Unclassified **CCNM/STD(98)44**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 28-May-1998
Dist. : 04-Jun-1998

English text only

CENTRE FOR CO-OPERATION WITH NON-MEMBERS
STATISTICS DIRECTORATE

CCNM/STD(98)44
Unclassified

SEASONAL ADJUSTMENT OF INDUSTRIAL PRODUCTION SERIES IN TRANSITION COUNTRIES IN CENTRAL AND EASTERN EUROPE AND THE RUSSIAN FEDERATION

Revised version of OCDE/GD(97)142

English text only

66045

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FOREWORD

The development of reliable statistics, oriented towards the requirements of policy-making in a market-based economy, is a priority activity in the programme of the Centre for Co-operation with the Economies in Transition. Activities on statistics include the provision of advice on the practical implementation of western statistical systems focusing on those areas where the OECD possesses internationally recognised expertise (e.g. national accounts, prices and volume measures, short-term economic indicators and business surveys) and the development of a database of key economic statistics to monitor economic and social developments.

The main reason for compiling high frequency statistics such as monthly indices of industrial production is to form a time series which may be used for monitoring short-term fluctuations in a continuous way over a period of less than a year.

This document focuses on seasonal adjustment as an analytical technique that can be used to help users identify the underlying trends in a time series of short-term economic statistics such as indices of industrial production. The use of such techniques will assist in the interpretation of a time series in terms of its true direction at any time and in the identification of economic turning points or changes in direction.

The document also stresses the need to ensure the underlying quality of the data that is to be seasonally adjusted.

This document is published on the responsibility of the Secretary-General of the OECD.

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1. INTRODUCTION

Trends in the time series for the recent past are often used as the basis of predictions about likely developments in the near future. It is therefore important to be able to identify the underlying trends in a time series to be able to identify their direction at any time, and to be able to identify turning points or changes in direction.

The main reason for compiling high frequency statistics such as the monthly indices of industrial production is to form a time series which may be used for monitoring short-term fluctuations in a continuous way over a period of less than a year.

Seasonal adjustment of short-term economic indicators (i.e. monthly or quarterly time series) is undertaken in order to eliminate seasonal variation which mainly result from causes exogenous to the economic system. By removing seasonal variation in the original data, the adjusted series may be more easily interpreted and used to measure changes between consecutive periods.

For the purpose of seasonal adjustment a time series is generally considered to be made up of three basic components:

- *Trend cycle* (TC_t): The underlying path or general direction reflected in the data, i.e. the combined long-term (trend) and medium-to-long-term (cycle) movements in the original series.

- *Seasonal variations* (S_t): The seasonal variation includes seasonal effects proper and other systematic effects. A seasonal effect is an effect that is reasonably stable in terms of annual timing, direction and magnitude. Possible causes are natural factors, administrative or legal measures, and social traditions. Other effects on the time series are due to variations in the number of working or trading days in a period or events that occur at regular intervals, for example, pay days for large groups of employees, pension payments, etc. Both the seasonal and the other effects represent, persistent, predictable calendar-related effects.

- *Irregular variations* (I_t): An irregular effect is an effect that is unpredictable in terms of timing, impact, and duration. It can be caused by sampling errors, non-sampling errors, unseasonable weather changes, natural disasters, strikes, and socio-economic changes.

The following introductory outline of seasonal adjustment is drawn from a document prepared by N. Maehle. The document was attached as an Appendix to an IMF National Accounts Statistics mission report prepared in October 1996[1].

The relationship between the original series and its trend cycle, seasonal variation, and irregular components can be additive or multiplicative depending mainly on the nature of the seasonal movements in the original series. Time series models can be represented as either:

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1. International Monetary Fund, Washington DC, *Report on National Accounts Mission*, N Maehle, October 1996, Appendix V on seasonal adjustment

$$X_t = TC_t + S_t + I_t$$
or
$$X_t = TC_t \cdot S_t \cdot I_t$$

Seasonal adjustment identifies and removes by means of analytical techniques the regular pattern within a year to highlight the underlying trends and short-run movements in the series. A seasonally adjusted series consists of the trend plus the irregular component, and if the irregular component is strong, may not represent a smooth easily interpreted series.

To further highlight the trend-cycle, the irregular component may be removed and the underlying trend-cycle estimated by smoothing the seasonally adjusted series using a moving average or other trend estimation techniques. Most standard seasonal adjustment packages in addition to seasonal adjustments, separate estimates for the trend-cycle component.

The appropriate series (i.e. seasonally adjusted or trend-cycle) that should be published is still the subject of debate between experts in this area. It is recommended that both be presented, preferably in the form of graphs incorporated into the same chart.

