QUALITY OF SEASONALLY ADJUSTED TIME SERIES

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Statistical institutions, central banks as well as other state and private agencies spend a lot of human and software resources on seasonal adjustment of time series. Why do they do it? What is a seasonally adjusted time series? For which purposes can it be used? How to assess the quality of seasonally adjusted time series? As no appropriate methodological literature can be found in Estonian, we try to make up for this gap a bit.

Introduction

Periodic fluctuations are a characteristic feature of economic time series (see definitions in Annex 1, p 48). The most important of them are: seasonal fluctuation, the effect of working- or trading days, the effect of a leap year and holidays of national calendar and outliers. As a result of the effects of such fluctuations, time series are very complicated to analyse. It is practically impossible to compare even two random elements of time series with one another. This is one of the reasons why seasonal fluctuations are eliminated.

The aim of the seasonal adjustment of time series is to identify and eliminate the effect of regularly recurring factors or a seasonal component with a view to gaining a clearer picture of the dynamics of economic processes. In other words, seasonal adjustment transforms our everyday world into a world which lacks a seasonal component. Such a world and the different components thereof are already easier to analyse, compare and forecast.

Seasonally adjusted time series can be used for:

- *a) analysing economic and financial indicators;*
- *b) comparing the neighbourhood components of time series (for example, it is possible to compare the data of the fourth quarter, whereas these data are influenced by Christmas, with the data of the first quarter which can be influenced by the length of the month of February and by Easter);*
- *c) analysing the economy or its sectors in the EU countries;*
- *d) calculating specific economic indicators of the EU;*
- *e) analysing the banking sector indicators;*
- *f) forecasts, etc.*

Content of the seasonal and calendar adjustment of time series

***The seasonal adjustment procedures** are based on certain assumptions. First, we assume that time series can be divided into invisible components. Division into three components (trend, seasonal and irregular components) and prerequisites for further processing have, for example, been described in the article "Seasonal adjustment of time series" (Täht 2007). These three components can be further divided into sub-components. This division is based on definite relations between the different components of time series. The most significant of them are set out in Annex 2, pp 35–36.*

The second assumption, significant in terms of mathematics, is the method according to which time series and their components are processed. The philosophy of the given processing is based on two main types of methods: parametric or model based methods and non-parametric or filter based methods.

***Model based methods** proceed from the definition that a time series is realisation of a stochastic process with discrete time. It is assumed that time series and their components can be modeled with the help of relatively simple mathematical functions, which depend on a few parameters. Their use is subjected to observance of relatively strict prerequisites: for example, every component of a time series can be modelled as a stochastic process. It is also assumed that residuals represent "white noise" i.e. they are a stochastic process, the arithmetic mean of which equals zero and standard deviation is a constant. For example, widely used software TRAMO/SEATS is based on parametric methods.*

***Filter based methods** present only general assumptions on time series: small rank polynomial trend and locally linear or polynomial seasonality. Fixed filters are applied in order to divide a time series into a trend cycle, and seasonal and irregular components. As a rule, weighted moving averages serve as their basis. The given averages "move" by the time axis of a time series and, this way, a new time series – smoother than the previous one – is derived. As a rule, asymmetrical linear filters are used for calculating the final components of time series and, symmetrical – in case of all the rest.*

The seasonal adjustment theory began to develop namely from non-parametric methods. The whole software, too, was oriented to these methods. X11, X11-ARIMA and X12-ARIMA can be mentioned as a widely used software based on non-parametric methods.

***A lot of users cannot understand the content of seasonally adjusted time series.** According to a widely recognised opinion there can exist only one "right" seasonally adjusted time series. In fact, the reverse is true, i.e. for every time series, one can find lots of seasonally adjusted time series that appear suitable and are competing with one another (see S. Öhlen, 2006). Although we indeed do not know which "the rightest" seasonally adjusted time series is, we nevertheless have a possibility to calculate a whole series of indicators or, more specifically, quality indicators that carry information about the characteristics of respective time series. These indicators enable us to change the selection we are making towards a certain direction. In other words, we can always select the most suitable one out of a whole range of seasonally adjusted time series which virtually have extremely similar characteristics. Figure 1 illustrates the situation. (Figure 1, p 25)*

