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## Seasonal adjustment and reliability of euro area GDP – Increased uncertainty in times of unusual developments?

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# **Seasonal adjustment and reliability of euro area GDP – Increased uncertainty in times of unusual developments?**

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## **1. Introduction**

Seasonally adjusted gross domestic product (GDP) data are inevitably surrounded by uncertainty. Disregarding methodological improvements, two main sources of revisions can be distinguished: First, revisions that reflect the incorporation of more comprehensive or more representative, but generally less timely source data and, second, revisions that are related to seasonal adjustment. This paper aims to gain some insights into the overall statistical uncertainty surrounding first estimates of quarter-on-quarter seasonally adjusted GDP volume growth in the euro area, in particular what is known as the “flash estimate” published by Eurostat around 45 days after the end of the reference quarter, and the first regular estimate published around two and a half weeks later.

Chapter 2 presents the euro area GDP releases and revision indicators that will be considered in the analyses. The results of a revision analysis of the flash estimate are presented. In addition, further insight is provided into the scope for revisions through a tentative quantitative assessment of the amount of the main primary or “hard” source data underlying the unadjusted GDP estimates. Chapter 3 examines the statistical uncertainties related to seasonal adjustment by applying alternative statistical treatments of the extreme developments that occurred in the recent economic crisis. In addition, revisions are tentatively explored with respect to the reliability of these different treatments of extreme values.

In order to gauge the extent to which revisions can be traced back to changes in unadjusted data, or rather recalculations in seasonal adjustment, a refined version of Mehrhoff’s decomposition approach<sup>2</sup> is introduced in Chapter 4. This approach takes into account the fact that the size of revisions of seasonally adjusted data, as reported on the day of publication (“real time data”), could be affected by the size of revisions in unadjusted real time data. By way of an example, the effect ascribed to seasonal adjustment is estimated for two alternative approaches to the seasonal adjustment of euro area GDP, comparing the results from a certain vintage of the time series with those from a truncated version of that vintage. Chapter 5 concludes.

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<sup>1</sup> This paper was prepared for the “6th Colloquium on Modern Tools for Business Cycle Analysis: the lessons from global economic crisis”, Luxembourg, 26-29 September 2010. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank, the Deutsche Bundesbank or their staff. Martin Eiglsperger and Wim Haine are responsible for Chapters 1, 2, 3 and 5; Jens Mehrhoff is responsible for Chapter 4. Comments were provided by Robert Kirchner (Deutsche Bundesbank) and Daniela Schackis (European Central Bank). E-mail addresses for correspondence: Martin.Eiglsperger@ecb.europa.eu, Wim.Haine@ecb.europa.eu, Jens.Mehrhoff@bundesbank.de.

<sup>2</sup> Mehrhoff, J.: “Sources of Revisions of Seasonally Adjusted Real Time Data”, Frankfurt am Main, 2008.

## 2. Euro area GDP estimates and source data

### *Selected releases and revision indicators*

Since May 2003, Eurostat publishes a “flash estimate” of quarter-on-quarter seasonally adjusted euro area GDP volume growth around 45 days after the end of the reference quarter (denominated as “ $t+45$  days”). The flash estimate refers only to the most recent quarter and does not include revisions to backdata. This is followed by two “regular” estimates, denoted “first” and “second” estimates, which include further detailed information, but may entail revisions to the GDP flash estimate or earlier observations. The flash estimate addresses policymakers’ need for timely information, but is generally based on less comprehensive source data than later estimates and may, therefore, be subject to revisions. The first regular estimates, which comprise data on GDP, its main expenditure components and the activity breakdown of value added, are published around two and a half weeks after the “flash” (around  $t+63$  days). On the occasion of the second regular estimates, published around 100 days after the end of the reference quarter, the remaining details are provided.

When first regular estimates of the next quarter become available, i.e. at around 150 days after the end of the reference quarter one quarter earlier, all quarterly source data can be assumed to have been incorporated in the data referring to one quarter earlier. Henceforth, this paper refers to this update as the “quarterly update”. An estimate that may incorporate important new information from, in particular, annual data sources, referred to as the “annual update”, is typically released in the fourth quarter of the subsequent calendar year.

Taking the euro area GDP volume growth the first quarter of 2008 as an example, Table 1 illustrates the updates of the flash estimate in terms of dates and results.

**Table 1: Releases of quarter-on-quarter GDP volume growth in the first quarter of 2008, quarterly percentage changes (%)**

| Flash estimate<br>( $\approx t+45$ ) | First estimates<br>( $\approx t+63$ ) | Second estimates<br>( $\approx t+100$ ) | .. | Quarterly update<br>( $\approx t+150$ ) | Annual update   |
|--------------------------------------|---------------------------------------|-----------------------------------------|----|-----------------------------------------|-----------------|
| 15 May 2008                          | 3 June 2008                           | 9 July 2008                             | .. | 3 September 2008                        | 3 December 2009 |
| 0.7%                                 | 0.8%                                  | 0.7%                                    | .. | 0.7%                                    | 0.8%            |

Below, the reliability<sup>3</sup> of the euro area GDP flash estimates is assessed by comparing the flash estimate with the first regular estimate and the quarterly and annual updates, using selected revision indicators. For this revision, analysis the following notation is used:

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<sup>3</sup> In line with the IMF’s Data Quality Assessment Framework, “reliability” is defined as the closeness of the initial estimate with subsequent estimates.

By denoting the value in quarter  $t$  of the seasonally adjusted time series as  $a_t$ , the respective quarter-on-quarter rate of change,  $\Delta a_t$ , can be written as

$$(1) \quad \Delta a_t := a_t / a_{t-1} - 1 \approx \ln(a_t / a_{t-1})$$

Furthermore, let  $\Delta a_{t|t}$  denote the flash estimate of quarter  $t$  and  $\Delta a_{t|t+\tau}$  a later estimate of series' value in quarter  $t$ , based on time series data available up to quarter  $t+\tau$ ,  $\tau > 0$ , revisions can be defined as

$$(2) \quad r_{t,\tau}^a := \Delta a_{t|t+\tau} - \Delta a_{t|t} = \text{later estimate} - \text{flash estimate}$$

Here,  $\tau$  shall vary, so that  $t+\tau$  refers to the first regular estimate, the quarterly update and the annual update, respectively.

Revision measures applied in this analysis include measures of size and sign of revisions as well as indicators that focus on tracing turning points, i.e. how well the flash estimate indicates the direction of change in GDP (percentage of cases in which the sign of a quarter-on-quarter growth rate remained unchanged after revision) and whether GDP growth is accelerating or decelerating (percentage of cases in which the sign of a difference of two consecutive quarter-on-quarter growth rate remained unchanged after revision). Using  $T$  to denote the number of observations used for the calculation of a revision measure, the revision measures are defined as:

$$\text{Average revision:} \quad r_\tau := \sum_t r_{t,\tau} / T$$

$$\text{Average absolute revision:} \quad R_\tau := \sum_t |r_{t,\tau}| / T$$

$$\text{Direction of change} \quad := \% \text{ of } \{\text{sgn}(\Delta a_{t|t+\tau}) = \text{sgn}(\Delta a_{t|t})\}$$

$$\text{Acceleration and deceleration} \quad := \% \text{ of } \{\text{sgn}(\Delta a_{t|t+\tau} - \Delta a_{t-1|t+\tau}) = \text{sgn}(\Delta a_{t|t} - \Delta a_{t-1|t})\}$$

Chart 1 shows, for each quarter from the first quarter of 2007 to first quarter of 2010, the respective quarter-on-quarter euro area GDP volume growth as it was published as flash estimate (1), as first regular estimate (2) and when the quarterly (3) and the annual update (4) were released. Comparing these four releases of GDP volume growth quarter by quarter illustrates the fact that the flash estimates had not been revised much when the first regular estimates and the quarterly updates were published. Most of the revisions are accounted for by the annual updates.