It is important to emphasize that seasonal adjustment and trend-cycle estimations represent an analytical massaging of the original data. As such, the seasonally adjusted data and the estimated trend-cycle component complement the original data but can never replace the original. The non-seasonally adjusted data shows the actual changes that have taken place, while the seasonally adjusted data and the trend-cycle estimate represent an analytical elaboration of the data showing the underlying developments.

Seasonal adjustments and trend-cycle estimates should not be built into the original data compilation process but should be done after the original data has been compiled. This may be unavoidable if the original series is interpolated from less frequent data.

Seasonal adjustment is easy to do with off the shelf programs such as X-11 and X12-ARIMA developed by the United States Census Bureau, or X11-ARIMA developed by Statistics Canada. These programs include options for adjustment for varying numbers of working days, holidays, irregular events, treatment of extreme values, tests for stable seasonality.

OECD Member countries apply seasonal adjustment at different levels. Some countries adjust all individual series, while others make the adjustments only at aggregated levels. Most countries obtain seasonally adjusted totals as the sum of the adjusted components, whilst others also adjust the totals independently.

Aims of paper

The aims of this paper are to:

- present a number of basic issues concerning data requirements in connection with time series analysis (Section 2);
- outline concepts and procedures used in seasonal adjustment (Sections 3 and 4); and

- illustrate and discuss some of these concepts and procedures with an application of the X12-ARIMA program to seasonal adjustment of indices of industrial production for some transition countries in Central and Eastern Europe and the Russian Federation (Section 5).

2. DATA QUALITY, REQUIREMENTS AND STATISTICAL PROBLEMS

The main specific data requirements for the basic data used for time series analysis are:

- accuracy and comparability over time; and
- a minimum time period required for different time series methods.

The first issue covers topics related to data collection and use of data and to data adjustments. The second issue concerns the pre-processing of data and is discussed in the next section in relation to data preparation in connection with seasonal adjustment.

The main issues relating to data accuracy influencing comparability over time are dealt with below with reference to the situation (both past and current) in many transition countries. This is followed by a brief outline of time period requirements in connection with seasonal adjustment.

As mentioned above in the introduction, seasonal adjustment is a tool for massaging basic data to facilitate the analysis of a time series. The various packages available for seasonal adjustment will not remove any of the underlying problems discussed below that may be inherent in the basic data. There is an underlying assumption that the basic data used in seasonal adjustment actually measures what it purports to measure, i.e. that the sub-annual movements in the series reflect real movements in production. Some of the data problems (particularly that of cumulative reporting and the use of appropriate price indices) experienced in transition countries are explored in more detail below.

A more detailed discussion of the problems experienced by transition countries in the compilation of basic data is provided in the general methodological issues section of the OECD's annual publication, *Short-term Economic Indicators: Transition Economies, Sources and Definitions* (latest issue April 1997).

2.1 Data coverage

A major source of error in the use of data in time series analysis is that the characteristics of a sample or population may change over time. As a result, the observations reported for different time periods may actually represent slightly different samples or populations. In general, all time series methods are based on the assumption that the historical data used come from a homogeneous population. This assumption implies that when there are significant changes, substantial errors may occur in the analysis.

When data are collected from large populations, errors frequently occur as a result of either omitting or double counting parts of the population. Where coverage changes over time it is difficult to fit data together into a meaningful time series. This is a particular problem in transition countries where the statistical systems are undergoing rapid change as the economies they purport to measure evolve.

In the past, statistics in transition countries only covered state enterprises and co-operatives. Establishing and updating the business register and the collection of data on a sample rather than by census (exhaustive enumeration) are major innovations which will take time to implement fully and effectively. Over the transition period, therefore, many series will still cover only the state and co-operative sectors and some part of the private sector will be missing. The extent of the omission will vary over time and from series to series.

2.2 Classification and definitions

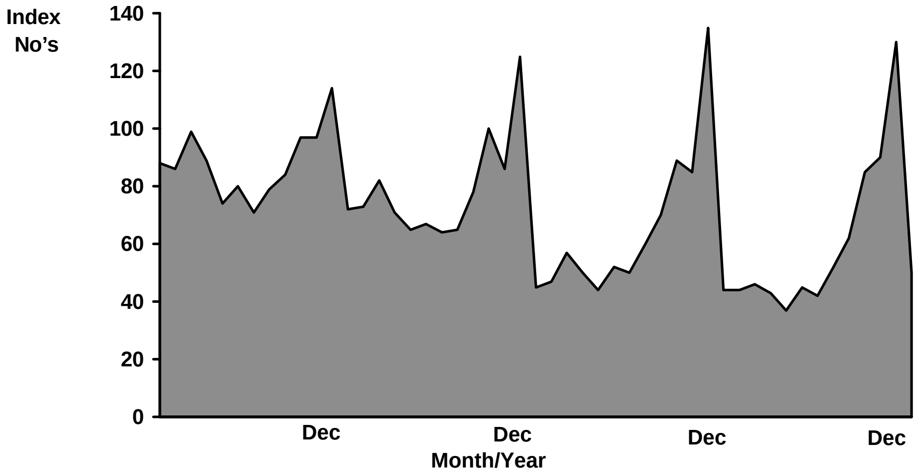
The use of appropriate international classifications and quantifiable variables harmonised with those used in many OECD Member countries are very important elements of data collection. Changes in classifications and variable definitions may introduce breaks in a time series and it may be necessary, if possible, to recalculate the historical part of the series to create a consistent time series.

