Background Facts on Economic Statistics

2004:02

Report from the Swedish Task Force on Time Series Analysis

Department of Economic Statistics

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1 Introduction and summary

A national statistical institute like Statistics Sweden (SCB) is first and foremost a production unit for statistical data. Production is controlled by rules and restrictions on timeliness, quality, efficiency, etc. Behind every statistical figure there is a huge amount of work, and the work on a figure often continues as revisions for months and years after the event, so as to achieve as high accuracy as possible. It is not an exaggeration to say that the total quality model is on the mind of all taking part in the production process. A quality aspect that has received large attention at SCB is the use of optimal sampling methods. Another area where SCB' competence is internationally recognised is the measurement of prices. Among the quality aspects, the temporal dimension has not been given very high priority. The best-known application of time series analysis, seasonal adjustment, has been paid little attention. Only a couple of years ago there was just one person at SCB with a thorough knowledge of time series techniques. Missing values when reporting preliminary figures, have been imputed using non-optimal methods, although this can be seen as a classical time series forecasting problem. SCB has been slow in publishing long time series of historical statistics, reflecting the economic history of the country.

This was the background to the present project on aspects of time series analysis at SCB, established on 1 July 2002. The work started gradually and the Task Force (TF) reached full capacity only in March 2003. The task was to suggest good methods for calendar/trading day correction, seasonal adjustment and construction of long time series. The TF was to stimulate the use of time series methods. Another TF was assigned to find ways of speeding up the publication of early figures and to the construction of flash estimates. The time series group was asked to assist in the work on flash estimates. It was emphasised that the TF should also recommend software for seasonal adjustment and that other possible uses of the method to be recommended should be reported. An organisational plan for work on time series was to be suggested. Finally, the TF was requested to discuss its work with Eurostat before publishing the final report.

This report tries to meet these requirements. Given the short time available for the work, especially since all involved have also had many other duties, the TF has found it possible only to give recommendations and to outline the problems. Very little has been implemented. Some examples of seasonal adjustment, long time series, imputation and leading indicators have been enclosed as appendices to this report. We apologise to our non-Swedish-speaking readers that only two of the appendices are in English.

Chapter 2 gives some basic features of time series analysis and its use in a national statistical institute. The choice of recommended method was an easy problem, not least since Eurostat had already made clear that the model-based TRAMO/SEATS method is to be used by the member countries. The question of the choice of software, on the other hand, was much harder, cost us a lot of time and effort, and still couldn't be settled in a completely unequivocal way.

Time series models can be used for other purposes than just seasonal adjustment. In Chapter 3 some of these areas are studied. An important application is quality control. A method that detects outliers can find errors in the raw data. Another use of time series forecasting techniques is imputation. A third application area is to utilise all components of the time series decomposition in connection with seasonal adjustment. The business cycle component may after all be of better use to analysts than the adjusted series. Finally, the time series forecasts are of interest as benchmarks to those who themselves make forecasts.

The task of finding good rules for producing long time series is methodologically not well connected to the rest of the tasks. Time series decomposition and forecasting belongs to the area of signal theory, while linking time series is a fundamental statistical problem of how to register quantitatively what happens in a society; the changes in the society and the changes in the ways they are recorded. In Chapter 4 only a few recommendations can be given, because often choices have to be made *ad hoc* and according to the planned use of the long time series. The need for historical time series is recognised, those available on SCB's web site are listed and two examples of historical time series and how they could be analysed are given in Appendices C and D.

Chapter 5 first outlines the early indicators published by SCB: the Activity Index and the quarterly Leading Indicators for Manufacturing. The rest of the chapter contains the blueprint for a new 'Leading Flash Indicator', two elements of which already exist, namely the aforementioned quarterly Leading Indicators and their monthly analogues, described in Appendix E.

In Chapter 6 some recommendations are presented for how to organise time series work at SCB. Following a general international model it is suggested that a separate Time Series Unit should be introduced. This unit would have the competence to perform and lead time series work at SCB, relieving the departments and units of the responsibility and the costs of maintaining the high and uniform time series quality requirements of today and tomorrow. An alternative solution to what the group finds as the optimal organisation, a temporary one, is also given.

The names of the persons who, in one way or another, have been involved in the project, as well as some information on how the TF has worked are given in Chapter 7.

The recommendations can be found in italics in the main text. For convenience the collection of recommendations are also presented here[1]:

1a Seasonal adjustment

- Start publishing more seasonally adjusted time series, notably price series.

- Never attempt to seasonally adjust a time series that does not contain a seasonal that is statistically significant.

- Model-based preadjustment (TRAMO) for calendar and outlier effects and model-based decomposition (SEATS) for seasonal adjustment are recommended.

- The chosen model should be fixed for a longer period (one-two years). The model choice can be re-evaluated more often, depending on available resources. The maintenance of the decomposed time series should be well established and responsibilities clearly defined.

- Direct seasonal adjustment is the recommended method but in some cases there are reasons for doing indirect adjustment.

- No software can be recommended today, but as soon as TRAMO/SEATS works in the new version of X12 that software will be an ideal choice, because the Bureau of Census is a guarantor for high quality, maintenance and support.

- Develop a model for a standard quality report on seasonally adjusted time series based on the suggestions put forward by Eurostat and ECB.

- Regardless of the choice of software, an interface will have to be built to meet the requirements of the Swedish data production system. A temporary solution is to develop the existing SAS-interface for T/S, taking into account the future system requirements of the new version of X12.

- When publishing a seasonally adjusted time series, or any of its components, the original series should always be published in parallel.

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[1] The order in which the issues appear in the report is followed, not necessarly importance.

1b Other uses of seasonal adjustment

- TRAMO, or its special variant, TERROR should be used routinely for quality control. Outliers detected by TRAMO (or TERROR) may be errors and should be investigated.

- It is suggested that for small companies with short and noisy time series Trend Imputation is used, and for larger companies, TRAMO with Regression. The former requires little effort, the latter can be done in automatic mode, in which case it is a fast method.

- It is suggested that Statistics Sweden systematically publishes the estimated trend-cycle component, possibly also both separately, together with the seasonally adjusted series.

- It is suggested that Statistics Sweden systematically saves both the estimated irregular component of a time series that has been seasonally adjusted and the forecasts. They can be made available to researchers and analysts on request, or published, if that is regarded appropriate.

1c Long time series

- It is important to recognise the temporal dimension when producing statistics. Breaks in time series should be minimised ex ante. Long time series should be maintained – within reasonable cost limits. When changes are made a wrong decision can produce a break that is irreparable.

- When changes are of less importance for the purpose of the time series, the ratio method is swift and simple. It is particularly well suited for heavy aggregates.

- The method of ex post reclassification of micro-data is costly, and hence should be avoided.

- Long time series make sense only as long as the variable is defined more or less in the same way for its entire length. This may depend on what the time series is used for. Even the simplest ratio-linking requires closer knowledge about the time series.

- SATS can only maintain and publish long time series of a general interest, while special interest groups should finance more detailed long, or historical time series.

- Regardless of the effort put into linking time series, lack of information reduces quality. The conclusion is that constructed long time series have lower quality than series of shorter length. Hence, in publications, a distinction should be made between recent official data and long constructed time series.

- It is suggested that more long time series be added to the homepage under the heading "Historical Statistics". An entirely new data set could be introduced containing historical statistics of all sorts: demographical, social, economic, etc.

- Construction of long time series should be commissioned to external experts.

- Preparations for changes in classification, method, coverage, etc. should be started years before the change so as to make the break as smooth as possible. Parallel measurements should be made for a sufficiently long period. The old method can be phased out gradually, keeping in mind, and announcing to users, that only the new data are official. The minimum is one parallel measurement so that the ratio method can be applied. Linear regression can be used if more parallel measurements are provided.

- Start a working group for preparing the transition to the standard SNI2007. Its main objective is to find methods for linking the new standard to the old.

1d Flash estimtates

- Work on Leading Flash Estimators should be continued at SCB.

1e Organisation

- Start a new unit (Swedish “funktion”), responsible for all time series applications of Statistics Sweden. Highly competent persons would be concentrated to this joint unit, at a reasonable cost and optimising the synergy effect.

2 Seasonal Adjustment

2a Introduction

According to Kendall and Buckland (1960): "A time series is a set of ordered observations on a quantitative characteristic of an individual or a collective phenomenon taken at different points in time". At SCB most time series observations are made at equidistant time points: annually, biannually, quarterly, or monthly. When the period is shorter than a year, the series often exhibits a more or less seasonal pattern. That variation component is called *seasonal variation*, or seasonal for short. In many time series of SCB the seasonal is the major component of variation. Most analysts of economic time series regard the seasonal as a nuisance that makes it harder to compare consecutive periods and to distinguish economically important components, like the long term trend and the business cycle. That is why National Statistical Offices publish seasonally adjusted series, as a service to the users. All over the world, the most important economic quarterly time series, the Gross Domestic Product (GDP) is available as seasonally adjusted.

This chapter addresses the following two questions: Which seasonal adjustment method should be recommended, and which software is best suited for the computer environment of SCB? The decision has not only to be based on superiority right now, but there has to be a guarantee for future maintenance of the software.

The description of methods and software in this chapter is very brief. Considering how complex the issues are, a deeper understanding requires a closer study of the references given in the text.

2b The background

Above, the seasonal was called a component of variation of a time series. One can distinguish three additional components that a short period economic time series may consist of.

The four components are:

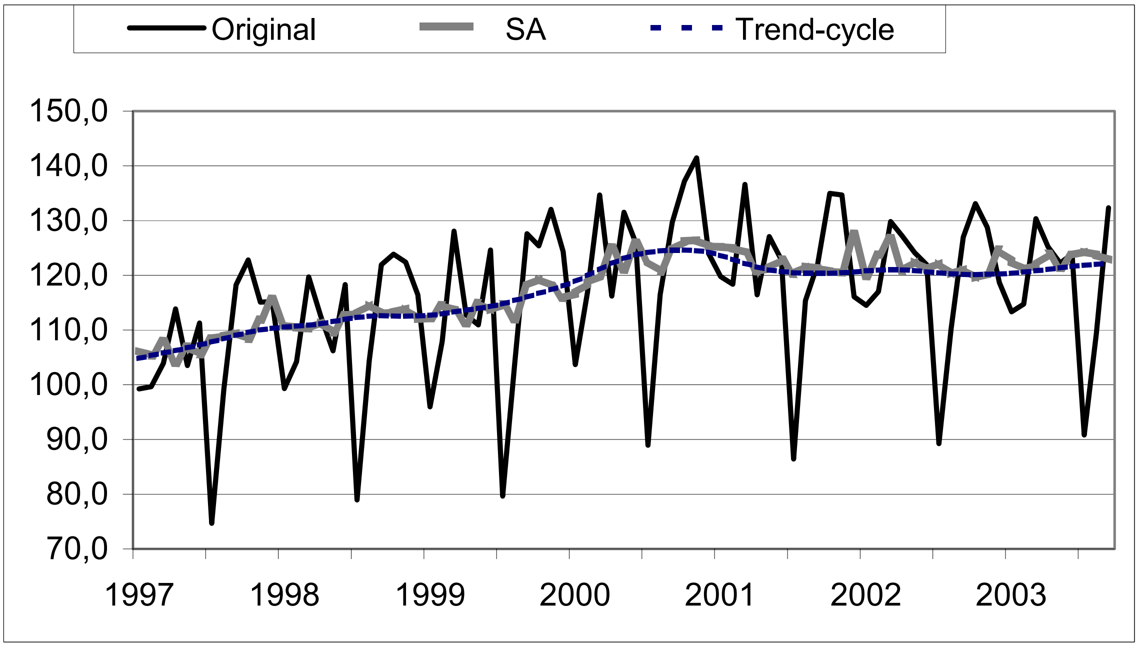
- Trend
- Cycle
- Seasonal
- Irregular

Estimating the components is commonly called Seasonal Adjustment, although 'decomposition' would be a better term. Before estimating the components time series often need to be preadjusted, removing deterministic effects like calendar variation and outliers. The question of how to remove these effects, mentioned as a task for the TF in the introduction, is thus an introductory step in the decomposition of a time series.