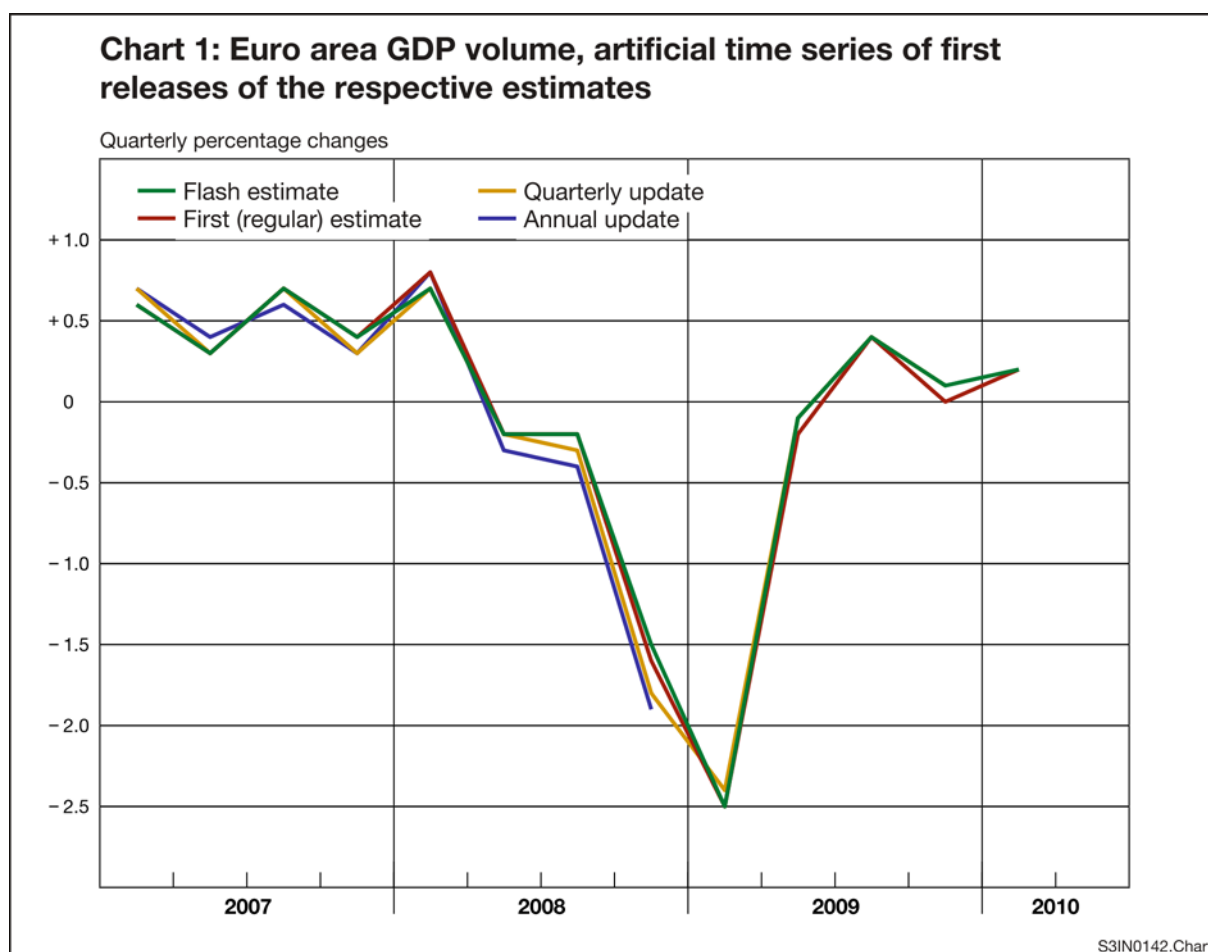


Table 2 reports on the results of the revision analysis of quarter-on-quarter euro area GDP volume growth, conducted for the releases of data from the first quarter of 2003 to the fourth quarter of 2009. According to the revision measures used for the analysis, the flash estimate of euro area GDP exhibits no bias and the average size of absolute revisions is small, being, for example, 0.1 percentage point when compared with the quarterly update and the annual update, respectively. The “flash” also performs well in capturing turning points and has been successful in indicating the direction and pace of GDP growth.

**Table 2: Revisions to the flash estimate of euro area GDP volume, 2003 Q1 to 2009 Q4, in percentage points (pp) and as a percentage (%)**

|                                        | <i>First regular estimate</i> | <i>Quarterly update</i> | <i>Annual update</i> |
|----------------------------------------|-------------------------------|-------------------------|----------------------|
| <i>No. of time series observations</i> | 29                            | 28                      | 24                   |
| <i>Average revision</i>                | 0.0 pp                        | 0.0 pp                  | 0.0 pp               |
| <i>Average absolute revision</i>       | 0.0 pp                        | 0.1 pp                  | 0.1 pp               |
| <i>Direction of change</i>             | 100.0%                        | 100.0%                  | 100.0%               |
| <i>Acceleration and deceleration</i>   | 96.6%                         | 96.3%                   | 81.3%                |

### ***Information content of euro area GDP releases***

In order to gain some further insight into the reliability of GDP flash estimate, it is worth looking into the development of the information content of euro area GDP estimates for a certain reference quarter across subsequent releases. More specifically, this section presents the short-term data sources that underlie the GDP estimates for a certain quarter and provides an approximate quantitative assessment of the development of the amount of primary or “hard” source data used on the basis of methodological information published by the national statistical institutes of Germany, Italy and Spain.

In terms of the information content in estimates of a certain reference quarter, producers of statistics have to strike a balance between timeliness and reliability. The initial release is inevitably based on less comprehensive sets of information, the degree of which also varies across the components of GDP. The output side of GDP is often estimated by extrapolating value added by economic activity with closely related short-term output indicators. These include the industrial production index or physical quantity measures, such as transportation statistics on numbers of passengers or tonne-kilometres. Other commonly used statistics are balance of payments and administrative data, financial statements and central banking statistics. Other indicators or estimates are often based on employment, hours worked and compensation of employees data. For taxes, it is worth mentioning that, although the basic information may be available for the three months of the quarter that is being estimated, the monthly results may need to be shifted back by one or two months to achieve accrual based estimates in accordance with ESA95.

The source data used for estimating the expenditure side of GDP vary across components. Turnover and sales statistics, as well as surveys are commonly used for estimating private consumption. Government consumption is often estimated on the basis of financial statistics and administrative data. Gross capital formation estimates draw on production and turnover statistics. Exports and imports are compiled on the basis of foreign trade and balance of payments statistics.

A quantitative assessment of the relative amount of primary information in the above-mentioned source data that are used for selected GDP estimates in the largest euro area economies is available only for Germany, Italy and Spain.<sup>4</sup> The results for the euro area – calculated as a weighted average of available country information - are shown in Table 3. The alignment of quarterly GDP with annual data sources and the introduction of methodological improvements are disregarded in this context. The shares of short-term information refer either to primary sources or suitable indicators that well reflect the variable that is being estimated.

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<sup>4</sup> National statistical institutes are legally required to provide Eurostat with a detailed inventory of the sources and methods used for compiling the annual national accounts. This is not the case for the Quarterly National Accounts (QNA). Some national statistical institutes publish on a voluntary basis a methodological description of the QNA estimates. A number of national statistical institutes do so in accordance with a Eurostat template for the “Inventory of sources and methods for quarterly national accounts”.

**Table 3: Primary short-term information content of euro area GDP, as a percentage of total short-term information used in the estimate at  $t+45$ ,  $t+63$  and  $t+150$**

| <u>Output approach</u>            | $t+45$ | $t+63$ | $t+150$ |
|-----------------------------------|--------|--------|---------|
| Value added in                    |        |        |         |
| Agriculture, forestry and fishery | 57     | 70     | 80      |
| Industry including energy         | 89     | 89     | 97      |
| Construction                      | 59     | 59     | 85      |
| Services                          | 66     | 68     | 91      |
| Taxes less subsidies on products  | 71     | 71     | 100     |
| GDP                               | 71     | 72     | 91      |
| <u>Expenditure approach</u>       |        |        |         |
| Final consumption                 | 56     | 57     | 95      |
| Gross capital formation           | 64     | 64     | 85      |
| Exports                           | 86     | 88     | 100     |
| Imports                           | 85     | 87     | 100     |
| GDP                               | 59     | 60     | 93      |

The output side is based on a larger amount of primary information (roughly 71% for the flash estimate of euro area GDP) than the expenditure side (59%), which reflects a higher and timelier availability of short-term production indicators when compared with expenditure data. The increase in coverage of the output and expenditure sides to 91% and 93%, respectively, at  $t+150$  days shows that the quarterly update contains the bulk of short-term primary information. Moreover, it is interesting to note that the quarterly update does not entail significant revisions to the GDP flash estimate, despite this relatively strong increase in coverage (from 72% to 91% for, say, the output side). This may be due to partly offsetting revisions to the components but also illustrates the important role that can be played by alternative indicators, estimates and expert judgement in compensating an initial lack of primary information.

