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Guidelines on time series methods, 2026

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1 Introduction

A **time series** is a sequence of estimates compiled at regular time intervals. These data provide information on a well-defined statistical concept for a specific reference period, like months, quarters, or years. Most economic data disseminated by Statistics Canada are presented as time series that are available for a long sequence of periods, to facilitate comparisons over time. Examples include the consumer price index, retail sales, employment and gross domestic product. Time series can measure different types of quantities, like **flows** (quantities accrued over time, like revenue, expenses, or hours worked) or **stocks** (quantities associated to a specific point in time, like assets, inventory, or employment).

Monthly or quarterly time series data can be influenced by seasonal and calendar effects. For example, monthly retail sales have historically been at their highest level for the year in December as a result of holiday shopping and then declined to lower levels in January. This occurs year after year and affects the extent to which analysis on trends in retail industries can be informed by comparing raw sales data for these two months. A **seasonally adjusted time series** is a monthly or quarterly time series that has been modified to eliminate seasonal and calendar effects. The seasonally adjusted data allow for more meaningful comparisons of economic conditions from period to period. The original unadjusted time series is sometimes referred to as the raw time series.

Many users of economic and social statistics rely on time series data to understand changes in socio-economic phenomena over time. Important features of a time series include its direction and turning points, as well as its relationship to other socio-economic indicators. A seasonal pattern in a series can obscure these important features by making period-to-period movements in the data more difficult to interpret. Many users of time series data do not consider movements in the data that relate to seasonal and other calendar effects to be analytically meaningful. These seasonal and calendar effects can obscure “true” underlying movements related to the business cycle, or to non-seasonal events such as strikes or unanticipated disruptions in production. Consequently, seasonal adjustment techniques that remove seasonal and calendar effects from the original data can sharpen the extent to which a time series can be used to evaluate meaningful changes in economic conditions over time. Seasonal adjustment of highly volatile series may not be enough to draw a conclusion on the current trend-cycle direction. In those cases, further smoothing of the seasonally adjusted series can be performed to eliminate the irregular movement as much as possible.

In order to support the analysis of time series data for various uses, different processes may be required to ensure that they are comparable over time, coherent with other sources and to produce products that isolate features of interest. This document presents guidelines on time series methods at Statistics Canada, starting with seasonal adjustment and trend-cycle estimation in section 2. This section also includes guidelines on revising seasonally adjusted data when new observations are added to time series, or updates are made to the unadjusted data as a result of historical, annual, or ad hoc revision processes.

Statistics Canada sometimes measures the same quantities at multiple frequencies – for instance when monthly or quarterly statistical programs have an annual counterpart with which they share some content. For coherence purposes, we will often want to benchmark the high-frequency series to the lower-frequency series (generally assumed to have higher quality). This is the topic of section 3, which also discusses related techniques like interpolation, calendarization, temporal distribution, and linking.

Coherence can also be sought for groups of time series with the same frequency, which must often respect a vast array of rules or relationships between them. These are cross-sectional constraints (e.g., regional estimates adding up to national estimates) and can be combined with temporal/longitudinal constraints (e.g., quarterly estimates adding up to annual estimates). Discrepancies may arise because time series come from different sources or because treatments like seasonal adjustment broke pre-existing relationships. Section 4 presents reconciliation techniques which can be used to restore coherence.

Finally, the time series produced by Statistics Canada should serve as the basis for reliable comparisons across time in describing the evolution over time of specific characteristics in the Canadian population, economy, or environment. However, changes in the standards for defining, observing or measuring a variable within a statistical program can cause breaks in time series that are not caused by real changes. Various measurement issues, such

as a statistical program redesign or a change in classification, can cause such breaks and they interfere with the seasonal adjustment process, as well as with potential analysis. Preserving comparability from one period to another is particularly relevant in these situations. Section 5 describes methods for mitigating breaks in time series, drawing from methods like benchmarking and linking.

These guidelines apply to all statistical programs (such as administrative and alternative data programs, surveys, macroeconomic accounts or censuses) conducted by Statistics Canada that produce statistical outputs or data files for a series of time points at regular intervals.

The guidelines should be considered throughout the planning and execution phases of any project impacting the statistical outputs of a program. It is strongly encouraged that supporting documentation is produced and archived to explain the analysis and rationale behind decisions that are made. As with any methodological guidelines, the underlying assumptions should first be understood, and the applicability of the methods should be verified – most frequently by a thorough analysis of the data before and after the techniques are used.

Note that the guidelines for seasonal adjustment, trend-cycle estimation and benchmarking are adapted from the 5th edition of the Statistics Canada Quality Guidelines (Statistics Canada, 2009).

Assistance with the interpretation and implementation of these guidelines can be obtained from the Time Series Research and Analysis Centre (TSRAC), Economic Statistics Methods Division.

2 Seasonal adjustment and trend-cycle estimation

2.1 Scope and purpose

2.1.1 Seasonal adjustment

A **time series** is a sequence of measurements of one variable observed through time. In most situations, the observations are dependent through time, and it is this dependence in itself that is of interest. For the purpose of seasonal adjustment, the time series is assumed to be observed either monthly or quarterly and constituted of three distinct components: the trend-cycle, the combined seasonal and calendar effects, and the irregular. The objective of seasonal adjustment is to identify and estimate the seasonal and calendar effects, and to remove them from the time series. The resulting series is then called **seasonally adjusted** and consists of only the trend-cycle and irregular components. It enables the assessment of the economic movement with month-to-month or quarter-to-quarter comparisons.