As an example, Figure 2.1 shows the monthly Industrial Production Index (IPI) for Sweden[2]. This series has a distinct seasonal component, characterised by the low value for July.

[2] For two examples of decomposition of historical time series, see Appendices C and D.

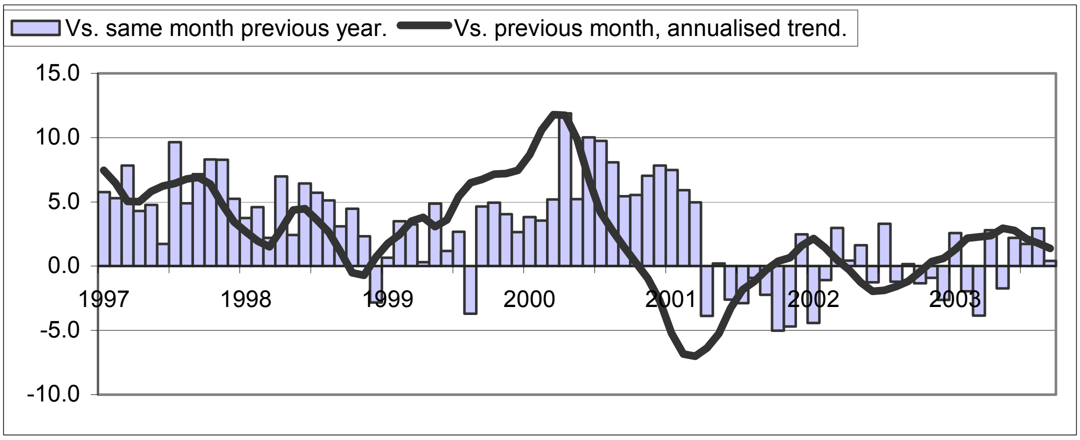
Figure 2.1
The Industrial Production Index for Sweden, January 1997–September 2003
Index: 1995= ‘100’



Often turning points are in focus. Figure 2.2 shows the percentage change of the seasonally adjusted IPI series when the comparison is made between two successive cyclical estimates vs. comparing a raw figure to the same one the year before. Note that the turning point at the end of the year 2000 is registered six months before the change in raw figures. Figure 2.2 could be used for finding turning points. A better method is given in Kaiser and Maravall (2001).

However, Figure 2.2 may give a too rosy picture of how well and early a turning point can be detected from the estimates of cyclical changes. First, this detection can be done only after the time series in question is published. This often happens with a considerable delay, see Chapter 5. Second, a preliminary figure may be substantially revised, see Öller and Hansson (2002). Third, half of the information behind the decomposition of the last observation is based on a forecast. When more data accrue, the cyclical change figure must be revised. Forth, model-based adjustment uses mostly final outcome data. This model may not be the same as that generating preliminary data. All these factors result in errors in the crucial last observations. For early signals of turning points, leading indicators such as the one in Appendix E, or in Öller and Tallbom (1996) and in Koskinen and Öller (2004) are more relevant, but as a late indicator the cyclical change component of seasonal adjustment may be useful.

Figure 2.2
Industrial Production Index (Sweden), change in percent, January 1997 –September 2003



2b.1 Estimated number of time series at SCB that could be seasonally adjusted

Table 2.1 gives crude, and probably low, estimates of the number of time series with a shorter period than one year at SCB, which could potentially be seasonally adjusted. Many of them contain a seasonal component; an estimate of that number is 3000 time series. There are many more series with a period shorter than a year, but these will hardly become relevant for regular adjustments. Of course, by commission it could be done.

Some price time series have statistically significant seasonality. There is no reason why they should not be published both with and without seasonal adjustment. The first recommendation is:

Start publishing more seasonally adjusted time series, notably price series.

Table 2.1
Monthly and quarterly series

Unit	# in database	# SA
Economic Statistics:		
National Accounts	200	62
Industrial Indicators	1 000	417
Retail Trade and Prices	100	18
Foreign Trade	500*	2
Total	*1 800*	*499*
Labour Market:		
Labour Cost Survey	2 200	0
Short-term statistics,	100	0
Total	*2 300*	*0*
Environ. & Region. Stat.:		
Energy	65	0
Building	304	0
Traffic and tourism	28	0
Total	*397*	*0*
SCB Total	**Approx. 4 500**	**499**

*) The number of time series that may be worth adjusting. If all series are included the number is at least 10 000. Source: Swedish Statistical Data Bases 2002–12–18.

2b.2 History

The problem of seasonality has a long history. Economic analysts have traditionally regarded this variance component as a nuisance, although it may contain interesting information, see Appendices C and D. As a first attempt to get rid of this component, it was assumed that it was periodic up to a random component that was assumed to be normally and independently distributed with mean zero and constant variance. This was a crude assumption that may have offered some relief if the data covered a very short period, say 2–3 years. But it was useless for longer time series where the seasonal profile changed over time. Computers opened the way for more data-intensive methods. Several rather elaborated methods were in use already before 1967 when they were abandoned in favour of a more powerful method, initiated by J. Shiskin, A.H. Young and J.C. Musgrave at the US Bureau of Census. This was the program X11, which is still applied. The program was based on moving average filters, such as Henderson's Trend Filter and a seasonal filter. It also included a way of handling outliers. The X11-program used fairly primitive methods (The Box-Jenkins model was yet to come[3]), but according to the empirical standards of the time it was fairly advanced. The X11 had two disadvantages. One was the lack of transparency. There was no statistical model supporting the method. Hence, it was difficult to evaluate on sound theoretical grounds. Nevertheless, some efforts were made, see the classical studies of Cleveland and Tiao (1974) and Wallis (1974). The other disadvantage was the poor accuracy of the forecasts that are necessary in order for the adjustment to reach the ends of the time series, especially the recent and most exciting observations. The forecasts used were deterministic trends although the trends are stochastic. In 1988, E. B. Dagum at Statistics Canada introduced Box-Jenkins model forecasts and the new version was called X11-ARIMA[4]. But the adjustment method was not changed and the filters are not based on maximum likelihood estimations of stochastic model parameters. Methods like X-11 will henceforth be referred to as "Empirically-Based", contrary to "Model-Based".

Soon after the publication of the seminal book on time series analysis by G. E. P. Box and G. M. Jenkins in 1970, work started at the University of Wisconsin, USA, on how to utilise the new models for filtering time series, notably the seasonal component. The first results were published by G. C. Tiao and S. C. Hillmer in *Biometrica* 1978. The first computer program of ARIMA-Model-Based decomposition was introduced in the UK, see Burman (1980). The program was called SEATS (**S**ignal **E**xtraction in **A**RIMA **T**ime **S**eries), which still today is the decomposition program in TRAMO/SEATS. First an adequate ARIMA model is specified and then by allocating different frequencies to different components, a decomposition of the series is obtained. The other model-based method, named Structural Time Series, was published by Engle (1978). The software is available in the program package STAMP (**S**tructural **T**ime Series **A**nalyser, **M**odeller and **P**redictor), see Harvey (1989). It has not yet been developed into a user friendly mass production software.

In the 1990s, the major improvement was the development of efficient preadjustment of time series, preceding actual decomposition. The computer software was given the name TRAMO (**T**ime Series **R**egression with **M**issing **O**bservations), and this is the other half of the current **T**RAMO/**S**EATS (T/S) program package, see Gómez and Maravall (1996). Combining TRAMO with Burman's SEATS, signified the emergence of the first practical tool for seasonal adjustment using model-based decomposition. This method became a viable challenger to the old empirical methods. The advantages of the new seasonal adjustment method were: maximum likelihood estimation of calendar effects, an automatic outlier detection and correction procedure based on sound statistical grounds, automatic specification of an ARIMA model and a model-based decomposition using maximum likelihood parameter estimates and optimal signal extraction.

At that time the US Bureau of Census developed the program X12 (X-12-ARIMA), which extends X11 (with ARIMA forecasts), see Findley et al.(1998). But X12 is still empirically based. The new feature is a regression program, REGARIMA, to be used before the decom-

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[3] Box and Jenkins (1970).

[4] ARIMA, see Section 4.1 in Appendix A (in Swedish), or any standard textbook in time series analysis.

position; the purpose of this program is similar to that of TRAMO. The program has extensive diagnostics, which is useful when working with time series.

During the last few years there has been a convergence of TRAMO/SEATS and X12. Eurostat has developed the software DEMETRA that includes both TRAMO/SEATS and X12. The Bureau of Census is now working on a third version of X12, which includes SEATS, see Hood (2002). Eventually, X12 will also include the automatic model selection and outlier correction features of TRAMO.

During the period 1994–1998 there was very active research in seasonal adjustment. The first report to be mentioned is a study by Eurostat (1998). A European task force compared several methods for seasonal adjustment during 1996–2000 and reported at a conference in Bucharest 1998. Model-based adjustment was found to be superior to empirical methods. Another important report is ECB (2000). The ECB recommends model-based seasonal adjustment, but did not exclude the use of X12, especially not its excellent diagnostics. The ECB task force mentioned the structural time series method, but this method was never returned to in subsequent writings. Since 1998, Eurostat has commissioned programmers to develop an interface to the DOS-programmed T/S. First an Excel-macro was released and then the software DEMETRA. The problem with the last program was that it contained bugs, and still does.

An ECB task force made the following conclusion (ECB (2000)): "Looking at the results of the comparison performed in this chapter, the combined use of the two programs is the preferable option. In other words, it appears, from a statistical point of view, neither possible nor appropriate to exclude one of the two programs from further consideration. The REGARIMA parts of the two programs are very similar in general. Differences concern the automatic model selection, which is superior in TRAMO, but they are expected to disappear since the US Bureau of Census plans to incorporate this part of TRAMO in X-12-ARIMA. The seasonal adjustment part of the two programs differs by definition, with the advantage of the model use of TRAMO-SEATS and the 'practical' advantages in the adjustment of X-12-ARIMA. The combination of the two approaches in one seasonal adjustment tool, as is apparently intended by the authors of the two programs, is the most promising way forward."

The SCB TF has come to the same conclusion. The ECB task force also notes that output and empirical measures were better in X12, see p. 5 in ibid., and this led them to recommend X12, for the present, whereas the SCB TF recommends T/S, but preferably as part of the X12 software.

The Bureau of Census has also compared T/S and X12, including the new program X-12-ARIMA-SEATS. They conclude that SEATS performed well but they would not completely abandon X12 for T/S, due to the lack of diagnostics in the latter.

Eurostat has developed the software DEMETRA that includes both X12 and T/S. However, this product has not been reliable and practical for extensive data sets like those of SCB. As a result several interfaces have been developed: a SAS-interface in Italy, a Java-interface in Belgium and the SAS-interface used by the National Accounts in Sweden, see Appendix A.

