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ISSUES IN THE CONSTRUCTION OF ANNUALLY CHAINED VOLUME INDICES

Invited Paper submitted by the Office for National Statistics, United Kingdom**

INTRODUCTION

1. Following the recommendations of the System of National Accounts 1993 (SNA93) that annually chained Fisher indices of GDP volume growth are preferred to fixed-base indices, Eurostat set up a task force to consider how these recommendations should be implemented in European Union member states. The outcome was a Decision by the European Commission of 30 November 1998 in respect of the principles for measuring prices and volumes. The United Kingdom plans to produce annually chainlinked estimates of GDP volumes in line with the provisions of the Commission Decision, by 2003.

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* Due to the late submission, the paper could not be translated before the Meeting.

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2. The requirements of the Commission Decision are not comprehensive. They lay down broad rules but do not prescribe processes in detail, for instance how annual chaining should be applied to quarterly estimates. In addition there is no requirement to produce chained series before 1995, though for users in many countries this will be a strong requirement.

3. The purpose of this paper is to consider a number of areas where the UK is currently researching methodology, in order to make decisions about the processes to be used in compiling a set of chainlinked estimates. The areas covered are:

- level of aggregation
- quarterly and monthly estimates in an annually chained system
- reference year
- treatment of recent periods
- back series
- consistency with other volume and price index numbers

Some of these issues are still under discussion. Where a decision has already been made, this is noted.

EUROSTAT REQUIREMENTS

4. The Eurostat requirements in respect of volume indices are summarised below:

> Laspeyres indices should be used for the measurement of volumes, implying that price deflators should be Paasche indices;
>
> Volume measures should be calculated using weights from the previous year, and the resulting growth rates chained annually;
>
> Weighting should take place at the most detailed level possible.

5. The ESA95 questionnaire requires member states to provide chained volume estimates for the production and expenditure approaches to GDP, for components as well as totals, and for quarters and years. The Commission Decision requires these to be provided as annually chained volume series from 1995. The basic level price indices used as deflators are not however within scope of the Decision.

LEVEL OF AGGREGATION

6. Ideally, chaining should take place at the most detailed level possible, that is at the level at which deflation takes place. In practice, for the production approach, there may be other issues to consider, for instance the cost of estimating annual weights, and the reliability of weights at a very detailed level.

The current UK system

7. Currently the Office for National Statistics (ONS) produces and publishes quarterly fixed-base (Laspeyres) volume indices of gross value added (GVA), as the main component of the production approach to GDP. (These estimates are combined with estimates of the volume of taxes less subsidies on products to give estimates of GDP at market prices, but we are not concerned here with the latter part of the calculation.) The purpose of this estimator is to provide reliable and timely estimates of short-term movements in GDP. The approach used is to extrapolate base year estimates of value added using indicators which reflect the quarterly movement in constant price value added. The indicators for the most part measure output rather than value added; the method relies on the assumption that, in the short term at least, the relationship between value added and output at constant prices is unchanged. This procedure is described in SNA93, paragraph 16.69.

8. At present, longer-term estimates of growth in GDP at constant prices are estimated by deflating current price GDP balances in supply use tables using the expenditure approach. However, the UK is moving over the next few years to using constant price supply and use tables as the basis for estimating annual GDP growth, and the short-term production estimates will be benchmarked to these annual growth rates.

9. In the United Kingdom, volume series are rebased every five years; the latest rebasing, to 1995 weights, took place in 1998. Weights for the GVA volume series are produced at a detailed 4-digit NACE level, and in some cases in more detail, giving around 400 component series. The derivation of these weights starts with the value-added data from the supply-use tables, available at a 123-industry level. Additional data are used to break down the weights further to the 4-digit level. This second stage is at present a relatively time-consuming exercise, as the data come from a variety of sources.

10. Quarterly volume indices are published at the 2-digit industry level. In addition, 4-digit level series are published for the production industries.

11. For expenditure series, there is no standard classification of components, and the level of detail at which the data are compiled and published varies greatly between components, reflecting both data availability and user demands.