Seasonal effects are the intra-year (monthly, quarterly) fluctuations which repeat more or less regularly from year to year. They result from composite effects of events related to the climate, institutional decisions or modes of operation which repeat with a certain regularity within the year. **Calendar effects** are related to the composition of the calendar. They include trading-day effects associated with the weekday composition of each month or quarter, moving holiday effects associated with non-fixed date holidays such as Easter, and other predictable events from the calendar. **Trading-day effects** are present when the level of activity varies with the days of the week. The **Easter effect** may be seen as the variation in level due to the displacement of a volume of activity from April to March when Easter falls in March instead of the usual April occurrence.

The **trend** is the underlying long-term movement lasting many years. The **cycle**, also called business-cycle, is a quasi-periodic oscillation lasting for more than a year around the long-term trend. It is characterized by alternating periods of expansion and contraction. The trend and the cycle are difficult to estimate separately and thus are considered and analyzed jointly as the trend-cycle.

The **irregular component** represents random variations that are unforeseeable movements related to events of all kinds, and which cannot be attributed to the trend-cycle component, the seasonal component, or the calendar effects.

2.1.2 Trend-cycle estimation

Seasonal adjustment of highly volatile series may not be enough to draw conclusion on the current trend-cycle direction. In those cases, further smoothing of the seasonally adjusted series is advised to eliminate the irregular component as much as possible. The resulting trend-cycle estimate is to be considered auxiliary information to the seasonally adjusted series.

2.1.3 X-12-ARIMA and X-13ARIMA-SEATS

The foundation of Statistics Canada's seasonal adjustment program is 1967's X-11 Variant of the Census Method II (Shiskin et al., 1967; Ladiray & Quenneville, 2001). In 1980, Statistics Canada incorporated the autoregressive integrated moving average (ARIMA) (Box & Jenkins, 1976) models to forecast and backcast the series before the seasonal adjustment process, as well as several major modifications to improve the Census method. This new variant was called X-11-ARIMA (Dagum, 1980). Extending the series with ARIMA forecasts yielded, on average, smaller revisions to the seasonally adjusted series. In 1988, Statistics Canada released an improved version of X-11-ARIMA (Dagum, 1988) available for microcomputers.

In 1998, the U.S. Census Bureau released X-12-ARIMA (Findley et al., 1998). X-12-ARIMA generalized the use of linear regression with ARIMA errors (regARIMA modelling) to estimate calendar effects as well as additive outliers, level shifts and other predefined regression effects. Additionally, X-12-ARIMA permits user-defined regression variables for unusual or nonstandard calendar effects and includes a variant of the TRAMO (Time Series Regression with ARIMA Noise, Missing Observations and Outliers) algorithm (Gómez & Maravall, 1996) for automatic regARIMA modelling. Other features are described in the user guide (U.S. Census Bureau, 2008). X-12-ARIMA is available for several computing platforms. The X12 and X13 procedures (SAS Institute Inc, 2020) in SAS® also implement most of the method's options.

In 2012, the U.S. Census Bureau expanded X-12-ARIMA into X-13ARIMA-SEATS (U.S. Census Bureau, 2024), which incorporates the SEATS (Signal Extraction in ARIMA Time Series) algorithm of Gómez and Maravall (1996). The X-12-ARIMA method (as implemented in software X-12-ARIMA and X-13ARIMA-SEATS) is the recommended seasonal adjustment method at Statistics Canada as X-11-ARIMA was phased out and is no longer supported.

2.2 Principles

2.2.1 Seasonal adjustment

As seasonal adjustment aims to filter out the combined seasonal and calendar effects, it should be applied when those effects can be properly identified and estimated. When seasonal or calendar effects cannot be identified in a time series, the series is considered de facto seasonally adjusted. Seasonally adjusted series should have no residual seasonality and are generally smoother than the corresponding raw series.

As new data become available, the various time series components can be better estimated. This results in revised and more accurate estimates for past seasonally adjusted values which should be acknowledged. However, overly frequent or large revisions may hinder the usefulness of the seasonally adjusted data. Seasonal adjustment options should be selected to minimize the amplitude of the revisions without affecting the overall quality of the adjustment. A revision strategy should be implemented to minimize the frequency of the revisions to the published data.

Inappropriate seasonal adjustment options may lead to misleading results. As such, proper time and effort should be put into the analysis of the series and on the initial selection and maintenance of options. Similarly, as the selected options influence the seasonal adjustment outputs, collections of series which measure the same economic activity should not be treated independently. This usually entails the use of similar seasonal adjustment options within a given group for coherence purposes.

2.2.2 Trend-cycle estimation

As a complement to the seasonally adjusted series, trend-cycle estimates may indicate the direction of the short-term trend (within the current year). When new data points are added to the series, past trend-cycle estimates can be estimated more accurately and are therefore subject to revisions. Trend-cycle estimates are sensitive to the current phase of the business cycle (turning point, recession, recovery, or expansion); thus, the reliability of the current trend-cycle estimates depends on the proximity of a turning point as well as on the amplitude of the cycle.

Trend-cycle estimates should be fully consistent with the published seasonally adjusted series. Similarly, if the seasonally adjusted series underwent further adjustments such as aggregation, reconciliation, the trend-cycle should be estimated from the aggregated or reconciled series.

