SEASONAL ADJUSTMENT OF SHORT-TERM STATISTICS USING X-12-ARIMA AND X13 IN JDEMETRA+

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ABSTRACT

The results of economic time series – for instance monthly data on turnover in industry or quarterly gross domestic product figures – are affected by annually recurring seasonal effects and calendar variations. This makes an assessment of current development more difficult. Such effects can be eliminated using statistical methods of seasonal adjustment in order to permit a better assessment of current trends. This article describes the use of the seasonal adjustment methods X-12-ARIMA and X13 in JDemetra+ for purposes of seasonal adjustment of the short-term statistics of the Federal Statistical Office.

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Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

1

Why seasonal adjustment? [1]

Short-term statistics provide monthly or quarterly data on the development of various economic sectors and the economy as a whole. The variables include, for instance, turnover, the number of persons employed and the volume of output in the different economic branches, and the results of the quarterly domestic product calculations for Germany. Regarding these statistics, the focus of interest is more often on the development of results over time than on the absolute values of individual statistical results. For this reason, the relevant publications primarily present growth rates on a comparative period. However, changes are often strongly affected by seasonal effects which make an assessment of current trends difficult.

The aim of seasonal adjustment is to eliminate seasonal variations which occur with similar intensity every year from the time series values. An example is the effects of typical seasonal fluctuations in weather or average decreases recorded in holiday months. [2] Seasonal adjustment allows it to be assessed, for instance, whether a month-on-month increase in construction output recorded in March is to be regarded as extraordinarily strong or as being in line with the typical seasonal trend.

Seasonal adjustment often includes calendar adjustment. [3] This is aimed at adjusting effects which arise from different numbers of working or trading days or certain days of the week in a specific quarter or month due to the position of weekends or statutory holidays.

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1   We would like to thank Jonas Flechsig (mathematics student) for his research assistance for this article.

2   The effects of bridging days (days lying between a public holiday and a weekend) or movable school holidays are not part of adjustment. Similarly, no adjustment is made for "extraordinary" weather effects, that is weather effects other than those that can typically be expected during the course of a year. As agreed in the European Statistical System, the effects of extraordinary concentrations of leave or weather conditions that are atypical of a season can and should be reflected in the seasonally adjusted results as they do not occur with similar intensity at the same time each year (Eurostat, 2015, here: page 20 f.).

3   In this article, the concept of seasonal adjustment generally covers the adjustment for both seasonal fluctuations and calendar effects. Where seasonal adjustment explicitly excludes calendar adjustment, it is referred to as "seasonal adjustment in the narrow sense".

In addition to values that are both calendar and seasonally adjusted, purely calendar adjusted and also unadjusted values are generally available for all statistics for which adjusted results are published.

↘ Excursus: year-on-year comparison

Year-on-year comparisons are a simple method to eliminate the usual seasonal fluctuations from observation. In this context, the unadjusted value or the purely calendar adjusted value of the current period is compared with the relevant value of the same quarter or month of the previous year.

Figure 1
Year-on-year and month-on-month comparison

Value of the previous month
Current value
Value of the previous year

2019 - 01 - 0628
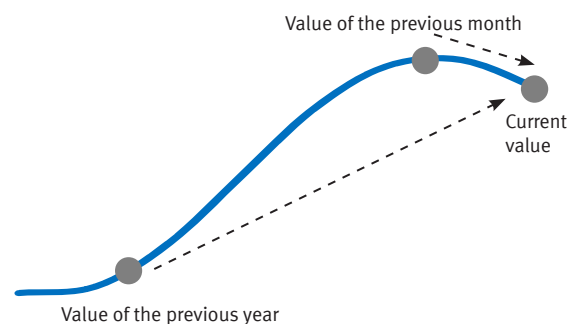
However, the results of year-on-year comparisons may point in a different direction to that of month-on-month or quarter-on-quarter comparisons based on seasonally adjusted results. This is for instance the case when a longer upswing is nearly over and the month-on-month comparison already reveals a downward trend, while the current result is still above the value of the previous year. As a rule, comparisons with the previous period using seasonally adjusted results allow economic analysis that is based on a comparison with a period closer to the one under review and is therefore more relevant than year-on-year comparisons.

It is common at the international level to publish seasonally adjusted results. This facilitates economic analysis based on month-on-month or quarter-on-quarter comparisons - especially if the relevant analysis covers many economic branches and the seasonal fluctuations common in the individual branches cannot be presumed to be known. However, seasonal adjustment has the

disadvantage that mathematical-statistical methods of analysis are used which require various assumptions to be made and parameters to be set. Therefore the results obtained by means of different adjustment procedures and by various individuals engaged in seasonal adjustment may differ. To increase the objectivity of seasonally adjusted results and enhance their comparability within the European Statistical System, harmonised seasonal adjustment methods are applied and both nationally and internationally coordinated standards of seasonal adjustment are observed (see Chapter 3).

2

The underlying time series model

Seasonal adjustament is based on the assumption that a time series can be decomposed into several components. The trend-cycle component reflects long-term tendencies and cyclical movements. The seasonal component covers movements which recur with similar intensity each year. The calendar component includes the average impact of calendar constellations, for instance due to the varying number of working days between months or quarters of the same name. The irregular component comprises effects that are incidental or can be explained economically, but do not belong to the other components. Examples are the effects of an exceptionally warm winter on construction activity or the impact of strikes on the turnover of a given branch. In applying X-12-ARIMA and X13 in JDemetra+, the bodies of official statistics mostly use a multiplicative model for the decomposition of time series into individual components:[4]

(1) $X_t = S_t \cdot K_t \cdot T_t \cdot I_t$

X_t (unadjusted) value

S_t seasonal component

K_t calendar component

T_t trend-cycle component

I_t irregular component

t time

In the adjustment process, only the calendar and seasonal components are excluded from the time series so that both the trend-cycle component and the irregular component are still included in the calendar and seasonally adjusted result. The following equation shows this relationship:

(2) $X_t^{KSB} = \dfrac{X_t}{S_t \cdot K_t} = T_t \cdot I_t$

X_t^{KSB} calendar and seasonally adjusted result

The goal of seasonal adjustment is not to present smoothed time series or trends. Irregular movements are rather an important element of the adjusted time series and are to remain there. Only in this way can specific cyclical developments at the current end of a time series be identified and considered in interpreting the figures.

3

Nationally and internationally harmonised approach

Seasonal adjustment using X-12-ARIMA and X13 in JDemetra+ is carried out by the Federal Statistical Office in collaboration with Deutsche Bundesbank as its partner. The methods applied are largely harmonised within the European Union (EU).[5] The ESS guidelines on seasonal adjustment (Eurostat, 2015) contain general requirements for the adjustment. They apply to all statistics of the European Statistical System (ESS) which are to be adjusted. As set out in the principles of the guidelines, seasonal fluctuations which can be expected to recur and calendar effects should be identified and eliminated as they can mask the movements that are of actual interest in a time series and impede a clear understanding of the underlying phenomena. Seasonal adjustment is considered a fundamental process in the interpretation of time series (Eurostat, 2015, here: page 6). The guidelines also point out that different approaches can lead to different results:

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4   In some cases, however, additive models or combinations of additive and multiplicative components are used. The following explanations always refer to the multiplicative model.

5   The basic principles of cooperation with Deutsche Bundesbank were laid down in a Memorandum of Understanding. This memorandum considers the relevant responsibilities of both institutions (Deutsche Bundesbank/Federal Statistical Office, 2014).

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

"The downside of seasonal adjustment is that seasonality cannot be precisely defined and different approaches – such as the signal extraction approach […] and the semi-parametric approach based on a set of predefined moving averages […] – may result in different outcomes. The expertise of an analyst will also impact on the quality of seasonal adjustment, although the primary drivers are the quality of the unadjusted time series and the production timetable." (Eurostat, 2015, here: page 6)

The guidelines on seasonal adjustment are intended to enhance comparability between statistics in the ESS, which is to be achieved by adherence to given standards of seasonal adjustment and the application of certain seasonal adjustment methods. Individual stages of the seasonal adjustment process are detailed and different options are described for each case. They are classified as Alternative A (best alternative), B (acceptable) and C (to be avoided). In addition to the guidelines, EU regulations regarding the relevant statistics specify further European requirements for seasonal adjustment. Some examples are given below:

› In national accounting, the requirement to provide calendar and seasonally adjusted quarterly data is set out in the Regulation on the European System of Accounts (ESA 2010). The following notes are provided, for example, concerning the data of the table of main aggregates to be supplied: *"Quarterly data are to be provided in non-seasonally adjusted form, as well as in seasonally adjusted form (including calendar adjustments, where relevant)."*[6] The ESA 2010 regulation also specifies how seasonal adjustment is to be made.