2c Method

There is one obvious reason why the development has been estranging from empirical and moving towards model-based methods. A system like X11 or X12 is a standardised tool that works quite well for many time series. But a model-based method uses time series analysis to find the optimal model by maximum likelihood estimation. This model determines a filter that is particularly designed for that individual time series. The decomposition can be regarded as a model for the time series. Hence, a seasonal adjustment that is based on statistical theory is preferred to a method that lacks such foundations. Empirical comparisons corroborate this statement, see e.g. the studies by Öhlén and Lundqvist (1998), Öhlén (1999a, b, c) and (2000b).

It is worth noting that the ARIMA models used by T/S are optimal, but only among the class of linear models. During the last 10–20 years there has been a strong development in non-linear modelling. The new models have been successfully applied in areas where long time series are available, e.g. in finance. A tribute to this was the Nobel Prize in economics 2003. The T/S program has been developed for typical statistical producers that generally have quite short time series, see section 4.1 in Appendix A. But many statistical offices also have long quarterly or monthly time series on their websites, see Section 4. There is a limitation on the number of observations in T/S, which is not caused by any limitations in computer capacity but rather stems from the linearity assumption. Appendices C and D show that it would have been difficult to apply one linear model to the entire time series of monthly Industrial Production, Exports and Imports, each containing more than 1000 observations. Probably, in the near future we will see new methods of SA that are based on nonlinear models[5].

Modern seasonal adjustment is done in three steps:

- Transformation and model specification,
- Preadjustment and forecasts, and
- Signal extraction/ decomposition.

If the time series to be decomposed are independent of the level, no transformation is needed, but most economic variables are growing proportionally and then a multiplicative relationship between the components is a more natural choice. Additivity can then be achieved by a logarithmic transformation, see Section 2 in Appendix 1. A more flexible scaling is obtained by the Box-Cox transformation,

$$y = \frac{x^{\lambda}}{\lambda}, \text{ for } \lambda \neq 0 \text{ and } y = \ln(x), \text{ for } \lambda = 0,$$

where the parameter λ varies between 0 and 1, and $\lambda = 0$ means the fully multiplicative (log-) model and $\lambda = 1$ implies the additive model with no transformation. In X12 there is a pseudo-additive decomposition.

2c.1 Preadjustment and forecasts

Some deterministic or other disturbing effects are eliminated in the TRAMO part of T/S. The effects are estimated simultaneously with the ARIMA model. The two most common ones are the calendar effect and the outlier effect.

The national calendar may have a strong impact on some time series, such as monthly production, sales and transportation data. The number of working or trading days in a month varies, and the position of Easter changes from year to year, and all holidays are not the same in every country. Christmas can be estimated as a seasonal because it occurs at a fixed day, although the number of Christmas holidays varies from country to country.

Outliers are extraordinary events that cannot be described by an ARIMA model, see Appendix A, p. 19, and Gómez and Maravall (2001a). Since model-based adjustment minimises squared errors, outliers will bias the parameter estimates and hence also the decomposition. Outlier detection and removal is also done in X11 but again, the maximum likelihood simultaneous estimation of calendar, outlier effects and ARIMA parameters is based on sound statistical grounds, an advantage of TRAMO and REGARIMA, as compared to X11. T/S detects outliers consisting of single extreme values, level shifts and dynamic outliers, as when a strike is reflected as a peak down in a time series, but also as a higher than normal value after the strike, signifying a compensation of lost work. Another T/S dynamic outlier is the mirror image of this, if a rise in prices has been known in advance it may lead to hoarding, followed by low sales.

[5] Note that with long time series the model can be continously respecified and re-estimated by sliding through the data, thus mimicking a non-linear specification.

In many cases, large "stochastic" variance in seasonally adjusted time series can be blamed on bad preadjustment. Some users have criticised series adjusted by T/S as being "too smooth". Often the reason to this is that T/S removes calendar and outlier effects much better than other methods with poor or no outlier correction and inappropriate calendar adjustment. Another explanation is that T/S optimises the signals (trend and seasonal) and transfers as much as possible of the stochastic variance to the noise term. A reprehensible method for calendar adjustment is the "proportional method", see Figures 5.3.1 and 5.3.2 in Appendix A. The recommended method is the "regression approach", see Eurostat (2000), as in TRAMO and REGARIMA.

The ARIMA model that has been estimated together with the preadjustment can now be used for forecasting, see Section 3c. Forecasts are needed in SEATS for smoothing the end of the time series with a symmetric filter, the right leg of which must consist of forecasted values.

2c.2 Signal extraction/decomposition

Independently, A.N. Kolmogorov and N. Wiener solved the problem of extracting a deterministic signal from a stationary time series during WWII. The method was generalised to a stochastic signal by Whittle (1983). It is sufficient to know the model for the observations and the signal. The result has been extended to non-stationary time series. When applied to seasonal adjustment the model for the signal is unknown. It is specified and estimated from the observed time series by the classical ARIMA methodology, see Box & Jenkins (1970). The signal extraction is then done in two steps, see Gómez and Maravall (2001b):

- From the ARIMA model for the series, estimated in TRAMO, determine models for each of its components (trend, cycle, seasonal and irregular).
- Extract the components by applying the appropriate filters to the TRAMO-corrected time series.

The models for signals is determined by spectral decomposition, see Hillmer and Tiao (1978). This is because the signals: Trend, Cycle and Seasonal are all identified by their frequencies, hence it is natural to work in the frequency domain. Before continuing we give an example. The casual reader can skip the example.

Example: Assume that monthly data y_t are generated by the Airline Model, $(0,1,1)(0,1,1)_{12}$. By inverting the left hand side polynomial (AR-parts including differencing) of the Airline Model, we get the transfer function[6], *h(B)*:

$$y_t = \frac{(1+\theta B)(1+\Theta B^{12})}{(1-B)(1-B^{12})} e_t = \frac{(1+\theta B)(1+\Theta B^{12})}{(1-B)^2 S(B)} e_t = h(B) e_t ,$$

where e_t is white noise. The roots of the polynomials in the numerator in the transfer function between e_t and y_t are allocated to different components of the time series. The $(1 - B)^2$ is allocated to the trend-cycle and the *S(B)* is allocated to the seasonal factor. Hence if the observed series can be decomposed, three components can be distinguished,

$$y_t = \frac{MA_T(B)}{(1-B)^2} e_{T,t} + \frac{MA_S(B)}{S(B)} e_{S,t} + h_I(B) e_{I,t} ,$$

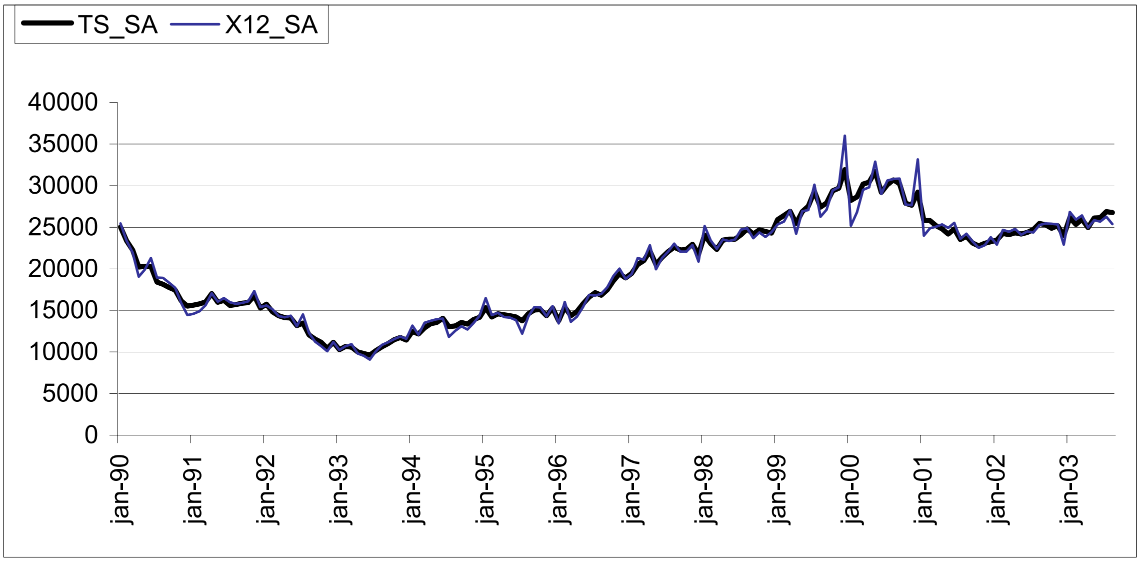
where the trend component MA_T is a second degree polynomial and the seasonal component MA_S is an eleventh degree polynomial in the lag operator *B* with coefficients depending on the parameters of the ARIMA model, and $e_{T,t}$, $e_{S,t}$ and $e_{I,t}$ are white noise. The polynomial $h_I(B)$ can be obtained residually. Note that the decomposition is not unique. In order to make it unique a canonical decomposition is performed, see Hillmer & Tiao (1982). It maximises the variance of the irregular component $e_{I,t}$, emphasising the signals in *S* and *T*. Not every ARIMA model can be decomposed. If no admissible model exists one has to resort to a close but admissible model.

[6] The transfer function describes how white noise is transformed.

Once the optimal *MA* polynomials have been found, the Wiener-Kolmogorov filter is used to extract the signals by minimising the mean square error of the trend-cycle and seasonal components. This is the decomposition method in SEATS. The difference between T/S and X12 is that X12 has only a limited choice of filters, selected according to the signal to noise ratio, while the SEATS filter adapts to data. Consequently, when the seasonality is weak or the series are noisy, seasonal adjustment with SEATS outperforms X12, see Planas (97), Hood et al. (2000) and Hood (2002), especially for longer time series. In Hood et al. (2000) it is suggested that X12 may be better for short time series.

In Figure 2.3 we see that SEATS produces a much smoother adjusted series than X12. The signal in the seasonal component is in SEATS individually maximised for this time series, whereas X12 with its general filter interprets some of those signals as belonging to the irregular component.

Figure 2.3
Seasonal adjustment of new registrations of cars in Sweden, 1990–2003/09



2c.3 Recommendations

A problem when choosing a method for seasonal adjustment is that there is no consensus quality measure. There are a lot of indicators for many dimensions of quality, but not a unique measure[7]. This makes it difficult to evaluate methods. It is hard to see which seasonally adjusted series is the best out of a collection of adjusted series, all using different methods. Also the same method can yield different adjustments depending on the choice of parameters.

In a wide sense one could say that a good decomposition is characterised by estimated components having highest density in their respective frequency bands: the trend-cycle component on the lowest frequencies, the seasonal on the seasonal frequency and its aliases, and the irregular component having its density uniformly distributed across the entire frequency spectrum. This shows the importance of having a program with rich diagnostics, including spectra. Some practical criteria for choice between methods are given in Appendix A and in Eurostat (2000). But before contemplating on choice of method one should check the test values of the hypothesis of no seasonal in the time series. This produces the rule:

Never attempt to seasonally adjust a time series that does not contain a seasonal that is statistically significant.