It should be stressed that these shares are the result of a self-assessment by national statistical institutes, rather than of external audits, such as those conducted by Eurostat's Gross National Income (GNI) committee. Therefore, they may not be fully comparable and should not be taken at face value. Nevertheless, they are indicative of the scope for possible future revisions, although there is no direct link between the coverage of primary data and revisions, as primary data itself may be subject to revisions and alternative indicators, models and expert judgement could, in principle, effectively compensate for the lack of primary information. Furthermore, a quantitative assessment of the short-term information content of GDP is not available for France. However, since the French national statistical institute (INSEE) already publishes both the output and expenditure breakdown at the time of the GDP flash estimate, it can be assumed that these are based on an adequate amount of basic data, so that the above-mentioned relative shares of primary information should be seen as lower-limits for the euro area.

### **3. Seasonal adjustment of euro area GDP in times of economic crisis**

#### ***Some basic principles and characteristics of seasonal adjustment***

Another source of revisions is seasonal adjustment. Adjusting a quarterly or monthly macroeconomic indicator series for seasonal fluctuations, i.e. for movements which recur every year in the same quarter or month and impact to a similar extent on that series, can support the analysis of short-term developments,

since new developments may become more obvious when the significant, sometimes obscuring impact of the regularly repeating seasonal influences is removed from the series. In this context, it has to be kept in mind that a seasonally adjusted time series not only represents trend and cyclical movements, but also irregular effects.

Seasonal adjustment procedures commonly use a decomposition of a time series into unobservable components that reflect trend-cycle, seasonal and irregular movements (and, if relevant, calendar-related movements). Further, it is assumed that the series can be made up by combining these components either additively or multiplicatively. By denoting the value in period  $t$  of an unadjusted time series  $u_t$  and the respective values of its components  $c_t$ ,  $s_t$  and  $i_t$ , the multiplicative decomposition model, as used for seasonal adjustment calculations of this paper, can be written as

$$(3) \quad u_t = c_t \cdot s_t \cdot i_t$$

The seasonally adjusted value in period  $t$ , time series  $a_t$ , is then obtained as

$$(4) \quad a_t = u_t / s_t = c_t \cdot i_t$$

i.e. by dividing each value of the unadjusted series  $u_t$  by its respective “seasonal factor”  $s_t$ .

While it is commonly accepted as an intrinsic feature of a time series’ seasonal profile that it generally repeats itself year by year, although it may gradually change over time, this conceptual idea of a seasonal pattern is far too general to allow for a unique operationalisation of its quantification. Rather, the estimation of a seasonal profile requires additional and more concrete settings. The approaches to the quantification of the components  $c_t$ ,  $s_t$  and  $i_t$ , however, vary across seasonal adjustment procedures. What is known as the filter-based procedure X-11, for example, estimates the trend-cycle and seasonal components as moving averages. On the other hand, the model-based program TRAMO/SEATS applies a canonical decomposition into the time series’ components by referring to an ARIMA-model.

### ***Seasonal adjustment and extreme values***

Independently of the way in which the quantification of the seasonal component is operationalised by a program, extreme values may have the potential to adversely affect the outcome of seasonal adjustment.<sup>5</sup> This can be mainly traced back to the use of linear functions usually applied in seasonal adjustment procedures, which are applied in one way or another by both model-based and filter-based programs. Such approaches are not robust against violations of the assumptions about the data-generating process. Therefore, it is important to treat appropriately the forces that might cause non-linearities, so that - for seasonal adjustment purposes - a transformed version of the series can be produced for which it can be assumed that the underlying statistical assumptions approximately hold. While, in many cases, taking the natural logarithm of all time series values may help justify the assumption of linear relations in the components of the underlying data-generating process, distortions related to extreme values require a distinctive treatment of the affected time series values. It is particularly difficult to identify extreme

<sup>5</sup> For this and what follows, see European Commission (ed.): “ESS Guidelines on Seasonal Adjustment”, Luxembourg, 2009, p. 9. ([http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-RA-09-006/EN/KS-RA-09-006-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-006/EN/KS-RA-09-006-EN.PDF))

values at the recent end of a series, since the estimation of the size of extreme values and the number of such values is typically highly uncertain in such periods due to the lack of sufficient information about developments after the extreme values had occurred. In particular, the specification of the type of outliers that could be applied to model the extreme values requires some subsequent observations which provide sufficient evidence of whether the unusual situation remained present for some periods or disappeared at some point in time, whether its impact decreased fully or partially, in an abrupt or a gradual manner.

The sharp movements observed in the euro area in several macro-economic series during the deep economic downturn in late 2008 and early 2009, particularly on production and external trade, have been posing major challenges to their statistical treatment in the seasonal adjustment of that series. Depending on the specific pattern of the dramatic decrease in economic activity, it has to be decided whether or not outliers should be modelled and, if outliers are used, how to model the extreme development in terms of outlier specification and periods in which they may occur. In RegARIMA models, which are widely used in seasonal adjustment because of their scope for combining stochastic and deterministic elements like working-day regressors, outliers are typically specified dummy regressors which can take the form of an additive outlier, i.e. one single extreme value; a level shift, i.e. a permanent change in the average level of the series; or of a temporary (or “transitory”) change outlier, i.e. an extreme value followed by a gradual return to the previous level of the series.

In general terms, the overall aim of the statistical treatment of extreme values or developments is not to let the downturn in economic activity impact adversely on the estimate of the seasonal pattern which is extracted via seasonal adjustment. However, since it is generally not possible to make a clear-cut distinction between changes in the seasonal pattern and non-regular, extreme movements, there is no unique optimal approach to the treatment of the crisis in seasonal adjustment. In fact, different dynamics in different time series in late 2008 and early 2009 might allow, or may even require, alternative solutions, taking due account of country or indicator-specific developments and circumstances, while safeguarding that the estimate of the seasonal component is kept undistorted. Against this background, it seems advisable to refer to additional information from other sources. While for several output, production and trade series, strong empirical evidence can be combined with economic phenomena underpinning it – for instance, about short-time work widely introduced for many production activities –, thereby making a strong case for a non-standard statistical treatment, determining the most appropriate statistical approach is not a straightforward matter. Typically, there is more than one option for dealing with the economic downturn that would avoid the possibility of the seasonally adjusted series being distorted by an unduly large change in the estimated seasonal pattern stemming from a partial misallocation of the economic downturn as a change in the seasonal profile. For example, by “forcing” a certain high degree of stability in the seasonal component, say, by applying long-term seasonal moving averages in X-12 and not allowing the detection of any outliers in the periods affected by the crisis, substantial parts of the abrupt downturn in economic activity are adopted by the trend-cycle component, albeit with a different pattern than in an approach which makes use of level shifts.

### ***Seasonal adjustment of euro area GDP and outlier treatment: Facts and alternative test calculations***

Since the seasonally adjusted GDP for the euro area is compiled as an aggregate of the respective seasonally GDP data obtained at national level,<sup>6</sup> the euro area data reflect, to a varying extent, the country-individual statistical treatments of the crisis. According to information collected by Eurostat from national statistical institutes, the seasonal adjustment of, for example, German GDP was performed by means of modelling level shifts in 2008 Q4 and 2009 Q1. For the seasonal adjustment of Italian GDP, however, a temporary change outlier is used. By contrast, no outliers were introduced in the adjustment of Spanish GDP.

