Prospective change in seasonal adjustment methodology: consultation with users

The Bank of England plans to change the seasonal adjustment methodology that it uses in the monetary and related statistics. Although many of the basic features of the new – more sophisticated – methodology will be similar to the present one, and tests so far suggest that the results will be generally similar, there may be some differences. The Bank's work on moving to the new methodology is in its initial stages; this paper sets out our preliminary thoughts, and indications of where we expect to see differences. Comments on this paper are welcome, as soon as convenient or at latest by 10 January 2003.

Historical background

1 Since 1990 the Bank has used ‘GLAS’ (General Linear Abstraction of Seasonality) to seasonally adjust the monetary and related statistics that the Bank produces. This method was developed in-house, to provide a less complex and less resource-intensive method than that used previously, but one that still met the ‘additivity’ or ‘balancing’ criterion then seen as paramount, of preserving the accounting relationships of the non-seasonally adjusted series (eg retail M4 plus wholesale M4 equals total M4).\(^1\) The Bank has kept its methodology under review, to check particularly that the quality of its results adequately matches that of alternatives.\(^2\) In March 2000, methodological experts, statisticians and users attended a workshop in the Bank to discuss the Bank’s methodology. This workshop concluded that the methodology was behind international best practice and that, as the case for additivity was no longer so strong, the Bank should consider moving to a widely used international standard method.

Reasons for changing from GLAS to X-12-ARIMA

2 GLAS has advantages of simplicity, and therefore of transparency and ease of application. The same, linear, moving-average filter is applied to all series, using in practice only a short span of years to determine the seasonality, so that the seasonality of a particular month is defined essentially as the average deviation from trend in that month in the three years centred on that month (or, for observations at the start or end of the series, the first or last three years of the series). GLAS therefore automatically meets the additivity criterion mentioned above. Its results are generally similar to

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\(^1\) An account of the introduction of GLAS was given in ‘1990 annual update of seasonal adjustments’, Bank of England Quarterly Bulletin, February 1991, pages 93-98. References to the Bank’s previous seasonal adjustment work can be found in “Further references on monetary and banking statistics” in Part 2 of the Bank’s annual Statistical Abstract.

those of more sophisticated methods. But the March 2000 workshop confirmed that the gap in technical quality between GLAS and more sophisticated methods has widened.

Moreover the workshop concluded that the additivity criterion is no longer so strong, even though many users see it as valuable. Less emphasis is now put on studying M4 in terms of its position in a comprehensive matrix, and more weight is placed on using individual monetary series (especially the sectoral breakdowns of M4 and lending) to illuminate economic developments. It therefore seems reasonable to give priority to obtaining the best seasonal adjustment of the main individual series that are studied, rather than maintaining precise additivity.

The Bank has therefore decided to move from GLAS to X-12-ARIMA, the latest in the family of seasonal adjustment methods that have been developed over several decades by the US Census Bureau and Statistics Canada, with contributions also from others. Although based on a moving-average technique similar to the one used in GLAS, the method contains also a time-series-modelling feature which aids both the identification of extreme values and of level shifts (that could distort the seasonal adjustments) and the estimation of seasonality at the start and end of the series. Examples of X-12-ARIMA’s technical refinement are that it can provide multiplicative – proportionate – seasonal adjustments (GLAS was designed to provide only additive – linear – adjustments, especially as this readily preserves additivity) and that it includes sophisticated estimation of calendar effects, for the differing lengths of months, public holidays etc (GLAS has a routine for adjusting for the effects of public holidays on notes and coin within M0, but otherwise has to be supplemented by simple ad hoc adjustments for calendar effects). X-12-ARIMA also has wide-ranging statistical diagnostics, available graphically where appropriate, enabling the nature and robustness of the seasonal adjustments to be easily monitored. It has been continually developed, is well supported and maintained by the US Census Bureau, and future development seems assured; for example, the Census Bureau is currently working on making available within this family more of the capabilities of TRAMO-SEATS, the model-based method developed by Professor A Maravall at the Bank of Spain. X-12-ARIMA, or a closely related predecessor, is used by many statistical agencies and central banks, including the UK Office for National Statistics and the European Central Bank. Although X-12-ARIMA will require more staff and computing resources than GLAS, this seems worthwhile in order to gain a more refined and flexible method of seasonal adjustment.

For example, see the minutes of the monthly meetings of the Monetary Policy Committee (including the annexed ‘Summary of data presented by Bank staff’) and the quarterly Inflation Report. Both these are on the Bank’s website.