Statistics Canada uses a weighted moving average of the data to compute the trend-cycle. This method is called the Cut and Normalize Variant of the Cascade Linear Filter of Dagum and Luati (Dagum & Luati, 2008; Picard & Matthews, 2016). This weighted average is computed using the previous six months, the current month and (for older estimates) up to six of the subsequent months in the series. In real time, for the most recent reference month in the series, only data for the six previous months and current month are used, as data for subsequent months are not yet known. As these data become available, the trend-cycle estimates will be revised.

The estimate of the trend-cycle obtained with the selected method exhibits good statistical properties, as it provides smooth results with limited revisions and has a low incidence of falsely identifying turning points. Additionally, it is a linear process that preserves additive relationships in the data.

2.3 Guidelines

2.3.1 Seasonal adjustment

a. Before seasonally adjusting a series for the first time, one should assess if the seasonality is identifiable and if it can be properly estimated.

b. If a series does not have identifiable seasonality or calendar effects, no treatments are applied, and the series is deemed de facto seasonally adjusted.

c. Seasonally adjusted series should have no (significant) evidence of residual seasonality or calendar effects.

d. For proper identification and estimation of seasonal and calendar effects, it is recommended to use a span of 10 to 15 years of data. The minimum is five (5) years to properly estimate a seasonal pattern and seven (7) years for calendar effects such as trading days and moving holidays.

e. It is recommended to use regARIMA modelling to calculate calendar adjustment factors and temporary adjustments such as those applied by means of additive outliers or level shifts. This regARIMA model should also be used to extend the series beyond the observed periods before seasonal adjustment in order to reduce revisions in the seasonally adjusted series.

f. There are various seasonal adjustment options; the most important ones revolve around the selection of the decomposition mode, the specification of a regARIMA model (in particular, outliers and calendar effects) and the seasonal and trend-cycle filters. X-12-ARIMA's automatic selection processes may be used for a preliminary setting of those options. To ensure a high-quality seasonal adjustment, the automatic selections should be reviewed using relevant diagnostics, expert knowledge and graphical analysis. If time does not permit this, it is recommended to review at least the options for the most important time series.

g. Seasonal adjustment options for each series should be reviewed periodically to verify their continued applicability and appropriateness, and to increase accuracy. The recommendation is to review options annually. However, to avoid artificial revisions, the pre-selected seasonal adjustment options should not be changed between scheduled reviews. (See Appendix A – Protocol for analysis and intervention in the seasonal adjustment process.)

h. Although the main seasonal adjustment options should usually be fixed between reviews, the adjustment factors and the regARIMA model parameters should be concurrent – that is, recomputed using all available data points. Exceptions may apply when the most recent observations have been historically subjected to large revisions. In this case, year-ahead (forecasted) factors may be more appropriate.

i. For an aggregate (or composite) series comprising several component series, seasonal adjustment can be done **directly** or **indirectly**. For indirect seasonal adjustment, the seasonally adjusted component series are aggregated to form the seasonally adjusted composite series. For direct seasonal adjustment, the aggregate is seasonally adjusted independently. With this last method, there can be discrepancies between the aggregate series and the aggregated components after seasonal adjustment. When required, a raking or a reconciliation method should be applied to reconcile the direct seasonally adjusted aggregate series with its seasonally adjusted components (see section 4).

j. For either the indirect and direct approach, the aggregate should not contain residual seasonality and should be relatively smooth. The direct approach is preferred when more importance is given to the aggregate series than its components or when the components have very similar observed seasonal components. The indirect adjustment is usually appropriate when the component series have very different seasonal patterns and can be seasonally adjusted individually.

k. Forcing the annual totals of the seasonally adjusted data to be equal to those of the original (or calendar adjusted original) series is rarely theoretically justified but could be used when there is a need for consistency with external benchmarks such as in the System of National Accounts or in reconciling an aggregate and its components. This should be implemented using a benchmarking technique that minimizes changes to the period-to-period movements of the seasonally adjusted series (see guideline 2.3.2e and section 3).

l. To assess whether a time series is seasonal and to evaluate the quality of the seasonal adjustment process, indicators and diagnostics should be examined carefully, in particular the following:

- Simple time plots and a year-over-year graph to inspect the series for seasonal patterns and to visually find other perturbations.
- Statistics to assess the significance of the estimated regARIMA parameters and the overall quality of the fitted model (described in standard time series textbooks).
- Various statistics such as the two Fisher tests for stable and moving seasonality, spectrum graphs (Ladiray & Quenneville, 2001; Findley et al., 1998), and smoothness indicators.

- Residual seasonality test statistics on the seasonally adjusted data (Ladiray & Quenneville, 2001) and plots of the seasonally adjusted series (year-on-year, spectrum).
- Simple summary statistics on the historical revisions of both the level and the period-to-period change in the seasonally adjusted data.

2.3.2 Revisions to seasonally adjusted data

By the nature of the seasonal adjustment process, any additions or modifications to the unadjusted data have ripple effects over time throughout the seasonally adjusted series. Revisions in the seasonal adjustment context usually improve accuracy because they are estimated using observations that were not initially available. Since the ripple effects generally decrease rapidly away from the affected periods, revising seasonally adjusted data over a smaller window of time is usually sufficient for dissemination purposes. This ensures that historical published data does not constantly get overwritten. Determining the length of the revision window comes down to reaching a compromise between the need to keep historical data stable (with a shorter window) and the need to avoid artificial breaks in the seasonally adjusted series (with a longer window).