While such different statistical treatments across countries are justified as long as they reflect differences in time series dynamics underlying the actual developments in production in late 2008 and early 2009, it might be of interest to gauge to what extent – *ceteris paribus* – alternative outlier treatments may have impacted on the outcome of seasonal adjustment. In order to gain some insights into the potential impact the outlier treatment of the crisis may have, we investigated different approaches to the seasonal adjustment of euro area GDP. These test calculations were conducted with an experimental version of the hybrid program X-13-ARIMASEATS,<sup>7</sup> which basically merged the seasonal adjustment procedures X-12-ARIMA and TRAMO/SEATS. Different sets of outlier dummies were specified, while the seasonal component was either estimated with moving-average filters, i.e. by activating the X-11 part of X-13-ARIMA-SEATS (henceforth denoted as “X-12-ARIMA seasonal adjustment”), or via an ARIMA-based canonical decomposition, i.e. by using the SEATS part (henceforth denoted as “TRAMO/SEATS seasonal adjustment”).

In the case of X-12-ARIMA seasonal adjustment, we also conducted different treatments of extreme values that may be identified in preliminarily estimates of seasonal factors. For this, the lower and the upper sigma limits (measured in units of standard deviations of the irregular component) were varied, in-between which more extreme period-specific deviations from trend-cycle movements are substituted in order to achieve greater consistency with the seasonal factors observed in the same period in neighbouring years. When these sigma-limits were increased from a range of 2.0 and 3.0, i.e. two-times and three-times the respective standard deviation of the irregular component, to a range of 3.0 and 4.0, eventually none of the quarter-specific deviations from trend-cycle movements in the X-12-ARIMA test calculations was identified as extreme.

The regression part of the RegARIMA model comprises not only those outlier dummy regressors that have been specified for some of our alternative calculations, but also a working-day regressor used for approximating calendar adjustment, since a purely calendar-adjusted GDP volume series is not yet available.<sup>8</sup> Turning to the ARIMA part, it is an intrinsic feature of TRAMO/SEATS that the specification

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<sup>6</sup> For short-term statistics, such as industrial new orders, industrial production and retail sales, seasonally and calendar-adjusted data for the euro area are obtained “directly”, i.e. by aggregating the only calendar-adjusted national series and then seasonally adjusting directly this aggregated series.

<sup>7</sup> See, for example, US Census Bureau (ed.): “X-13ARIMA-SEATS Reference Manual, Version 0.1 (Beta)”, Washington, 2009.

<sup>8</sup> GDP volume series are adjusted for calendar effects at national level by the vast majority of data compilers.

of the ARIMA model plays a crucial role for seasonal adjustment, while the results of an X-12-ARIMA seasonal adjustment may not be very much affected by changes in the specification of the ARIMA model. Therefore, TRAMO/SEATS test calculations were conducted with and without fixed ARIMA model specifications, in the latter case allowing an automatic choice of the model specification. Altogether, eight alternative approaches to the seasonal adjustment of euro area GDP series were taken. In order to assess how the results of the test calculations differed in the course of subsequent releases of the euro area GDP volume time series, the calculations were conducted vintage by vintage, i.e. the seasonal adjustment was conducted anew for each of the subsequent releases of data from the first quarter of 2003. In X-12-ARIMA seasonal adjustment, the filters were kept fixed, while the seasonal factors, which quantify the impact of seasonality to the series, were re-estimated for each vintage. The parameters and coefficients of the RegARIMA models were re-estimated as well. Specifications of RegARIMA models were generally not changed, but one TRAMO/SEATS adjustment was based on an automatic choice of the model specification.

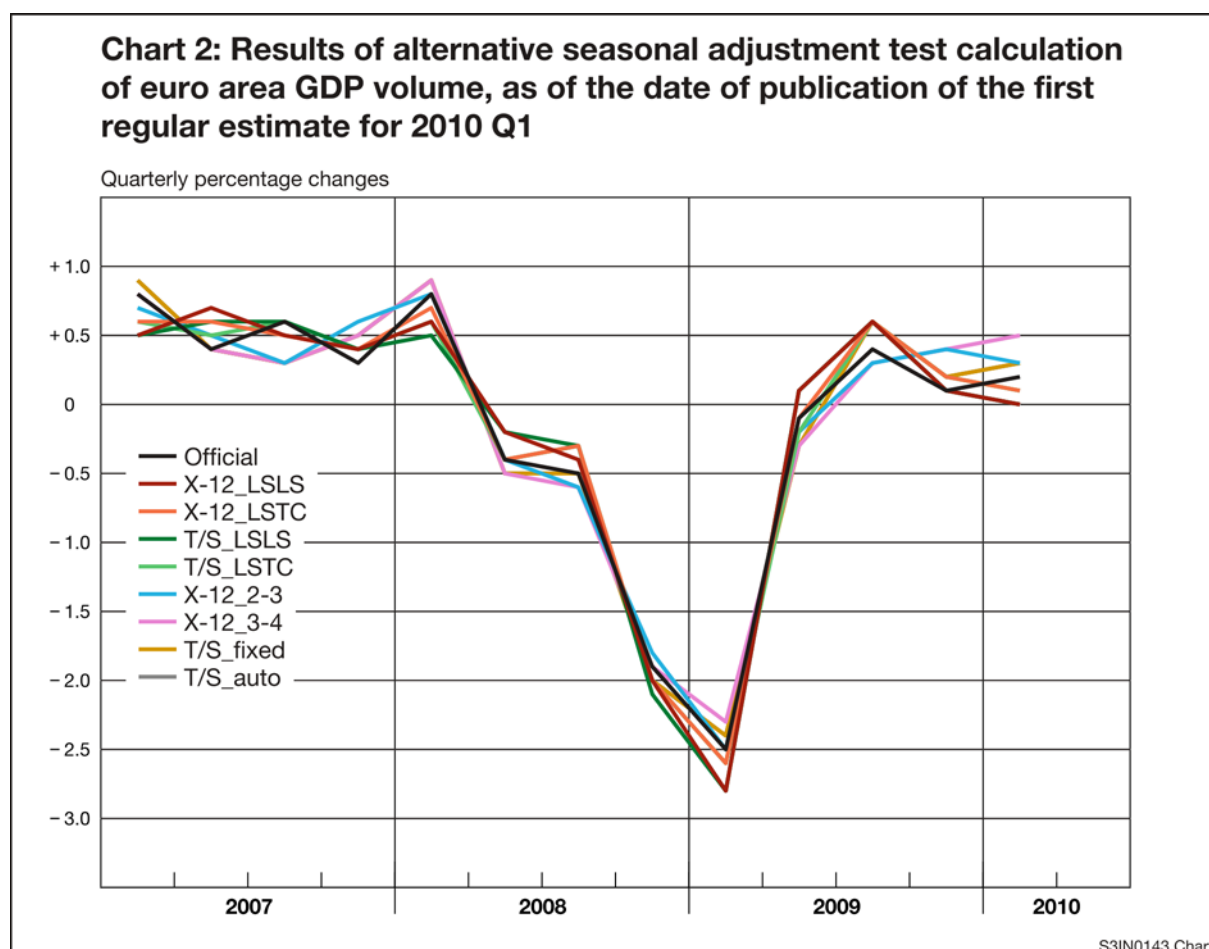
The following list summarises the approaches of seasonal adjustment taken in this paper.

- 1) RegARIMA level shifts in 2008 Q4 and 2009 Q1, X-12-ARIMA seasonal adjustment (“X-12\_LSLs”)
- 2) RegARIMA level shift and temporary change outlier in 2008 Q4, X-12-ARIMA seasonal adjustment (“X-12\_LSTC”)
- 3) RegARIMA level shifts in 2008 Q4, 2009 Q1 and TRAMO/SEATS seasonal adjustment (“T/S\_LSLs”)
- 4) RegARIMA level shift and temporary change outlier in 2008 Q4, TRAMO/SEATS seasonal adjustment (“T/S\_LSTC”)
- 5) No RegARIMA outlier dummies, X-12-ARIMA seasonal adjustment with sigma-limits of 2.0 and 3.0 (“X-12\_2-3”)
- 6) No RegARIMA outlier dummies, X-12-ARIMA seasonal adjustment with sigma-limits of 3.0 and 4.0 (“X-12\_3-4”)
- 7) No RegARIMA outlier dummies, TRAMO/SEATS seasonal adjustment referring to a fixed specification of the ARIMA model (“T/S\_fixed”)
- 8) No RegARIMA outlier dummies, TRAMO/SEATS seasonal adjustment referring to an automatically chosen specification of the ARIMA model (“T/S\_auto”)

The most recent observation of GDP volume growth covered by this investigation refers to the first quarter of 2010, for which the first regular estimate was available when this paper was written. The test calculations were conducted on the basis on unadjusted GDP time series. Since the “flash” GDP is not provided in the form of a time series, our alternative calculations, vintage by vintage, were conducted on the basis of the data reported when the respective first regular estimate was published.

