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RETROSPECTIVE BENCHMARKING
Aligning Quarterly Estimates with Annual Benchmarks

Note by the OECD Secretariat

INTRODUCTION

1. In order to present a clear and helpful view of economic developments, it is essential that quarterly national accounts (QNA) are consistent with the annual accounts (ANA) - differences in growth rates between quarterly and annual GDP would confuse and irritate users. Differences are inevitable, however, as a result of the different data sources used for QNA and ANA, but they must be reconciled. Commonly, the most comprehensive and detailed information is only available at a fairly low frequency (annually, five yearly or even 10 yearly) due to the expense of collecting and processing such volumes of data. Also, such data are often available only after a considerable lag because of the time needed for collection and processing. These comprehensive data may form the basis for the ANA but it is usually necessary to use more timely, but less complete, data for QNA (and even for the most recent ANA years in some cases). These more frequent, timely data are generally less accurate but they give an indication of how the comprehensive data would behave if they were available.

2. The common feature of such indicators is that their coverage is less complete than is the case for the less frequent benchmark data, i.e. coverage of establishments, variables, commodities, industries or geographical areas. Thus, indicators suffer from bias in comparison to the more comprehensive data, arising from factors such as sampling error, differences in use of the business register (different versions of the register, grossing methods, reclassifications of establishments), different quarterly and annual accounting methods used by respondents, and respondent error. Other causes of bias are weak assumptions about the relationships between proxy indicators and target variables (e.g. constant IO ratios), and failing to account for quality change or changes in product mixes.

3. As a result of indicator bias, quarterly source data are viewed as serving only to determine short-term movements (quarterly path), whereas annual data determine the overall levels and the long-term trends. Thus, quarterly data and QNA estimates are adjusted as necessary so that they correspond with the trends shown by annual estimates, i.e. once benchmark (annual) data become available, the indicators need to be brought into line (benchmarked) with the long-term trends shown by the benchmarks. Indicators will also need to be subsequently revised in line with any later revisions to the benchmark data. The benchmark to indicator (BI) ratio for any benchmark period is a measure of indicator bias, and adjustments are made so that the BI ratio becomes one.

4. Some of the causes of bias are likely to have systematic and thus predictable effects so that it is possible to make adjustments each quarter, i.e. “real-time” adjustments. Of course, it would be better to determine the causes of the bias and remedy them, but this type of analysis may be too expensive to carry out in practice. However, it will inevitably be the case that these “real-time” adjustments will not be sufficient, and that once the benchmark data are available, the BI ratio will not equal one, i.e. retrospective adjustment of the quarterly data will also be needed. It is the retrospective adjustment which will be considered in this paper.

THE STEP PROBLEM

5. For any benchmark period (e.g. a year for which ANA are available) the BI ratio can be calculated. Since this can be viewed as a measure of the indicator bias it would be tempting to simply adjust for the bias by distributing the annual level data according to the distribution of the quarterly indicator, i.e. some means of pro-rata distribution across quarters. This would be fine in cases where the BI ratio is constant from year to year. If, however, BI ratios for adjacent years are different, and pro-rata adjustments are used in each year, a discontinuity in the growth rate from the last quarter of one year to the first quarter of the next will be introduced. This is known as the “step problem”. In other words, the growth between Q4 of one year and Q1 of the next will reflect the change in the BI ratio (adjustment) between the years as well as any genuine growth between Q4 and Q1.

BENCHMARKING TECHNIQUES

6. The step problem is solved by smoothing the changes in BI ratios need to be smoothed and this can be achieved to some extent using straightforward techniques such as a Henderson moving average. In other words, the BI ratios themselves are treated as a quarterly time series which initially appears as a series of steps with each year (step) consisting of four equal data points. This stepped series is smoothed, to give a series made up of BI ratios which are then applied to the indicator data to give a smoothly benchmarked series.

7. Another alternative is to use a least squares method to minimise the difference in the first difference between the adjusted quarterly series and the original quarterly series, subject to the constraint that the sum of the quarters equal the annual estimate**1**. This method is applied to estimates for two years each time new annual estimates become available, so each year is adjusted twice.

8. The common feature of these methods is that they try as far as possible to maintain the original quarterly growth rates under the constraints of a smooth transition between years and the need for the annual totals to reconcile.

INTEGRATED MODELS

9. In fact, benchmarking has two main dimensions, which are generally seen as separate topics by QNA compilers but are, in fact, derived from common principles, and are combined in practice in the more sophisticated QNA software applications.

Quarterisation – i.e. interpolating quarterly estimates using annual data as a base, or, put another way, splitting annual estimates into quarters. This may take the form of:

- revising preliminary QNA estimates to align them with corresponding annual estimates when available – retrospective benchmarking of recent quarterly estimates to annual benchmarks, as discussed above
- constructing time series of historical QNA estimates (back series) – interpolating for years when quarterly data were not available

Extrapolation – linking quarterly source data onto previous annual estimates, for:

- constructing forward series by adjusting the last available benchmark level according to movements in an indicator.