Two main types of revisions to seasonally adjusted data must be distinguished: revisions done over the course of regular production, usually involving a short revision window for the unadjusted data, and revisions done as part of an annual or historical process often associated with a longer revision window for the unadjusted data.

a. The periodical review of the seasonal adjustment options should be synchronized with the annual or historical revision process.

b. For both types, revisions to the seasonally adjusted data should be published according to an officially stated revision policy and in alignment with the release calendar of the unadjusted data. Publishing a history of unadjusted and seasonally adjusted data releases (sometimes called a revision triangle) can help make the revision process transparent to users.

c. During regular production, seasonally adjusted data should be revised for at least the previous period. If unadjusted data for previous periods is also revised during regular production, seasonally adjusted data should be revised starting from one period before the start of the updates to the unadjusted data.

d. For an annual or historical revision process, seasonally adjusted data should be revised starting from at least two years (but ideally three) before the earliest revised period in the unadjusted data. Revisions to seasonally adjusted data should also start at the beginning of a year whenever coherence between raw and adjusted annual totals is imposed.

e. When forcing annual totals (guideline 2.3.1k), it is recommended to use forecasts to ensure the existence of a benchmark for the current (incomplete) year. In practice, this produces smaller benchmarking revisions throughout the year rather than a larger revision at year end (Ferland et al., 2014).

2.3.3 Trend-cycle estimation

a. The trend-cycle estimation method should be applied to the published seasonally adjusted series to ensure that the trend-line is centered on this seasonally adjusted series. The cut and normalize variant of the cascade linear filter of Dagum and Luati (Dagum & Luati, 2008; Picard & Matthews, 2016) or an appropriate variant of it is the recommended method for trend-cycle estimation.

b. Users should be informed that the last few trend-cycle estimates (and especially the very last estimate) are subject to revisions of a larger magnitude than seasonally adjusted data when additional points are added. This higher variability associated with the estimates around the end of the series can be indicated, for example, by a dashed line on the trend-cycle graph or by publishing an information note with the data.

c. Trend-cycle estimates should be revised as far back as the seasonally adjusted estimates were revised, plus additional periods to account for the half-length of the trend-cycle filter (e.g., 6 months with the Dagum-Luati filter).

2.3.4 Data presentation and data access

a. Period-to-period growth rates and changes should be computed on seasonally adjusted data.

b. In the absence of seasonally adjusted data, year-on-year same period comparisons can be computed on calendar adjusted data, or, in the absence of calendar effects, on raw data. However, these comparisons suffer from a lack of timeliness in the assessment of the economic movement.

c. Users should be given access to the full historical raw series, the seasonally adjusted series and, upon request, to the seasonal adjustment options.

2.3.5 Implementation

The Time Series Research and Analysis Centre (TSRAC) develops and maintains the **Time Series Processing System (TSPS)**, a metadata-driven production tool that can be used to define customized sequences of time series tasks for sub-annual data (monthly or quarterly). The TSPS enables the implementation of the present guidelines on seasonal adjustment, trend-cycle estimation, and revisions to seasonally adjusted data, as well as guidelines on benchmarking and related techniques (section 3), and reconciliation (section 4). The TSPS also incorporates functionality for the treatment of missing values, the treatment of undesirable negative values, and the validation of inputs and outputs. Finally, it produces logs and return codes for each processing step, allowing for auditing and troubleshooting in a production environment.

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3 Benchmarking and related techniques

3.1 Scope and purpose

Important statistical programs often have two sources of data measuring the same target variable: 1) a more frequent measurement (typically, monthly or quarterly) with an emphasis on an accurate estimation of the period-to-period movement and 2) a less frequent measurement (typically, annual) with an emphasis on an accurate estimation of the level.

Benchmarking refers to techniques used to ensure coherence between time series data of the same target variable measured at different frequencies, for example, monthly and annually, quarterly and annually, or monthly and quarterly. Benchmarking consists of imposing the level of the benchmark series while minimizing the changes to the observed movement in the high-frequency series as much as possible. Benchmarking can improve the accuracy of the high-frequency series and timeliness of the low-frequency series.

Nonbinding benchmarking, interpolation, temporal distribution, calendarization and linking are related techniques which are based on similar methodological principles and guidelines as those of benchmarking. Nonbinding benchmarking is used when the benchmark series can also be revised. Interpolation is the estimation of intermediate terms between known values and can also be used to benchmark stock series where the benchmarks cover a single high-frequency period (anchor point). Temporal distribution is the disaggregation of the benchmark series into more frequent observations. Calendarization is a special case of temporal distribution. Linking is used to join different time series segments into a consistent single time series. More details on those techniques can be found in Dagum and Cholette (2006).

Benchmarking in the context of time series should not be confused with weight adjustments that can be applied at the estimation stage for calibration purposes.

3.2 Principles

3.2.1 Benchmarking

One should make sure that there are as few conceptual, methodological and operational discrepancies as possible between the high and low frequency data sources at the design stage. Discrepancies between the series should be thoroughly investigated and understood, after which an informed decision can be made on whether to publish the high frequency series as is, or to benchmark it to ensure numerical coherence. If the decision is made to not benchmark, the discrepancies should be explained to users as per the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000).

In the case where the designs of the data sources are compatible or when external constraints impose the need for numerical coherence, benchmarking methods can and – from a statistical point of view – should be used. In typical situations, the high-frequency series is implicitly assumed to be less reliable than the low-frequency series. By its nature, the benchmarking process will cause revisions to the high-frequency data and thus, a willingness to revise is necessary.