› In the area of business statistics, the Regulation concerning short-term statistics, as it is called, plays a central role. In accordance with this regulation, data for the variables of "production", "turnover" and partly "hours worked" in industry, construction, retail trade and repair as well as other services are to be transmitted in a working-day adjusted form.[7] The obligation to provide seasonally adjusted data is to be extended in the context of the newly created FRIBS framework

regulation (Framework Regulation Integrating Business Statistics).[8]

› Regarding the labour cost index, the compulsory transmission of seasonally and working-day adjusted results is governed and substantiated in an implementing regulation: *"Seasonal and working-day adjustment of the labour cost index is an essential part of the compilation of the index. Adjusted series make it possible to compare results and to interpret the index in a comprehensible manner."*[9]

4

Mathematical-statistical methods and software

4.1 Mathematical-statistical methods

Regarding the mathematical-statistical methods of seasonal adjustment, three "families of methods" are relevant in the context of German and European official statistics. ↘ Chart 1

Chart 1

Families of seasonal adjustment methods used in official statistics in Germany and the EU

(1)	Census X11, X-12-ARIMA, X13 in JDemetra+
(2)	SEATS, TRAMO/SEATS, Tramoseats in JDemetra+
(3)	Berliner Verfahren, BV4.1

Census X11, X-12-ARIMA, X13 in JDemetra+

The family shown at the top of Chart 1 became popular through a software program developed by the United States Census Bureau in the 1960s (Census X-11). The underlying mathematical-statistical method is based on weighted moving averages (so-called filters) that are iteratively applied to determine the trend-cycle and the seasonal component of a time series. X-12-ARIMA is the extended method where both a pre-treatment and forecast of the time series using RegARIMA models are made before trend and seasonal filters are applied. These are

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6 Regulation (EU) No 549/2013 of the European Parliament and of the Council of 21 May 2013 on the European system of national and regional accounts in the European Union, Annex B, Table 1.

7 Council Regulation (EC) No 1165/98 of 19 May 1998 concerning short-term statistics, consolidated version.

8 See Waldmüller/Weisbrod (2015) for FRIBS.

9 Commission Regulation (EC) No 1216/2003 of 7 July 2003 implementing Regulation (EC) No 450/2003 of the European Parliament and of the Council concerning the labour cost index.

regression approaches that are combined with time series models (so-called ARIMA models) in order to estimate calendar effects, to identify, model and estimate outliers and to reduce methodological problems in applying the filters.[10] X-12-ARIMA is also available in the software JDemetra+ where it is referred to as X13 (see Chapter 4.2).

SEATS, TRAMO/SEATS, Tramoseats in JDemetra+

The mathematical-statistical method SEATS, promoted by the Bank of Spain, is based on a signal extraction technique for modelling the trend-cycle and seasonal components. As a result of further development, TRAMO/SEATS appeared in 2001. This includes time series pre-treatment and forecasting using the TRAMO algorithm (which is also based on RegARIMA models) and seasonal adjustment in the narrow sense using SEATS.[11] The method is also available in the JDemetra+ software where it is referred to as Tramoseats.

Berliner Verfahren (Berlin procedure), BV4.1

The Berliner Verfahren is designed for modelling time series components through moving linear regressions. The outliers of a time series are identified beforehand using probability models. The mathematical bases of this method were developed together by Technische Universität Berlin and the German Institute for Economic Research in the late 1960s. The method has been used at the Federal Statistical Office since 1972. From 1983 onwards, the Office applied the fourth version of the Berlin Verfahren (BV4), which was the result of further development by the Federal Statistical Office. That version was replaced by BV4.1 in 2004. BV4.1 differs from BV4 to the extent that it comprises methodological improvements regarding the treatment of calendar effects, outliers and user-defined components.[12]

The mentioned guidelines of the European Statistical System also contain recommendations as to the seasonal adjustment method to be used. The methods X-12-ARIMA and TRAMO/SEATS (or X13 and Tramoseats

in JDemetra+) are based on procedures that are classified as (A) alternative in the guidelines. Besides, the latter classify the use of seasonal adjustment procedures not mentioned under (A) or (B) - including the Berliner Verfahren- as a (C) course of action. However, the relevant classification is only based on the criterion of international comparability rather than the quality of the methods.

For reasons of international comparability, the Census family methods were introduced at the Federal Statistical Office in the late 1990s in addition to the Berliner Verfahren that had exclusively been used until that time.[13] Today the seasonally adjusted results based on X-12-ARIMA or X13 in JDemetra+ are typically shown at the top of the relevant publications of the Federal Statistical Office.

4.2 Software

So far the Federal Statistical Office has carried out seasonal adjustment according to X-12-ARIMA on the basis of a software with the same name (version 0.2.8). This software was developed by the United States Census Bureau. Since the end of 2017, the Federal Statistical Office has gradually changed over to the program JDemetra+ (at present version 2.2) which was developed within the European Statistical System and the System of European Central Banks. Eurostat generally recommends the use of JDemetra+ for the seasonal adjustment of official statistics in the European Union.[14] The platform-independent open source software is available, for instance, as a client application; it permits seasonal adjustment using X-12-ARIMA or TRAMO/SEATS.[15] As currently the use of JDemetra+ is largely based on the same elements as X-12-ARIMA at the Federal Statistical Office, the changeover to X13 in JDemetra+ (abbreviated: X13 JD+) does not involve fundamental methodological changes.

The Federal Statistical Office uses the software BV4.1 for seasonal adjustment according to the Berliner Verfahren. A client solution is available to external users for free download (www.destatis.de).

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10 The X-12-ARIMA method is described in more detail in the fifth chapter of this article.

11 See Gómez/Maravall (2001) for the TRAMO/SEATS method. The acronym TRAMO stands for "Time Series Regression with ARIMA Noise, Missing Observations and Outliers" and SEATS for "Signal Extraction in ARIMA Time Series".

12 See Speth (2004) for the Berlin method.

13 See Hauf (2002) for a detailed description of the respective background.

14 See Eurostat (2018) for methodological descriptions and download options.

15 As mentioned above, X-12-ARIMA is referred to as X13 in JDemetra+.

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

For the sake of completeness, it should be mentioned that, in recent years, the United States Census Bureau has provided software called X-13-ARIMA-SEATS as a client solution, too, which enables seasonal adjustment based on X-12-ARIMA and TRAMO/SEATS.[16]

5

Setting parameters for seasonal adjustment

5.1 Why to set parameters?

The X-12-ARIMA and X13 JD+ procedures provide a wide range of options to consider both the specific characteristics of a time series and the time series development over certain periods in determining the components of the series (seasonality, trend-cycle, etc.).[17] To use these options, various specification parameters relating to the RegARIMA model to be applied, the trend and seasonal filters and other features have to be determined. The specification of parameters required during the various calculation steps will be briefly explained below. As the names X-12-ARIMA and X13 JD+ refer to the same procedure, only the first designation will be used for reasons of simplification.

5.2 First stage of the method: pre-treatment and forecasting

The first stage of the method comprises a pre-treatment of the time series using RegARIMA models, during which calendar and outlier effects are identified, modelled and estimated. In addition, the time series of unadjusted values is extended at both ends by means of forecasts. Extending the time series is required, for instance, for the second stage of the procedure. During that stage, weighted moving averages are calculated which cannot be determined as such at the ends of the time series.

The term ARIMA refers to a set of modelling tools which is based on visible interdependencies between the values of different periods of the same time series (see excursus on ARIMA models). ARIMA modelling permits the interrelations identified in this time series – based on the data available - to be applied to the future. So part of the future development can be anticipated, which facilitates forecasting in order to extend the time series.