In a statistical sense we have seen that a model-based method, using maximum likelihood estimation, such as TRAMO, is better than an empirical method. Also the decomposition applying the minimum mean square error decomposition, as in SEATS, is better than some

[7] One suggestion for how to evaluate seasonal adjustment methods is given in Bell and Hillmer (1984).

empirical method to construct filters. Both these statements are conditional on there being data enough to use a model-based procedure.

In case the time series to be adjusted is very short, and/or very noisy, and if in particular, there are many such time series to be adjusted, T/S may not be able to do the adjustment for all series because in some there are too few observations for estimating a model. Then one should reconsider if the series should be adjusted at all.

A minimum of five years of data is required to get any decent seasonal adjustment. Shorter series should not be adjusted by SCB for general publishing.

But even a series slightly longer than five years may be difficult to handle if no adequate model can be found to describe it. Then some empirical method has to be chosen. X12 could be the next choice, but since that method also requires an ARIMA model for the forecasts, it will fail, too. One then has to resort to some cruder method. When very few observations are available one knows at the outset that the adjustment cannot be very accurate. On the other hand, it is known (see e.g. Meade, 2000) that simple empirical methods like those based on exponential smoothing lead to as good results as X11. In Miller and Williams (2003) an even better adjustment method is proposed, based on Stein shrinkage.

Another method in this case is suggested in Ruist (1963) and generalised in Öhlén (2000a) to include calendar and other regressors. The method maximises the smoothness of the Trend-Cycle component. It is shown to work quite well in examples containing six years of data in Öhlén (2000a). A minimum of two years of data is required.

The number of working/trading days in a period does not imply a directly proportional increase or decrease in the variable to be adjusted. The effect is usually smaller because some people work on holidays and some work is compensated for before or after a holiday. Hence, one should always try to construct a reliable calendar variable and estimate its regression on the reference variable. The regression will also be a check of the calendar variable constructed. Empirical tests corroborate the theoretical statement that TRAMO outperforms X12 for preadjustment and model choice. Therefore we reach the same conclusion as Eurostat in condemning quotient corrections:

Model-based preadjustment (TRAMO) and decomposition (SEATS) are recommended.

Seasonal adjustment is a complex procedure because of the interaction of different factors, choice of model, outliers and calendar effects. In order to obtain high quality of the estimated decomposition, the process should be controlled by an operator using good diagnostics, see Section 5.1 in Appendix A. The model determines the forecasts in both model-based and empirical decomposition and additionally the filters for past data in model-based adjustment. Therefore diagnostics of the assumptions, i.e. the model parameterisations, and the adequacy of the model (statistical properties of the residuals), are important. The diagnostics should include checks of the quality of the decomposition, including seasonality tests and spectral density tests.

One quality aspect is how much an adjusted figure has to be revised when more data accrue. Good forecasts imply small revisions. Hence forecasting accuracy should also be checked. How stable is the model, regarding both model structure and parameter estimates? Robustness can be tested by dropping observations or sliding the model through the data. There are also statistical tests for robustness, such as the Chow (1960) test.

When the model underlying the decomposition is updated, either the parameter values or the entire model structure is changed – all decomposed values, from beginning to end, change. Hence, there are revisions in the whole time series. That is why it is not desirable to change the model too often. To reduce such revisions, the model should be fixed for a longer period, at least a year, even if there are slight signals of inadequacy. This is also the conclusion of Eurostat. The point where a change of model becomes necessary is to some extent a question of subjective judgment. A general rule is that the risk of the model becoming inadequate is smaller the more parsimonious the parameterisation is. The number of times the models are evaluated using fresh data also has to be minimised in order to save work when many series are seasonally adjusted. If a model becomes inadequate soon after it was adopted that could signal an outlier, or that the model might have been a bad choice. The need for frequent model updating can also signal a unit root that hasn't been handled in the model.

The chosen model should be fixed for a longer period (one-two years). The specification can be re-evaluated more often, depending on available resources. The maintenance of the decomposed time series should be well established and responsibilities clearly defined.

In T/S there is a default algorithm for model choice, see Gómez and Maravall (2001a). The algorithm is efficient but not optimal in the BIC sense. For more information on model choice in the National Accounts in Sweden, see Appendix A.

The model choice problem has no general and definitive solution, because, as said, there is no objective quality measure of decomposition. Also, we know that the linear models are probably only approximations, and the assumption of mutual independence of components is often doubtful. It has been shown that the seasonal may correlate positively with the business cycle, so that e.g. the Christmas sales, a typical seasonal, are lower than usual in slump periods.

An important quality aspect for many users is aggregation consistency. There are three dimensions; vertical, temporal, and geographical. An example of a vertical aggregate is the balance of expenditures in the National Accounts. Which aggregation approach should be applied, direct or indirect seasonal adjustment (SA)?[8] For indirect SA, the SA aggregate is the sum of the SA subaggregates, so that consistency is preserved. The choice is related to data quality and the models for both the elementary series and their aggregates. If all series can be said to follow the same model, then a direct adjustment is to be preferred, because the law of large numbers reduces the variance of the aggregate as compared to its components. However, if the subaggregates have high data quality but very different dynamics, the indirect adjustment is the preferred method. For a discussion of which approach to use in different situation, see Planas and Campolongo (2000).

Still, it is not easy to decide whether indirect or direct SA should be used. There are reasons to believe that direct adjustment yields better quality than indirect. In addition to the law of large numbers, a quality improvement of the aggregate is more important than the difference in dynamics between the components. Indirect adjustment is the only possible method if one requires all sums to match for adjusted and non-adjusted National Accounts. SCB has not published adjusted accounts that preserve summation since only constant price data have been adjusted and these do not sum up, due to the deflation procedure used. The need among users of statistics of accounts that sum up is recognised, but the TF is not prepared to recommend that harmonisation of both seasonal adjustment and deflation discrepancies be corrected through constraints on the former procedure.

Direct seasonal adjustment is the recommended method but in some cases there are reasons for doing indirect adjustment.

The problem with the choice of aggregation approach (direct or indirect) is the same as with the choice of SA method: there is no universally agreed consensus quality measure. Ladiray and Mazzi (2001) contains a review of proposals for the choice of aggregation approach. At SCB the direct approach is used in the National Accounts, see section 5.10 in Appendix A.

Model based adjustment has the advantage of supplying the researcher with a battery of tests of the adequacy of the chosen model and approach. Additionally, the robustness and stability of a particular adjustment can be studied using methods such as sliding spans analysis and revision history[9]. They will reflect the quality of the SA, see Section 3.2 in Findley et al.

[8] See Section 5.10 in Appendix A, and Ladiray and Mazzi (2001).

[9] It supports the decision-making between indirect and direct SA.

(1998). The revision history shows if there is convergence from the first SA estimate to the final figure. As mentioned before large revisions are a warning signal. Sliding Span Analysis studies changes in an estimated component for different time spans.

Idempotency is a quality criterion. A SA and calender corrected series should not have seasonality and calender effects anymore. If it does there is something wrong in the SA. Spectrum estimates can be used to test for this, see Section 3.1 in Findley et al (1998). Unfortunately, stability analysis and spectrum estimates are not contained in T/S, but are rather easy to program. This is an aspect in favour of X12[10].

Every seasonally adjusted time series should be accompanied by a quality report, see Museux and Juki (2003).

Develop a model for a standard quality report on seasonally adjusted time series based on the suggestions put forward by Eurostat and ECB.

2d Software

Introduction
In Section 2c it was concluded that from a methodological point of view a model-based method is to be preferred to empirical methods. The next question is then how to implement the method. Some software has to be chosen in which the method works in a correct way. In this section we will discuss software programs that contain T/S and how well they work in the data environment of SCB.

At this point we exclude the software STAMP which has a state-space approach to decomposition. The reason for this is that it needs to be evaluated. We look forward to evaluation reports and new programs produced by bigger actors with larger resources.

A method that is implemented in a program is called a *software*; it is composed of definitions and algorithms. A program that does not include algorithms but sets parameters and creates graphs and elementary statistics is called an *interface*. To take an example, TRAMO includes outlier correction. In order to run TRAMO for outlier detection and correction, values have to be set to some parameters. The running of T/S is controlled by an interface. Even if the program itself is reliable, for the use at SCB the interface must also be reliable and practical, and this is where this project has discovered shortcomings making it hard to give unequivocal recommendations.

At the present four softwares are used at SCB:
- TS with a SAS interface,
- TS with a Excel interface,
- X11, and
- DEMETRA.

The X11 is used for the Industrial Production Index, the Retail Trade and the Labour Force Survey. T/S (SAS interface) is used for National Accounts and the T/S in DEMETRA for total monthly foreign trade in current prices. T/S (Excel interface) is used for new car registrations.

[10] It could be introduced into a proper interface of T/S.

The choice of software must be geared to the intended use. Seasonal adjustment can be used for:

- official statistics,
- temporarily published data, and
- analysis.

The main focus of SCB is on the first use. This puts some special constraints on the software.

In the production process of official statistics seasonal adjustment is the last stage before publication. This means the time for seasonal adjustment is short. One quality component of a time series is its *timeliness*. This means that the software must be reliable and user-friendly to guarantee that it will result in a net increase in quality. The software should also have versatile and reliable diagnostics that reveals low quality and supports improved decomposition.

The criteria for seasonal adjustment software can be classified according to methodological and production aspects. From a methodological point of view it should include preadjustment, model choice, ARIMA model-based seasonal adjustment and sufficient diagnostics. These points were already mentioned in Section 2c.

From the production point of view, the software should be reliable in the production system working with hundreds, if not thousands of time series, see Table 2.1. Both input and output of data should be easy to connect to the current data bases at SCB. The software product should be well documented, evaluated, compared to other methods, and accompanied by adequate support and maintenance. Mass production implies that batch processing should be possible, where input and parameters are separated. It is not possible to evaluate some software and use it in production if only a graphical interface is available. The software should include an easy interface to the database used at SCB (a Microsoft SQL server).

Right now, the available softwares are the DOS-version of T/S (TS), DEMETRA and TSWIN, the latter two are Windows programs. Interfaces have also been developed separately by the national statistical institutes in Belgium, Italy and Sweden, the last being a SAS-interface used for the National Accounts. There is also a Swedish Excel-interface.

When comparing the software products we also considered X12, despite the fact it is not model-based. The reason for that is the good diagnostics of X12 and because the US Bureau of Census is currently working on including SEATS (in DOS) into the X12 framework and on the support for the program. TS and X12 are DOS-programs. We exclude the interfaces from other national institutes because there is doubt that they can guarantee support and maintenance. The interface of DEMETRA is very user-friendly. It can be used as an analytical tool[11]. But at the present time DEMETRA does not fulfil all the requirements listed above. The main shortcomings are that there is no batch processing in DEMETRA and that it is unreliable in the SCB computer environment. When running DEMETRA it sometimes crashes and just disappears[12]. Furthermore, the well documented DOS version[13] has been changed and the amendments have been insufficiently documented. Examples of this are that something is wrong with the calendar correction and that the model specification routine has changed in an unknown way.

TSWIN is an extension of the DOS-version. It has a user-friendly interface. But the program can not be recommended because there is no guarantee of support in the future. It is now maintained by Professor Maravall of the Bank of Spain, not by a software house. Furthermore, TSWIN is not as reliable as the DOS-versions.

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[11] Demetra can be used for a small number of series, but not in massproduction.

[12] It can not easily be determined if the fault is entirely in DEMETRA or also in the SCB computer environment.

[13] See Maravall (2003) and Gómez and Maravall (1996).