Practical considerations

12. For the UK index of gross value added, the level of deflation is not at issue; the intention is to continue with the present 400 detailed indicators weighted together using gross-value added weights. The issue under consideration is whether annually changing weights should be used at all levels of aggregation, or whether the fixed weight system should continue at the lowest, unpublished, level of aggregation, with annually changing weights adopted only at some higher level.

13. There are several reasons why chaining at the most detailed level may not be the best option:

- at the lower level weights may be subject to substantial error;
- for the UK, the more detailed series at 4 digit level are not generally balanced from the supply-use tables (unlike the 2 digit series);
- at this level there are more problems with individual series, for instance breaks in series.

14. The practical considerations and resources involved in implementing and using a detailed level of aggregation have to be considered against the associated improvements in quality. A comparison between fixed base indices of gross value added and indices chained at the 2-digit and 4-digit level showed that using a greater level of detail gave substantially greater changes. It was therefore judged that it was preferable to chain at the 4-digit level.

15. For expenditure components, it makes more sense to chain at the lowest level of deflation, because all the information required to do this is already available.

Decision

16. The UK has in principle decided to use annual weights at the 4-digit level for the calculation of quarterly estimates of gross value added.

QUARTERLY ESTIMATES IN AN ANNUALLY CHAINED SYSTEM

17. The UK quarterly national accounts are fully integrated with the annual accounts; that is, quarterly estimates are constrained to sum to annual estimates, both in terms of current and constant prices. It is therefore an important requirement for the UK that these basic accounting conventions are preserved within a chain-linked system. A further requirement is that the quarterly system of accounts should provide good measures of growth, with no discontinuities, and it should allow for growth to be estimated over varying period lengths. It should be noted that everything in this section of the paper that refers to quarterly series applies also to monthly component series of GDP, such as the index of production and external trade in goods.

18. The choice of an annually-chained Laspeyres index as the formula for computing annual growth rates is straightforward and unambiguous. However, in compiling quarterly indices a number of issues arise. The first is whether quarterly indices should have quarterly or annual weights. It might be thought that using the most up-to-date weights possible might lead to improved growth rates. But the SNA cautions against this practice. It points out that chain indices should only be used to measure year-to-year movements and not quarter to quarter movements. Using quarterly weights would destroy temporal consistency, and the increased volatility at the quarterly level would lead to drift between the annual and chained quarterly series.

19. It is proposed therefore to use annual weights to aggregate quarterly series. However, there remain other issues to be resolved concerning the linking of quarterly growth rates to generate a time series, and the place of seasonal adjusted and unadjusted series in a chain-linked system. The next section looks at guidance on these issues which has been formulated since the publication of SNA93.

Eurostat guidance

20. The Commission Decision on the measurement of prices and volumes which provides the framework for annual chain-linking does not mention the issue of compiling quarterly series. The Eurostat Handbook on quarterly national accounts has some guidance. The main points are:

- annual estimates and the sum of the four quarterly estimates should be the same;
- Q4 of year t and Q1 of year t+1 should be computed in the weights of

the same base year;

– where the quarterly series is compiled from a monthly series (as in the case of the index of production or foreign trade data), the requirements for chain-linking the quarterly data should also be applied to the monthly figures.

Methods for linking quarterly data

21. Three techniques are commonly considered for incorporating quarterly indices into an annually chained system. The merits of the three methods handbook are discussed below.

Description of quarterly methods

Method 1: Annual overlap

22. In year t, growth into Q2, Q3, and Q4 is measured in the prices of the previous year. Growth across the year joins i.e. from Q4 of year t-1 to Q1 of year t, is calculated using the annual indices as link factors to give a consistent reference period, and is thus more complex than the other quarterly growth rates. It can be understood as a discontinuity which is necessary to maintain consistency with the chain-linked annual data (i.e. the average level of the four quarters indices = annual level of index).