Figure 1 shows that there can theoretically exist an infinite quantity of admissible solutions that all fit in the given confidence interval (confidence interval is a good visual quality indicator: the narrower this interval is, the better). This figure also indicates that it would be incorrect to state that growth compared to the previous period is a fixed size. A fixed growth has been induced by application of a specific model. If we change a model and even parameters – we should do it from time to time due to rapid changes in the economy –, the development rate i.e. the growth or decline also changes a bit. Naturally, the new solution also remains in the predetermined confidence interval. Hence, we can only talk about an ascending or descending tendency and, to some extent, also about its speed. This figure clearly demonstrates that the growth rate of our economy started to slow down from the second quarter of 2007 and the last decline started in the first quarter of 2008. Since the fourth quarter of 2009, our economy has been slowly growing again. For the moment (in terms of seasonally adjusted GDP) we are positioning more or less at the 2005 level.

***After having selected an additive or multiplicative decomposition scheme, the preadjustment process of seasonal adjustment starts, as a result of which all outliers and, if needed, also the calendar effects (calendar adjustment) are eliminated.** Calendar adjustment is a process, the purpose of which is to identify and eliminate calendar effects. Calendar adjustment should be applied to only the time series where the respective influence appears to be statistically significant.*

Why is calendar adjustment necessary? There are at least three reasons.

1. *It is necessary to gain a more accurate estimation of neighbourhood periods. For example, how can one compare the first and fourth quarter data? The month of Febrary may pose a problem in the first quarter, and Christmas – in the fourth quarter.*

2. It is necessary to gain a more accurate estimation of different periods.

3. It is necessary to compare the data of one and the same period in different years. It is a known fact that the number of weekdays in one and the same month of different years is different. The productivity of different weekdays often varies, too. This implies that if we want to compare data, we have to take into consideration the effect of different weekdays in case of every particular time series.

Calendar adjustment is performed either by working days (working day adjustment) or by different weekdays (trading day adjustment). Moving holidays (e.g. Easter), other holidays in national calendar and calendar-based events are also taken into account. For instance, adjustment by the effect of school holidays, freezing days or bridging days can sometimes appear to be rather useful. All this can be done with the help of user regressors.

***Adjustment by the effect of school holidays.** Economic activities can sometimes depend also on school holidays. Employees who have school-age children may take vacation right during school holidays and, by doing so, they suspend their main job.*

***Adjustment by the effect of freezing days.** Results in some economic activities, for example in construction, depend on ambient temperature. Labour productivity may decline if it's too low. Thus, in case we compare the results of different periods, we should also take into account the effect of cold weather days (when the temperature is, for example, below zero) on production activities.*

***Adjustment by the effect of bridging days.** Bridging days are the days between a public holiday and a weekend day or turn of the year. Their effect depends on whether they are at the beginning of a calendar year (Independence Day), in the middle of the year (Midsummer Day) or at the end of the year (Christmas). For example, some agencies are closed between Christmas and the turn of the year. As a rule, the effect of a bridging day occurring at the end of the year is different from the effect thereof if it occurs in some other period.*

The effects that these three factors produce have been described by R. Kirchner (2007).

***Let us explain the necessity for calendar adjustment on the basis of an example taken from literature in order to describe the effect of different weekdays on a final result.** Let us imagine that the production (March, 1999–2002) of an enterprise is as follows: in 1999 – 112,000 conventional units of goods; in 2000 – 110,000; in 2001 – 104,000; and in 2002 – 99,000 conventional units of goods. Can we conclude from these data that labour productivity was lower in March 2002 than in March 1999?*

Let us assume that we know the daily production of the enterprise: Monday – 4,000 conventional units of goods; Tuesday – 6,000; Wednesday – 6,000; Thursday – 5,000; and Friday – 3,000 conventional units of goods. Saturday and Sunday are not working days. Consequently, in total 24,000 conventional units of goods are produced per week. Next, we are going to draw two small tables. Let us insert the number of weekdays in March 1999–2002 in the first table. (Table 1, p 27)

Let us insert the calculated production values in the other table (Table 2, p 27). In this particular case, we consider that there are four full weeks in March every year (the production of which is 4 x 24,000 = 96,000 conventional units) in addition to different weekdays: in March 1999 there are additionally three more days i.e. Monday, Tuesday and Wednesday; in March 2000 full weeks are complemented by Wednesday, Thursday and Friday; in March 2001 – Thursday and Friday, and in March 2002 – Friday. Table 2, p 27, demonstrates that the differences in production in March by years have only been caused by a different number of different weekdays (thus, also by different effects) or, in other words, by the calendar effect only.

