Interpreting the results of Revision Analyses: Recommended Summary Statistics

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Contribution to the OECD/Eurostat Task Force on
"Performing Revisions Analysis for Sub-Annual Economic Statistics"

1 Introduction

The purpose of this document is to provide a guideline to both users and producers of statistics on how to interpret the results of a revision analyses for economic variables published on a monthly or quarterly frequency. The key issues this document attempts to address in regards to the various summary statistics that can be calculated when performing a revisions analysis are:

- What question about revisions to the economic variable does the summary statistic answer?
- What type of user does the summary statistic target?

1.1 Classification of summary statistics from revisions analysis

This document presents summary statistics that can be calculated from a revisions analysis in regards to specific questions they answer which will be appropriate to different user groups depending on the sophistication of analysis required. Within the list of summary statistics which answer the relevant questions concerning revisions, the following classification will be made:

- Basic / core measures
- Additional / advanced measures
- Sophisticated / specific user measures

The document gives a detailed description on how each of the summary statistics described can be interpreted and also provides links to formulae where appropriate.

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1.2 Interaction with OECD / Eurostat revisions analysis tool-kit

A key output of the *OECD / Eurostat task-force on Performing Revisions Analysis for Sub-Annual Economic Statistics* was the creation of a pre-programmed tool[2] allowing users to automatically perform their own revisions analysis for an economic variable if they have the required data[3]. The tool has been programmed to automatically output all basic / core measures of revision as listed in this paper, and provides the user with the option of calculating the additional / advanced measures. It then provides a reference to this document for other sophisticated / specific user methods.

1.3 Interval of interest for revisions analysis study

When performing a revisions analysis, a user may be interested in different types of revision intervals depending on the purpose of the study they are undertaking. For example, a user may be interested in studying revision between first published data and its revision after different intervals of time (e.g. 3 months later, 1 year later), or the incremental effect of revisions between subsequent releases (e.g. revisions between second and third releases etc.). These issues depend largely on the research questions posed, therefore it is difficult to be prescriptive in recommending analysis of certain revision intervals. Therefore, the revisions tool-kit has been constructed in such a way to allow the user to specify any revision interval they wish to study[4]. Users should also be aware of changes to compilation methods that may have occurred over time to the variable being studied which can affect the consistency of time series for revisions that may also need to be taken into account[5].

It may also be that the certain summary statistics as presented in this document may be more or less relevant depending on the revision interval being evaluated and some information is given on this issue when describing the purpose of the relevant summary statistics. In addition, users may also be interested in studying revisions which occur to an economic time series at fixed intervals which may relate to the revisions policy of the statistical agency publishing the data. For example, if reconciliation with annual data sources (i.e. annual benchmarking) for gross domestic product (GDP) occurs with the release of second quarter data each year, then users may be interested in studying the revisions which occur to each reference quarter at this time (i.e. implying a different

[2] This tool can be accessed at:
http://www.oecd.org/document/27/0,3343,en_2649_34257_40010971_1_1_1_1,00.html

[3] The task-force has made recommendations on how to build a database of 'real-time' data required for revisions analysis which can be accessed at:
http://www.oecd.org/document/15/0,3343,en_2649_34257_40010127_1_1_1_1,00.html . In addition, there are several sources of freely available real-time databases containing the data required for revisions analysis for a wide range of countries and variables. A listing of these sources providing access to the databases is available at: http://www.oecd.org/document/10/0,3343,en_2649_34257_39129226_1_1_1_1,00.html

[4] The degree to which different revision intervals can be studied will of course depend on the structure of the real-time dataset available to analyse. The reader is therefore referred to the guidelines on how to build a real-time database at:
http://www.oecd.org/document/15/0,3343,en_2649_34257_40010127_1_1_1_1,00.html

[5] For more detail on the importance of the role of metadata when performing revisions analysis and practical application to German industrial production, see Lorenz (2008).

revision interval for say first published estimates of third quarter and fourth quarter data). Unfortunately the revisions tool developed by the task-force does not have the degree of sophistication to handle this type of analysis.