⬂ Excursus: ARIMA-models

The term ARIMA (Autoregressive Integrated Moving Average) originates from time series analysis.[18] ARIMA models contain three different modelling options: differencing, modelling of autoregressive processes (AR) and of so-called moving average processes (MA). These three options are applied to the respective preceding periods in non-seasonal modelling or to the relevant previous-year periods in seasonal modelling. On the whole, six specification parameters are used for the presentation of ARIMA processes; these are shown as follows:

(3) Outline of the ARIMA model:
ARIMA$(p,d,q)(P,D,Q)_S$

(p,d,q) specification parameters of the non-seasonal part of the ARIMA model

$(P,D,Q)_S$ specification parameters of the seasonal part of the ARIMA model

First the parameters of non-seasonal modelling which are indicated in small letters in the first brackets are explained. Parameter d relates to differencing. In the case of non-seasonal first-order differencing, further calculations are based on the period-to-period difference of the unadjusted values rather than the unadjusted values themselves.

(4) Non-seasonal first-order difference:
$$\Delta^1 X_t = X_t - X_{t-1}$$

$\Delta^1 X_t$ first-order difference of the unadjusted value at time t compared with the previous period

X_t unadjusted value at time t

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16   See the website of the United States Census Bureau for methodological descriptions and download options. [Accessed on 30 May 2018]. Available at www.census.gov/srd/www/x13as

17   See Findley et al. (1998) for the X-12-ARIMA method. A detailed description with reference to its application at Deutsche Bundesbank is given by Kirchner (1999). Gericke/Seidel (2014) provide an overview of X-12-ARIMA.

18   See Box/Jenkins (1970) for ARIMA models in time series analysis. An easy-to-read and application-oriented introduction is given by Nazmen (1988).

Differencing is required if the time series includes a trend so that AR and MA processes could not be applied. AR and MA processes are based on the assumption that current values only depend on preceding values and on random variables and do not follow a general trend. In most time series of economic statistics, and especially with multiplicative time series models, the unadjusted values are subjected to logarithmic transformation before differencing. Parameter d for period-to-period differencing is used to determine how many reiterations of differencing should be made. Usually, parameter d takes value 0 or 1, and seldom 2.[19] No differencing is applied for value 0, which means that calculation continues directly with the unadjusted values.

Parameter p relates to autoregressive processes. The assumption is that the current values of a time series depend on the previous values of the same time series:

(5) Autoregressive process:
$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_p X_{t-p} + \varepsilon_t$$

X_t unadjusted value at time t

p order of the AR process

a estimation coefficients

ε_t random variable at time t

Parameter p specifies the number of periods over which previous values have affected the current values. Here again the parameter is set to 0, 1 or 2, and seldom to 3.

Finally, q denotes the order of the moving average process. These processes are based on the assumption that a random variable which impacts a times series at a given time affects not only the value at that time but also values at later times. This in turn means that current values can be influenced by both current and past random variables:

(6) Moving average process:
$$X_t = \varepsilon_t + b_1 \varepsilon_{t-1} + b_2 \varepsilon_{t-2} + \cdots + b_q \varepsilon_{t-q}$$

X_t unadjusted value at time t

q order of the MA process

b estimation coefficients

ε_t random variable at time t

Parameter q is used to specify the number of periods over which previous random variables have affected the current values, with the values again being typically set to 0, 1, 2 or 3.

As mentioned above, the three modelling options can additionally be applied to monthly data from 12 months ago or quarterly data from four quarters ago. In this way seasonal time series processes can be modelled, too.[20] The three parameters D, P and Q, denoted in capital letters, are designed for seasonal ARIMA processes.

For instance, the model specification $(011)(011)_S$ is often used for time series of economic statistics.[21] In the case of monthly data, this model specification is designed to form the difference to the previous period ($d=1$) and also the seasonal difference to the relevant month of the previous year ($D=1$).[22] For purposes of further modelling it is assumed that the increases in the unadjusted values in a month depend on the current random variables and such variables of the preceding month ($q=1$) as well as the relevant variables of the same month a year earlier ($Q=1$). Autoregressive modelling (p and P) is not applied in this model.

ARIMA modelling with X-12-ARIMA is supplemented by regressors to form RegARIMA models, as they are called, which represent a more general form of regression anal-

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20   As ARIMA modelling takes place before the actual seasonal adjustment, seasonal patterns must temporarily be modelled already at this point in order to avoid bias in the regression coefficients to be estimated. However, this kind of seasonal modelling is only required during pre-treatment; it is not applied in seasonal adjustment in the narrow sense.

21   In the literature, this model specification is referred to as the "airline model" (Box et al., 2015).

22   Regarding monthly data, the first-order difference in the non-seasonal part, combined with the first-order difference in the seasonal part, is obtained as follows:
$$\Delta_s^1(\Delta^1 X_t) = \Delta^1 X_t - \Delta^1 X_{t-12} = (X_t - X_{t-1}) - (X_{t-12} - X_{t-13})$$

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19   As for $d=2$, instead of the unadjusted value the simple difference is applied to the first-order difference, which means $\Delta^2 X_t = \Delta^1 X_t - \Delta^1 X_{t-1}$.

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

ysis. The regressors are intended to reflect calendar and also outlier effects. Equation (7) refers to a multiplicative time series model with a logarithmic transformation of the unadjusted values, where Z_t represents the ARIMA part:[23]

(7) RegARIMA-model:

$$ln(X_t) = \sum_l \alpha_l \cdot k_{lt} + \sum_m \beta_m \cdot LS_{mt}$$
$$+ \sum_n \gamma_n \cdot AO_{nt} + \sum_v \lambda_v \cdot TC_{vt} + Z_t$$

k_{lt}	calendar regressors
LS_{mt}	level shift
AO_{nt}	additive outlier
TC_{vt}	temporary change
$a, \beta, \gamma, \lambda$	estimation coefficients
l, m, n, v	running indices for regressors of a regressor type
Z_t	ARIMA modelling

When applying X-12-ARIMA in the short-term statistics of industry, the calculation of calendar regressors k_{lt} is based on the number of working days which can vary from month to month.[24] Typically, working days are all days from Monday to Friday. To calculate a working day regressor, first the number of working days in the current month is determined after deducting statutory or quasi statutory holidays.[25] Public holidays that are statutory only in some Länder are weighted using the number of employees subject to social insurance contributions in the industry of those Länder as a proportion of the total number in Germany as a whole.[26] Afterwards the difference is calculated between the number of working days of the relevant month and the month-specific long-term average. For instance, the average number of working days in all months of May between 1991 and 2030

is subtracted from the number of working days in May 2018. The effect of this approach which is called calendar centring is that the overall level of the time series is not shifted by calendar adjustment.[27] Another desired advantage of calendar centring is, for instance, that the annually recurring low number of working days in February has no calendar effect, but is covered by the later calculation of seasonal components. In certain cases, several working day regressors can be used for different periods of the year, for instance, a regressor for January to November and another for December.

The outlier regressors LS_{mt}, AO_{nt}, TC_{vt} can be used to explicitly model extraordinary time series developments such as the impact of strikes. There are three different outlier models. The level shift regressor (abbreviated: LS) is used to model a remaining structural break. The additive outlier regressor (AO) represents the shift of an individual data point of the time series that returns to the previous level as early as during the next period. The temporary change regressor (TC) is designed to model a development where a sudden change decreases again gradually in the following data points. Not all types of outliers are always applied in RegARIMA models.

RegARIMA modelling has two functions in X-12-ARIMA. First, the calendar factor K_t required in equation (2) can be calculated from the estimation coefficients of the calendar regressors. This factor is applied in calculating the calendar and seasonally adjusted result. Here the ARIMA part serves to measure the effects of the calendar regressors more precisely; a regression across time series values without the ARIMA part could possibly provide biased results. At this point, the function of the outlier regressors is that of control variables, which also improve estimation. To calculate the calendar factor, the estimation coefficients are multiplied by the regressor values, and afterwards the logarithmic transformation is reversed:

(8) $\quad K_t = exp(\sum_l \alpha_l \cdot k_{lt})$

In the multiplicative model with previous logarithmic transformation the estimation coefficients can be interpreted as semi-elasticities. They indicate, for the

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23 See for instance Bee Dagum/Bianconcini (2016) for the RegARIMA model.