***By summarizing the above written and by supplementing it, we can state that seasonal adjustment** is a process of identifying and eliminating a seasonal component. In the preadjustment stage, a calendar component or factor and outliers are identified and eliminated. In case of need (if we want to include special factors: school holidays, effect of freezing days, effect of bridging days, etc.), user regressors are taken into use. In the final stage, final components are* *found: level shift is added to the preliminary trend, calendar component is added to the preliminary seasonal component, and additive outlier and transitory changes are added to the preliminary irregular component. Factors found with the help of user regressors are added according to the components (trend, seasonal or irregular) they were used for.*

There are four different situations in the practice of the seasonal adjustment of time series.

1. *A time series contains seasonal effect but it does not contain a calendar component. In this case, only seasonal adjustment needs to be performed, or in other words, only a seasonal component has to be identified and eliminated.*
2. *A time series does not contain a seasonal component but it contains a calendar effect. In this case, calendar adjustment is the only adjustment that can be performed.*
3. *A time series contains a seasonal effect as well as calendar effect. In such a case, first, the calendar factor can be eliminated and, then, seasonal adjustment can be performed.*
4. *A time series contains neither a statistically significant seasonal component nor a calendar component. In such a case, a seasonally adjusted time series is the same as the original time series. In other words, in case of such time series, we do not perform seasonal adjustment.*

Revision and publication of seasonally adjusted time series

Revision of seasonally adjusted time series is performed mainly due to the updating of preliminary data, models or parameters thereof. If preliminary data are revised, often models have to be revised, too. This, in turn, changes the whole seasonally adjusted time series. A seasonally adjusted time series change even if the next monthly or quarterly data are added to it. This way, consumers may get confused as to why the seasonally adjusted data of previous periods also change whereas only one element was added to the original time series. Indeed, changes can sometimes be rather significant especially if they concern the last periods of time series and the reason thereof lies in the algorithm used for calculating the components of seasonally adjusted time series.

While calculating the components located at the end of a seasonally adjusted time series, the program designed by model-based methods takes account of the forecasts made by the program itself, whereas in the selection of forecasts the program is guided by the program-predetermined criteria. Provided that economic changes are very fast, the forecast can sometimes differ a lot from the real result. This is one of the reasons, why the components positioning towards the end of adjusted time series should be treated with certain caution.

A seasonally adjusted time series that changes due to revision poses problems when the data thereof are published. The European Statistical System Guidelines on Seasonal Adjustment (ESS Guidelines, 2009) set out different strategies for the revision and publication of seasonally adjusted data. One recommendation is as follows: when original data are revised for less than two years, then models, filters and outliers are identified once a year and all parameters are re-estimated every time when new data become available. The Guidelines also recommend to change the seasonally adjusted data starting from a point 3–4 years before the beginning of the revision period of the unadjusted data. Earlier data should be frozen.

Quality of seasonally adjusted time series

Since seasonal adjustment is quite a complicated procedure, it should be accurately monitored before the results can be accepted and published. In order to ensure high quality of seasonally adjusted time series, our results are checked against different tests or quality indicators. What are the criteria for a high quality of seasonally adjusted time series? By which parameters can it be evaluated? This seemingly simple question does not have a simple answer. The problem can be approached from two points of view: a potential general quality and an actual quality of the results *gained through seasonal adjustment of a particular time series backed by the methods applied by the used software.*

In case of potential quality we take the quality of software and preliminary data as well as the knowledge and experience of involved employees into consideration.