3.2.2 Interpolation

Interpolation is the process of fitting a function or a curve through a set of data points, either exactly or approximately. In the context of time series, interpolation usually arises for stock series where, for example, a yearly value corresponding to the fourth quarter or twelfth month is provided and estimates for the other quarters or months are needed. This is a problem of producing estimates for the missing values within the temporal range of the data.

3.2.3 Temporal distribution

Temporal distribution (or **temporal disaggregation**) is the process of distributing (or disaggregating) data with low-frequency reference periods (e.g., years) into higher-frequency reference periods (e.g., months). It is usually associated with flow series where the data from the less frequent periods correspond to sums of the data from the more frequent periods. For example, transactional tax data (like GST/HST) may be remitted quarterly or

annually, but monthly figures are needed for monthly economic programs. A type of temporal distribution called **calendarization** can be used to provide the required disaggregation.

The mechanics of temporal distribution are similar to benchmarking. However, whereas for benchmarking both the low-frequency and high-frequency time series are known and must be made coherent, the unknown high-frequency series is the end goal for temporal distribution. An initial proxy for the high-frequency series must be used, which often takes the form of a constant series (to distribute the data as evenly as possible while preserving smooth movements and satisfying the low-frequency constraints) or a seasonal signal (to impose a plausible seasonal pattern in the disaggregation).

For disaggregating stock series, benchmarking or interpolation techniques can be used.

3.2.4 Linking (bridging)

Linking (or **bridging**) is the process of joining different time series segments into consistent time series. It can be used to minimize abrupt level changes (breaks) caused by methodological changes like statistical program redesigns, changes in classifications, changes in measured concepts, a new sampling frame, and so on. Benchmarking can be used effectively to join the new series with the old. The reasons behind the breaks and operational constraints influence how benchmarking is applied.

In order to assess whether methodological changes induce breaks in series, estimates can be produced under the old methodology and the new. This can sometimes require collecting and processing two samples in parallel, if a panel-like sample is refreshed or redrawn. Changes in level can be investigated for significance through subject matter expertise and statistical testing.

3.3 Guidelines

3.3.1 Benchmarking

a. Before considering benchmarking, the discrepancies between the two sources of data should be investigated, documented and quantified. These differences should be minimized as much as possible at the design stage. The following may be used to document and quantify the discrepancies:
    - Descriptive statements of conceptual aspects: reference periods of the low-frequency source, definition of the variables measured and of the target population, etc.
    - Descriptive statements of operational aspects: sampling frame, collection process, etc.
    - Descriptive statements of methodological aspects: sampling, use and source of administrative data, etc.
    - When appropriate, quantitative descriptions of the discrepancies: counts and weighted counts by reference period to estimate the impact of the non-calendarization of low-frequency data, differences between administrative data, sampling errors of the two estimates and corresponding changes, etc.

b. Benchmarking will result in changes to the high-frequency data. Benchmarking should only be considered when the gain in consistency is useful to users or when it improves the accuracy of the high-frequency series. Applying the benchmarking techniques and thoroughly analyzing the results may also provide a good indicator of the appropriateness of the method. Discrepancies, revision to the series through the benchmarking adjustments, and revision to growth rates may all be studied with graphs or summary statistics.

c. For benchmarking, it is preferable that the low-frequency series provides both an accurate measurement of the level and an accurate measurement of the change, since the low frequency changes will also be imposed on the benchmarked series.

d. When the data sources are designed differently, benchmarking should be considered only if strong external constraints impose the need for numerical coherence, as the resulting coherence may come at a cost of reduced accuracy. In particular, benchmarking when low-frequency values are less reliable than the corresponding high-frequency series will produce less reliable benchmarked series.

e. Seasonal adjustment can introduce unwanted discrepancies between the yearly sums of the raw and the corresponding yearly sums of the seasonally adjusted series. When required, seasonally adjusted series may be benchmarked to yearly totals of the raw series.

f. Appropriate benchmarking methods should be used, such as the regression-based techniques described in (Dagum & Cholette, 2006) or one of the various enhanced Denton methods described in the Quarterly National Accounts Manual (International Monetary Fund, 2018). Simple prorating techniques should be avoided as they introduce discontinuities at every benchmark transition (e.g., between years), something known as the "step problem".

g. Benchmarks (low-frequency values) for the most recent observations of the low-frequency series are often missing, either because the low-frequency period is incomplete or the low-frequency data is not yet available. Benchmarking techniques generate adjustments for the periods not yet covered by benchmarks by leveraging the relationship between the high- and low-frequency series. Alternatively, external projections of the next benchmarks, obtained through a different model (e.g., imputation), can be used.

h. A pre-adjustment with the average discrepancy (sometimes referred to as a bias pre-adjustment) can be considered, as it often improves the quality of benchmarking for the periods not covered by the benchmarks. Alternatively, this can also be achieved by projecting unobserved benchmarks explicitly before benchmarking is applied (through imputation or forecasting).

i. An alternative approach to benchmarking consists of computing high-frequency adjustment factors directly by benchmarking a constant series to appropriately converted benchmarks. It should be noted that this approach yields benchmarked data that only approximately satisfies the benchmarks.

j. When implementing benchmarking or related techniques, proven benchmarking methods should be relied upon (Dagum & Cholette, 2006) and the use of common tools should be considered first. This minimizes programming error and reduces development cost and time. Specialists offer support within Statistics Canada, especially for the generalized system G-Series (Statistics Canada, 2016; Ferland, 2025), which incorporates benchmarking functions.