2 The purpose of revisions analysis

The results of revision analyses provide important information to users on the robustness of first published data, and enable producers to better understand the statistical compilation process, possibly facilitating the identification of problems and / or improvements that could be made.

With regards to the statistical outputs of a revisions analysis in the form of summary statistics, they should be viewed in the context of:

What question about revisions to the economic variable does the summary statistic answer?

Naturally such questions may differ depending on the purpose of the study or use of the outputs. Of particular interest are basic summary statistics which give information on the normal expectations for revision. Such measures may be appropriate to include in a press release in conjunction with the latest release data for an economic variable which should also give information on revision to previously published points in the time series[6].

The following section attempts to pose a range of standard questions which various summary statistics calculated from a revision analysis <u>for a given revision interval</u> can answer, grouping the measures into the following three groups:

1) Basic/ core measures: targeting users that require quick, easy to understand information
2) Additional/ advanced measures: targeting users that require more in-depth analysis
3) Sophisticated / special user measures: information for detailed research purposes.

Given that certain questions may themselves be more or less complicated, summary statistics in each of the above categories may not be provided for each question. For each summary statistic listed, a detailed description of its purpose in simple language is given, followed by its formula of calculation. The formulas for calculation are based on the following terminology:

$t = 1...n$, number of reference time points in the analysis period
L_t: later estimate for reference period t
P_t: preliminary (earlier) estimate for reference period t
R_t : $L_t - P_t$, revision (over a specified interval being analysed)

[6] See the task-force output on recommendations for the formation of revisions policy which addresses these issues, available at: http://www.oecd.org/document/5/0,3343,en_2649_34257_40014277_1_1_1_1,00.html

3 Questions to be answered by revision analysis

3.1 What standard parameters should be output in a revisions analysis to explain its scope?

3.2 What is the average size of revisions, or the usual range that revisions lie within?

3.3 Is the average level of revision close to zero, or is there an indication that revisions are more in one direction than another, suggesting possible bias in the earlier estimate?

3.4 What is the extent of variability of revisions?

3.5 In the case of growth rates, how often is the later published growth rate in the opposite direction to the earlier published rate?

3.6 What is the average size of revision relative to the estimate itself?

3.7 Is the earlier published estimate a good or 'efficient' forecast of the later published estimate?

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3.1 What standard parameters should be output in a revisions analysis to explain its scope?

For a complete understanding of the concept of vintages on which real-time datasets for performing revisions analysis are built, the reader is referred to Section 2 of McKenzie & Gamba (2008).

Analysis period: it describes the reference data points of the time series being analysed (e.g. from 1994Q1 – 2007Q3).

Revision Interval L_P: it corresponds to the revision interval being analysed for the vintages of the sampled time points, all statistics which follow would relate to this interval (e.g. M3_P implies the revision between first published estimates (i.e. P) and those published three months later (i.e. M3).

n: represents the number of observations used for the analysis (i.e. number of reference data points of the time series. For example, 1994Q1 – 2007Q3 represents 55 observations).

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3.2 What is the average size of revisions, or the usual range that revisions lie within?

Basic / core measures

Mean absolute revision: is a useful measure to gauge the size of revisions because it avoids offsetting effects on the indicator from negative and positive revisions (so it is more stable than the mean revision). Expressed in absolute percentage points, it indicates the average size of the revisions, but it cannot provide an indication of directional bias (refer to section 3.3).

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

Range that 90% of revisions lie within: it is the interval of the 5th to the 95th percentile of the distribution of revisions. It is useful because it gives a normal range expected for the revision without being impacted by unusually large revisions or 'outliers' which generally require specific explanation when they occur. It is an easy to understand measure to be put in a press release when talking about expected revision.