***High-quality software** functions as an important objective factor. Experience shows that previous versions of DEMETRA used by lots of institutions contain some bugs that sometimes prevent us from gaining a good result. This, in turn, makes us look critically at other results gained with the help of this software (and at the respective software).*

***The quality of original data** is an important subjective factor. We know well enough that the data on a lot of economic indicators released by statistical offices are often revised. The reason for that may lie, for example, in methodological changes or amendments made to classifications. Thus, indicators become "more accurate", but the achievement of accuracy is shifted in time. This means that data are revised also after the first publication of them i.e. the quality of published data must not necessarily be sufficient. Errors made in the course of rewriting or calculation cannot be ruled out either.*

*It is essential to understand that the quality of seasonally adjusted time series depends a lot on the **knowledge and experience** of the employee working on it. From the perspective of result analysis of seasonally adjusted time series, it would be very useful if the person working on the matter knew the subject area and had also knowledge in the field of seasonal adjustment methods.*

In general, we can assess potential quality according to a formula based on expert assessment. Presuming that all three above mentioned conditions can be subjected to expert assessment (e.g. expressed in figures from 0 to 1, where 1 means 'very bad' and 1 – 'ideal'), the expected potential quality of the seasonally adjusted time series can be calculated by using the following formula:

$$SK_{kv} = \sqrt[3]{AA_{kv} \times TV_{kv} \times TK_{kv}} \quad ,$$

*where **SKkv** $\in$ [0.1] represents the expected potential quality of the seasonally adjusted time series,*

***AAkv** $\in$ [0.1] represents the quality of original data,*

***TVkv** $\in$ [0.1] represents the quality of used software,*

***TK** $\in$ [0.1] represents the knowledge and experience of the employee.*

This formula enables to assess possibilities and envisage development trends. Despite the fact that we cannot change the quality of the used software, we can still change the two other components. In other words, this formula can help us in taking right decisions.

*Some publications have been issued on the quality indicators calculation methodology of seasonally adjusted time series and, based on them, respective chapters have been included in software user manuals. We are mainly guided by two publications: "Quality and Uncertainty in Seasonal Adjustment" by S. Öhlén (2006) and the publication "Seasonal Adjustment Methods and Practices" by the Hungarian Central Statistical Office (E. Földesi et al 2007). Some references can also be found in the ESS Guidelines on Seasonal Adjustment (2009). In his work Sven Öhlén focuses on three general principles that should be taken into account while assessing results. He tries to treat the problem in a systematic way using the **theoretical, empiric and other aspects.***

An important theoretical aspect is that the seasonal adjustment methods, especially the model based ones, proceed from certain mathematical and statistical presumptions, and in decision-making the results of statistical tests are taken into consideration. This means that it is possible to calculate different statistical indicators for model parameters as well as for the decomposition *model components. On the basis of these indicators it is possible to evaluate the preliminary as well as final results.*

From the empiric aspect, the (statistical) suitability of the model for exisiting data is of greatest importance. Repeated seasonal adjustment for one and the same time series should lead to identical results. Another important condition is, for example, that consistency conditions have to be used in the seasonal adjustment of quarterly national accounts. The meaning of these conditions is, first, that the sum of four quarters of original time series and the sum of four quarters of seasonally adjusted time series are the same and equal the yearly GDP (time consistency). Secondly, the consistency condition between components may also be of interest. For example, the sum of GDP components must be the same for the sum of original data as well as for the sum of seasonally adjusted components. It is assumed that consistency algorithms change quality indicators to the minimal extent.

Another aspect interesting from the theoretical point is the average gap between the "right" value and the calculated estimation thereof. By now, many statistical indicators have been proposed for the estimation thereof. Whether to apply the direct or indirect seasonal adjustment method is also a relevant problem.

***Regarding specific quality indicators, we will shortly discuss five groups of them:** visual analysis of graphs, statistics of residuals, and stability of seasonally adjusted time series, autocorrelations and model consistency statistics. The author tries to follow the publication (E. Földesi et al 2007) by Hungarian Central Statistical Office.*

Visual analysis of graphs is a very effective and necessary quality indicator. Some institutions use the average, the standard deviation and graphs of original and seasonally adjusted time series as indicators. Graphs are also used for visual analysis of trends (with standard deviations). On the basis of visual analysis of these graphs, one can make preliminary conclusions with respect to the quality of seasonally adjusted time series. Some countries also use other graphs: preliminary and final seasonal factors, changes compared to the same period of the previous year and spectral peaks that correspond to the seasonal or calendar frequencies, changes compared to the same period of the previous year for seasonally adjusted time series and trends. The graphs of residuals of time series and of their spectra are also used.