A note on ‘Additivity and seasonal adjustment’, annexed here, discusses the topic more fully. It includes an example given by Professor A Maravall of the Bank of Spain to show that components should not necessarily add to a seasonally adjusted total (an annual Book Fair that moves around many regions from year to year: while one would expect the series for total book sales to be seasonal, the series for each region would not be). There could be a similar situation in the monetary statistics if, for example, seasonal peaks of tax payments (implying seasonality in the public sector net cash requirement) were financed in a different way from year to year, eg from deposits – ie M4 itself, from ‘lending’, or from other M4 counterparts.

Documentation of the X-12-ARIMA programme, and the programme itself, are on the US Census Bureau’s website (www.census.gov/srd/www/x12a). ‘New capabilities and methods of the X12-ARIMA seasonal adjustment program’, Journal of Business and Economic Statistics, April 1998, also available on the Bureau’s website, describes the method and includes comments (not on the website).
**Possible differences from seasonal adjustments produced by GLAS**

**Additivity**

5 Because of the multiplicative nature of the seasonal adjustments generally produced by X-12-ARIMA, and its other options designed to tailor the adjustments to each series, seasonally adjusted aggregates will no longer automatically equal the sum of their seasonally adjusted components, eg M4 will not automatically be the sum of its analysis by instrument (type of deposit etc), or by holding sector, or by counterpart (lending etc).

6 Recent tests on the sectoral analyses of M4 and lending suggest that this lack of additivity may not be substantial. Indeed in some, perhaps many, instances the diagnostics available in X-12-ARIMA may indicate that ‘indirect’ seasonal adjustment of an aggregate (ie where the seasonally adjusted aggregate is defined as the sum of its seasonally adjusted components) is of similar quality to direct adjustment of the aggregate itself. But, in cases where an aggregate can be built up in more than one way (eg, for M4, by instrument, or by holding sector, or by counterpart), it is virtually certain that each approach would produce a different seasonally adjusted total. We do not yet know how large these potential differences will be.

7 In any table that shows a breakdown of an aggregate that has been directly seasonally adjusted, or seasonally adjusted by summing a different set of components, it will be necessary to decide whether to show the residual between the sum of the components in that table and the aggregate, rather than just omit it. Alternatively, the residual could be spread across the other series (eg in proportion to those series or to their volatility) or added to the series judged to be less important, although these approaches risk impairing the quality of the series.

**Constraint over a 12-month period**

8 Constraining the seasonal adjustments to zero systematically over a 12-month period (eg a calendar or financial year) in principle worsens the quality of the adjustments, though probably not substantially. We therefore do not intend to continue to constrain the adjustments in this way (the adjustments in the M4 statistics are currently constrained over the financial year). An exception might be the public

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by seasonal adjustment specialists. ‘Seasonal Adjustment with the X11 Method’, by Dominique Ladiray and Benoît Quenneville, published by Springer in 2001, provides a detailed review both of the X-11 module that remains at the core of X-12-ARIMA and of the additional features of X-12-ARIMA.

6 Indirect adjustment is likely to be better when the components have differing seasonal patterns from each other, that are comparatively clearly identifiable. Conversely, direct adjustment is likely to be better when the components have similar seasonal patterns but are noisy (so that summing the components may cancel some of the noise). See ‘Comparing direct and indirect seasonal adjustments of aggregate series’, by C C Hood and D F Findley, American Statistical Association proceedings, October 2001, available on the US Census Bureau’s website referred to earlier. But indirect adjustment may prove to be better even in a case where X-12-ARIMA’s diagnostics show that a component of an aggregate is non-seasonal (eg in M4’s counterparts, where the seasonality in at least one area – the external and foreign currency counterparts – may be unstable or non-existent).
sector net cash requirement, to enable the seasonal pattern over each individual financial year to be seen precisely.\footnote{Such ‘additivity across time’ is discussed in more detail in the annex.}

**Stability of the seasonal adjustments**

9 The seasonal adjustments are likely to be more stable from year to year in the series, and revised less, because we shall use the optimum filter-lengths suggested by X-12-ARIMA rather than the very short filter – in essence three years – that has been applied in GLAS. This short filter has been applied because of the requirement of users when GLAS was designed, that a seasonally adjusted monthly outturn should not deviate in the same direction from the local trend more than two years in succession. A disadvantage of invariably applying so short a filter is that the seasonality thus defined includes short-term variations from trend that users may prefer to define as part of the erratic or irregular element in the series (the ‘noise’): the seasonal adjustments smooth the series rather than removing only well established seasonality. Another reason why the adjustments may be more stable in future is that X-12-ARIMA may suggest that more of the extreme values (‘outliers’) in the unadjusted series should be modified or completely discounted before the seasonal adjustments are derived; under GLAS, outliers have generally been modified only when there is a very clear non-seasonal cause of the extreme value.