Method 2: Quarterly overlap

23. In year t, growth into Q1, Q2, Q3, and Q4 is measured on the prices of year t-1. In other words, the index has identical quarterly growth to the annual overlap method for all quarters other than across year joins. This different quarterly growth rate into each new year accounts for the annual drift of this index, relative to the index using annual overlaps (or chain-linked annual data). Linking on Q4 provides a better estimate of growth for Q1, but a consequence of this is that the average of the quarters does not equal the annual.

Method 3: Over the year

24. This method measures growth from Q*i* (*i*=1,2,3,4) in year t-1 to Q*i* in year t, at the prices of year t-1. This is a quarterly index which is effectively comprised of four annual indices i.e. one for each quarter. The index of the Q4's is equal to the Q4 values obtained by the quarterly overlap

method (linking on Q4). The four indices can drift independently. In this method the average of the quarters is approximately equal to the annuals; that is, the separate drift effects will tend to counterbalance each other.

25. This method seems to be endorsed by paragraph 16.49 of SNA93, where the objective is to give good estimates of 4-quarter growth rates. This seems too limited an objective; our need is for good measures of growth over periods of varying length within the whole time series.

26. The relative advantages and disadvantages of the three methods are as follows:

	Annual overlap	**Unconstrained quarterly overlap**	**Over the year**
Advantages	Quarterly growth rates average to years, so quarterly and annual levels keep in step	No discontinuity in quarterly growth rates	average of quarters close to year
Disadvantages	Discontinuity in Q1 growth rate	Drift between quarters & years: quarterly growth rates don't average to years but can be constrained to do so	only suitable for measuring 4-quarter growth; discontinuity in growth rates may be worse than for annual overlap drift same as for quarterly overlap method

Drift between annual overlap and quarterly overlap methods

27. The drift between the annual overlap and quarterly overlap methods can be understood by looking at the ratio of the first quarter growth rates obtained by the two methods. It can be shown that this term is less than 1 when movements in relative prices and volumes are negatively correlated, and greater than 1 when they are positively correlated. Thus where there is substitution bias, the quarterly overlap method will drift above the annual overlap method. Relative movements in prices and volumes could also be the result of measurement errors, and in this case a systematic drift would not be expected.

Drift between over-the-year and annual overlap methods

28. With the over-the-year technique, each quarter can drift independently. As has been seen, the drift of Q4 is identical to that for Method 2 (linking on Q4). Q1 has an equal propensity to drift, and any systematic effect would see Q1 and Q4 drift in opposite directions. If substitution bias is present Q1 would drift lower than the index with annual overlaps, and Q4 would drift higher. Q2 and Q3 may drift less since the drift of Q2 for example, depends on quantity changes and their interaction with price changes. Q2 is very close to where the average of the year is centred, so the possibility for systematic drift is limited, although random drift could still occur.

29. The Eurostat Quarterly Handbook recommends the quarterly overlap method, but this method by itself does not give temporal additivity. However, the quarterly overlap method can be extended by adding a further step, to constrain the average of the quarterly figures to the required annual figure. The effect of this constraining would be to spread the discontinuity shown in first quarter growth rates using the annual overlap method across all four quarters. In practice, consideration needs to be given to whether the improvement gained by constraining is worth the additional processing required.

30. In practice, rather than constraining the four quarters' growth rates to match the annual growth derived from the annual overlap method, they would be benchmarked to the annual growth rates determined by the system of supply use tables in previous years' prices. In the most recent quarters or months, benchmarking or constraining would not be possible, so that using the quarterly overlap technique would give some drift in these periods, reflecting the extent to which the index would have to be revised when constrained to be consistent with later annual data.

Seasonal series: Should chaining take place before seasonal adjustment or vice versa?

31. SNA93 recommends that chaining seasonal data that are not adjusted for seasonal fluctuations is not advisable (16.49), because of the likelihood of drift where series are subject to regular fluctuations. It seems, at least to the author of this paper, that there could be two interpretations of this passage:

- quarterly and monthly weighting is undesirable, but annually weighted sub-annual series are acceptable;
- or, because of the drift which occurs whenever chaining takes place, chaining seasonal data is not desirable even with annual weights.