Residual statistics as quality indicators. According to a general theoretical requirement, residuals should be of normal distribution, independent and not contain residual seasonality. The requirement of software TRAMO/SEATS is that residuals should follow the conditions of "white noise". This software uses five types of statistics for testing residuals: the Ljung-Box Q-statistics, the same statistics for squared residuals, the Box-Pierce Q-statistics, the same statistics for squared residuals and normality tests. A short overview of the listed statistics can be found in the author's paper (M. Täht, 2007).

Other indicators are also used: the significance of ARIMA model, standard deviation of seasonally adjusted time series, BIC (Bayesian Information Criteria), sign test for residuals and DW-test (Durbin Watson test).

The content of stability, as a quality indicator, of a seasonally adjusted time series, is as follows. If we add a new value to a time series, the seasonal adjustment procedures undertaken evoke changes in the seasonally adjusted time series. Preferred are the procedures which evoke minimal changes. Statistical offices in a lot of EU countries use the stability test in exceptional cases only for time series which are of utmost importance like after major revisions of preliminary data, after changes in models or if consumers require the test.

The autocorrelation function as a quality indicator helps to determine the statistical significance of a seasonal component. The Box-Pierce or F-test is applied to evaluate the significance of a seasonal component.

Two indicators are mainly used to check the consistency between a model and original data: AIC (Akaike Information Criteria) and BIC (Bayesian Information Criteria).

Quality indicators of some other countries. *According to the results published by E. Földesi et al (2007), Sweden makes use of six supplementary indicators: spectral analysis of residuals, variety of seasonally adjusted time series, parameter test of ARIMA model, stability of calendar effect, graphical visual analysis of residuals, outliers and time series. Germany uses the stable seasonality test and checks the statistical significance of regressors as supplementary indicators. Poland notes down the shares of outliers and Slovakia – the growth rates. The United Kingdom uses also descriptive statistics as a quality indicator.*

It should be mentioned that most of the above referred indicators are already used by default in most common software packages. The rest of indicators can be used only with suitable software.

Quality indicators of seasonally adjusted time series in case of the software package DEMETRA+

Demetra+ is a modern module-based software for seasonal adjustment of time series. The software packages DEMETRA (versions 1.0 to 2.2) are considered its predecessors. Demetra+ was ordered by Eurostat and its main designer was the National Bank of Belgium. This software package was designed to offer a convenient and flexible software solution for performing the seasonal adjustment of time series. It is assumed that these procedures are in conformity with the recommendations laid down in ESS Guidelines on Seasonal Adjustment (ESS Guidelines …, 2009).

This software package allows for a fast and complex analysis of original data as well as results of seasonally adjusted time series and it is meant for beginners as well as professionals. This software, like its predecessors, is based on the two leading programs in this area – TRAMO/SEATS and X12-ARIMA. It enables to simultaneously process single as well as multiple time series. At the same time, the software offers a lot of user friendly facilities for testing the quality of received results.

The software provides a lot of possibilities for processing time series and evaluating results. It is possible to upload information from different sources. For example, the software allows using time series presented in different formats (e.g. text, TSW, USCB or X12-ARIMA/X13-AS format, Excel) as well as generating databases or WEB-servers (in .xml-format). Further versions will be provided with a tool for in-house applications.

Demetra+ offers an abundant choice of diagnostics indicators for the quality check of seasonally adjusted time series. Indicators are treated in further detail in the DEMETRA+ manual (DEMETRA+: User Manual, 2010) and in the paper by N. A. Koçak "An Analysis of German industrial production with DEMETRA+" (2010). These quality indicators have been integrated into various seasonal adjustment software modules. Their interpretetation may unfortunately appear complicated for beginners. For simplification purposes, a majority of these indicators have also been supplied with information in text format. The text values and their meanings are as follows.

Undefined *– quality is undefined. The reason may lie in an unprocessed test, meaningless test, failure in the computation of the test.*

Error *– there is an error in the result. The reason may lie in the fact that values of unauthorized indicators may have occurred among the data or in noncompliance with some kind of restriction. The processing should be rejected.*

Severe *– there are no logical errors in the results, but the results are still unacceptable due to some statistical reasons.*

Bad *– although a general quality of results is not good, the results of statistical tests are acceptable. Despite that, results can be considered acceptable.*

Uncertain *– the result is uncertain.*

Good *– the result of the test is good.*

After the procedure is finished, the statement 'accepted' may be displayed. This text invites to accept the result as a whole in spite of specific values of indicators.