### Comparison of alternative test results

The results of the test approaches varied not only in terms of values but also with respect to their statistical quality. In terms of statistical criteria used for assessing the quality of seasonal adjustment and its results, approaches with outlier dummy regressors did not show any particular problem in the adjustment process and results. When outlier dummies were not used, however, some of the diagnostics indicated that the results of RegARIMA modelling might have been significantly affected by the extreme values. Also, from the changes in the seasonal factors of those approaches it was possible to derive that approaches without outlier dummies may significantly differ from calculations in which the intensive period of the crisis was treated as an outlier. Chart 2 compares the official seasonally adjusted euro area GDP volume growth with the results of our alternative test calculations.



The chart illustrates that the differences in quarter-on-quarter rates of change of alternative approaches to the seasonal adjustment of euro area GDP vary between 0.2 and 0.5 percentage point. Referring, as a yardstick, to variations in results of alternative test calculations obtained under more normal circumstances, this range of differences in the results does not provide any strong indication that the statistical uncertainty underlying seasonal adjustment, in terms of different outlier treatment, might have become substantially more pronounced in the periods of the most intensive part of the crisis. However, it has to be stressed that, from the perspective of the most intensive part of the crisis, this is an *ex post* assessment. Insights into revisions of alternative test estimates are provided below by analysing results vintage by vintage. In terms of quarterly rates of change, the test results indicate that it is difficult to

derive economic signals from most recent seasonally adjusted data. In this respect, the different volatility observed in the alternative seasonally adjusted quarter-on-quarter growth rates may be considered as reflecting statistical uncertainties that might have been heightened by the extreme values observed in the most intensive part of the crisis.

The largest difference is observed for the most recent quarter, i.e. the first quarter of 2010. In the second quarter of 2008, all approaches produced negative quarter-on-quarter rates of change. The size of the relative downturn, however, tends to be more pronounced when growth was high one quarter earlier. In 2009, the quarter-on-quarter rates of change obtained by the approaches with level shifts in 2008 Q4 and 2009 Q1 already turned positive in the second quarter, while other approaches produced a last negative rate before reaching positive territory one quarter later. However, it has to be stressed that the two positive growth rates of that quarter as well as the negative rate reported officially by Eurostat are very close to zero. By contrast, approaches without outliers tend to produce more negative results for that quarter. Another difference between the outcome of the double-level shift approaches and other alternative test calculations can be identified in 2010 Q1, for which the double-level shift approaches produce quarter-on-quarter rates of change which are very close to zero. Other results provide more indications that GDP might have grown in that quarter. Eurostat's official results are basically well in-between the range of different results produced by alternative calculations.

### ***Investigation of revisions in alternative test results***

The latest quarter referred to in the revision analysis is the fourth quarter of 2009, for whose value the quarterly update became available when the first regular estimate of 2010 Q1 was published. For the periods when the economic downturn was most intensive, i.e. the fourth quarter of 2008 and in the first quarter of 2009, a quarterly and an annual update are available. Estimates of values in the quarters up to 2006 Q4 have been considered to be almost final when referring to the respective estimates published in 2010. At that point in time, the respective seasonal profile is estimated by means of symmetric filters for which all values are actual observations rather than RegARIMA forecasts. However, further revisions of these “final” data cannot generally be ruled out; for example, they might be caused by revisions in the unadjusted data, due, say, to methodological changes incorporated into the whole time series.

As explained above, the analysis of our alternative seasonal adjustment calculations takes the first regular estimate as a reference, while the flash estimate (the reference value of the revision analysis in Chapter 2) is disregarded. In terms of revision measurement, referring to equation (2), this means that, below,  $\Delta a_{t|t}$  denotes the first estimate, published at  $t+63$  days and not the flash estimate, published at  $t+45$  days.

This also allows presenting the data structure used for the revision analysis in the typical triangle form. By way of an example, Table 4 gives an overview of the releases of 2003 data taken into account in the revision analysis of this and the following chapter, assuming that the relevant estimates can be considered almost final when the data were reported in 2010 Q1. Column headers are reference quarters, row headers

are dates of publication for which the first regular estimate was reported. This means that the time series published at the respective dates are printed in the particular rows.<sup>9</sup>

**Table 4: Data structure for revision analysis**

| Date of publication | Reference quarter |                  |                  |                  |     |
|---------------------|-------------------|------------------|------------------|------------------|-----|
|                     | 2003 Q1           | 2003 Q2          | 2003 Q3          | 2003 Q4          | ... |
| 2003 June 05        | First estimate    |                  |                  |                  |     |
| Sep 09              | Quarterly update  | First estimate   |                  |                  |     |
| Dec 03              | ⋮                 | Quarterly update | First estimate   |                  |     |
| 2004 Mar 04         | ⋮                 | ⋮                | Quarterly update | First estimate   |     |
| June 01             | ⋮                 | ⋮                | ⋮                | Quarterly update | ⋮   |
| Sep 07              | ⋮                 | ⋮                | ⋮                | ⋮                | ... |
| Dec 01              | Annual update     | Annual update    | Annual update    | Annual update    | ... |
| 2005 Mar 02         | ⋮                 | ⋮                | ⋮                | ⋮                | ... |
| ⋮                   | ⋮                 | ⋮                | ⋮                | ⋮                | ⋮   |
| 2010 June 04        | Final estimate    | Final estimate   | Final estimate   | Final estimate   | ... |

Revisions to seasonally adjusted euro area GDP series, according to the alternative approaches, are shown in the following Charts 3.1-3.8. The vintages of GDP volume series are denoted by the quarter for which the first regular estimate was published.

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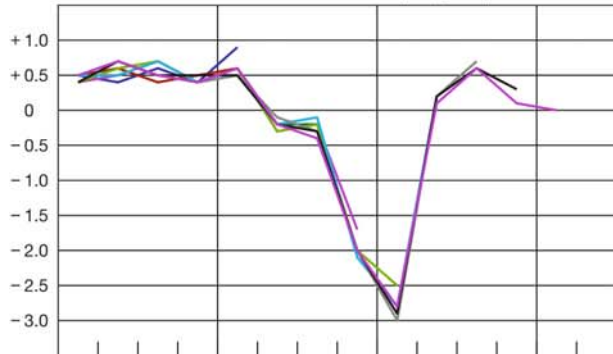
<sup>9</sup> The presentation of the revision matrix is not standardised in the literature. Depending on the authors, dates of publication are not arranged as row headers like here but as column headers. Accordingly, reference quarters switch from column headers to row headers. Technically speaking, the revisions matrix may be transposed.