**Adjustments for calendar effects**

10 X-12-ARIMA enables very detailed estimation of calendar effects, for the differing lengths of months, public holidays etc. This improvement may cause some differences from the GLAS-produced series.

**Weekly seasonally adjusted series for notes and coin (in M0)**

11 As X-12-ARIMA does not have a supported programme for weekly series, notes and coin (in M0) will be available seasonally adjusted only monthly (as with the M4 family), no longer weekly. Non-seasonally-adjusted weekly data will continue to be available; they and their year-on-year growth rates will be published, with indications of instances where the growth rates are likely to be distorted by effects such as the position of public holidays.

‘Concurrent updating’

12 Under GLAS, the seasonal adjustments are generally updated in the light of each new observation (‘concurrent’ or ‘current’ updating). Under X-12-ARIMA we intend to continue to do this in respect of the moving-average, GLAS-like, part of the programme, but it may be appropriate to review other elements (particularly in the ARIMA-modelling part of the method) only once a year.

**Timetable and request for comments**

13 This paper will be reproduced in the November issue of *Monetary and Financial Statistics*, on the Bank’s website. Comments are welcome: they should be
sent to Joanna Place, the Head of the Monetary and Financial Statistics Division, at joanna.place@bankofengland.co.uk or the Bank’s postal address (Bank of England, Threadneedle St, London EC2R 8AH), as soon as convenient or at latest by Friday 10 January 2003.

14 To allow time for study of the over 200 series that are at present seasonally adjusted by the Bank, and integration of the new method into the computer system, we plan to implement the change of method around the end of 2003.

Bank of England
20 November 2002
Additivity and seasonal adjustment

Introduction

The aim of this note is to explain how the issue of additivity arises in seasonal adjustment and why additivity is not necessarily a property of series that have been optimally adjusted. Key to the explanation is the hypothetical ‘Book Fair Example’ devised by Professor A Maravall of the Bank of Spain. This gives a clear and intuitive example of how the goal of additivity in a set of seasonally adjusted series can conflict with the primary purpose of seasonal adjustment, that of helping users to interpret a series’ behaviour. The note continues to explain other ways in which non-additivity can arise. References are made to observed or potential occurrences of these phenomena.

What is additivity in the context of seasonal adjustment?

There are two ways in which the issue of additivity can arise in seasonally adjusted datasets: additivity across series and additivity across time.

The first relates to the additivity of components of a total. For example, if we have time series for the numbers of unemployed men and women in the UK, then it seems reasonable to assume that, for each point in time, seasonally adjusted male unemployment and seasonally adjusted female unemployment should sum to seasonally adjusted total unemployment.

In practice, using the leading methods of seasonal adjustment, the most obvious approach to seasonal adjustment – seasonally adjusting the male, female and total series separately – will not normally achieve this additivity. An alternative approach that will guarantee additivity is to derive seasonally adjusted unemployment by adding the seasonally adjusted male and female series. When an aggregate series is seasonally adjusted in its own right, independently of its components, we refer to it as ‘direct’ seasonal adjustment. When an aggregate is derived from its seasonally adjusted components, we call it ‘indirect’ seasonal adjustment.

The second type of additivity relates to annual totals of original and seasonally adjusted series. For example, if 20 million cars were produced in the year 2001 in the UK, then it seems reasonable to assume that this total should be unaltered by the process of seasonal adjustment. Hence, we expect the seasonally adjusted figures for monthly car production in 2001 to sum to exactly 20 million. This implies that

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8 This note has been provided by Simon Compton of the Office for National Statistics, to whom the Bank of England is grateful for permission to reproduce it here.
seasonal adjustment is a redistribution of activity within any given year to take account of systematic time of year effects across years.

In fact, as the rest of this note attempts to show, both these concepts of additivity are not only problematic in a practical sense for seasonally adjusted series, but do not make theoretical sense either. In fact, additivity can sometimes be achieved only at a considerable cost to the optimality of the seasonal adjustment itself and hence to the interpretation of the series being adjusted.