Quarterisation is retrospective in nature, whereas extrapolation is forward looking. The two dimensions are often associated, however, as extrapolated series generally need to be retrospectively benchmarked at a later date. Thus, two phases can be envisaged:

1) In the operational phase, there will be no annual benchmarks for the most recent quarters. So, the challenge is to extend the series beyond the last benchmark period, anticipating future ANA estimates so that future revisions are minimised, whist preserving, as far as possible, the short-term movements in the quarterly source data. Most extrapolation techniques are based on the idea that the last BI ratio based on actual data is projected forwards (flat) for each quarter and applied to each new quarterly estimate in real time. Further real-time adjustments are made to quarterly data if and when particular bias issues arise.

2) Following the operational phase, quarterly data will be treated retrospectively and subjected to continuing cycles of revisions. These revisions will arise from
   - the arrival of annual benchmarks for the most recent year
   - revisions to the quarterly source data

- revisions to the annual benchmarks of the previous year

Any new information needs to be incorporated into the QNA estimates as quickly as possible.

10. In order to satisfy the need for constant yet smoothed, updating and reconciliation, sophisticated models, such as the proportional Denton technique are available. These provide an integrated means of dealing with extrapolation, alignment and updating and give superior results to methods that treat these phases separately. For good indicators, the results are fairly insensitive to the choice of technique, but where significant bias exists different techniques are better suited to differently behaved biases, i.e. it is important to understand the nature of the bias.

11. The more sophisticated approaches to benchmarking may be classified as purely numerical, or statistical modelling, approaches. The numerical approach does not specify a time series model for the series, but instead uses least squares minimisation, e.g. the methods proposed by Denton and others (1971), Bassie (1958) and Ginsbergh (1973). The statistical modelling approach includes ARIMA model based methods (Hillmer and Trabelsi, 1987), state space models (Durbin and Quenneville, 1997), and a series of regression models proposed by Statistics Canada. In addition, Chow and Lin (1971) have proposed a multi variable general least squares regression approach for interpolation, distribution and extrapolation.

12. The basic Denton method aligns the back series using a least squares approach to minimise the differences in adjustments to adjacent quarters (i.e. smoothing the series of BI ratios – the same principle as described above in connection with Henderson moving averages) within the constraints of the annual totals. For forward extrapolation, the last BI ratio based on actual data is projected forwards (flat**2**) for each quarter and applied to each new quarterly estimate in "real time".

13. For the aligned back series, quarter to quarter growth rates will differ from those of the source data, and in extreme cases, new or different turning points may be introduced. This should be viewed as a necessary consequence of the reconciliation process. For the forward series, quarter to quarter growth rates will be the same as those of the source data, but the annual rate will be different, as expected.

14. When benchmark data for the most recent year become available, that year will be retrospectively benchmarked, and quarters in the year before (and maybe for several years before that) will also be revised. This is because smoothing the series of BI ratios may require trend adjustments stretching back more than four quarters. In general, the best results will be obtained if the entire time series is revised each time new annual benchmarks become available. However, with the recommended proportional Denton technique, the impact on data for proceeding years will gradually become smaller and smaller, and will normally become insignificant after three to four years.

15. Thus, the level and movements of final QNA estimates will depend on:

- Movements in short-term indicators, which determine the quarterly path/pattern of QNA
- Levels of ANA for the current year, which, through retrospective benchmarking, determine the sum of the quarterly levels
- Levels of ANA estimates for several preceding and following years, which through retrospective benchmarking, determine the trend.

16. It should be emphasised that in the case of incorporation of revised or new benchmarks, the calculations should be based on the original non-seasonally adjusted quarterly indicator, not on the preliminary QNA estimates that have already had adjustments made to them. Otherwise, the compilation process risks deteriorating into data hashing, in which the compilers lose track of the original data, the effects of benchmarking, and the effects of other adjustments.

17. A detailed explanation of the theory behind the Denton technique and other methods can be found in the IMF's draft *Handbook on Quarterly National Accounts Compilation*[3] .

CONCLUSIONS

- QNA estimates should be aligned with ANA estimates, as soon as ANA data become available
- QNA estimates should be revised in line with subsequent revisions to ANA data
- Except in the extraordinary case where BI ratios are constant from year to year, it is important to use a system which smoothes the transition between years, not a simple pro-rata distribution within each year
- Various benchmarking applications are available which provide an integrated approach to retrospective alignment and forward extrapolation. It is worth spending time selecting and setting up a system correctly, as different models are better suited to data with different time series characteristics
- The importance of good benchmarking methods increases as quarterly indicators show more divergence in movements from annual data.

NOTES

[1] This is the method used by Statistics Sweden.

[2] The fact that the BI ratio for the last quarter of actual data is projected forwards flat during the operational phase, means that the annual BI ratio for this year is likely to be different to the average annual BI ration in the previous year. If there is a large amount of noise in the indicator's annual rate of change relative to systematic bias, there is danger of a "wagging tail effect".

The basic Denton method has been enhanced to improve the forecasting of BI ratios for the operational phase. For example, if the annual growth rate of the indicator is systematically biased, then the BI ratio series shows a trend, and the best forecast for the next year's BI ratio would be obtained using trend extrapolation of the BI ratio series. Thus the BI ratio is not projected flat during the operational phase, but rising or falling in line with its behaviour in previous years.

[3] The draft can currently be viewed at:
http://www.imf.org/external/pubs/ft/qna/2000/Textbook/index.htm

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