# **Results of alternative seasonal adjustment test calculation of euro area GDP volume, vintage by vintage (denoted by that quarter for which the first regular estimate was published), quarterly percentage changes**

2008 Q1      2008 Q3      2009 Q1      2009 Q3      2010 Q1  
 2008 Q2      2008 Q4      2009 Q2      2009 Q4

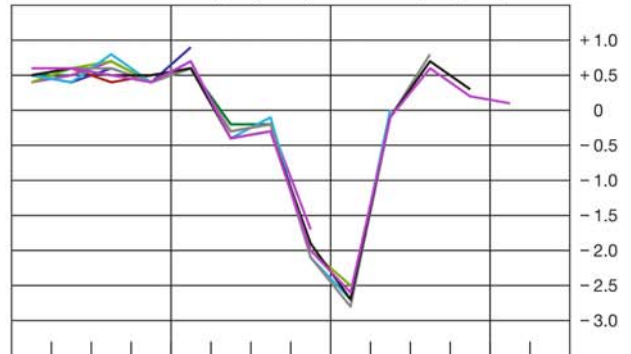
**Chart 3.1:**

X-12 and level shifts in 2008 Q4 and 2009 Q1 (X-12\_LSLs)



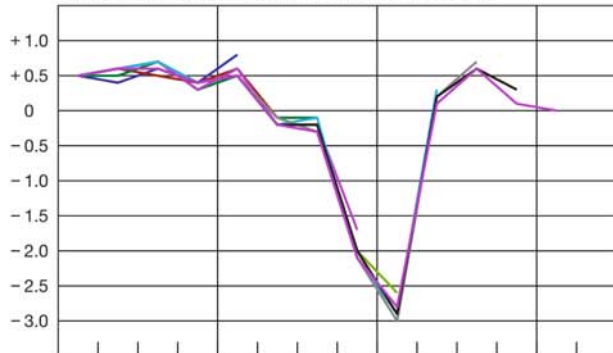
**Chart 3.2:**

X-12 and level shift and temporary change in 2008 Q4 (X-12\_LSTC)



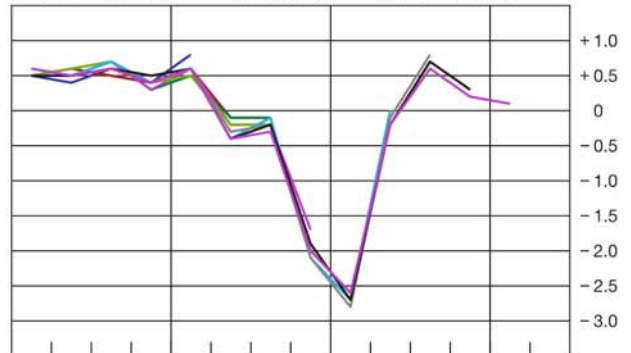
**Chart 3.3:**

SEATS and level shifts in 2008 Q4 and 2009 Q1 (T/S\_LSLs)



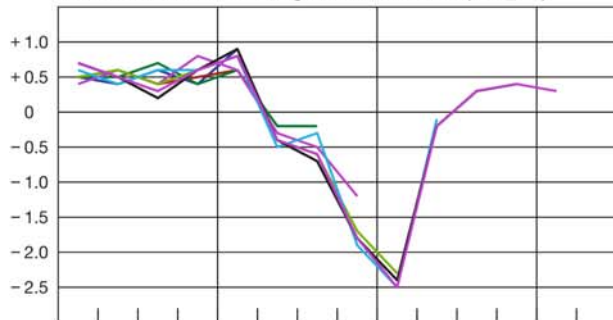
**Chart 3.4:**

SEATS and level shift and temporary change in 2008 Q4 (T/S\_LSTC)



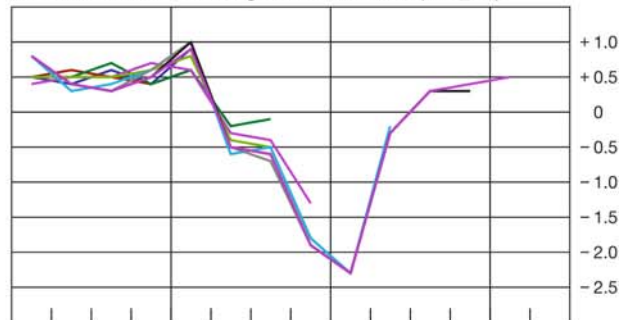
**Chart 3.5:**

X-12 and no outlier dummies, sigma-limits 2.0 and 3.0 (X-12\_2-3)



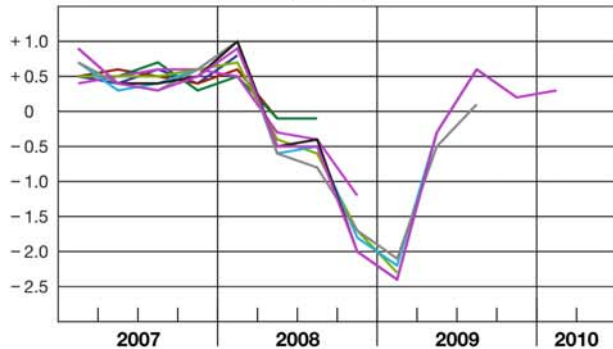
**Chart 3.6:**

X-12 and no outlier dummies, sigma-limits 3.0 and 4.0 (X-12\_3-4)



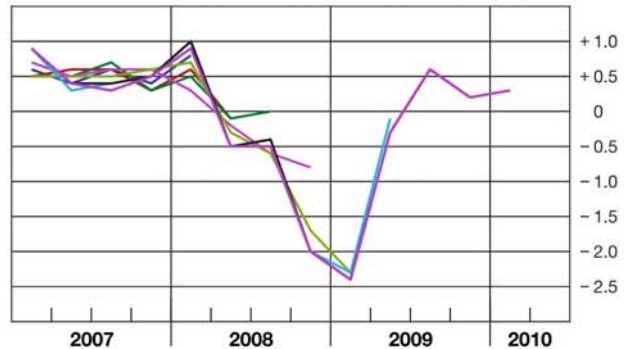
**Chart 3.7:**

SEATS and no outlier dummies (T/S\_fixed)



**Chart 3.8:**

SEATS and no outlier dummies and automatic model choice (T/S\_auto)



Comparing seasonal adjustments with X-12-ARIMA and TRAMO/SEATS, when level shifts were set in the fourth quarter of 2008 and the first quarter of 2009, with an approach of modelling simultaneously a level shift and a temporary change in 2008 Q4 does not reveal any striking difference. It could be mentioned, though, that the value in 2009 Q2 led to consistently positive quarter-on-quarter growth rates when two level shifts were set, while the second approach to outlier treatment produced zero or negative rates of change. These differences are very small, however.

Approaches without outlier dummies tend to produce more volatile rates of change in 2007 and in 2008 in the periods before the crisis began to deepen. Then, in the fourth quarter of 2008, revisions of the results which do not take account of the downturn in the form of an outlier are visible, while introducing an outlier dummy, estimates the depth of the crisis in a fairly reliable manner. However, in practice, this would have required the compilers of the seasonally adjusted data to have already decided in favour of modelling outlier dummies at an early stage, in this case when the value of 2008 Q4 was reported for the first time. Owing to the heightened statistical uncertainty in data of these periods and the potential risk that outlier dummies had been misspecified, practitioners might nevertheless have preferred to introduce outlier dummies only when some subsequent observations strengthened the empirical evidence with respect to the need for modelling outlier dummies and the type of outliers to be chosen.

Another difference can be found in the quarter-on-quarter rates of change from 2009 Q2 onwards, which increase quarter by quarter according to the results of X-12 seasonal adjustments without outlier dummies. By contrast, other calculations show a peak in the growth rate in 2008 Q3, while first estimates of the quarter-on-quarter rate of change in 2008 Q4 are then closer to zero. However, the degree of statistical uncertainty is even more heightened in these values, since assumptions about future developments have to be made in order to estimate the seasonal pattern at the recent end of the series, which are themselves by far more uncertain than usual.

The differences in the results of the alternative test calculations can also be interpreted in terms of revisions. Tables 5.1 to 5.8 summarise the results of the different calculations in terms of revision measures; revision measures are also calculated for the seasonally GDP volume, as published by Eurostat on the occasion of the first estimate.