32. If the second interpretation is correct, the advice can be followed only if seasonal adjustment takes place at or below the level of elementary aggregation. This will cause problems where, as often happens, seasonal adjustment is more reliable at a higher level of aggregation. In the case of the United Kingdom, the level of seasonal adjustment is generally higher than the level of aggregation. A further drawback of this approach is that quarterly data would not always be available on an unadjusted basis.

33. The alternative therefore is to chain first and then seasonally adjust at the appropriate level of aggregation. For series with regular seasonal fluctuations, this will introduce a further source of drift. We need to consider whether this process leads to an unacceptable level of drift.

34. To the extent that drift is systematic, there is no reason to expect that seasonality would introduce greater drift, since there is no reason to expect that the quarterly patterns of volume change over the level of the previous year would be correlated with the annual price changes which determine the change in weights. However, to the extent to which drift is a random effect, seasonality is likely to introduce greater drift. In the trivial case where an identical seasonal pattern is introduced across components, the degree of drift is unaffected. However in general seasonal patterns will differ across components, and this will cause quantity changes to be more volatile and therefore increase the degree of drift. So seasonality is likely to increase the drift between the two methods, and the drift will be greater where the seasonal patterns are strongest, and where they differ most across the components.

35. In summary, drift between the annual overlap and quarterly overlap methods can be random, or systematic (e.g. substitution bias), but in most circumstances is likely to be small. Seasonality is likely to increase random drift, but the potential for systematic drift is not increased. The UK will carry out more work on the potential for drift, before coming to a decision on quarterly linking and seasonal adjustment.

Decision

36. The UK will use annual weights for calculating chain-linked quarterly and monthly data. It is considering using the quarterly (or monthly) overlap technique for linking quarterly and monthly data, with quarterly or monthly growth rates constrained to annual rates, to maintain temporal consistency and avoid long-term drift. Further work is required before deciding whether the extent of drift involved in seasonally adjusting above the level of basic aggregation is acceptable.

TREATMENT OF RECENT PERIODS

37. Is it more important to ensure that weights are as up-to-date as possible, or should the reliability and coherence of the most recent data be a consideration? In other words, which year should be the most recent base year? There seems to be no international guidance on this point. The following possibilities might be considered:

- The latest year balanced through supply-use tables (t-2)
- The latest full year at the time of the annual exercise (t-1)

38. With the introduction of constant-price supply-use tables, the first option provides current price weights and constant price growth rates for year t-2, as these are fully balanced and consistent across the three approaches to GDP. The second option proposes using information available at the time of the annual exercise for the latest full year (t-1) to provide weights for the latest quarterly data. But there are several disadvantages in this procedure:

- Industry information is not available to calculate detailed weights for the production approach;
- The latest full year's data are provisional at this stage and may be subject to substantial amendment when benchmark data become available. Quarterly growth rates may thus become more erratic and subject to revision;
- UK revisions policy is to keep this latest year (t-1) open to revision at each quarterly exercise. Thus the weights would change each quarter, so that the quarterly exercise would become more complex. Moreover, if this were combined with updating the reference period each year, then the entire time series would be updated each quarter.

Decision

39. The UK will take the latest year for which supply-use tables are available, as the last base year in the time series, with the weights of this year applied to subsequent periods.

REFERENCE YEAR

40. The reference year is that at which the index is set to 100, or volumes scaled to equal their current price equivalents. For fixed-base series, it is usual to take the base year as reference year. In contrast, there is no obvious choice for annually chained series. There are two possibilities:

- a fixed reference year which is periodically updated (e.g. every 5 years);
- the most recent base year (i.e. updated every year).

The first option is that required for data delivery to Eurostat, currently specified as 1995. There are some advantages in adopting this approach for domestic publication. As long as the reference year is not revised, back data will not change, and there would be consistency of presentation with series which continue to have a fixed base - for instance some price indices and lower level volume series. On the other hand, the additive discrepancy would tend to increase with distance from the reference year, and some users would be concerned by this.

41. The use of the most recent base year would ensure that the latest data are additive, which users would find very helpful. Less conveniently, the entire data set would change every year, though as most users who maintain databases obtain their data electronically, this might not be a major consideration.