24 See Deutsche Bundesbank (2012) for a detailed description of calendar adjustment using X-12-ARIMA in the German official statistics.

25 Although quasi statutory holidays are not prescribed by law, many employers offer them to their employees on a voluntary basis. For instance, carnival is a quasi statutory holiday in some Länder.

26 For reasons of data availability, the number of employees subject to social insurance contributions in industry is sometimes also used for weighting purposes in other than industry statistics.

27 Deutsche Bundesbank provides a plug-in called "TransReg" (download at https://github.com/bbkrd/TransReg/releases) for calendar centring when applying the JDemetra+ software.

Table 1
Semi-elasticity of the calendar regressors in the production index for intermediate goods

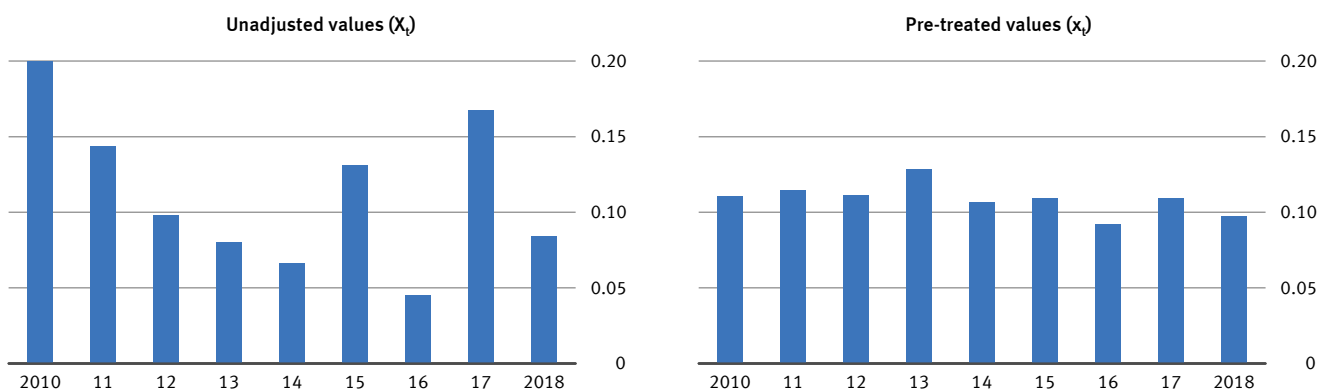|	Estimation coefficients
	%
January to November	3.2
December	2.1

monthly data, the average percentage increase in the unadjusted values if a given month has one working day more than the long-term average. ⬊ **Table 1** shows the estimation coefficients for the calendar regressors in the production index for intermediate goods.[28]

The data available show that an additional working day in the months from January to November will lead to an average 3.2 % increase in the production of intermediate goods in the German industry. An additional working day in December will only yield a 2.1 % increase. In December it is more likely that additional working days are offset by employees taking leave. If, for instance, the Christmas holidays fall on a weekend in years with an "employer-friendly" calendar, there is a trend towards taking more time off around the public holidays although, arithmetically, more working days are available.

The big challenge in adjusting quarterly data is that the different calendar effects of the months in a quarter may superimpose each other. In the national accounts, the

calendar factors are therefore estimated on the basis of monthly time series which are closely related to the quarterly national accounts aggregate to be analysed. When adjusting gross value added in manufacturing, for instance, the monthly production index for manufacturing is used to estimate the calendar factors. The monthly calendar factors are then aggregated to obtain quarterly values which are used for the calendar adjustment in national accounting (Deutsche Bundesbank, 2012, here: page 55).

A second function of RegARIMA modelling in X-12-ARIMA includes the "pre-treatment" of unadjusted values and extensions at the ends. Pre-treatment is designed to temporarily remove both calendar and outlier effects from the data; the pre-treated and extended series is then used as the basis for performing the second stage of the procedure (see Chapter 5.4). ⬊ **Figure 2** shows the month-on-month changes in the production index for intermediate goods in March with and without pre-treatment. To distinguish the pre-treated values from the unadjusted values X_t, the former are written in small letters (x_t).

While the month-on-month change rates of the unadjusted values of the production for intermediate goods show clear variations over the years, the values pre-treated for calendar and outlier effects increase rather regularly by roughly 10 % in March. The thus more clearly emerging seasonal pattern can be eliminated during the second stage of the procedure.

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28   See Bald-Herbel (2013) for the production index.

Figure 2
Month-on-month change rates of the production index for industrial intermediate goods, March
Percent

Unadjusted values (X_t)

Pre-treated values (x_t)

2019 - 01 - 0629

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

It should be noted that, due to pre-treatment, outliers are not incorporated in the seasonal component calculation. This in turn means that outlier effects are fully visible in the calendar and seasonally adjusted time series. The final calculation of the calendar and seasonally adjusted result according to equation (2) is performed using again values which have not been pre-treated.

5.3 Second stage of the method: application of trend and seasonal filters

The above calculation of calendar factors and pre-treatment of unadjusted data are followed by the second stage of the X-12-ARIMA procedure. This stage is designed for seasonal adjustment in the narrow sense.[29] As mentioned earlier, this refers to smoothing the pre-treated time series using trend and seasonal filters which are calculated by means of weighted moving averages. The trend and seasonal filters of the second stage of the X-12-ARIMA procedure are applied step by step using various iterations and partial iterations.[30]

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29 A detailed description of the second stage of X-12-ARIMA using an example is given by Ladiray/Quenneville (2001).

30 A reason for the iterative approach is that, although extreme values are smoothed through trend and seasonal filters, the filtered results remain, to a certain extent, affected by extreme values. For this reason, the extreme values are replaced by substitute values during the various iteration steps. However, extreme values can eventually be identified and replaced only when the final filtered results are available. Regarding the role of extreme values, it should be noted that these are only excluded from the seasonal component and are consequently included in the irregular component of the time series. This means that they are not eliminated from the seasonally adjusted result which also contains the irregular component.

Determining the trend-cycle

The second stage of X-12-ARIMA begins with the estimation of a trend-cycle component to be used as the basis for measuring the seasonal variation.[31] The trend filters applied here are weighted moving averages:

$$(9) \quad T_t = \sum_{i=t-a}^{t+a} \theta_i \cdot x_i$$

T_t trend value for period t

θ_i weights

x_i pre-treated value of the time series to be adjusted for period i

i running index over the support span

a half range of the support span (without period t as such)

Different trend filters are applied in various partial iterations during the second X-12-ARIMA stage.[32] In adjusting monthly data, for instance, a weighted moving average whose support span covers 13 periods is used to calculate the first provisional trend-cycle. The two months at the ends of the support span are included with a lower weight in the calculation, while all other months are given a weight of one twelfth. ↘ Figure 3

To determine the trend-cycle more precisely, so-called Henderson filters are used at later iterations. These are also weighted moving averages whose weights have however been optimised and set using mathematical procedures. In determining the trend-cycle, the person

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31 For reasons of simplification, the filters used to determine the trend-cycle component are called trend filters.