3.3.2 Interpolation

a. For interpolation, the use of spline interpolation or benchmarking-based methods (Dagum & Cholette, 2006) is generally recommended, for smoothness and continuity reasons. Linear interpolation can be used if circumstances demand that previous interpolated values not be revised with the addition of new data points.

b. Interpolation methods should be used for the benchmarking of stock series (or cumulated flow series).

3.3.3 Temporal distribution

a. Guidelines for temporal distribution are the same as for benchmarking and interpolation.

3.3.4 Linking (bridging)

a. Prior to linking, the significance of the breaks and the need to join the old and new series should be assessed. Subject matter experts and end users can assess the importance of the changes and whether linking will introduce too many revisions in the old data. Determining whether the new and old series are significantly different can be accomplished through statistical testing (sampling/total error). The significance of level shifts can also be estimated from appropriate time series modelling.

b. Linking should be performed using benchmarking techniques (following the same guidelines), using the new series as the benchmarks and the old series as the series to be benchmarked. Forecasting methods can be used to create an overlap if required.

c. If required, an anchor point (benchmark) from the old series can be used, which introduces a gradual change in level from that point and prevents revision prior to that point.

3.4 References

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4 Reconciliation

4.1 Scope and purpose

Time series data must often respect a vast array of rules or relationships among series. These can be cross-sectional (e.g., regional estimates adding up to national estimates) or temporal/longitudinal (e.g., quarterly estimates adding up to annual estimates). In complex cases, cross-sectional relationships across multiple dimensions (geography, industry, occupation, product, trading partner, etc.) could coexist with one-dimensional temporal relationships.

However, actual data may not respect those relationships. Data may come from various sources (surveys/censuses, administrative data, alternative data) with conceptual, methodological or operational discrepancies. Non-linear data processing steps such as seasonal adjustment can also break preexisting relationships.

Discrepancies can sometimes be explained to users, but coherence in the set of time series must often be restored using a **reconciliation** process. The previous section illustrated how benchmarking techniques can be used to impose one-dimensional temporal relationships. Reconciliation techniques can be used to restore relationships in a time series system subject to multidimensional (multivariate) linear constraints (while preserving the temporal constraints imposed in a previous benchmarking step when applicable). More details on those techniques can be found in (Dagum & Cholette, 2006).

4.2 Principles

As with benchmarking, one should make sure that there are as few conceptual, methodological and operational discrepancies as possible between the various data sources at the design stage. Discrepancies between the series should be thoroughly investigated and understood, after which an informed decision on whether to publish the series as they are or to reconcile them to ensure numerical coherence can be made. In the former case, the discrepancies should be explained to users as per the Policy on Informing Users of Data Quality and Methodology (Statistics Canada, 2000).

In the case where the designs of the data sources are compatible or when external constraints impose the need for numerical coherence, reconciliation methods can and – from a statistical point of view – should be used. In typical situations, series that are part of a total are assumed to be less reliable than the totals (because of their higher variability). In practice, these hypotheses can be tempered through the use of binding and non-binding values in the reconciliation problem (see below). By its nature, the reconciliation process will cause revisions to the data and thus, a willingness to revise is necessary.

Relationships to be restored or preserved correspond to constraints in an optimization problem (overwhelmingly, linear equalities or inequalities). A constraint can be defined on a time series to prevent its values from being altered by the reconciliation process. In this case, the series is deemed **binding** and all the discrepancies are allocated to the other (**non-binding**) time series involved in the same relationships. The extent to which a series is alterable can be controlled quantitatively in terms of its importance and variability through **alterability coefficients**.

4.3 Guidelines

a. Reconciliation can introduce large distortions in the estimates – in particular, if too many constraints are imposed (e.g., too many binding series). The need for coherence must be balanced with the loss in precision in period-to-period movement introduced by the process.

b. Reconciliation applied to seasonally adjusted series can reintroduce seasonal patterns in some cases. It is therefore recommended to perform residual seasonality tests on the reconciled series to ensure the absence of seasonal patterns.

c. When deciding which series are binding, it is important to factor in the importance of the series (for example, some series might need to be kept fixed to ensure coherence with other data sources). For series deemed alterable (non-binding), the alterability coefficients can be tied to a measure of variability (for example, a coefficient of variation), so that more of the discrepancy can be attributed where there is more uncertainty in the estimates.

d. It is tempting, for practical reasons, to seasonally adjust series at the finest (most disaggregated) level possible and derive all higher-level series through aggregation (i.e., as indirect seasonally adjusted series). While this ensures coherence without the need for reconciliation, the fact that variability is generally higher in finer-level series makes this undesirable from a quality point of view. Additionally, the finest-level estimates are not always produced in practice (perhaps only marginal estimates are). A middle-out approach is recommended instead. With this approach, a middle level is selected for which quality is deemed good. Series at that level and finer levels are seasonally adjusted directly and reconciled with the middle level series. Series at coarser levels are derived indirectly through aggregation.

e. Applying the reconciliation techniques and thoroughly analyzing the results provide a good indicator of the appropriateness of the method. Large discrepancies between series before and after reconciliation should be investigated. The following indicators may be used to document and quantify the discrepancies.