Advanced / additional measures

Median absolute revision: a useful measure of central tendency to compare with the mean absolute revision or to provide supplementary information. The median, the value in the centre of the distribution of absolute revisions, might be preferred to the mean as it is an expression of the central tendency of the values not affected by extreme observations.

$$|Me| = Me|R_t|$$

Note, in the revisions analysis tool these parameters are output under the heading: 'Usual size and range of revisions'.

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3.3 Is the average level of revision close to zero, or is there an indication that revisions are more in one direction than another, suggesting possible bias in the earlier estimate?

Basic / core measures

Arithmetic average or *mean* revision: when this measure shows a positive sign it indicates that on average earlier releases have been under-estimated (negative sign means over-estimated). Revisions of opposite sign will have a tendency to cancel out, consequentially the size of the mean revision, beyond determining the average direction of revisions, can be of limited use (also called "average bias").

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

Statistical significance of the mean revision

A test can be performed (see t-test in advanced measures) to determine whether the mean revision is statistically different from zero which may give an insight of whether a bias[7] exists in the earlier estimates. Four possible outcomes have been chosen to describe whether the mean revision is statistically significant.

No: Mean revision is not statistically different from zero.

Yes*: Mean revision is statistically different from zero, but not with a high degree of significance (significance at the 10% level).

Yes**: Mean revision is statistically different from zero (significance at the 5% level).

Yes***: Mean revision is statistically different from zero with a high degree of significance (significance at the 1% level).

Advanced / additional measures

Median revision: the median revision corresponds to the value in the centre of the distribution of revisions. It can be useful supplementary information to the mean revision as it is not affected by extreme revisions in either a positive or negative direction.

$$Me = Me(R_t)$$

[7] One should be wary of concluding a bias exists for the earlier published estimate if the mean revision is statistically significantly different from zero, particularly when studying revisions over a long interval (e.g. revisions between first published data and the latest available data), because there may be valid reasons to expect a non-zero mean revision, such as the impact of methodological or definitional changes which may have occurred to the time series over time. For a deeper discussion on this issue, see McKenzie (2007).

% of positive revisions: it returns the number of cases revised upward as a proportion of the total number of observations and can therefore be useful supplementary information to the mean revision.

$\%POS\_R_t = 100 * \frac{1}{n}\sum_{t=1}^{n} V_t$,where V_t=1 if R_t>0

% of negative revisions: it returns the number of cases revised downward as a proportion of the total number of observations

$\%NEG\_R_t = 100 * \frac{1}{n}\sum_{t=1}^{n} V_t$,where V_t=1 if R_t<0

% of zero revisions: it returns the number of cases with null revision as a proportion of the total number of observations

$\%NZ\_R_t = 100 * \frac{1}{n}\sum_{t=1}^{n} V_t$,where V_t=1 if $P_t \neq L_t$ R_t=0

Adjusted t-statistic for significance of mean revision

$$t = \frac{\bar{R}}{\text{st.dev(Rbar) - HAC Formula}}$$

where st.dev(Rbar)-HAC Formula, or the heteroscedasticity and autocorrelation consistent standard deviation[8] of mean revision is defined as the square root of:

$$\text{var}(\bar{R}) = \frac{1}{n(n-1)}\left\{\sum_{t=1}^{n}\hat{\varepsilon}_t^2 + \frac{3}{4}\sum_{t=2}^{n}\hat{\varepsilon}_t\hat{\varepsilon}_{t-1} + \frac{2}{3}\sum_{t=3}^{n}\hat{\varepsilon}_t\hat{\varepsilon}_{t-2}\right\} \text{ with } \hat{\varepsilon}_t = R_t - \bar{R}.$$

Critical values of t statistic for significance of mean revision: Given R as a random variable that follows a normal distribution with variance estimate as above, the t-critic returns a value t for which: P(|R| > t) = P(R < -t or R > t). The P(|R| > t) = 0.1, 0.05 and 0.01 define the values of t used for the qualitative interpretation of the 'statistical significance of the mean revision' heading above in the Basic / Core measures.