Presenting volume series as index numbers or monetary values

42. There may be a case for changing the current style of data presentation, so that more volume series are presented in index number form, to emphasise growth over level. This issue will be reconsidered in consultation with users closer to the publication date.

Decision

43. In view of the advantages provided by the additivity of the latest data (and more generally the reduction of discrepancies for recent data) the UK is considering using the most recent base year as the reference year.

RECONSTRUCTING HISTORIC DATA ON A CHAIN LINKED BASIS (RETRAPOLATION)

44. The Commission Decision which set out the rules for annual chain-linking required data to be provided only from 1995, although the ESA95 requirement for volume series applies to data from 1970. However, users, once they are convinced of the benefits of annual chainlinking, are unlikely to be content

with such a short run of data. For the UK, there are a number of potential problems in reconstructing back series:

- changes in the classification of component series (e.g. from industries to products);
- non-availability of lowest level data from which published estimates were originally calculated;
- adjustments to original data (e.g. for re-classification) which have been applied at some aggregate level rather than at the original level;
- cost/resources involved in recalculating data.

45. These problems are minimised in countries with a long tradition of constructing annual supply and use tables. In the case of the UK, though supply use tables go back to 1954, the earlier tables were compiled at irregular time intervals, on incompatible bases (e.g. classifications); the present series of consistent tables goes back only to 1989, and then only at current prices.

46. Users in the United Kingdom, particularly model builders, are concerned to have a long run of data estimated using a consistent methodology. They are particularly concerned that there should be a consistent dataset from the early 1970s, when there were severe price shocks to the economy.

47. The UK will not be able to compile chain-linked volume estimates at the same level of detail as later data, for the reasons described above. At present, investigations have not advanced sufficiently for decisions to be taken, but a possibility might be:

- 1995 on: fully balanced data aggregated at lowest level of detail (equivalent to SIC 4-digit level);
- 1989 – 1994: data aggregated at broadly the same level, but balanced through supply-use tables only at current prices;
- 1988 and earlier: data aggregated at a higher level (possibly equivalent to 2-digit level of SIC), and balanced using the methods which applied at the time of compilation (average of three approaches to GDP).

48. Indications from other countries who have recently adopted or who will be adopting annual chainlinking for the first time, is that most intend to produce a long run of back data (typically from 1970), with several countries compiling earlier years in less detail.

Decision

49. For the construction of annually chainlinked data prior to 1986, the UK expects to adopt a less detailed level of aggregation than for later periods.

CONSISTENCY WITH OTHER VOLUME AND PRICE INDEX NUMBERS

50. A further issue to be considered is whether other volume and price series published as official statistics should also be re-weighed annually. There are several categories of such data:

- other economic series which fall within the National Accounts framework but are published separately, for instance the Index of Production, imports and exports of goods;
- price and earning indices;
- volume series which form an input to the national accounts but are not within the framework, and have a different constituency of users. This will vary greatly depending partly on countries' institutional arrangements; in the UK a significant example would be construction statistics (volumes, prices, orders).

In principle, there would seem to be advantages in adopting a common approach for all official volume and price series.

51. In the UK we are not yet at a point where decisions have been made in respect of all of these series. Our initial thoughts are:

- the index of production will become annually chain-linked using the same methodology (in a monthly context) as the national accounts;
- the consumer price index (known in the UK as the retail prices index) and the UK HICP already have annual weights; we are looking into the possibility of annually re-weighting producer prices indices;
- we will consider the possibility of using annual re-weighting for all economic index number series.

ISSUES FOR DISCUSSION

- level of aggregation:
  is it acceptable to weight at a level above the lowest level of deflation?

- quarterly and monthly estimates in an annually chained system:
  how should quarterly/monthly data be linked?
  relationship between level of seasonal adjustment and chaining

- treatment of recent periods:
  which year should be the latest base year?

- reference year:
  fixed reference year or updated to latest base year?

- consistency with other volume and price index numbers:
  plans for annual chainlinking of price and volume series outside national accounts?

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