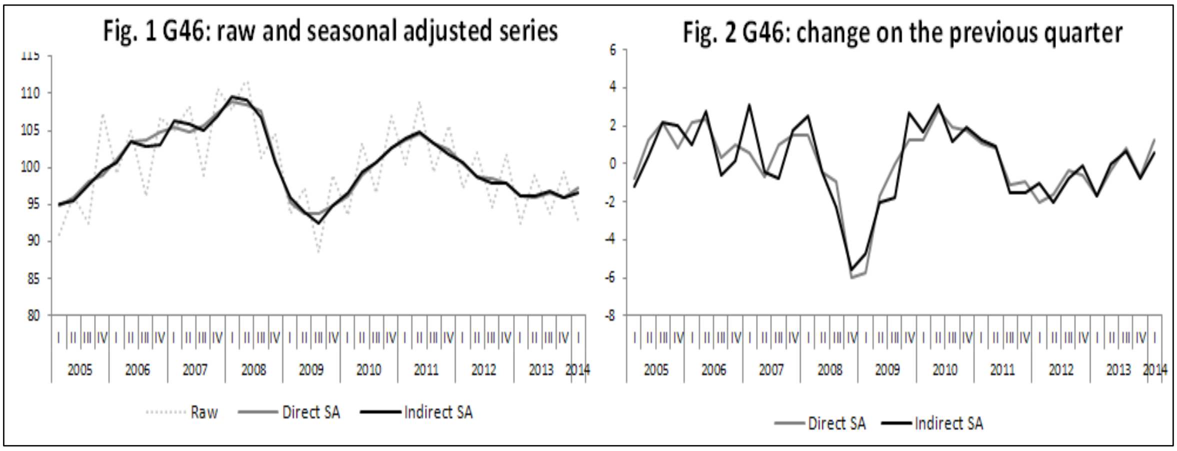
The revision analysis measures calculated using the triangle approach and presented in Table 11 goes in favor of the indirect approach looking at most of the indicators. Indeed, although the t-test computed to evaluate the significance of the mean revision to early estimates accept the null that the mean revision is zero for both the approaches, the indirect approach shows a lower positive average error (SD-HAC) for the horizons considered. Moreover, the mean absolute revision (MAR) the relative ones (RMAR) and mean square revision (MSR) are lower in the indirect approach compared to the direct one.

Table 11 – Main Future of the Seasonal adjustment for the wholesale trade series

REVISION INDEX	Direct Approach			Indirect Approach		
	H = 1	H = 2	H = 4	H = 1	H = 2	H=4
N. Obs.	15	14	12	15	14	12
MAR	0.76	0.60	0.75	0.41	0.32	0.36
RMAR	0.63	0.48	0.52	0.34	0.26	0.25
MR	-0.02	-0.12	-0.08	-0.07	-0.08	-0.06
SD-HAC	0.15	0.14	0.18	0.10	0.11	0.13
T-statistic	-0.11	-0.85	-0.46	-0.69	-0.71	-0.51
$t_{(1\text{-}0,05/2,\ n\text{-}1)}$	2.14	2.16	2.20	2.14	2.16	2.20
MSR	0.82	0.50	0.76	0.25	0.18	0.22
RANGE	3.3	2.2	2.6	1.9	1.6	1.7

The following figures show the seasonal adjusted series obtained through the application of the two approaches and the relative change on the previous quarter. The main differences between the two SA series and the growth rates, as stressed in the previous section, can be observed in the period 2005-2006 in connection with the change of the seasonal pattern in the raw series (G46).

Figure 5 – Seasonal adjustment results



6. Conclusions

In this paper the direct and indirect seasonal adjustment for the wholesale trade turnover index has been tested. More in detail after checking the best Arima model for each component series as well as for the wholesale indicator the idempotency test has been computed and some measures coming from the revision analysis have been estimated. The results obtained, in line with the Eurostat Guidelines, go in favor of the indirect approach, probably due to the greater accuracy through which the component time series are decomposed that provides the opportunity to treat better the presence of the seasonal break introduced in the series in the period 2005 - 2006.

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