Note, in the revisions analysis tool these parameters are output under the heading: 'Assessment of possible directional tendency in revisions'.

[8] This formula attempts to take into account serial correlation of revisions.

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3.4 What is the extent of variability of revisions?

Basic / core measures

Standard deviation of revision: It is used to measure the spread of revisions around their mean, thus giving an indication of the volatility of revisions for a given revision interval. It is sensitive to outliers; therefore it is not a good measure of dispersion for revisions with skewed distributions. It is useful for symmetric/ normal distributions, or comparing volatility for different revision intervals and for international comparisons.

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

Advanced / additional measures

Root mean square revision: it essentially combines the degree of bias (i.e. mean revision) and the variance of the revision around its mean. As such it is a broader measure than the standard deviation of revision.

$$RMSR = \sqrt{\frac{1}{n}\sum_{t=1}^{n} R_t^{\,2}}$$

Quartile deviation: if the bias is measured by the median, the quartile deviation is the fit measure of dispersion, since it is the distance between the first and the third quartile positions, Q1 and Q3. The smaller the distance, the closer the revisions are to the median.

QDEV =Q3-Q1

Minimum revision: it returns the lowest (most likely –ve) value for the revision interval.

Maximum revision: it returns the highest value for the revision interval.

Range of revision: it measures the difference between the highest and the lowest revisions for all observation periods. This range indicates the volatility of the first release. The total range covers all the revisions therefore it may include outliers.

Range = (Max Revision-Min Revision)

Sophisticated / special user measures

Skewness: it indicates when the distribution of values around the median value is non-symmetric. The distribution is called negative (positive) when the median is greater (smaller) than the mean, with the distribution presenting a longer tail towards the left (right). This can be useful to provide context to other tests and statistics that rely on the symmetry and or normality of the distribution of revisions.

$$SKEW = \frac{3*(\overline{R} - Me)}{SDR}$$

Note, in the revisions analysis tool these parameters are output under the heading: 'Variability of revisions'.

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3.5 In the case of growth rates, how often is the later published growth rate in the opposite direction to the earlier published rate?

This is an extreme case of unreliability, although it may be that the change of a small positive growth rate to a small negative growth rate (or vice versa) is not so serious.

Basic / core measures

% sign (later) = sign (earlier): the percentage of observations where the sign of later estimate and the sign of earlier estimate are the same.

Advanced / additional measures

Acceleration / deceleration: the second order extension of the above sign test is the acceleration / deceleration test. That is, if the earlier estimate indicates that growth is increasing (from the previous reference period), what is the percentage of times that the later estimate also signifies this.

Note, in the revisions analysis tool these parameters are output under the heading: 'Impact of revisions on sign of growth rates'.

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3.6 What is the average size of revision relative to the estimate itself?

Relative measures of revision can be useful for analysing revisions to level series, or to supplement the absolute measures (see 3.2) when making comparisons in the size of revisions across countries or across components / industries in a country where average growth rates differ widely, or in comparing the size of revisions for original and seasonally adjusted data

Basic / core measures

Relative mean absolute revision: this is simply the mean absolute revision scaled in terms of the size of the earlier estimates. Aside from the above issue, it is useful as a measure of robustness of first published estimates, as it can be interpreted as the expected proportion of the first published estimate that is likely to be revised over the revision interval being considered.

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

Advanced / additional measures

Average absolute value of first published estimate: this is used to give context to RMAR, and is only relevant for growth rates analysis.

$$\overline{P} = \frac{1}{n} * \sum_{t=1}^{n} |P_t|$$

Note, in the revisions analysis tool these parameters are output under the heading: 'Normalised revision analysis'.

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3.7 Is the earlier published estimate a good or 'efficient' forecast of the later published estimate?