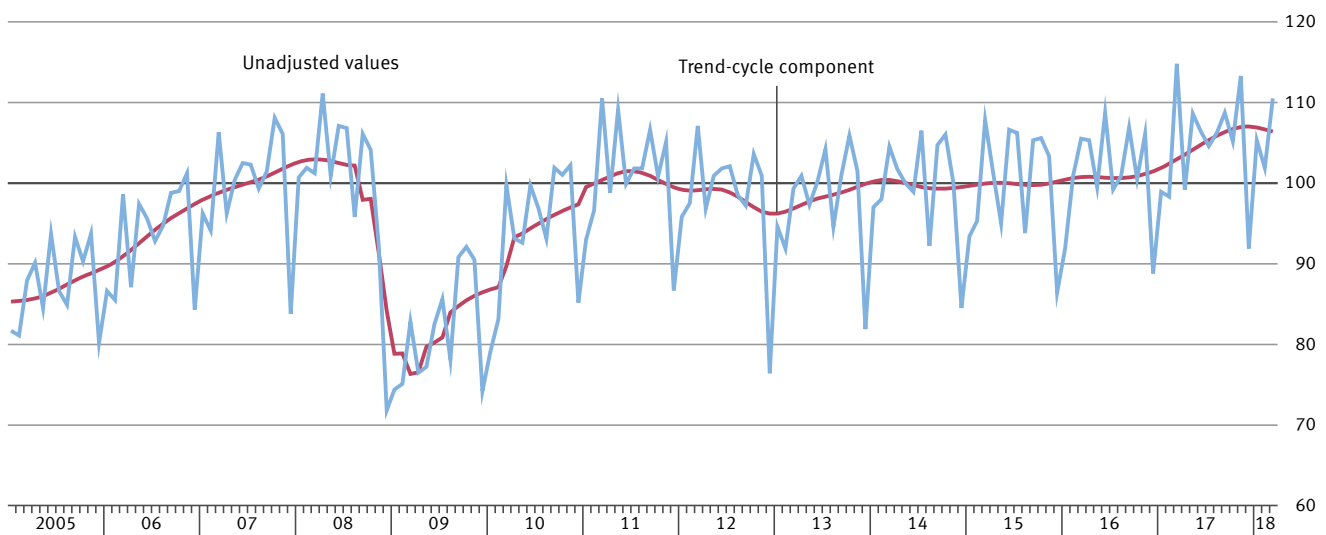32 The task of the different trend filters is to filter specific fluctuations gradually out of the time series.

Figure 3

Weights (θ) of the moving average for calculating the provisional trend-cycle in the first iteration
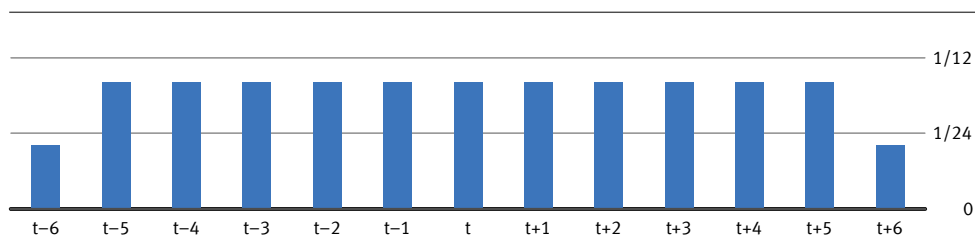
2019 - 01 - 0630

Figure 4
Unadjusted values and trend-cycle component in the production index for industrial intermediate goods

2019 - 01 - 0631

engaged in seasonal adjustment may adjust the support span of the Henderson filter as a specification parameter.

⬂ **Figure 4** shows the unadjusted values and the trend-cycle component eventually determined after completion of the iterations, using the production index for intermediate goods as an example.

Determining the seasonal-irregular ratio (SI ratio)

As a next step, the differences are determined between the pre-treated values and the trend-cycle values obtained. These are referred to as the seasonal-irregular ratios (SI ratio). Regarding the multiplicative time series model, the SI ratios are calculated as follows:

$$(10) \quad S_t^r = \frac{x_t}{T_t}$$

S_t^r value of the SI ratio at time t

⬂ **Figure 5** shows the SI ratios as data points in the production index for intermediate goods. The data points are sorted first into months and then into years. For example, the points for the month of June depict the SI ratios of that month in all years of the presentation period. The SI ratio of 0.97 for August 2017 means, for instance, that the pre-treated value of the production index of this month was 3 % below the trend-cycle.

The seasonal pattern of the production index for intermediate goods (e.g. base chemicals, metal products) becomes already apparent in Figure 5. Production tends to increase during the year. In winter the conditions are less favourable for production and related transports, and there is less demand for intermediate goods than during the rest of the year. Clear deviations from this tendency are observed in March (upwards) as well as in August and December (both downwards). The production peak in March can be expected to be due to the regularly high number of calendar days in that month which, because of calendar centring, is reflected in the seasonal figure rather than the calendar factor. Although July and August also have 31 calendar days and nearly no statutory holidays, the fact that there is a regular extraordinary concentration of leave during the summer holidays has a noticeable effect especially in August. As mentioned above, December is characterised by a very low production level, which is attributable to the public holidays and the extraordinary concentration of leave in this month.

Determining the final seasonal component

Figure 5 also shows the variance of the seasonal component from year to year. As a next step, smoothed values which are representative of the typical seasonal varia-

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

Figure 5
SI Ratio in the production index for industrial intermediate goods, 2010 to 2017
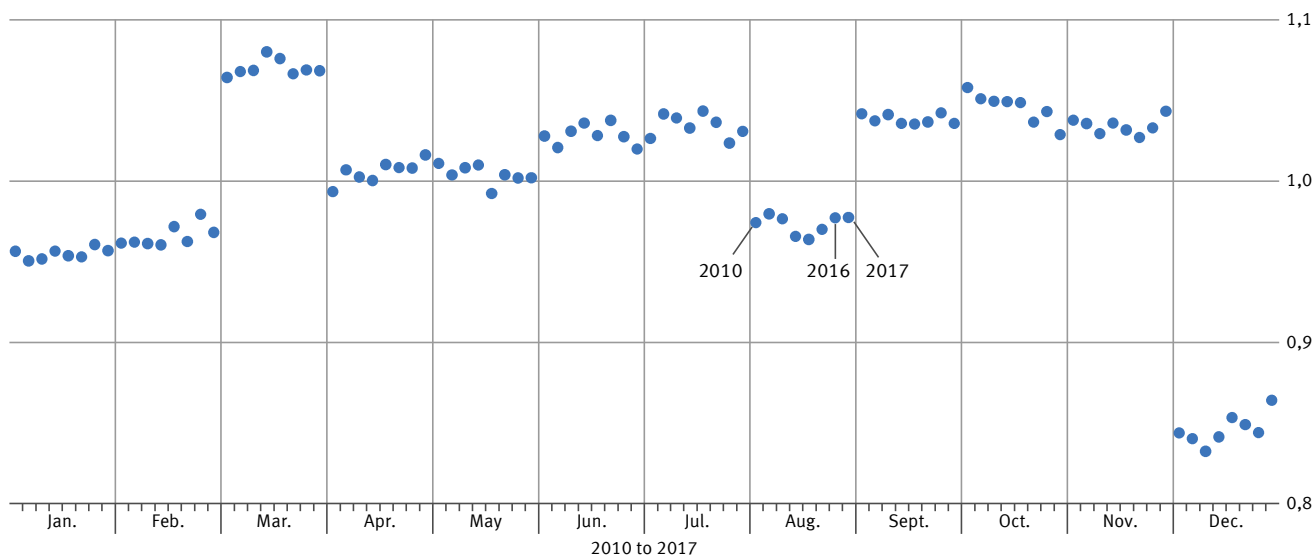
The data points are sorted into months and into years. The points for a month show the raw seasonal factors of that month in all eight years of the presentation period.