   - Distribution of ratios between the reconciled and original estimates. An analysis of the ratios, together with graphical inspection, can help determine whether reconciliation introduces too much distortion in the estimates. Distortion can be mitigated through the choice of the middle level in the middle-out approach, the use of alterability coefficients, and a coordinated, cohesive application of options in seasonal adjustment.
   - Residual seasonality statistical tests. When handling seasonally adjusted series, testing for residual seasonality after reconciliation can determine whether the process has re-introduced seasonal patterns.

f. When implementing reconciliation techniques, modern reconciliation methods should be relied upon (Dagum & Cholette, 2006) and the use of common tools should be considered first. This minimizes programming error and reduces development cost and time. Specialists offer support within Statistics Canada, especially for the generalized system G-Series (Statistics Canada, 2016; Ferland, 2025), which incorporates raking and balancing functions.

4.4 References

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5 Temporal comparability

5.1 Scope and purpose

Statistics Canada produces many statistical products as time series to describe the evolution of a specific characteristic in the Canadian population, economy or environment. Statistics Canada's products are often the only source available to measure the social and economic history of the Canadian population and serve as the basis for reliable comparisons across time. Preserving this comparability of a time series to support these comparisons is thus critical to the value of the agency's products (Statistics Canada, 2017).

Temporal comparability is particularly relevant when there is a change considered in the standards for defining, observing or measuring a variable within a statistical program, such that estimates are no longer comparable from one period to another. Discontinuities are also commonly referred to as breaks in a time series.

Significant efforts are made to use comparable, if not identical data sources and methods for the statistical output for each period. Program redesigns and revisions are often motivated by a desire to improve quality, particularly with regard to the dimensions of timeliness, accuracy and relevance. However, they can have a negative impact on coherence and interpretability, especially regarding comparisons over time, and can introduce artificial differences into comparisons drawn between time periods.

This section provides guidance for maintaining appropriate temporal comparability for the agency's statistical outputs.

5.2 Principles

Temporal comparability is a property of a series of statistical estimates, meaning that periods within the series are comparable with respect to the underlying concepts, the population represented, and the methods used in their measurement. With this property, changes observed in the data from one period to another correctly track the evolution of the measured quantity (or economic signal) up to measurement uncertainty.

Temporal comparability in methodology does not imply smooth data series, as real shocks to the signal could still introduce abrupt changes or other apparent discontinuities that represent real changes in the economy. However, we are concerned with changes that could produce misleading or artificial discontinuities in data.

This property is fundamental to support various types of analysis including trend-cycle estimation, seasonal adjustment and modelling, as well as simple comparisons between historical values. The concept of temporal comparability is not absolute and needs to be considered in the context of fitness for use. Some degree of incomparability may be acceptable if it does not affect reasonable comparisons or the related analytical conclusions.

A number of circumstances can lead to the introduction of an artificial discontinuity in a time series, including classification or content changes, methodological updates or redesigns, or definitional changes to the information being measured. When a discontinuity is identified in a series, decisions need to be made regarding the measures that can be taken to preserve the comparability of the time series. Removing all discontinuity from the series is rarely feasible due to availability of data or prohibitive costs. The following guidelines should be followed when an artificial time series discontinuity is potentially introduced for a statistical program. Selecting treatments to preserve comparability involves a significant amount of judgment and must take into account the nature and intended use of the time series.

5.3 Guidelines

a. For any project that could lead to time series discontinuities, appropriate time and resources should be allocated to allow for their appropriate assessment, as well as the planning and application of any measures to restore temporal comparability. These activities should be incorporated into the project plan and communicated to users in advance to allow for suitable consultation.

b. Any corrective measures applied should be justified and should improve the quality of the final statistical product. The impact of discontinuities should be considered in assessing the product's fitness-for-use. For example, errors in market-moving indicators such as the Consumer Price Index or the unemployment rate

could have important consequences, and more caution may be necessary when evaluating or addressing discontinuities.

c. A statistically significant level shift as part of a model that takes into account all other effects can support the hypothesis that there is a discontinuity as described above. However, it is preferrable to conduct a parallel run to generate estimates with and without the source of the discontinuity for a sequence of reference periods. A parallel run typically serves as the most reliable means of estimating a time series discontinuity. A properly designed parallel run enables direct estimation of the magnitude of the discontinuity, and generally yields higher precision compared to other approaches relying on statistical modelling or other means, which can justify the additional cost. The size of the discontinuity should be estimated using multiple reference periods to ensure that there is no trend or seasonality to the direction or magnitude of the discontinuity.

d. The method(s) used to restore temporal comparability should be selected based on cost, as well as all dimensions of data quality. The preferred order of methods to produce high-quality revised historical statistics is typically as follows; (i) recompile statistics using a methodology analogous to future estimates, (ii) apply movement preservation methods based on data from a parallel run, (iii) apply movement preservation methods with a relevant auxiliary source, and (iv) apply a level shift as a constant additive or ratio adjustment. There may be exceptions to this order of preference depending on the quality of auxiliary information available, or other particular characteristics of the discontinuity. When movement preservation is selected, it is recommended to use a benchmarking approach as described in section 3 to avoid the "step problem" that results when individual years are adjusted independently.

e. Temporal comparability should be assessed for sub-groups of interest within the population, and not only at a highly aggregated level.

f. There should be a plan for monitoring the performance and maintaining the statistical process used in the treatment of time series discontinuity and the tools used to apply it throughout the product lifecycle. This includes future treatments that may be required to ensure comparability, for example after annual revisions or other updates are made to historical values.