Advanced / additional measures

Correlation between revision and earlier estimate (test if revisions are 'noise'): If the revision is correlated with the earlier estimate this implies that not all information available at the time of the earlier estimate has been used efficiently in the estimation process. Thus one concludes that revisions are noise[9] if the correlation between P_t and R_t is statistically significant.

$$\rho_{R_t P_t} = \frac{\sum_{t=1}^{n}\left(P_t - \bar{P}\right)\left(R_t - \bar{R}\right)}{(n-1) * \hat{\sigma}_P \hat{\sigma}_R}$$

where: $\hat{\sigma}_x = \sqrt{\frac{\sum_{t=1}^{n}\left(x_t - \bar{x}\right)^2}{n-1}}$

Correlation between revision and later estimate (test if revisions are 'news'): If the revision is correlated with the later estimate this implies that information which becomes available between the compilation of the earlier and later estimate (i.e. 'news') is being effectively incorporated in the estimation process of the later estimate. Provided revisions are not noise (see above), it implies that the earlier estimate can be regarded as an efficient forecast of the later estimate. Thus one concludes that revisions contain news[9] if the correlation between L_t and R_t is statistically significant.

$$\rho_{R_t L_t} = \frac{\sum_{t=1}^{n}\left(L_t - \bar{L}\right)\left(R_t - \bar{R}\right)}{(n-1) * \hat{\sigma}_L \hat{\sigma}_R}$$

Serial correlation of revisions: If for a given revision interval there is correlation between the revision for subsequent data points this needs to be taken into account when considering whether there is bias in the revision process (i.e. there may be some degree of predictability in the revision process). Note that serial correlation is perhaps more relevant when looking at revisions over short intervals rather than longer intervals because there is a complex interaction of revisions between many releases when one looks at longer revision interval. The same could perhaps be said for the news and noise tests. As with the news versus noise test the serial correlation needs to be tested for statistical significance.

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[9] A straight forward interpretation of the News vs Noise assessments of data revisions and how these can be used by statistics organisations to improve their processes can be found at: http://www.oecd.org/dataoecd/44/36/40308976.pdf?contentId=40308977

$$\rho_{R_t R_{t-1}} = \frac{\sum_{t=2}^{n}\left(R_{t-1}-\overline{R}\right)\left(R_t-\overline{R}\right)}{(n-1)*\hat{\sigma}_{R_t}\hat{\sigma}_{R_{t-1}}}$$

Note, this formula is conditional on the specified revision interval

Sophisticated / special user measures

Decomposition of the Mean Squared Revision: here is Theil (1961)'s decomposition of *MSR* following Granger & Newbold (1973):

$$MSR = \overline{R}^2 + \left(\sigma_P - \rho\sigma_L\right)^2 + \left(1-\rho^2\right)\sigma_L^2$$

where $\overline{R}$ is the mean revision, σ_L and σ_P are the standard deviations of the largest and preliminary estimates, respectively, and ρ is their correlation. Dividing throughout by *MSR* gives:

$$1 = UM + UR + UD$$

where:

UM(%), *UM* is the proportion of *MSR* due to mean revision not being equal to zero. It is thus also known as mean error.

$$UM = \frac{\overline{R}^2}{MSR}$$

UR (%), if we consider a linear regression model of the earlier and later estimates $L_t = \alpha + \beta P_t + u_t$, UR is the proportion of *MSR* due to the slope coefficient β being different from 0, or the slope error.

$$UR = \frac{\left(\sigma_P - \rho\sigma_L\right)^2}{MSR}$$

UD (%), UD is the disturbance proportion of *MSR*, i.e. the proportion of *MSR* that is not caused by systematic difference between earlier and later estimates.

$$UD = \frac{\left(1-\rho^2\right)\sigma_L{}^2}{MSR}$$

The lay interpretation of the above measures is that earlier estimates are ‘good’ if the above breakdown gives low values for *UM* and *UR* and a high value for *UD*.

Note, in the revisions analysis tool these parameters are output under the heading: ‘Efficiency assessments’.

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