2019 - 01 - 0632

tion of a month have to be generated from the fluctuating SI ratios. Neither the causes of seasonal fluctuations nor their effects on the time series can be fully observed. Since, however, the seasonal effects are assumed to affect the time series to a similar extent every year, a certain relatively stable level of the month-specific seasonal variation can be presumed. The final seasonal components are intended to adequately reflect the supposed trend of the seasonal variations that cannot be directly observed, on the one hand, by being as close as possible to the SI ratios and, on the other, by maintaining a relatively stable level over the years. In this context, the month-specific seasonal variation is to be allowed to change gradually from year to year. To calculate a month-specific final seasonal component, moving averages with specific weights, also called seasonal filters, are therefore applied again. In the equation, period t for the SI ratios is expressed in months m and years j:

(11) $\quad S_j^{r,m} := S_t^r$

$\quad S_j^{r,m} \quad$ value of the SI ratio for year j in month m

$\quad m \quad$ month

$\quad j \quad$ year

Final seasonal components are determined as month-specific weighted moving averages by applying seasonal filters to the SI ratios of one month each throughout the years:

(12) $\quad S_j^{\overline{m}} = \sum_{i=j-b}^{j+b} \delta_i \cdot S_i^{r,m}$

$\quad S_j^{\overline{m}} \quad$ value of the month-specific final seasonal component in year j

$\quad \overline{m} \quad$ specific month for which the weighted moving average is determined

$\quad j \quad$ year

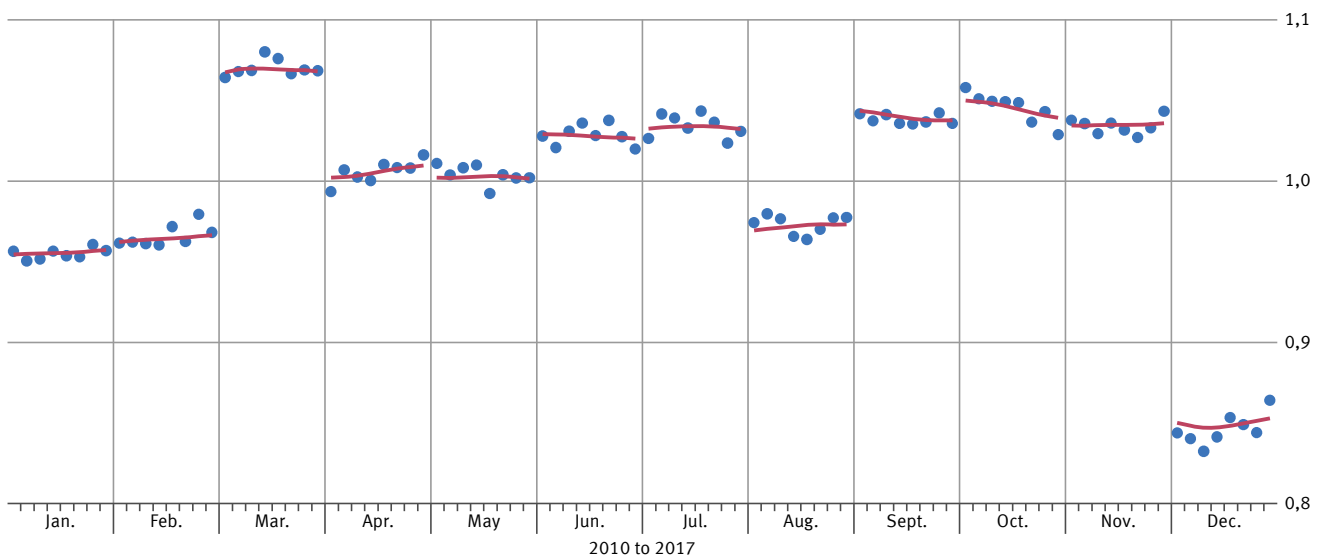$\quad \delta \quad$ weight

$\quad b \quad$ half range of the support span (not including year j itself)

$\quad i \quad$ running index over the support span

Applying the X-12-ARIMA seasonal adjustment method, the person engaged in seasonal adjustment selects the support span and the type of seasonal filter with a view to covering the typical seasonal amplitude in the best-possible way while, at the same time, taking into account gradual changes in the seasonal variation.

SI ratios and final seasonal components for the production index for industrial intermediate goods, 2010 to 2017

The data points are sorted into months and into years. The points for a month show the seasonal-irregular component of that month in all eight years of the presentation period.
The final seasonal factors are shown as red lines.

2019 - 01 - 0633

Past experience has shown that, for a large number of time series, the so-called 3x9 filter is very well suited to reflect a gradually changing seasonal pattern. It covers a support span of eleven years and is regarded as the standard filter in adjusting economic time series. If the seasonal patterns change more quickly, seasonal filters with shorter support spans can be used. An example is the 3x5 filter which covers no more than seven periods (see the following excursus on seasonal filters for the relevant names). If the seasonal patterns of individual months change at different rates, different seasonal filters can be chosen for the various months of a time series. ↘ Figure 6 shows the final seasonal components in the form of lines. Here the final seasonal components were obtained by using 3x9 seasonal filters.

↘ Excursus: seasonal filters

To illustrate the names of the seasonal filters, these can be shown as overlapping simple, composite moving averages. ↘ Figure 7 provides an exemplary calculation of the value of a 3x5 filter for the month of January 2013 where the filter is shown in the form of three overlapping unweighted moving averages across five periods each. The entire support span of the filter covers the January values of the years 2010 to 2016. Since, however, the January values located towards the middle are included in the calculation several times, their implicit weight is higher than that of the values at the ends. The chart below the computation formula shows the weights of the 3x5 seasonal filter resulting from the overlapping of the unweighted moving averages.
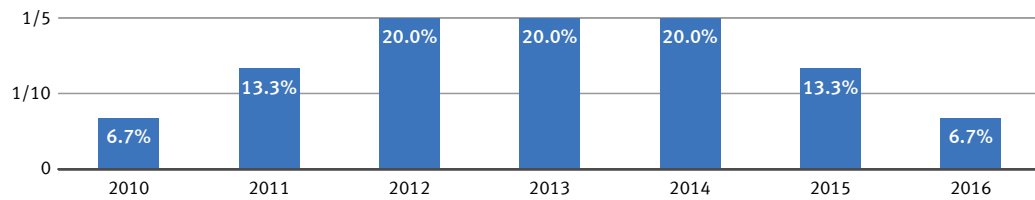
As can be seen, the three values in the middle are included in the calculation with a weight of 20 % each. The weights decline towards the two ends, and the weights of the values at the ends are just under 7 % each.

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

3x5 seasonal filter shown as overlapping composite moving averages

$$S^{Jan}_{2013} = \frac{1}{3} \cdot [\; \frac{1}{5} \; (\; S^{r,Jan}_{2010} \; + \; S^{r,Jan}_{2011} \; + \; S^{r,Jan}_{2012} \; + \; S^{r,Jan}_{2013} \; + \; S^{r,Jan}_{2014} \;)$$

$$\frac{1}{5} \cdot \qquad\qquad (\; S^{r,Jan}_{2011} \; + \; S^{r,Jan}_{2012} \; + \; S^{r,Jan}_{2013} \; + \; S^{r,Jan}_{2014} \; + \; S^{r,Jan}_{2015} \;)$$

$$\frac{1}{5} \cdot \qquad\qquad\qquad (\; S^{r,Jan}_{2012} \; + \; S^{r,Jan}_{2013} \; + \; S^{r,Jan}_{2014} \; + \; S^{r,Jan}_{2015} \; + \; S^{r,Jan}_{2016} \;)]$$

Implicit weights (δ_i) of the 3x5 seasonal filter

6.7%	13.3%	20.0%	20.0%	20.0%	13.3%	6.7%
2010	2011	2012	2013	2014	2015	2016

2019-01-0634

Calculation of seasonally adjusted results

To calculate the calendar and seasonally adjusted time series using the multiplicative model option, the unadjusted values X_t that were not pre-treated are finally divided by both the final seasonal components and the calendar factors. The final seasonal components are again sorted chronologically.