The Excel interface does not support regression variables. This implies that a national calendar variable can not be included in the preadjustment phase. It can be used only in the rare occasion of few time series to be adjusted that additionally do not need a specific calendar.

The SAS interface (DOS-version) for seasonal adjustment of the Swedish National Accounts has been in use since 1999. It is reliable, but the interface is specifically designed for that particular use. It can and has been modified for other series. For general use at SCB it is not flexible enough and more diagnostics have to be added. This could be done at some cost as a temporary solution. Support and maintenance would then have to be organised within SCB, which would be unsustainable in the long run. Hence the software investment would have to pay off in a short time.

The TF planned to test the prototype program of the new X12, including SEATS but we did not receive the program before writing this report. The Bureau of Census will send a beta version to SCB for testing. The new program would be introduced in the summer of 2004.

A beneficial solution would be to try to persuade the copyright owners to transfer the software to a reliable software company that would make the algorithms available to users at a price. Then SCB would develop its own software/interface within that software at a moderate price and have full control over the method. Other national statistical offices could do the same.

At the present the best option is the SAS-interface for the Swedish National Accounts. The X12 has good documentation, batch processing and good support. It also includes REGARIMA and the regression approach to calendar correction. Since the Bureau of Census uses it, one may expect it to be very reliable. The software satisfies all criteria except that the decomposition is empirically based.

The conclusion must be that:

Right now no software can be recommended. As soon as the new version of X12, incorporating T/S, works, that will be an ideal choice, because the Bureau of Census is a guarantor for high quality, maintenance and support.

If a new and reliable version of DEMETRA is developed and the maintenance and support are transferred to a large software house, this software may be a viable option, but at the present Eurostat has no intention to do so. As it is now DEMETRA is unreliable, lacks complete documentation and batch run options.

Regardless of the choice of software, an interface will have to be built to meet the requirements of the Swedish data production system. A temporary solution is to develop the SAS-interface for T/S, taking into account the system requirements of the new version of X12.

As said in the introduction of this chapter, the choice of decomposition is to a certain extent arbitrary. Hence, the old principle should be honoured that:

When publishing a seasonally adjusted time series, or any of its components, the original series should always be published in parallel.

3 Other uses of time series analysis

3a Quality control

When a time series is seasonally adjusted using TRAMO/SEATS, TRAMO identifies and estimates any outlier. This property of the program can be used as a device for quality control. An outlier can either be a reflection of some real event (a strike, the effect of some political action, etc.), or it can be a data error. The program calls the attention of the analyser to this observation, and it is his/her understanding of the data that decides which one it is.

For years TRAMO has been used at SCB for quality control of National Accounts and Industrial Production. T/S includes a supplement called TERROR, see Caporello et al. (1996)[14]. This program is a variant of TRAMO that has been adapted to simultaneous quality control of large data masses.

TRAMO, or its special variant TERROR, should routinely be used for quality control. Outliers detected by TRAMO (or TERROR) may be errors and should be investigated.

3b Imputation

The project has experimented with another application of time series analysis: imputation of missing data from some respondent in a situation where a preliminary figure has to be published without delay.

The presence of non-response is a source of inaccuracy in surveys that is hard to handle and has been a matter of concern for decades. Inaccurate imputations result in inaccurate preliminary figures and large revisions, a serious problem at SCB, see Öller and Hansson (2002).

There are several methods for dealing with missing values. Conventional methods may be using available information inefficiently. Those based on expert opinion lack both objectivity and transparency. The project has studied the application of forecasts using ARIMA, transfer function models, TRAMO with Regression and a simple variant of the temporal-spatial approach called *Trend Imputation*. They are data-efficient, objective and transparent.

In statistical mass production, neither time nor skills are always at hand. That may be why time series methods are not as commonly used, but for some years now, a few statistical agencies have applied ARIMA-forecasting for imputations, notably Statistics Netherlands, see van Laanen and Stam (2003). These applications use the program REGARIMA to handle outliers and calendar effects, whereas the project used the more efficient TRAMO program.

The study shows that using temporal and spatial information simultaneously could pay off, even in short time series. In a majority of cases, where the TRAMO with Regression imputation gave the best results, the mean of the variable was above the mean of the sample. This is interesting because it is more important to get good imputation values for the observations contributing the most to the changes. These time series can also be expected to have a higher signal-to-noise ratio, due to the law of large numbers.

It is recommended that for small companies with short and noisy time series Trend Imputation is used, and for larger companies, TRAMO with Regression. The former requires little effort; the latter can be done in automatic mode, in which case it is a fast method.

3c Estimated components, forecasts and quality reports

As mentioned above a seasonal adjustment program like T/S, has a much larger output than just a seasonally adjusted series. Today, in many cases the adjusted series is the only part of the output that is published.

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[14] TERROR was presented at SCB in a seminar held by Professor Maravall on 3 October 2003.

The first question to be asked is if the *seasonally adjusted series* is the most interesting series for analysts to monitor? It is composed of the trend-cycle[15] component, the irregular component and the outliers. Now, the irregular component of an adequate time series model is by definition that part of the series that contains no other information than its zero expected value, its variance and its supposedly normal distribution, determined by these two parameters. This component should be of little interest to an average analyst. The outliers can be important to identify and could be mentioned and explained in the text, but should they be allowed to appear in the series being analysed, where presumably the present stage of the business cycle and perhaps the trend are of primary interest?

It is suggested that Statistics Sweden systematically publishes the estimated trend-cycle component, possibly also both separately, together with the seasonally adjusted series.

What about the irregular component that does not contain any predictable information? For that very reason it may also be interesting, if not necessarily to the public at large, but it should be worth recording for further research. After all, the irregular component can be interpreted as the exogenous shocks hitting that variable and in fact driving the whole process.

As side products of seasonal adjustment one obtains the forecasts generated by the ARIMA model used for decomposing the series. Analysts and forecasters have overlooked their importance. But note that their interest is focussed on the last seasonally adjusted observations, and these depend on forecasts, more so the closer to the end one comes. Not knowing how the model sees the near future can lead to serious misinterpretation of the last figures. An obvious inconsistency between adjusted observations and forecasts results if the analyst's forecast deviates considerably from the model forecast. Consistency between seasonally adjusted figures and the analyst's forecasts can be achieved by substituting the latter into the TRAMO/SEATS estimation.

Another important use of the TRAMO/SEATS forecast is as a benchmark in forecast accuracy assessments. Agencies that publish forecasts of the macroeconomy from time to time check their accuracy (or at least they should). Commonly used benchmarks are naïve forecasts, such as growth the period before, or average growth. The reasoning is that a forecast is worthless if it can not beat the forward projection of an observed figure, or an average of historical figures, for which no forecasting agency is needed. Following that thought, a forecasting agency should also be able to beat a simple ARIMA-model that can be estimated automatically by the T/S program. Such comparisons have been done and they have shown that ARIMA is not so easy to beat .

It is suggested that Statistics Sweden systematically saves both the estimated irregular component of a time series that has been seasonally adjusted and the forecasts. They can be made available to researchers and analysts on request, or published, if that is regarded appropriate.

Model forecasts should also be included in the quality report suggested in Section 2c.

[15] Note that the trend-cycle component still contains a random component, although minimised by the canonical decomposition.

4 Long Time Series

4a Introduction

Statistics Sweden has recorded some variables for a considerable time. As a result a few long time series are posted on its website. Sweden has the longest unbroken population time series starting in 1749. Unfortunately, for many time series the homogeneity of the observations has not always been preserved during the entire period the statistics cover, because of repeated changes of methods of calculation, definitions, classifications, accounting principles and administrative register changes. Such changes may cause breaks in the time series, making comparisons between data before and after the break questionable, i.e. breaks jeopardise the very point of maintaining long time series.

This raises the question of how to construct, or rather reconstruct a time series that has undergone changes over time so that it would still retain some interesting features? Early Swedish examples of how long time series can be built are Bagge (1935) for wages, prices and salaries, Lindahl (1937) for National Income and Myrdal (1933) for the cost of living, covering the years 1861–1930. Some of the time series have been updated in Hassler et al. (1994), and analyzed in Skalin and Teräsvirta (1999).

A recent example of a change in classification is the new industrial code SNI92, which in 1995 replaced SNI69. The industrial classification was harmonised with the EU-standard NACE rev. 1. The new classification adapted to changes in the economy, e.g. in industry, where the changes in services were the most important. This improved the accuracy of the statistics and increased comparability with other countries. But it came at a price: a decrease in comparability with older data.

The report "Development and Improvement of Economic Statistics" (SOU 2002:18) contains a statement that SCB has a rather low supply of long time series compared to many other countries. Among those interviewed in the report, many would like to see more long time series. The recent study on new features in the Swedish economy (SCB (2004)) meets obstacles because the time series often are too short to provide evidence for or against the hypothesis of a structural change in the 90s.

From a methodological point of view there are two different problems, one *ex ante*, the other *ex post*. The first is backward linking, i.e. linking non-homogenous pieces into one fairly homogenous long time series. The second problem is to prepare in advance for known future changes in a time series, so as to make the transition as smooth as possible. Two examples of forthcoming changes are: the change in the Labour Force Survey in 2005 and the new industrial classification SNI2007, replacing the current classification SNI2002.

Working a time series backward in time according to a new system, reclassifying the microdata and recalculating according to new rules is costly and not always even possible. There are simpler and less expensive methods that sometimes are acceptable. However, even when simpler methods are used, closer knowledge about the time series is important.

When linking a time series backward the purpose of creating a long time series is important for the choice of linking method. When an economic historian links a time series backward in order to test a hypothesis, he/she chooses a linking method that does not interfere with the hypothesis to be tested in the data. On the other hand, the public at large may have less rigorous standards, but then the requirements may vary from one person to another. SCB's ambition should be to serve the general public using transparent, current best methods for producing a long time series that is published as SCB's time series, also providing the facts needed to apply other methods. SCB can not be required to act as a research department itself, except if special external funds are provided for this purpose. Historical time series, the homogeneity of which can be doubted, should be published in such a way that their status as inofficial constructs becomes clear to the user.

When creating a long time series for a variable, apart from the quality aspect, the following properties of the series should be considered:
- frequency,
- length, and
- aggregation level.

4b Long time series: availability and demand

A time series can be divided into three classes, according to its length:

- short, 5–15 years
- long, 15–40 years, and
- historical, longer than 40 years.

Before backward linking the need for ”long” or even “historical” series must be examined. Higher aggregates like GDP and its main components, Industrial Production, CPI, Unemployment, Population, etc. reflect the general development of the country in quantitative terms. Maintaining long time series of such data can be regarded as a national duty of SCB. Potential users are journalists, economic historians and econometricians. Any attempt to statistically estimate a model requires sufficiently long time series, for close examples, see Sections 5c and 5d. Even such a commonly asked processing as seasonal adjustment requires an absolute minimum of five years of uninterrupted data points.

Disaggregating heavy aggregates, like those mentioned above, the demand moves from the general public towards special interest groups. At the same time the responsibility for financing moves from central government towards those special groups. Naturally, the raw data should be kept available for others to investigate and for commissioned work.