The Book Fair example

The following stylised example demonstrates how direct and indirect seasonal adjustment can, legitimately, be very different for a particular group of series, giving rise to extreme non-additivity between seasonally adjusted components and totals.

Let us consider a country with several administrative regions. Quarterly statistics have been collected on a consistent and accurate basis for many years. However, this country has an unusual pattern of book sales. Books are sold throughout the year in each of the regions, but a very large number of books is sold at a Book Fair that is held every January. Each region takes its turn at hosting the Book Fair and the result is a huge boost to that region’s book sales in the January of the year in which it acts as host. Graphs showing monthly time series of book sales for the first three regions hosting fairs are shown below, together with the national total.
If we now seasonally adjust each of the regional series and the national series we get the following:

We can now compare the indirect seasonal adjustment derived by summing the seasonally adjusted regions, with the direct seasonal adjustment of the national total.

The difference is immediately apparent – the direct seasonal adjustment has interpreted the Book Fair peaks as seasonal and removed them, while the indirect adjustment has left them in. In fact, it is clear that for anyone interested in the national picture, that the indirect adjustment is going to be useless, failing to remove the main seasonal feature from the data.

We can now consider the implications for additivity. It is clear that the direct seasonal adjustment is the sensible one for the national series. However, it is also clear that for
regional administrations, the seasonal adjustment of their own region makes good sense, with the Book Fair being treated as a one off event rather than a regular seasonal feature of the regional economy. The result is that the set of seasonal adjustments that facilitates sensible interpretation of the regional and national series, consistent with seasonal adjustment theory and best practice, is a set that is not at all additive. Indeed, additivity can only be achieved for this set by severely compromising the interpretation of one or more of the regional and/or national series.

The Book Fair example stylises a situation that can easily arise in real series. Indeed, whenever there is evidence of a seasonal feature in a time series switching between its components then direct seasonal adjustment should be considered and additivity questioned.

An example of this in the ONS is the car production series, where seasonal peaks in production can be switched between cars for the home market and cars for export markets according to market conditions and car-manufacturers’ international production plans. The differences between the direct and indirect seasonal adjustments for these series are large and suggest that this might be happening. A direct seasonal adjustment is therefore used for total car production and no constraining procedures are introduced to reconcile total production with production for the home market and production for export. This lays open the possibility of each of the component series moving in the same direction, but the total series moving in the opposite direction in a particular month – but this is a consequence of the non-additivity and optimising the interpretation of each individual series.

One can envisage a similar situation arising in many datasets. For example, spending patterns might change each Christmas, with different types of goods and services accounting for the seasonal peak in overall household expenditure. The ways in which this spending is financed might also be different, giving rise to differential effects in the components of the monetary aggregates, and so on.

**Additivity across time**

If we consider a monthly time series running from January 1990 to December 2001, then it is intuitively sensible to think that the seasonally adjusted calendar year totals should be the same, whether the series is seasonally adjusted or not. However, one may go further and say that the choice of calendar year is arbitrary. If it is true that totals must be the same for calendar years, then the same must hold for financial years. Indeed, the seasonally adjusted total should be the same as the unadjusted total for any consecutive twelve months. Unfortunately, this severely restricts the allowable set of seasonal factors. In fact it necessitates strictly stable seasonality – the amount added or taken away by the process of seasonality must be exactly equal in the same month across different years.

This is not a sensible restriction for many series. Indeed, seasonality tends to evolve over time in most time series, and the assumption of stable seasonality can result in very poor seasonal adjustment. An example is the Average Earnings Index, where the size of March
bonus payments increased enormously over the 1990s. The very fact that seasonality is behaviourally ‘multiplicative’ for most series (ie the amplitude of seasonal patterns in the data varies with the underlying level of the series) gives rise to evolution in the magnitude of seasonality.

For many series this evolution is not strong and constraining calendar year totals leads to little distortion. The advantages of constraining can sometimes outweigh the loss of optimality. This is particularly true in the national accounts, where management of a complex accounting framework would be very much more difficult without the annual constraint in place. Note that constraining to calendar year totals only partially compromises the freedom of evolution of seasonal factor.