A summary of all tests used for the purpose of quality assurance of seasonally adjusted time series have been presented in Annex 3, pp 37–38. Below we are going to give a quick overview of them.

***1. Main results with respect to seasonally adjusted time series and their components.** This section includes ARIMA residuals, residual seasonality and standard deviations of seasonal and irregular components and their mutual cross-correlation. All indicators are presented in the numerical form and as text value. Besides, tables and graphs are presented on the original, seasonally adjusted time series and their components (trend, seasonal and irregular). Graphs on SI ratios are also displayed.*

***2. Preliminary processing.** The main results of this section include data on the need for logarithmisation of time series and on the adequacy check of the model (values of probability distribution, information criteria, Hannan-Quinn statistics and regression standard deviation), and also on the choice of ARIMA model, parameters, calendar effects and outliers.*

***2.1. The sub-section of pre-adjusted time series** contains information on the time series, from where outliers have been removed and that are calendar adjusted, and on the effects, outliers and other essential components of fixed calendar holidays and moving holidays.*

***2.2. In the sub-section of used regressors**, information can be found on all used regressors.*

***2.3. In the sub-section of residual values**, the values of residuals are presented in the form of a table and diagram. The independence of residuals and absence of autocorrelation as well as the symmetry and normal distribution of residuals are checked. The definition of residuals is a bit more complicated, because TRAMO/SEATS and X12-ARIMA represent different schools. In principle, residual is a difference between the original time series and the used model.*

The normality of residuals is tested on the basis of Doornik-Hansen statistics, the distribution of which is $X^2(2)$. Test results are presented in the form of the following values: bad, uncertain and good. The current version of program expresses results of tests only with probability value.

Ljung-Box statistics LB(k) are used for testing the independence of residuals. Provided that residuals are a random variable, the distribution thereof is $X^2(k - np)$, where np is the number of ARIMA model parameters. The current version of the program expresses test results only with probability value.

Diagrams which enable to visually estimate the normality (line and bar charts for normal distribution) and independence (autocorrelation and partial autocorrelation bar charts) of residuals are presented in order to test residuals.

***3. Diagnostics.** The main modules of this section are: visual spectral analysis, residuals and seasonality of residuals. All test results are also released in text format.*

Visual spectral analysis is intended for testing seasonal and calendar frequencies. This variant of diagnostics is used also for the software X12-ARIMA. A frequency testing method developed further by the U.S. Census Bureau has been taken as basis.

In case of residuals, normality (i.e. they are of normal distribution), independence of components, presence of the working/trading day (calendar day) and seasonality effects are checked.

The seasonality test sub-section provides comprehensive information on the presence of stable seasonality. The statistical tests of Friedman, Kruskal-Wallis and other statistical tests are used.

***3.1. In the spectral analysis sub-section**, it is possible to find periodograms and autoregressive spectra for residuals, irregular components and seasonally adjusted time series. The definition 'Fourier frequency', known for its good statistical attributes, is used for computing periodograms. On the assumption that residuals are of normal distribution, it is easy to diagnose specific frequencies (or groups of frequencies).*

3.2. Revisions. *This sub-section presents diagrams and numerics which characterise changes in the seasonal adjustment process over a whole period of time. Data are presented in the form of seasonally adjusted time series as well as trend-cycle line graphs. A red line graph represents final estimations, whereas a dot chart refers to preliminary estimations. Numerics, which in essence represent a relative difference between the preliminary and final indicators, are presented as a table. Statistically significant difference is marked in red.*

3.3. Analysis of sliding spans. *This-sub-section sets out comparisons of the results of mutually correlated seasonally adjusted time series. Such time series are formed of original time series by dividing the time series into four overlapping time series. As a rule, time series with the largest possible overlap are selected. The section contains a summary of the stability and seasonality identification tests and the monthly or quarterly averages of the seasonal factor for every sliding span.*

The respective sub-sections (for seasonal and calendar components and for seasonally adjusted time series) contain the results of analysis for every period.