Economic analysts and forecasters pay great attention to monitoring and forecasting the business cycle. Turning points between expansions and recessions, or vice versa are of particular importance. The full length of a business cycle is 3–6 years. Estimation of a turning point indicator requires data on at least a few cycles, i.e. a time series of a minimum of 20 years. Econometric models also need long data spans. The observation frequency depends on the horizon of the model. Medium and long term models, are often based on annual data, while the Turning Point Indicator (see Koskinen and Öller (2004)) of the Institute uses 30 years of quarterly data, as does the Leading Indicator of SCB (see Öller and Tallbom (1996)). The Leading Flash Indicators suggested in Section 5d and the Monthly Leading Indicator in Appendix E compensate the short time span by high frequency (monthly data) and a model that is essentially pre-specified in a longer time span of quarterly data. An econometric model requires more disaggregated data than pure leading indicators for the general business cycle, and in structural studies much of the message may be in the details. For some environmental and population studies even lower frequency than one year may be feasible, as long as the aggregation level is adequate for the purpose of the model.

SCB publishes the following long annual time series:
- Gross Domestic Product, 1950–,
- Retail Trade, 1956–,
- Industrial Production Index (also available as monthly), 1913– ,
- Foreign Trade (also available as monthly), 1913–,
- CPI, 1830–,
- Population, 1749–,
- Election statistics, 1929–,
- Registered passenger cars, 1923–, and
- Population by county, every five years, 1805–.

Quarterly GDP and Household Consumption Expenditures by durability start in 1980. For the labour market many time series start in 1976 and are both detailed and have high frequency. Other time series for the labour market start in 1987, because of the introduction of the industrial classification SNI92, see SCB (1998) and Hanaeus (1998). Most published time series are short, many start in 1990.

A less obvious reason for publishing long time series is that they may make SCB's statistics more appealing. High production costs are assumed to be the main reason to the too small number of published historical time series. Another may be that often it does not make sense to continue a time series too long back in time. Nobody would come upon the thought of extending an IT series back to 1920. For the same reason the time series on many items on a disaggregated level in foreign trade or manufacturing cannot be extended far back in time, although the meaning of the total of exports or imports, or industrial production is the same, see Appendices C and D. A third reason may be that the availability of long time series has been assigned low priority because of reasons mentioned in the Chapter 1.

4c Reasons for breaks in time series

Breaks in time series occur for various reasons, often specific to the time series in question, but sometimes there are common features. Some of the most common reasons are changes in: classification, method, regulations, laws, administrative registers and data availability. Here are some examples:

(i) As mentioned above, the reason why many labour market time series start in 1987 is the transition to SNI92. The official series on Industrial Production starts even later, in 1990, see Section 4d for the linking method used to link it back to 1913. SNI92 was a major revision while generally recurring smaller alterations, like SNI2002, do not cause breaks that cannot be bridged. By introducing SNI92, Sweden changed its traditional domestic classification to an international standard. Many time series were strongly affected by the change, which can be palpably evinced in the data bases. It would not make much sense to project such series backward using the ratio method.

(ii) A new questionnaire for the Labour Force Survey was introduced in 1987. It was planned that double questionnaires would be used during a transitory period of two years. For economic reasons the transition had to be interrupted after one year. Because of the system of rotating panels, a smooth transition would have required two years and the interruption caused an irreparable break (this is called the 'RIDA Break'). During the years 1992–1993 the distribution of sampling weeks was changed, leading to a break in the time series. Also, the definition of unemployment was changed according to an ILO recommendation, as was the calibration for non-response.

(iii) Breaks may arise because of changes in sampling technique. Just changing the sample size affects the variance of the time series, making it heteroscedastic.

(iv) The National Accounts experienced a break when the old SNA68 was substituted for ENS95 (SNA93)[16] in 1993.

Some time series have been intermittent in certain periods. Observations can be missing for one or more points in time, or the series has been measured on a lower frequency, such as quarterly, instead of monthly. An example of an interrupted and irreparable series is "Transports with Swedish Lorries". This series is measured quarterly until 1987, then data from the years 1988, 1989, 1991 and 1992 are completely missing. Cases like this should be avoided by all means.

[16] European National Accounts System 1995 (System of National Accounts 1993).

4d Methods

The methods for linking pieces of time series are not well developped, at least the project hasn't been able to find much literature on this matter; the only linking method mentioned is the ratio method. That takes the ratio of two parallel measurements (one in the old, the other in the new system) and multiplies the old series by this ratio. It should be noted that the ratio method works only if no radical changes have occurred in the variable.

Some fundamental considerations must be made before introducing a new classification or method so as to minimise the effect of the break. The first thing to do is to estimate the magnitude of the change. Have similar breaks occurred before? Imbedded experiments should be done ahead of the change. If there is a risk that a break may occur, parallel measurements in the old and the new way should be made during a sufficiently long period. Any large change should alert the statistician to check the calibration of weights.

In order to be able to discriminate between changes in methods and real changes in the variable being measured, statistical tests of regime shifts can be used. This can be done in several ways, one being testing the distributions of observations before and after the break, e.g. a Kolmogoroff-Smirnov test. The time series program TRAMO (see Chapters 2–3) contains break tests.

An example of linking is the Labour Force Survey 1987–92, see SCB (1998). Some key series were linked. Calibration was made on the level of individuals. This made the series consistent in the sense that the sum of hours worked across sectors became equal to the sum of hours worked across age brackets. The linking to SNI92 was achieved by recoding each individual according to SNI92 for the entire period 1987–1992.

When SNI92 was introduced the ratio method was not adequate for the sectors where large changes had occurred. At the end of 1993 the Business Database was double-coded in SNI69 and SNI92. Recalculations in the new system were made back to 1990. Wherever possible, enterprises were recoded. Data on Production of Commodities and Industrial Services were used to reclassify enterprises in SNA92 code back to 1990. Smaller companies were reclassified using a special transition matrix that was constructed during the double-coding period in 1993.

The above method requires considerable resources. Despite high costs, the SNI92 estimates may be poor for some sectors, because the sampling frame was optimised for SNI69.

When SNI92 was introduced translation keys between the old and the new nomenclatures were published. Here is an example of the impact of a big change. In SNI92 there is a main group, nr. 28 called "Industry for fabricated metal products except machinery and equipment". The sector employed 76 000 persons at New Year 1993/94. The closest sector in SNI69 (code 381) is "Industry for metal products". This sector had at that time 101 000 employed!

Table 4.1 shows how the SNI92/28 sector could be translated to SNI69/381. Note that Group SNI92/28 is composed of parts of a large number of SNI69 sectors on the finest level of disaggregation (5-digit)!

Table 4.1
Shares of various sectors in the total, SNI69 vs. SNI92

SNI 69	Employed	Share of SNI69 sector that moved to SNI92/28	Share in receiving SNI92/28 sector
37103 Iron and steel foundries	1 900	58.6%	1.4%
37204 Non-ferrous metal foundries	1 800	84.1 %	2.0 %
38110 Industry for cutting/shaping hand tools	8 100	97.3 %	10.3 %
38120 Industry for metal furniture and fixtures	5 200	10.3 %	0.7 %
38130 Industry for metal structures, containers and boilers	18 500	96.2 %	23.1 %
38191 Industry for metal packaging	1 300	8.6 %	1.7 %
38192 Industry for wire, wire netting and cables	1 600	48.4 %	1.0 %
38193 Industry for nails, screws, bolts and nuts	1 700	100.0 %	2.3 %
38194 Industry for other metal products for construction purposes	8 700	42.0 %	4.8 %
38195 Industry for cutlery and other household metal wares	1 000	79.3 %	0.9 %
38199 Industry for other metal products	45 000	76.9 %	45.1 %
38231 Industry for metal-working machinery	4 350	20.5 %	1.2 %
39090 Manufacturing industry not elsewhere classified	5 600	56.7 %	4.2 %

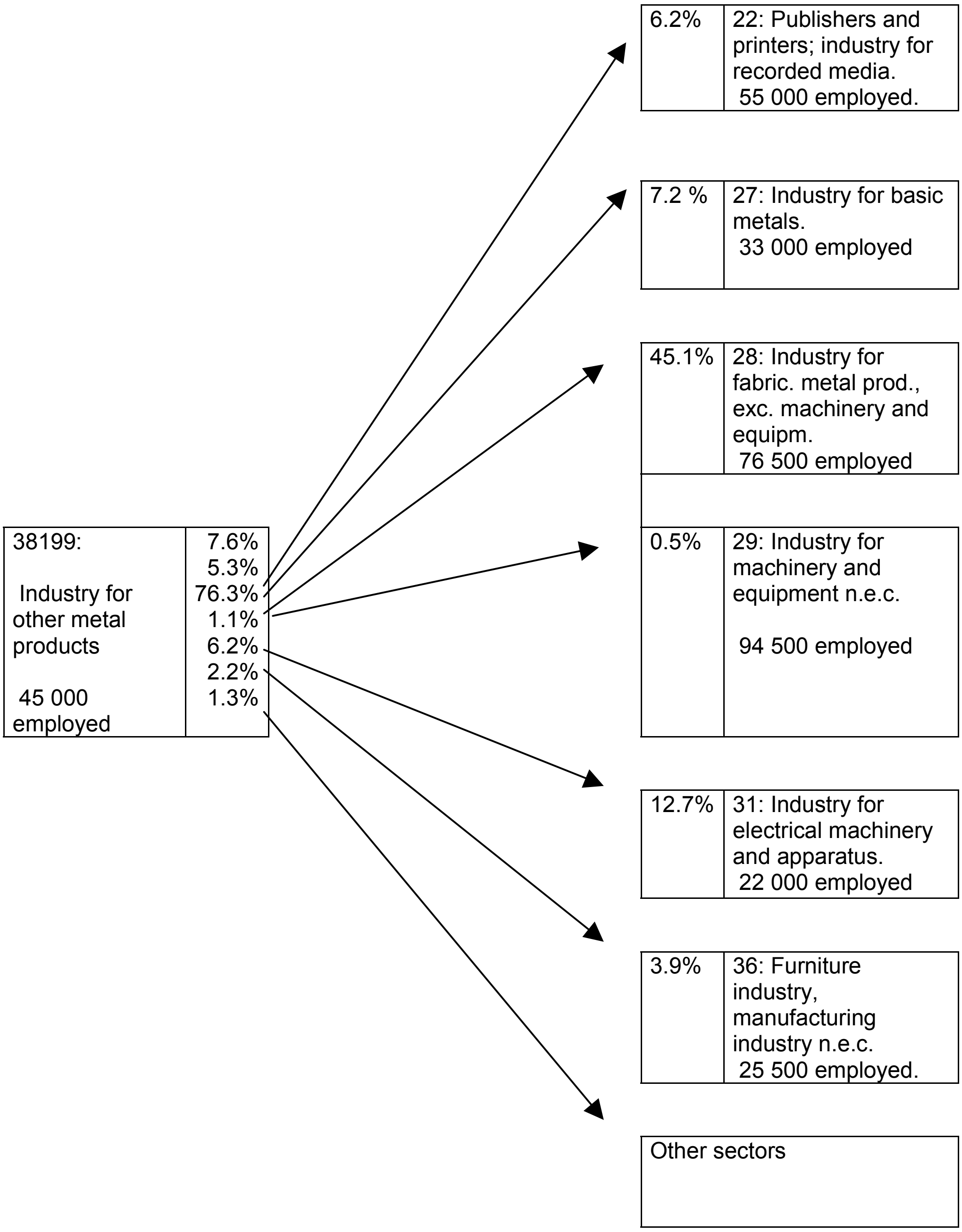
Assume that one wants to link the series of a sector total, value added, investments, etc. The sector must be well defined in terms of SNI69. A method that could work is to make linear combinations of the series of parts of the SNI69 classes in Table 4.1, using the shares in the middle column. This is a very simple method – maybe too simple – to construct a long time series. And yet, it would require a considerable amount of work because one would have to go all the way down to the 5-digit level in SNI69. Probably there is no statistics on this fine level for a majority of sectors; especially short term data are missing. Where data are missing the reclassification would have to be performed on microdata. The cost for doing that depends on what the microdata look like. Costs can be expected to be high, or prohibitively high.