**Tables 5.1 – 5.8: Revisions to alternative seasonal adjustment test calculation of euro area GDP volume, 2003 Q1 to 2009 Q4, in percentage points (pp) and as a percentage (%)**

**Table 5.1: X-12 and level shifts in 2008 Q4 and 2009 Q1**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.1 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 87.5%                | 81.3%                 |

**Table 5.2: X-12 and level shift and temporary change in 2008 Q4**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.1 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 87.5%                | 81.3%                 |

**Table 5.3: SEATS and level shifts in 2008 Q4 and 2009 Q1**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.2 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 91.7%                | 87.5%                 |

**Table 5.4: SEATS and level shift and temporary change in 2008 Q4**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.2 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 91.7%                | 87.5%                 |

**Table 5.5: X-12 and no outlier dummies, sigma-limits 2.0 and 3.0**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.1 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 87.5%                | 68.8%                 |

**Table 5.6: X-12, no outlier dummies, sigma-limits 3.0 and 4.0**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.2 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 83.3%                | 75.0%                 |

**Table 5.7: SEATS, no outlier dummies**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.2 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 91.7%                | 87.5%                 |

**Table 5.8: SEATS, no outlier dummies and automatic model choice**

|                                        | <i>Quarterly update</i> | <i>Annual update</i> | <i>Final estimate</i> |
|----------------------------------------|-------------------------|----------------------|-----------------------|
| <i>No. of time series observations</i> | 28                      | 24                   | 16                    |
| <i>Average revision</i>                | 0.0 pp                  | 0.0 pp               | 0.1 pp                |
| <i>Average absolute revision</i>       | 0.1 pp                  | 0.2 pp               | 0.2 pp                |
| <i>Direction of change</i>             | 100.0%                  | 95.8%                | 100.0%                |
| <i>Acceleration and deceleration</i>   | 96.4%                   | 87.5%                | 81.3%                 |

In order to indicate that the values of the revision measures of the X-12 approach with level shifts in 2008 Q4 and 2009 Q1 shall serve as a reference for comparison purposes, these values are highlighted in light blue in Table 5.1. Relative better or worse performances of other alternative test approaches are highlighted in green or red, respectively.

In most cases, the outcomes of revision measurement are either identical or lie very close to each other. A difference can be found in the average absolute revisions when the first full release is compared with the respective annual update. Three out of four X-12 approaches perform better in this respect, yet outperform the TRAMO/SEATS approaches by just 0.1 of a percentage point. On the other hand, the measurement of tracking the signal of acceleration or deceleration show some better results for approaches which make use of TRAMO/SEATS, particularly when the ARIMA model was not changed. This applies when the first full release is compared with the annual update and the final estimate, the latter reflecting “normal conditions” since the periods of the crisis are not covered by that comparison. Taking the annual update as a reference, the SEATS approaches, with two level shifts and with a level

shift and a temporary change in 2008 Q4, perform better than the respective X-12 approaches, yet outperform the latter only by one case. All in all, the results of this revision analysis do not differ considerably, suggesting that the alternative approaches are equally reliable. Taking the stance, though, that the graphical comparison revealed some differences between the approaches that may be considered more pronounced, especially in periods when the crisis was at its most intensive, it could be concluded that, at the current stage of data availability, revision analyses may not allow sufficient discrimination among the alternative approaches. This might be related to the fact that the number of data reported for periods after the intensive part of the crisis is far too small to consider the estimates of the crisis periods to be almost final.

The following chapter adds to the results of a conventional revision analysis a decomposition of revisions into its sources, i.e. revisions to the unadjusted data and revisions due to recalculations of seasonally adjusted data, and provides some indication on the interrelation between the two.

#### 4. Relative contribution of sources of revisions

Generally, revisions of seasonally adjusted real-time data have two main sources which are interrelated. One of these sources is the technical procedure of the method used for seasonal adjustment: the release of new unadjusted data, old unadjusted data remaining unchanged, leads to a shift of the base period and a change in the weights of the smoothing filters. The other source is the revision process of unadjusted data in real time: on their first date of release the data contain estimates for missing values which will be updated by and by with actual figures. In what follows a possible decomposition procedure is presented as to how much each of the sources contributes to total revisions.

##### *Decomposition methodology*

Revisions of period-to-period movements of seasonally adjusted real-time data can approximately be reformulated as the difference between the respective revisions of the growth rates of the unadjusted time series  $r_{t,\tau}^u$  and the seasonal component  $r_{t,\tau}^s$  to which analogous definitions apply (see Equations (1) and (2) for the definitions of growth rates and their revisions, respectively).

$$\begin{aligned}
 (5) \quad r_{t,\tau}^a &\approx \ln(a_{t|t+\tau} / a_{t-1|t+\tau}) - \ln(a_{t|t} / a_{t-1|t}) \\
 &= \ln(a_{t|t+\tau} / a_{t|t}) - \ln(a_{t-1|t+\tau} / a_{t-1|t}) \\
 &= [\ln(u_{t|t+\tau} / s_{t|t+\tau}) - \ln(u_{t|t} / s_{t|t})] - [\ln(u_{t-1|t+\tau} / s_{t-1|t+\tau}) - \ln(u_{t-1|t} / s_{t-1|t})] \\
 &= [\ln(u_{t|t+\tau} / u_{t|t}) - \ln(u_{t-1|t+\tau} / u_{t-1|t})] - [\ln(s_{t|t+\tau} / s_{t|t}) - \ln(s_{t-1|t+\tau} / s_{t-1|t})] \\
 &\approx r_{t,\tau}^u - r_{t,\tau}^s
 \end{aligned}$$

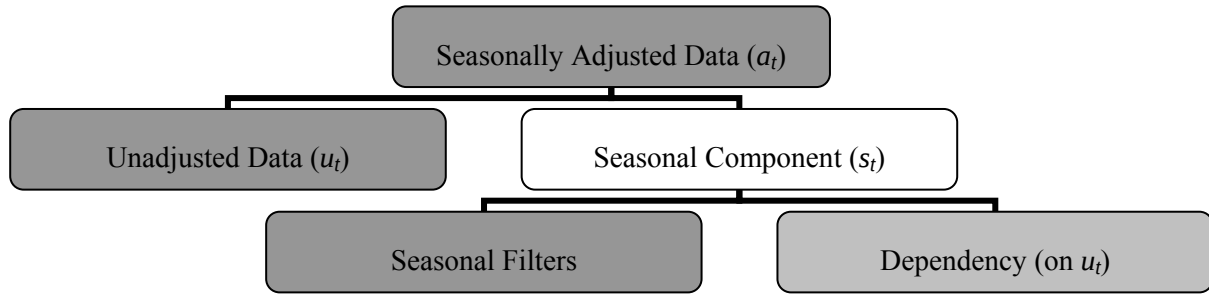
Before turning to the sources of revisions and their decomposition, it is worth revisiting four extreme cases – assuming that revisions of unadjusted real-time data cannot be predicted, i.e. that they are “news”.

- 1) In the case of no seasonal fluctuations, i.e.  $s_t = 1 \forall t$ , the unadjusted time series is equal to the seasonally adjusted time series,  $u_t = c_t \cdot i_t = a_t$ . Then, revisions from seasonal adjustment are necessarily zero, i.e.  $r_t^s = 0$ , and, thus,  $r_t^a = r_t^u$ .

- 2) With the aid of regARIMA modelling a time series is extended beyond its end and symmetric or less asymmetric smoothing filters become applicable. The closer the forecast comes to the realised value, the smaller are the revisions. In the case of perfect predictability of the seasonal pattern, revisions from seasonal adjustment are again zero.
- 3) If unadjusted data are not revised at all, i.e.  $r_t^u = 0 \forall t$ , revisions of seasonally adjusted data stem from seasonal adjustment alone, i.e.  $r_t^a = -r_t^s$ .
- 4) Revisions to unadjusted real-time data may have a seasonal pattern, which, in turn, would show up in revisions of the seasonal component. If both revisions cancelled out during seasonal adjustment, i.e.  $r_t^u = r_t^s$ , the resulting revisions of seasonally adjusted real-time data would be zero.

Equations (4) and (5) make the interplay of the sources of revisions, unadjusted data, on the one hand, and the seasonal component, on the other, evident. These are broken down in the chart below. In addition to revisions stemming from the seasonal filters, the seasonal component depends also on revisions of unadjusted data, constituting the “dependency” which can either attenuate or amplify total revisions.

**Chart 4: Sources of revisions**



In order to separate the effects of revisions stemming from unadjusted data and from seasonal adjustment, Mehrhoff (2008) calculates a pure seasonal filter revision  $r_t^\omega$  in a first step. By construction, it is not related to the revisions of unadjusted data. Thus,  $r_t^\omega$  does not measure revisions of the seasonal component  $r_t^s$  in real time but those that result from the automatic *History* procedure known from X-12-ARIMA. This is similar to revisions of seasonally adjusted real-time data with the difference that unadjusted data remain unchanged and the time series with data up to time  $t + \tau$  is truncated at time  $t$ . The following definition of  $r_t^\omega$  is comparable to  $r_t^a$  but now the subtrahend  $\Delta a_{t|t+\tau}^t$  is defined as the corresponding element of the truncated time series.

$$(6) \quad r_{t,\tau}^\omega = \Delta a_{t|t+\tau} - \Delta a_{t|t+\tau}^t$$

The dependency of the seasonal component on unadjusted data cannot be determined directly. Instead it will be defined in Equation (9) as the part of the seasonally adjusted real-time data revisions that remains unexplained by revisions of unadjusted real-time data and revisions of the seasonal filters.