Other reasons for non-additivity

1 Multi-dimensionality

In the unemployment example above, one way of achieving additivity is to derive the seasonally adjusted total indirectly, by adding the seasonally adjusted males and females series. However, in practice, totals may be analysed in many ways. For example the unemployed can be split by sex, age, region, duration of unemployment, ethnic origin, educational attainment, etc. If one was to seasonally adjust series for unemployment by age-band and add them together, they are likely to result in a different indirect seasonal adjustment of total unemployment from that derived indirectly from the male and female series. Under such circumstances additivity can be achieved, using standard seasonal adjustment methods, only in one of three ways:

i indirect seasonal at the lowest level of multi-dimensional disaggregation, eg seasonally adjusting males and females separately in each age band,

ii constraining out any non-additivity in the seasonally adjusted series,

iii restricting the method of seasonal adjustment so that it is entirely linear and results in a completely additive series.

Each of these is theoretically problematic and in some cases difficult in practice as well. All are potentially distortionary in their effects on the seasonal adjustment of one or more series in the dataset. However, examples of applying each of these exist in official statistics: the first characterises Eurostat’s approach to seasonal adjustment of European industrial production, resulting in the seasonal adjustment of thousands of series; there are many examples of the second in the ONS, including extensive constraining of the Labour Force Survey series; and the Bank of England currently uses the third to adjust the monetary aggregates dataset.
Another way in which non-additivity over time can arise in seasonal adjustment is when monthly and quarterly series are seasonally adjusted independently. This sometimes gives rise to a phenomenon conceptually similar to the one outlined in the Book Fair example. The key difference is that rather than a seasonal feature moving between components of a total, it moves between months of a quarter. Hence if all firms paid their bonuses in February rather than March in a particular year, it would not be recognised as seasonality in the monthly seasonal adjustment, but would in the quarterly seasonality. This can be a difficult problem to overcome in a meaningful way and is all too frequent in economic time series. For example, it is observed in energy series, where peaks in energy consumption switch between months according to the weather patterns. The weather also accounts for similar timing differences in harvests, affecting many agricultural statistics.

3 Calendar adjustment

By convention, seasonally adjusted series are also adjusted for any effects caused by the arrangement of the calendar. The most common of these is the effect of Easter sometimes falling in March and sometimes in April. Some monthly series are adjusted for occurrences of days of the week. For example, many manufacturing production series are adjusted to neutralise the effects of different numbers of week days and weekend days in the same month across different years.

Best practice dictates that one should adjust for these effects only if a statistical test suggests they are present and if they make sense for the series being adjusted. This can be an additional source of non-additivity if a direct approach is being used for the seasonal/calendar adjustment of the total. For example, if an Easter effect is present in some components of a total and the total itself, then the Easter adjustments will not be additive – partly because the method of estimating Easter adjustments is not inherently additive and partly because those series which are not being Easter-adjusted as individual components are being adjusted implicitly as part of the total.

Calendar adjustments can also contribute to the lack of consistency between annual totals of the original and of the seasonally adjusted series. In particular leap year effects should theoretically be evened out across years rather than being redistributed within a year. These effects tend not to be large in UK series but cause many problems for interpretation of economic statistics in continental Europe, where the patterns of public holidays can vary a lot from year to year. Indeed, the Bundesbank publishes a calendar-adjusted version of Germany’s annual GDP figures.

4 Non-standard reporting periods

Data for some series are not collected on a standard calendar basis. This usually necessitates additional adjustments needing to be made. For example, the 4-week, 4-week, 5-week collection pattern for Retail Sales data necessitates Bank Holiday adjustments and so-called ‘phase shift’ adjustments to deal with the effects of the
collection pattern and interaction effects with seasonality. Similarly, the claimant count is a count of people eligible to be paid unemployment benefit on the second Thursday of each month. This gives rise to an irregular pattern of 4- and 5-week intervals between counts, causing problems for the seasonal adjustment of ‘inflows’ and ‘outflows’ series. As a result, it is very difficult to reconcile stocks and flows (opening stocks plus inflows minus outflows equals closing stocks in the original series) without arbitrarily imposing constraining factors on the seasonally adjusted series and diminishing interpretation of each series in its own right.

**Conclusion**

An additive dataset brings many presentational benefits, having intuitive appeal for users, fostering trust in the quality of data and seasonal adjustment and facilitating analyses of data such as calculating proportions of totals. However, additivity, in time or across series, is rarely a theoretical property of seasonal adjustment and can often be achieved only by compromising the interpretation of one or more series in a seasonally adjusted dataset. It is for this reason that the ONS’s approach is to consider each dataset separately and to show an additive seasonally adjusted dataset only for those series where the distortion incurred in forcing additivity is negligible.