The weights in the central column in Table 4.1 have two disadvantages. First, they reflect the share of employed. This may not be a good weight for e.g. investments. The second disadvantage is even more serious. Could these shares be expected to stay constant over a longer time-span? There have been large structural changes in production in Sweden. An important use of long time series is to uncover such changes over time. Weights fixed at the year of break could then produce seriously misleading results.

Figure 4.1 shows what could happen in a sector. In the class SNI69/38199 there were 45 000 employees (see Table 4.1). Out of these, 23% were not moved over to SNI92/28. In fact, several 2-digit SNI92 sectors received employees from SNI69/ 38199. Figure 4.1 shows that 7.6 % of the 45 000 persons employed in SNI69/38199 moved to SNI92/22 (graphical production), were their share was 6.2%. SNI92/27 (steal and metal works) received 5.3% of the employees in SNI69/38199, but their share in the new sector was 7.2%, etc.

It proved difficult to continue the series backward in time even on sector totals on the 2 digit level, and of course it was even worse on more disaggregated levels. The entire primary statistics of SCB was calculated back to 1990, a very cumbersome and costly task, not always leading to results that would stand the quality tests of SCB. On the highest aggregation levels the situation is much better, because the breaks were small, so that even the ratio method would give satisfactory results.

Figure 4.1
Transfers from classes in SNI69 to classes in SN92



The linking backward of SNI92 could be done only for five years. There will always be narrow limits for how far it is sensible to link a series using reclassification. After that some simpler method may be feasible, depending on how much structural change there is in the time series. Where model assumptions have to be made these have to be clearly stated, and if possible their effects should be checked[17].

Backward linking can produce serious errors. In Hanaeus (1998) there is a warning example. The number of employees in a sector was reclassified according to SNI92 for the period 1985–1994 and compared to the old SNI69 figures. The difference between the two variables was ignorable for the period 1991–1994, but for the period 1985–1990 there is a divergence of the two variables; the reclassified variable overestimates the persons employed, because at the turn of the decade the number of misclassified persons suddenly starts to increase, and continues to do so the more backward in time one moves. If the parallel results for 1985–

[17] See the quality report SCB (2001).

1990 had not been known and the ratio method had been blindly applied on the older data, a serious bias would have been introduced. The conclusion is that even the ratio method requires closer knowledge about the time series, implying that data be well documented, inlcluding methods applied and assumptions made, if the series has been linked.

4e Conclusions

It is important to recognise the temporal dimension when producing statistics. Breaks in time series should be minimised ex ante. Long time series should be maintained – within reasonable cost limits. When changes are made a wrong decision can produce a break that is irreparable.

When changes are of less importance for the purpose of the time series, the ratio method is swift and simple. It is particularly well suited for heavy aggregates.

The method of ex post reclassification of microdata is costly, and hence should be avoided.

Long time series make sense only as long as the variable is defined more or less in the same way for its entire length. This may depend on what the time series is used for. Even the simplest ratio-linking thus requires closer knowledge about the time series.

SCB can only maintain and publish long time series of a general interest, while special interest groups should finance more detailed long time series.

Regardless of the effort put into linking time series, missing information reduces quality. The conclusion is that constructed long time series have lower quality than recent series of shorter length. Hence, in publications, a distinction should be made between recent official data and long constructed time series.

It is suggested that more long time series be added to the homepage under the heading "Historical Statistics". An entirely new data set could be introduced containing historical statistics of all sorts: demographical, social, economic, environmental, etc.

Construction of long time series should be commissioned to external experts.

Preparations for changes in classification, method, coverage, etc. should be started years before the change so as to make the break as smooth possible. Parallel measurements should be made for a sufficiently long period. The old method can be phased out gradually, keeping in mind, and announcing to users, that only the new data are official. The minimum is one parallel measurement so that the ratio method can be applied. Linear regression can be used if more parallel measurements are provided.

Start a working group for preparing the transition to the standard SNI2007. Its main objective is to find methods for linking the new standard to the old.

In addition to the suggestions given above it is hard to find general rules or methods that could be recommended. What to do when a time series has breaks depends on to what purpose the long time series is going to be used, and on the funds available.

5 Leading Indicators and flash estimates

5a The background

A parallel project "Speeding up the Statistics" was to develop flash-estimates for important Swedish economic variables. The Time Series Project was to deliver technical support. The application for resources to further develop the *Activity Index*, published for a few years by SCB, into a new flash estimator was not granted. Consequently, not much has been accomplished in this area.

The Activity Index is a kind of flash indicator estimated from quarterly GDP data and monthly data on Industrial Production, the Retail Trade Index, Employment, Exports and Imports. A regression model is estimated for quarterly GDP, where the above monthly series are aggregated into quarterly data. A transformation calibrates the monthly observations to quarterly ones. Autoregression in residuals is used to improve the Activity Index. The Index is reported in "SCB-Indikatorer". According to Eurostat experts the Swedish Acticity Index can be regarded as a flash indicator. Its average error seems to be much smaller than those of flash estimates in some other EU countries.

The Eurostat experts also suggested that SCB should rather extend the early second quarter fast estimates to cover the entire year than develop the kind of indicators suggested in Section 5d. There is very little documentation of how the second quarter fast estimates are calculated, and even less on how accurate they have been. The leading flash estimates suggested in Section 5d, on the other hand, are statistically controlled and transparent indicators, with a lead and inbuilt turning point warning. Hence, the fast estimates cannot be a viable alternative to the indicators suggested in Section 5d.

5b The Leading Indicators of Statistics Sweden

In April 2003 SCB took over the Leading Indicators of Industrial Production that have been published by the National Institute of Economic Research since 1994. They are now published in the monthly report "SCB Indikatorer", in the quarterly series (in Swedish) "Sveriges ekonomi" and on the SCB website.

The indicators are generated by a Kalman-filter and use the series of quarterly value added in manufacturing (SNI 15–37) as the reference variable and Business Tendency Survey data as leading information. Initially the model was used for many more variables, reported in Öller and Tallbom (1996). Two early indicators are generated, one for the quarter following the last one for which statistics exist and one for the next quarter. The former is called the "Coincident Indicator", the latter the "Forward Looking Indicator". They use a smoothing filter to avoid wrong signals and have a mechanism that switches off the smoothing when a strong signal occurs. This is also a turning point warning (down), as is the opposite (up), when smoothing is switched on again. A contraction is defined as four successive quarters of annual decline. The model has proved very robust over time. No wrong turning point signals have been issued and the latest alarm of a turning point was correctly given in the first quarter of 2001 and a signal "up" a year later.

5c Flash-estimators of the EU

The two projects mentioned in paragraph 5a were represented at a meeting in Brussels 28 March 2003, where the EU project "Busy and Flash" was on the agenda. The aim of this project is to report on methods that can be used for business cycle indicators and flash-estimates, and, if necessary, to construct easy-to-use programs for this purpose and to distribute such programs to the member countries. The ultimate goal is to be able to publish flash estimates, as early as those of the USA. Flash estimates for Euroland and EU should be available within 45 days after the quarter has expired. The Flash-software uses regression methods for short time series (10 years) and advanced time series methods for longer time series[18]. The Busy-project focuses on turning points in the business cycle, mainly *ex post* dating but also forecasting turning points, see Section 5d. The purpose is to introduce a similar system of turning point dating in Europe as the one that NBER[19] maintains for USA. Another topic of the project is to provide tools for measuring the convergence of national business cycles in Euroland. If convergence occurs this would simplify the monetary policy of ECB. The largest principal component is taken to represent the joint European business cycle and the deviation between this and the individual national business cycles is used to measure convergence.

Flash estimates are available for Germany, Great Britain, Italy and the USA. The Flash project is of interest to SCB, whereas the Busy-project clearly lies outside our sphere of interest.

5d Developing a new Leading Flash-Estimator

The robustness of the Kalman-model described in Paragraph 5b inspired a joint project with Stockholm University on constructing a *monthly* leading indicator using the same model. This has now resulted in a report, see Appendix E. The quarterly manufacturing series is proxied by the monthly Industrial Production Index (IPI), available for the period 1913–2003, also see Appendix B. Since 1996 a monthly BusinessTendency Survey (BTS) has been conducted according to EU rules. The Kalman-model produces a coincident and a leading indicator for the month following the last IPI-observation and one for the next month, respectively. The main difference between the quarterly and the monthly indicators is that in the latter case the switch is only used as a turning point signal but the smoothing has to be kept on, because of more noise in the monthly than in the quarterly time series.

The monthly indicators are earlier and more flexible than the quarterly indicators, producing a signal every month, instead of every three months. This raises the question if monthly IPI data and the monthly and the quarterly leading indicators could be combined into a *Leading Flash Estimator?* All three components are now available, but how to combine them? The following blueprint will clarify how it would work. A more casual reader can skip the following passage.

The easiest way to see how this could be accomplished in practice is to work oneself through the first three months of a year, starting at the end of **January**. Preliminary outcome data available at that time are the following: Quarterly Manufacturing (SNA 58–37) for the 3rd quarter and monthly IPI for October and November. Quarterly and monthly BTS-data are published one of the last days of January. The quarterly leading indicators can now be computed, i.e. the coincident indicator for the 4th quarter of year t -1 and the forward looking for the 1st quarter of year t. The monthly Kalman-model generates a coincident value for December t -1 and a forward looking one for January, year t. We now have two IPI outcomes from the 4th quarter and a coincident indicator value for December. The sum of these three monthly figures calibrated to the Manufacturing series, combined with the coincident quarterly indicator should be a good flash estimate of the 4th quarter. The forward looking monthly indicator is probably a less accurate estimate than the quarterly analogue for the entire 1st quarter of year t.

Now move to the end of **February** year t. Monthly IPI data are available for the entire 4th quarter of year t –1. To obtain a flash estimate one only needs to calibrate IPI through regression to quarterly Manufacturing of SNA. This is probably closer to the ultimate outcome than the flash estimated a month earlier and could be substituted into the quarterly Kalman-model to get a new forward-looking estimate of the 1st quarter of year t. A competitor is now the monthly coincident indicator of January and the forward-looking one for February, transformed into a quarterly value. A combination of these two estimates should be at least

[18] For methods of temporal disaggregation, see Chow and Lin (1971) and Guerrero (2003).

[19] National Bureau of Economic Research. In USA the *ex post* dating of turning points is done judgementally.

as accurate as the forward-looking quarterly indicator calculated on data available one month earlier.

At the end of **March** preliminary National Accounts data have been published for the 4th quarter of year $t-1$ and no flash is needed for that quarter anymore. This figure can be used as the jump-off value for the forward looking quarterly indicator to produce an estimate that should be more accurate than the analogous figures obtained one and two months earlier. However, the forward-looking information in the BTS-data is now three months old. Here the monthly data may be of the greatest help. The outcome of monthly IPI is available for January, and the monthly indicators cover both February (coincident) and March (forward-looking). A weighted average of this estimate and the one based on the quarterly model should provide a more accurate flash estimate than the ones published one and two months before. At the end of April new both quarterly and monthly BTS data are published and the process starts all over again.