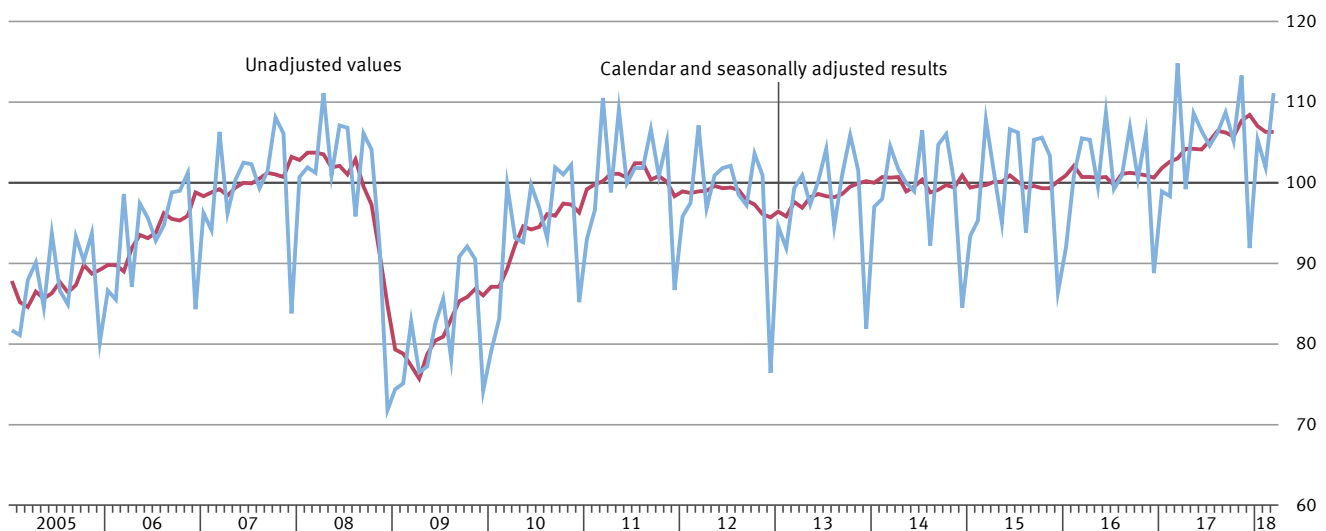$$(13) \qquad X^{KSB}_t = \frac{X_t}{S_t \cdot K_t}, \text{ mit } S_t := S^m_j$$

X^{KSB}_t calendar und seasonally adjusted time series

K_t calendar factor of formula (8)

S_t final seasonal components (sorted chronologically)

Unadjusted values and calendar and seasonally adjusted results of the production index for industrial intermediate goods

Unadjusted values

Calendar and seasonally adjusted results

2019 - 01 - 0635

↘ **Figure 8** shows the calendar and seasonally adjusted time series together with the unadjusted values of the production index for intermediate goods for the period from January 2005 to March 2018. The seasonally adjusted time series shows less variations than the unadjusted values, which is the reason why the trend-cycle component can be better identified. Nevertheless, it shows considerable fluctuations due to the irregular component included.

5.4 Specification as the total of parameter settings

The previous chapters have shown that seasonal adjustment using X-12-ARIMA requires various parameters to be set when modelling the RegARIMA regression and applying trend and seasonal filters. The total of parameter settings is referred to as the specification. The specification is determined individually for each time series to be adjusted. It is made in a way to take due account of all relevant information on the characteristics of the given time series, extraordinary effects and the characteristic

features of the seasonality.[33] Here various quality indicators, tests for residual seasonality and distribution characteristics of the model residuals can be considered as being helpful. Nonetheless, these can serve as a rough orientation only.[34] The complete specifications used at the Federal Statistical Office can be provided upon request. Thus data users can reproduce the seasonally adjusted results using the published unadjusted data. ↘ **Chart 2** shows central specification parameters for three examples of statistics.

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33 The basic problem in determining the specification is that the time series analysis is based on a decomposition of unadjusted values into unobservable components whose values cannot be measured objectively. Therefore a specification must be sought which provides an overall plausible solution to the decomposition problem.

34 For instance, the "M4" indicator refers to autocorrelation of the irregular component. High autocorrelation indicates that the irregular component still has systematic patterns that should probably be assigned to the other components, which could improve the specification. However, the indicator does not indicate which of the specification parameters should be adjusted. See Kirchner et al. (2018) for the use of quality indicators.

Chart 2

Selected specification parameters of seasonal adjustment using three sets of statistics as examples

	Production index for intermediate goods		Nominal turnover in accommodation and food service activities	Quarterly price adjusted gross domestic product
Method	X13 JD+		X-12-ARIMA	X-12-ARIMA
Time series model	multiplicative		multiplicative	multiplicative
Calendar regressors	(1) Working days, January to November (2) Working days, December		(1) Number of days in the month (2) Number of Mondays (3) Number of Tuesdays ... (7) Number of Saturdays	(no direct application of calendar regressors; see Chapter 5.2 in the text)
Outliers	LS (09.2008) LS (11.2008) LS (12.2008) LS (01.2009) LS (03.2009)	LS (05.2009) LS (08.2009) LS (03.2010) LS (04.2010) LS (01.2011)	LS (01.2009)	LS(Q4.2008) LS(Q1.2009) LS(Q2.2010)
ARIMA model	ARIMA(013)(011)$_S$		ARIMA(011)(011)$_S$	ARIMA(010)(011)$_S$
Trend filter	Henderson 17		Henderson 17	Henderson 13
Saisonal filter	3x9		3x9	3x5: third quarter 3x9: other quarters
Support span (see Chapter 6.3 in the text)	January 2003 until current reference month		January 1994 until current reference month	1st quarter of 1991 until current reference quarter

As at May 2018.

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

6

Setting a seasonal adjustment framework

6.1 Preliminary note

Seasonal adjustment using X-12-ARIMA and X13 JD+ requires specification parameters to be set and also various decisions to be taken that refer to the general framework of seasonal adjustment and apply to whole sets of statistics or statistical domains. A number of recommendations regarding this framework are included in the above-mentioned ESS guidelines on seasonal adjustment (Eurostat, 2015).

6.2 Revision regimes

As the seasonal patterns of time series and the relevant extent of seasonal effects can change over time, seasonal factors should be reestimated regularly, at least once a year (Eurostat, 2015, here: page 33).[35] Adjusting and recalculating the seasonal factors leads to a higher accuracy of the estimated seasonality. At the same time, however, this means that the results of previous periods of the seasonally adjusted time series may also change so that revisions of the adjusted results would normally be necessary. An all too frequent adjustment may therefore have disadvantages for users, especially if the accuracy gains of recalculating the relevant factors are not considerable, while extensive revisions would be required. In German official statistics, "Controlled current adjustment", as it is called, is used for adjustments according to X-12-ARIMA or X13 JD+. This is aimed at both achieving greatest possible accuracy of the estimated seasonality and avoiding revisions where they are not worthwhile due to small accuracy gains. The seasonal factors are calculated once per year and forecasted for at least one year. In addition, an alternative calculation including reestimated seasonal factors is

made before each monthly or quarterly data publication. The results of the calculation based on forecast seasonal factors are then compared with those of the alternative calculation; the seasonal factors are only updated if the accuracy gains of the recalculation justify this.

This approach requires greater effort than an annual adjustment of the seasonal factors involving an interim use of forecast factors. For this reason the seasonal factors of statistics that are not so much in the user focus are adjusted only once per year. This often applies to time series at lower levels of detail; partly many hundreds of adjusted series are provided in great detail every month (see Chapter 7).

6.3 Support span and routine revisions

To calculate calendar and seasonal factors using X-12-ARIMA, the time series must cover a period of at least three years. Longer data series are useful, although time series should not be too long (Eurostat, 2015, here: page 39 f.).

Regarding the industrial production index, for example, data from 2003 onwards are currently used as the support span for deriving the relevant factors. In the national accounts and in other statistics, the support span begins in 1991. The revision policy permits time series to be revised over the entire support span when the seasonal factors are recalculated. Usually, however, the extent of revisions of individual time series values is small if these values refer to a time in the more distant past. To avoid minor revisions of such back data, older seasonally adjusted results can be "frozen", that is, they are no longer revised (Eurostat, 2015, here: page 34). Regarding the production index, for instance, the seasonally adjusted results have been frozen for the whole period before January 2015.[36] In the quarterly national accounts however revisions of the whole time series are permitted when the final seasonal components are recalculated.

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35 This refers to changes in the seasonal pattern which go beyond developments that can be considered in the seasonal filters as these are calculated as weighted moving averages and therefore can reflect, to a certain extent, a gradual development of the seasonal pattern. Calendar effects are typically rather stable so that, generally, the calculated calendar factors have to be reviewed only once a year.

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36 This approach is linked to the rebasing of the unadjusted data and their recalculation from 2015. See Linz et al. (2018) for rebasing.

6.4 Direct and indirect seasonal adjustment

The unadjusted values of the statistics to be adjusted are typically provided as a set of time series subdivided, for instance, by the economic branches covered by the relevant statistics. In addition, aggregates are published which relate to several economic branches of the statistics or to other breakdowns. In the national accounts, for instance, aggregates are also calculated for institutional sectors.