3.4. Model stability *is the last sub-section of this section. It provides graphs for visual testing of the model's calendar effects and of the stability of ARIMA model.*

Conclusions

Seasonal adjustment is a process for identifying and eliminating a seasonal component. In the pre-adjustment stage, a calendar component and outliers are identified and, if necessary, eliminated. The significance of calendar adjustment is demonstrated with the help of an example assignment. Final components are found in the final step of seasonal adjustment: level shift is added to the trend, calendar component is added to the seasonal component, and additive outlier and transitory changes are added to the irregular component. Factors found with the help of user regressors are added depending on which component was specified by using it.

Revision of seasonally adjusted time series is performed mainly due to the updating of original data, models or parameters thereof. In the revision of preliminary data, often models also have to be changed and this in turn changes the entire seasonally adjusted time series. Seasonally adjusted time series change even if the monthly or quarterly data of the subsequent month are added to them. For the purpose of releasing time series, the ESS Guidelines on Seasonal Adjustment recommend to change the seasonally adjusted data starting from a point 3–4 years before the beginning of the revision period of the unadjusted data. Earlier data should be frozen.

The quality of seasonally adjusted time series depends on the software and indicators used therein as well as on the conditions not related to the software. All these factors have an effect (either direct or indirect) on the quality of the results of seasonally adjusted time series. The article provides a short overview of five groups of quality indicators: visual analysis of graphs, statistics of residuals, stability of seasonally adjusted time series, autocorrelations and model concordance statistics.

The new software Demetra+ offers an abundant choice of diagnostics indicators for the quality assurance of seasonally adjusted time series. These diagnostics indicators are "integrated" into the different modules of the software. Annex 3, pp 37–38, gives a summary of the diagnostics indicators used for testing the seasonally adjusted time series and their components.

Annex 1, p 48, gives the main definitions, and Annex 2, pp 35–36, lists, in a mathematical form, the basic relations of time series existing between the components in decomposition models.

Annex 1. Main definitions

Economic time series *is a set of data on the results of economic activity which contains economic results of a specific object at certain successive moments (for example, every month or every quarter).*

From the perspective of the probability theory, ***time series*** *is realisation of a stochastic process with discrete time. The time series y_t can be viewed as realisation of a random process Y, where there exists only a one-element sample y_t for every random size Y_t .*

Seasonal adjustment of time series *is a process for identification and elimination of a seasonal component. Seasonal adjustment should be applied to only the time series where the respective seasonal effect is statistically significant.*

Calendar adjustment of time series *is a process, the purpose of which is to identify and eliminate calendar effects. Calendar adjustment should be applied to only the time series where the respective calendar effect is statistically significant.*

Trend cycle *consists of a time series trend and an economic cycle.* ***Trend*** *is a time series showing a medium- or long-term development direction, which can be observed in different periods of time and from where seasonality and random effects have been removed.*

Seasonal component *represents fluctuations which can be observed during a year (by months or quarters) and which are repeated from year to year. Seasonality can be caused by natural factors, administration conditions, social and cultural traditions.*

Calendar component *is a part of seasonal component which is connected with the national calendar and public holidays in a particular country.*

Irregular component *consists of the residual of time series and of random fluctuations that cannot be attributed to other "systematic" components. It can also contain the effect of special unforeseeable events occurring in the economy (e.g. a strike or natural catastrophe) and errors in original data.*

Outliers *are extreme data which do not necessarily match the observed data of a time series and which lie outside the trend, outside the expected confidence interval of a seasonal or irregular component. The prevalent majority of software packages distinguish between three types of outliers: additive outlier, transitory changes and level shift.*

In case of ***additive outlier,*** *only one component of time series is affected, its neighbours are not affected. The reason for such an outlier may be a random effect, for example errors occurring in original data or in rewriting original data or some identifiable event, for example a strike or a natural catastrophe.*

In case of ***transitory changes,*** *the value of one component is either extremely big or small, thereupon it decreases (or increases) exponentially until the time series achieves its normal level.*

In case of ***level shift,*** *the values of the components of a time series (of a trend, as a rule) have, starting from a certain moment in comparison with previous periods, been "shifted" either upwards or downwards. The reason thereof may lie in concepts or definitions which have changed during the collection and classification of data, in the development of the economy, etc.*

SI ratio *(seasonal-irregular component) is a time series from which the trend has been removed. In case of a multiplicative model, it is expressed as the ratio of time series and trend.*