g. All relevant details on the methodology used in the process should be documented, as well as any limitations and modifications to previous practice that have been applied. This should, at minimum include assessment of the magnitude of discontinuities as well as the measures applied to restore comparability, technical references detailing the methods, and diagnostics used to validate their application. Any limitations or assumptions of the methodology should be reported as well, including any confirmed or suspected bias that may affect the use and interpretation of the statistical product. Where not prohibited by confidentiality, this documentation should be readily available to data users and for public scrutiny in general.

h. The final adjusted time series should be compared to other data sources to ensure that estimates are coherent with known results, in terms of order of magnitude in the levels as well as comparisons across time.

i. Quality indicators should be derived for the end statistical product, which reflect the process applied to restore temporal comparability. For statistical measures such as model variance or bias, ensure that the variance estimates include all relevant components of error, including sampling error, non-response error, variance of inputs and overall error associated with temporal comparability measures.

5.4 References

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Appendix A – Protocol for analysis and intervention in the seasonal adjustment process

This protocol describes principles and guidelines behind the analysis of the seasonal adjustment process and results. It also highlights recommendations related to intervention in the process. This protocol is part of a wider strategy for ensuring data quality (Statistics Canada, 2019) which includes amongst other things the validation of the unadjusted data (i.e. data prior to seasonal adjustment). Note that the validation of seasonally adjusted estimates is an activity included in the Guidelines for the Validation of Statistical Outputs (Statistics Canada, 2015).

A.1 Guiding principles

Seasonal adjustment is a process that uses well-established statistical techniques and certified software. It can help identify numerous occasions to further study and analyze the data, but when seasonal adjustment is applied properly (i.e. as per the guidelines above), the need for explicit interventions will be rare.

Interventions to modify the results of the seasonal adjustment process should not be made against the principles of seasonal adjustment described in this document and explained in Seasonal adjustment: Concepts and interpretation (Statistics Canada, 2026). In particular:

> "the seasonally adjusted series is the combination of the trend-cycle and the irregular component. The contribution of the irregular component is worth emphasizing, because seasonally adjusted data are sometimes misinterpreted as providing users with "pure" information on the trend-cycle. […] The irregular component could relate to unanticipated economic events or shocks (for example, strikes, disruptions, unseasonable weather, etc.), or can simply arise from noise in the measurement of the unadjusted data (due to sampling and non-sampling errors)."

As such, we should not intervene **just** to make the data appear less volatile. If a less volatile time series is needed to help with the interpretation of the underlying long-term economic situation, smoothing techniques can be used (e.g., trend-cycle, moving average, polynomial regression, penalized spline regression).

Moreover, the seasonal adjustment process should not be used to correct issues identified in the preceding data processing steps. In such cases, the processing steps or the unadjusted data itself should be corrected.

A.2 Interpretation, investigation and communication

At each production cycle, time series specialists are available to help with the interpretation, investigation and communication related to seasonal adjustment. This includes formal briefings to upper management if an explicit intervention to the seasonal adjustment process was applied. Even if no intervention is applied after investigation, time series specialists are available to explain the seasonal adjustment process and quality evaluation at upper management briefings as appropriate.

A.3 Interventions

As per the guidelines in this document: "Seasonal adjustment options for each series should be reviewed periodically to verify their continued applicability and appropriateness, and to increase accuracy. The recommendation is to review options annually. However, to avoid artificial revisions, the pre-selected seasonal adjustment options should not be changed between scheduled reviews."

In practical terms, this means that during production, seasonal adjustment options may be modified in the following circumstances:

a. Interventions are recommended when there is clear statistical evidence that the selected options are no longer applicable or appropriate. In practical terms, this means that there is significant residual seasonality in the results or an issue with other quality indicators. The seasonal adjustment diagnostics described below will help identify candidates for interventions.

b. Interventions are also acceptable when more than one set of seasonal adjustment options yield acceptable results as per the seasonal adjustment diagnostics. If an alternative set of options yields more plausible results in terms of subject-matter knowledge of the underlying economic situation while the current set

of options yields economically questionable results, the options may be changed. Interventions are also acceptable in a similar context to help control excessive revisions to the previous periods.

c. Interventions can also be appropriate if auxiliary information indicates an abrupt structural break in historical patterns of the seasonal component or calendar effects (e.g., the inclusion of a new statutory holiday, a bylaw change to business opening hours, changes to operational processes related to the calendar, very abrupt economic turning points, etc.).

A.4 Diagnostics

The following diagnostics are produced on an ongoing basis:

a. **System diagnostics** are automatically run to indicate if the seasonal adjustment process was completed successfully, completed with system warnings, or terminated with a critical error.

b. As part of the seasonal adjustment process, **analytical diagnostics** on the raw (unadjusted) series are produced to help identify series where the current values lie outside an expected range based on historical patterns. These series may be candidates for further analytical and data quality investigation. These values are **not** necessarily expected to represent erroneous data and **should not** be systematically modified to fit an expected range. Diagnostics outside an expected range can be acceptable if they arise from legitimate economic events or natural noise in the measurement of the data. These diagnostics may be reviewed jointly by analysts and time series experts.

c. **Seasonal adjustment diagnostics** are also produced to identify potential seasonal adjustment issues such as residual seasonality. These diagnostics are reviewed by time series experts on request. An ongoing review can be requested and scheduled by the statistical program manager.

A.5 References

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