### ***Mehrhoff's model***

The aim of Mehrhoff's model is to decompose revisions of seasonally adjusted real-time data into an unadjusted real-time data part and a seasonal adjustment part. Sources of information used are, firstly, the real-time vintages of unadjusted data, and, secondly, the user setting of seasonal adjustment options, which are held constant throughout all vintages. Using these settings, the vintages of unadjusted real-time data are seasonally adjusted, i.e. historical published figures are not used. In doing so, a third source of revisions is suppressed that would emerge if the user settings were changed. During the calculations, regression-ARIMA model parameters, namely those of calendar regressors, outliers and the ARMA parameters, are estimated with the full data span of the latest time series available. Therefore, the revisions derived mainly describe the properties of seasonal filters.

The hypothesis is that the variance of revisions of seasonally adjusted real-time data is the result of revisions from unadjusted real-time data and seasonal filters as well as the dependency of revisions of the seasonal component on revisions of unadjusted real-time data. Basically, a causal relationship of the form  $r_{t,\tau}^a = f(r_{t,\tau}^u, r_{t,\tau}^\omega)$  is presumed. In particular, revisions are considered in a regression model, which is formally stated below.

$$(7) \quad r_{t,\tau}^a = \beta_\tau^u \cdot r_{t,\tau}^u + \beta_\tau^\omega \cdot r_{t,\tau}^\omega + \varepsilon_{t,\tau}$$

Estimated slope coefficients represent marginal effects, i.e. the change in revisions of seasonally adjusted real-time data to a 1 percentage point change of either revisions of unadjusted real-time data or revisions of seasonal filters.

Employing average absolute revisions,  $\bar{R}_\tau^a$ ,  $\bar{R}_\tau^u$  and  $\bar{R}_\tau^\omega$  (see the definition in Chapter 2), absolute contributions can be calculated as follows. For this, absolute values are used, since, otherwise, revisions would cancel out to a large extent. Note that the  $\beta$ s are estimated according to the above equation and are plugged in here. This is done in order to calculate not only partial effects (the regression coefficients) but also average total effects of the respective (absolute) revisions, i.e. the typical influences of each of the sources on total revisions.

$$(8) \quad \bar{R}_\tau^a = \beta_\tau^u \cdot \bar{R}_\tau^u + \beta_\tau^\omega \cdot \bar{R}_\tau^\omega + \iota_\tau$$

The dependency  $\iota_\tau$  is defined as the unexplained revisions by the other two sources.

$$(9) \quad \iota_\tau = \bar{R}_\tau^a - \beta_\tau^u \cdot \bar{R}_\tau^u - \beta_\tau^\omega \cdot \bar{R}_\tau^\omega$$

For a convenient interpretation, absolute contributions can be expressed as relative ones.

$$(10) \quad 1 = \beta_\tau^u \cdot (\bar{R}_\tau^u / \bar{R}_\tau^a) + \beta_\tau^\omega \cdot (\bar{R}_\tau^\omega / \bar{R}_\tau^a) + (\iota_\tau / \bar{R}_\tau^a)$$

### ***Decomposition of revisions***

The model was estimated and the results are presented in the next table. Seasonal adjustment was performed with level shifts in 2008 Q4 and 2009 Q1 due to the superiority of this specification in the graphical analysis in Chapter 3.

**Table 6: Regression results\***

| Target           | X-12-ARIMA     |                |       | TRAMO/SEATS    |                |       |
|------------------|----------------|----------------|-------|----------------|----------------|-------|
|                  | $\beta^u_\tau$ | $\beta^o_\tau$ | $R^2$ | $\beta^u_\tau$ | $\beta^o_\tau$ | $R^2$ |
| Quarterly Update | .43***         | .62**          | .68   | .40***         | .64**          | .70   |
| Annual Update    | .30***         | .74***         | .60   | .28***         | .81***         | .63   |
| Final Estimate   | .15            | 1.09*          | .36   | .14            | 1.54**         | .48   |

\*  $p$ -values (significance levels): \*\*\* = 1%, \*\* = 5%, \* = 10%.

For the quarterly and annual updates, all estimated parameters are significant at least on the 5% significance level. For the final estimate, the results are not that clear-cut. With the increased availability of source data over time, marginal effects of unadjusted data revisions decrease, while those of seasonal filter revisions increase.

In combination with average absolute revisions stated in Table 7 (see also the results in Tables 5.1 and 5.3), the following picture emerges. Average absolute revisions stemming from the seasonal filters remain more or less the same. However, average absolute revisions of both seasonally adjusted and unadjusted real-time data increase with the passing of time.

**Table 7: Average absolute revisions (in percentage points)**

| Target           | X-12-ARIMA       |                  |                  | TRAMO/SEATS      |                  |                  |
|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                  | $\bar{R}^a_\tau$ | $\bar{R}^u_\tau$ | $\bar{R}^o_\tau$ | $\bar{R}^a_\tau$ | $\bar{R}^u_\tau$ | $\bar{R}^o_\tau$ |
| Quarterly Update | .10              | .17              | .06              | .09              | .17              | .06              |
| Annual Update    | .14              | .27              | .09              | .13              | .27              | .09              |
| Final Estimate   | .18              | .35              | .06              | .18              | .35              | .06              |

Using Equation (10), contributions to total revisions reveal the following development from the quarterly update via the annual update to the final estimate: Seasonal adjustment, i.e. seasonal filters and the dependency, becomes more important when trying to understand the revision process in the long run. However, in the short run, revisions from unadjusted real-time data are found to play the major role when explaining revisions, also reflecting the increasing availability of short-term “hard” data sources over subsequent releases.

**Table 8: Percentage contribution to total revisions**

| Target           | X-12-ARIMA     |                  |                 | TRAMO/SEATS    |                  |                 |
|------------------|----------------|------------------|-----------------|----------------|------------------|-----------------|
|                  | Unadj.<br>Data | Seas.<br>Filters | Depend-<br>ency | Unadj.<br>Data | Seas.<br>Filters | Depend-<br>ency |
| Quarterly Update | 72.17          | 36.19            | −8.36           | 71.42          | 37.85            | −9.27           |
| Annual Update    | 59.73          | 48.46            | −8.19           | 57.26          | 57.18            | −14.44          |
| Final Estimate   | 30.21          | 35.13            | 34.66           | 26.30          | 54.75            | 18.95           |

## 5. Conclusions

After introducing the release policy of euro area GDP volume growth and assessing the GDP estimates in terms of revision measures and primary information content, this paper examines the potential impact that alternative statistical treatments of the crisis may have on seasonal adjustment of euro area GDP. Approaches with and without outlier dummies have been investigated, using either the filter-based X-12-ARIMA procedure or, alternatively, TRAMO/SEATS. A comparison of the quarter-on-quarter rates of change of the alternative test calculations provided some evidence that the statistical uncertainty at the most recent end of the series might be more pronounced than under normal circumstances, particularly in terms of volatility of growth rates. The official series of euro area GDP growth, published by Eurostat, was well in-between the range of different test results. In terms of revisions, vintage by vintage, it was found that conventional revision measures do not allow sufficient discrimination between the alternative approaches. A more detailed graphical inspection, however, provided some evidence that differences in revisions were more pronounced when the steep downturn in economic activity started. Here, approaches without outlier dummies produced rates of change that were revised more substantially.

The decomposition of sources of revisions revealed that a large influence on total revisions of euro area GDP volume growth can be ascribed to revisions of unadjusted real-time data in the short run. This is consistent with the increasing availability of short-term “hard” data sources over subsequent releases. In the longer run, unadjusted data tend to be revised less, and seasonal filters revisions thus gain more relevance. In the end, the influence of seasonal filters decreases as well, and the dependency becomes more prominent. While unadjusted data are no longer revised at some point in the future, seasonal adjustment generates revisions long after that.