The question which arises in relation to seasonal adjustment is whether the aggregates themselves should be adjusted (direct adjustment of aggregates) in addition to the time series of the economic branches, or whether the seasonally adjusted aggregates should be calculated from the seasonally adjusted results of the individual branches of economic activity (indirect adjustment of aggregates; Deutsche Bundesbank, 2010). The solutions implemented in practice differ depending on the statistics concerned. Regarding the production index for industry, direct seasonal adjustment is made at a medium level of breakdown, while aggregates at higher levels are adjusted indirectly. Adjustments in the national accounts context are normally direct adjustments at a very detailed level, while adjustments at higher levels are typically made indirectly. However, the total gross domestic product is adjusted in a direct manner.[37] Turnover in wholesale trade is directly adjusted at all levels of aggregation.

In addition to nominal unadjusted values, price adjusted values (so-called volume data) are published for most of the statistics. Again several practical seasonal adjustment approaches are used in this respect. Regarding the production index for industry, first the nominal unadjusted values are adjusted directly. Dividing the nominal by the price adjusted original values, implicit price series are generated that are subjected to direct seasonal adjustment. The seasonally adjusted volume data are then obtained in an indirect manner by dividing the adjusted nominal data by the adjusted price series.

In the national accounts, however, the nominal data are always obtained on the basis of indirect adjustment.

7

Scope and critical assessment of the seasonal adjustment processes

In the process of regular seasonal adjustment, the Federal Statistical Office produces a large number of adjusted time series at monthly and quarterly intervals. As far as adjustments based on X-12-ARIMA and X13 JD+ are concerned, "Controlled current adjustment" is used for nearly 800 directly adjusted series where the seasonal factors and control features are reviewed every month or quarter. For another nearly 2,000 industry and retail trade time series for which detailed results are available, calendar and seasonal factors are forecasted once per year and then applied to the monthly data.[38] ⬊ Table 2 provides an overview of the number of directly adjusted time series of the statistical domains.

Table 2
Directly adjusted time series, X-12-ARIMA or X13 JD+, by statistical domain

	Controlled current adjustment	Current Adjustment
National accounts	212	–
Time series in industry (industrial sector: new orders, turnover, production, stock of orders, hours worked; construction: production and new orders)	338	1,821
Labour cost index	54	–
Retail trade, retail sales of motor vehicles, wholesale trade, accommodation and food service activities	99	105
Services (turnover, persons employed, wages and salaries, hours worked)	59	–
ILO unemployment statistics	8	–
Foreign trade	4	–
All domains	774	1,926

ILO: International Labour Organization.

Since the beginning of 2018, the software used for the regular seasonal adjustment of industrial indicators of short-term statistics in industry has been gradually

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37 To ensure coherence in the direct adjustment of the gross domestic product (GDP), taxes on products are indirectly adjusted using a derivation scheme: taxes on products (indirect) = GDP (direct) − gross value added (indirect) + subsidies on products (direct)

38 Apart from seasonal adjustment using X-12-ARIMA and X13 in JD+, many sets of statistics are additionally adjusted based on the BV4 procedure. And there are statistics which are adjusted using exclusively BV4.

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

changed over to JDemetra+ (incl. X13). In the national accounts, changing over to this software is scheduled for autumn 2019. Corresponding stepwise changes are also intended for the remaining short-term statistics.

The regular calculation of seasonally adjusted results is an integral part of the statistical production process. In the Generic Statistical Business Process Model, it is assigned to Phase 6 whose subprocesses are summarised under "Analyse".[39] ↘ Chart 3

Chart 3

Phases of the Generic Statistical Business Process Model

Phase 1 – Specify needs
Phase 2 – Design
Phase 3 – Build
Phase 4 – Collect
Phase 5 – Process
Phase 6 – Analyze
Phase 7 – Disseminate
Phase 8 – Evaluate

Regarding short-term statistics, for instance indices and growth rates are determined during this phase. Calculating seasonally adjusted results constitutes an additional step of analysis in this phase, which increases the data relevance further. In more concrete terms, user needs are met regarding current results of economic development which are not masked by seasonal fluctuations that can be expected to recur and calendar effects, and which therefore provide a better understanding of cyclical developments. However, various conflicting goals may occur in this respect.

First the relevance of statistical results can only be assessed in relation to a target group or a certain purpose of use. For instance, some business associations and enterprises (which, as reporting units, often provide individual data as the basis for the unadjusted values) regard the fact that seasonally adjusted results do not reflect the movements that are typical, known and expected by the operators in a given branch as a disadvantage. This target group sometimes prefers to use the unadjusted data for analysing the development of the

relevant economic branches. Although, as mentioned above, the Federal Statistical Office always provides the unadjusted values in addition to the seasonally adjusted results, for clarity reasons the focus is only on one type of results in first releases. Taking into account the needs of the different target groups, and in accordance with the recommendations of the European Statistical System and the Organisation for Economic Co-operation and Development (OECD), it was finally decided for most short-term statistics to list the month-on-month or quarter-on-quarter change rates of the seasonally adjusted results generally at the top of press releases.[40]

In assessing economic developments, other aspects than changes of seasonally adjusted data on the previous period may play a role and be more relevant to certain user needs. Let us look again at the example of Figure 1. Here the fact that, although the results were slightly down in the recent past, they were still at a rather high level at the time of observation might be important in describing the economic situation from a user perspective. In some of these cases, a year-on-year comparison is additionally used. However, it could also be useful to compare the relevant level with a longer-term average that does not change from period to period. This could for instance be achieved by providing information on the (positive or negative) extent to which the current results differ from such a longer-term average which could be calculated, for example, from a long-term trend.[41]

And finally, there is a competitive relationship between the relevance of the results and other quality aspects. As mentioned above, seasonal and calendar components are unobservable components which need to be made measurable by operationalisation approaches (selecting the adjustment procedure, setting parameters). Usually, different operationalisation approaches lead to different results. To avoid, as far as possible, potential losses of

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39 See Gehle/Lüüs (2017) for the Generic Statistical Business Process Model, here: page 48.

40 The ESS guidelines on seasonal adjustment require above all seasonally adjusted results to be presented in press releases (Eurostat, 2015, here: page 46): "Seasonally adjusted data are the most appropriate figures to be presented in press releases". And the OECD recommendations even apply to countries beyond Europe: "When applicable, the focus of press releases […] concerning the main sub-annual indicators should be on their appropriately seasonally adjusted version." (OECD, 2007, here: page 20 f.).

41 The Business Cycle Monitor of the Federal Statistical Office (www. destatis.de › Visualised statistics › Business Cycle Monitor) for instance combines the development at the current end with the difference between the current results and a long-term trend. Here a distinction is made between four different phases of short-term development.

objectivity and clarity of the results, the Federal Statistical Office uses X-12-ARIMA and X13 JD+ for seasonal adjustment, which are internationally recognised and harmonised methods. Seasonal adjustment continues to be carried out in close collaboration with Deutsche Bundesbank, and best-possible transparency is provided in presenting the underlying methods. ⊞

Dr. Stefan Linz, Dr. Claudia Fries, Julia Völker

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Abbreviations

WISTA	=	Wirtschaft und Statistik
JD	=	annual average
D	=	average (for values which cannot be added up)
Vj	=	quarter of a year
Hj	=	half-year
a. n. g.	=	not elsewhere classified
o. a. S.	=	no main economic activity
St	=	piece
Mill.	=	million
Mrd.	=	billion

Explanation of symbols

–	=	no figures or magnitude zero
0	=	less than half of 1 in the last digit occupied, but more than zero
.	=	numerical value unknown or not to be disclosed
. . .	=	data will be available later
X	=	cell blocked for logical reasons
I or —	=	fundamental change within a series affecting comparisons over time
/	=	no data because the numerical value is not sufficiently reliable
( )	=	limited informational value because numerical value is of limited statistical reliability

Figures have in general been roundes without taking account of the totals, so that there may be an apparent slight discrepancy between the sum of the constituent items and the total as shown.