Work is in progress to incorporate all these features into a single model that at the end of each month would produce a flash estimate of Manufacturing. However, most people would like to see a flash estimate of GDP, not just of one of its components. That could be accomplished by building similar models for other important components of GDP, much as the Activity Index in Paragraph 5a is constructed. The next variable to be modelled is Exports. An analogous quarterly Kalman model for exports was reported in Öller and Tallbom (1996), and would just have to be re-estimated. For exports, too, the necessary BTS data exist both in the quarterly and in the monthly survey, so the model for Manufacturing should be replicable on Exports data.

A third variable on which to replicate the Manufacturing models is Private Consumption, using as early data the Survey of Households (HIP). The monthly analogue in this case is Retail Trade. The HIP survey is available as a monthly series since 1996. Now, given these three important elements of GDP, albeit from different parts of the accounts, regression with quarterly GDP as the left hand side variable would produce a flash estimator of GDP. This Leading Flash Indicator would have three advantages as compared to conventional flash estimates, like SCB's Activity Index mentioned in Section 5a:

1) The estimator is updated every month, but it is much earlier than estimators using only outcome figures, since it has amalgamated leading indicators and preliminary monthly outcome figures.

2) While conventional flash estimators produce just one estimate viz. for GDP, this model produces estimates of four variables: GDP, Manufacturing, Exports and Private Consumption.

3) No flash estimators, to our knowledge, contain turning point warnings. Here you may be able to get them for all four variables.

6 Organisation

6a General background

The organisational structure at SCB is, with few exceptions, based on units that independently produce the statistics they have specialised in, from data collection to publishing. This makes the unit feel responsible for the quality of every step in the production chain. According to this model, time series analysis applications have been conducted within the units producing the data. Those who have been responsible have in some cases had very little knowledge of time series analysis. Different seasonal adjustment methods have been used, frequently empirical methods like X-11 and X-11 ARIMA. In the Department of Economic Statistics expertise in time series analysis has been available, although on a very small scale, so that T/S could be introduced for the National Accounts already in 1999. The great variety of methods and competence is one of the problems the TF has been asked to solve.

The TF cannot recommend a continuation of this scattered way of working, if seasonal adjustment is to be conducted using T/S, as recommended by Eurostat. The same applies to other time series methods requiring expert competence. The risk is too great that mechanical applications will produce misleading results. Worse still, if such results are published the person in charge may not be able to explain why the figures have raised suspicion[20].

A solution could then be to stick to the old organisation but to appoint time series experts at each unit where short term data are produced. But this would hardly guarantee that the same Current Best Method is used in all units, to produce seasonally adjusted data satisfying the same quality standards. More important, this would be an expensive solution. The experts would be isolated at their units and there would be no guarantee for synergy effects from close contacts. This could lead to large turnover of experts, probably also to wage competition between units.

6b The preferred organisation of time series work

The best alternative is to:

Start a new unit (Swedish "funktion"), responsible for all time series applications of Statistics Sweden. Highly competent persons would be concentrated to this joint unit, at a reasonable cost and optimising the synergy effect.

An independent unit is better suited to recruit competent persons, while in a scattered organisation recruiting may be done by persons with no ability to assess the time series competence of an applicant and the importance of the subject. Time series analysis is an area of rapid development in an entirely international environment. A scattered organisation encounters difficulties in staying up to date, not to mention own contributions to the development of new improved methods. This could lead back to the situation for which a remedy was to be found, i.e. varying quality in applications and backwardness in introducing new methods.

The centralised alternative would not deprive the data-producing units of their responsibility for data quality, as long as this concerns the raw data. *The Time Series Unit* would be entirely responsible only for the processed data, most often the seasonally adjusted figures. Furthermore, a close co-operation is needed between the Time Series Unit and the data production expert. The use of TRAMO/SEATS for quality control requires knowledge about fundaments of the time series so one could tell if an outlier is an error, or due to some special event, see Section 3a.

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[20] Examples of poor decomposition of T/S, when run in default mode, can be found in Figure 33 of Appendix C, where a change in the seasonal pattern has been identified as an outlier, and in Diagrams 5 and 6 in Appendix D, where the trend component has been contaminated by the cyclical component.

It is possible that, in some cases, the time series work could flexibly be divided between the central unit and the unit producing the data, according to the competence available in the latter unit. The TF has been working hard on spreading knowledge of time series techniques at SCB and this may have had some effect.

The new unit would be composed of a Head of Unit, a Deputy Head and four officials. Three officials would mainly work on seasonal adjustment, quality control and imputations. The duty of the fourth official would be essentially to develop and maintain the combination of leading indicators and flash estimates mentioned in Paragraph 5d. The two directors would lead the work, carry the responsibility for all work done at the unit, recruit staff, actively and with own contributions participate in the international co-operation to find better methods for the time series applications of SCB, and to increase the know-how, both internally and externally, of Current Best Methods in this area.

During the year 2004 the centralised unit would start taking over the seasonal adjustment that is now done locally. Before mass production can start the DOS-based version of T/S that is being developed at the US Bureau of Census has to be introduced. A prototype version will hopefully be in use at SCB before long, and a finished product will be available, according to plans, in June 2004. The software now available is not reliable enough to be recommended for general use. Some system (interface) work has to be done before the US program works in a reliable way in the SCB environment (for more details, see Section 2d). The Time Series Unit would provide help in establishing The Bank of Historical Time Series, see Section 4e.

The table gives crude estimates of costs:

Table 2
Estimated costs of a separate Time Series Unit 2004, 1000 SEK

Head	Deputy	Off. 1	Off. 2	Off. 3	Off. 4	**Wage Costs**	Travel	System	**Total**
590	510	430	430	410	410	**2.780**	120	250	**3.150**

Costs are estimates, gross. The Time Series Project has cost 1.590 tSEK during 2003, and when merged into the work of the unit lowers the costs of the new unit to 1.560 tSEK. Add to this costs that have been covered by the units of some members of the task force, the amount of which could well be 50 % of the above costs. When all seasonal adjustment is moved to the new unit, work and thus money is saved in other parts of SCB, how much is hard to say. Rationalisations when experts work with the data will also occur. Most important, this would be *a major increase in the quality* of seasonal adjustment.

The unit will not be able to work full scale from the start of the year; recruitment takes time and the system work could require up to six months work, all this would reduce costs in the start. Furthermore, this is an area where there is some external demand for assistance, both locally and internationally. An indication of this is the large attendance at the seminars that the TF organised and the interest EU has shown. This could result in commissions that would bring in money.

Hence, net costs would be considerably lower than the sum in the table, but how much lower is hard to say at this stage. It is possible that SCB's total costs for time series work would not rise at all, while quality would improve.

6c A Time Series Council

An alternative that would not change the present organisation and that would cost the same, net and gross, as The Time Series Project during 2003, is to establish a Time Series Council that would have as members those who worked in the project in 2003, with some compensation for those who left the TF. The duties of this council would be to implement some of the suggestions that the project has put forward. However, this could only be a temporary solution, not much improving on the present situation, which is unsustainable.

The Council would provide support to those who apply seasonal adjustment to introduce model-based methods (T/S), but neither the council, nor its members would carry responsibility for the published data, internally or externally. The support would comprise other uses of T/S, such as imputations and quality control. In particular, assistance would be offered to those who participated in the courses arranged by the TF. A repetition of the popular one day course on 2003–09–11 could be arranged, as well as an intensive course like the one led by Professor Maravall in 2003, but now with local teachers. The new X-12-ARIMA-SEATS software, including the interface, has to be thoroughly tested, especially because it is a beta version.

The council may also be able to provide some support to those who are engaged in augmenting the Bank of Historical Time Series, see Section 4e. But mainly, this should be the responsibility of those producing the statistics and who know the production process, and external researchers.

The tutoring of students writing their Bachelor's and Master's essays, with a view to the interests of SCB, would continue as in 2003. This is a risky way of conducting R&D work in a public authority. It is difficult to make commitments of new products being delivered at a certain date because students may not be up to the competence requirements, they drop out of projects and they may be late in delivery. Also, it requires substantial input from senior persons. This particularly pertains to the Leading Flash Project suggested in Section 5d, where a full time worker should be appointed.

Finally, some international contacts could be maintained to keep in touch with the development of time series methods.

7 Participants and activity

The *Time Series Project* started at the beginning of 2003, with a preparatory meeting 2002–12–11. The names of those who have been members of the Task Force are given in the table below.

Name	Dep/Unit	Period
Lars-Erik Öller, Chair	EconStat/Lead	1 Jan.– 31 Dec.
Stefan Svanberg, VC	EconStat/Meth	1 Jan.– 31 Dec.
Ann-Mari Flygare	Develop/Meth	15 March–31 May, 1 Sept.– 31 Dec.
Petra Jansson	EconStat/Price	1 Jan.– 31 Dec.
Viveca Koch	EconStat/R&D	1 Jan.– 28 March
Maria Krigsman	EconStat/ForTrade	1 Jan.– 31 Dec.
Per Anders Paulson	Env&Reg/Meth	1 Jan.– 31 Dec.
Leif Persson	Labour/Lead	1 Jan.– 15 Sept.

Mr Sven Öhlén has been an adjoint member of the TF.

The TF has held an ordinary meeting once every month, except in July. Technical matters were presented and discussed in four workshops.

The subjects were:

- Testing seasonal adjustments soft ware *(i)*,
- Long time series,
- Testing seasonal adjustments soft ware *(ii)*, and
- Leading indicators.

The members of the TF have organised seminars in their respective departments, four joint seminars in the department for Labour Market Statistics and Population & Regional Statistics, and one each in Environment & Welfare and Economic Statistics.

A one-day seminar on seasonal adjustment and more general time series analysis for both SCB staff and external persons was held on 11 September 2003 with more than 40 participants. The designer of the TRAMO/SEATS program, Professor Augustine Maravall was invited to Sweden and he gave two seminars, one 29 September and the other on 3 October 2003. He also held an intensive course in seasonal adjustment 30 September – 2 October.

The project gave a presentation at the Spring Meeting of the Scientific Council of SCB, to which the National Institute of Economic Research had been invited. Some parts of Chapter 4 (long time series) were discussed at its Autumn Meeting. The imputation study of Section 3b was presented at the International Symposium on Forecasting in Mérida, Mexico, in June 2003.

A draft of this report was discussed with Eurostat experts during a special one-day seminar in Luxembourg on 5 December 2003.

The ***Directing Council*** has consisted of the following persons:

Mr Staffan Wahlström, Chair
Mr Tor Bengtsson
Ms Eva Elvers
Mr Per Ericson
Ms Lena Hagman
Mr Ulf Jorner
Mr Lennart Nordberg
Mr Jens Olin
Ms Anna Wilén

The following persons have contributed to the project:

Mr Karl-Johan Dahllöf
Ms Johanna Erkelius
Ms Inga-Lill Kvist
Mr Jean-Marc Museux
Mr Lennart Nordberg
Mr Tom Persson
Mr Niclas Sjölund
Mr Anders Wallgren
Ms Britta Wallgren
Mr Richard Wiklander
Mr Jonas Zeed

The help from all involved in this work is gratefully acknowledged.

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