The classifications used in the past in transition countries are gradually being replaced with classifications based on international standards. This change took place at varying points from 1989 onwards and has introduced discontinuity in many time series.

2.3 Recording practices

In OECD Member countries it is common practice to ask firms to report subannual financial and other data for discrete monthly or quarterly periods, and to allocate data revisions to the month or quarter where they actually occurred. However, in transition countries a major function of production statistics in the past was to provide data for monitoring total production against targets. For this reason a common practice was to obtain sales or output data, etc., for the year to date, and to derive monthly or quarterly data only by subtracting the previously reported figure. This often led to errors in the month or quarter during which activity was recorded because errors and revisions in previously reported data would not be inserted in the appropriate time period but simply incorporated in a new cumulative total.

The practice of cumulative reporting which has continued in many transition countries introduces distortions in subannual data as many series show a larger than usual entry in March, June and September, and an exceptionally large one in December. Because of very tight publication deadlines and the compilation of statistics very soon after the end of the reference period reporting often lags behind schedule. At the same time there was strong pressure to ensure a more accurate picture at the end of each quarter and especially at the end of each year. This also lead to accusations, which may have had some basis in fact, that the terminal figures were deliberately over-stated to meet plan targets. These factors, together with a reluctance to revise the data for earlier periods often leads to a seemingly large seasonal component in some series. A typical index series produced this way is shown in the following graph.



Whilst cumulative reporting has minimal impact on annual production data it may (especially combined with the use of a biased price index to deflate current value data - refer Section 2.3 below) impact on the accurate distribution of monthly and quarterly production throughout the year. This limits the reliability of a series to reflect short-term movements. Because this reporting practice resulted in a seemingly (but not real) large seasonal component in the final month of each quarter it limits the usefulness of the basic data in seasonal adjustment.

Discussions with industry branch statisticians in transition countries shows that in many countries industrial production actually shows real regular decreases in output twice during the year, over the summer months and in December - January each year. The question is, how much of the decrease at the end of the year is due to the cumulative reporting effect described above and how much is due to actual declines in physical output at the end of the year? Examination of the raw data for industrial production for the countries included in this analysis shown in Charts 1-9 verifies this regular seasonal pattern of production which is crudely described in the following table. However, it shows that there is also variation in the relative magnitude of the mid year and end of year decreases in industrial production.

Table 1: Comparison of mid- and end-year industrial production decreases: transition countries

	Time series	**Mid year decrease**	**End of year decrease**
Bulgaria	1985-96	large	larger
Czech Republic	1990-96	large	smaller
Estonia	1993-96	large	smaller
Hungary	1980-96	large	smaller
Poland	1985-96	large	large
Romania	1990-96	small	larger
Russian Federation	1993-96	large (and irregular)	large
Slovak Republic	1989-96	large	smaller
Slovenia	1980-96	large	smaller

Examination of similarly graphed total indices of industrial production for six OECD Member countries reveals the same variation in the relative magnitude of the mid-year and end of year decreases in industrial production. Almost all of these indices are based on physical quantity data.

Table 2: Comparison of mid- and end-year industrial production decreases: selected OECD Member countries

	Time series	Mid year decrease	End of year decrease
Austria	1980-96	large	smaller
Canada	1980-96	large	smaller
Finland	1980-96	very large	much smaller
Germany	1991-96	large	smaller
Greece	1980-96	small	much larger
Turkey	1986-96	small	much larger

The only conclusion that can be made from the above discussion is that end of year decreases in industrial production is a real phenomenon in both transition and OECD Member countries. The absence of cumulative reporting in the latter could reasonably lead one to assume that the <u>entire</u> end of year decrease in OECD Member countries is a real phenomenon. Unfortunately, with information currently available for transition countries, it is not possible to determine the magnitude of the relative importance of real end of year production decreases and decreases due to the cumulative reporting effect.

The absence of any reliable information on this issue emphasizes the need for caution when one is about to seasonally adjust industrial production data produced by transition countries where the cumulative methodology for reporting is used.

2.4 Use of appropriate price indices

Many transition countries (including almost all of those listed in Table 1 above) compile indices of industrial production by deflating current value data by a suitable producer price index (PPI). Analyses of the PPI's used in some transition countries (none of those listed in Table 1 above) have identified a bias in the price index used which has the effect of producing an index of industrial production where production is accumulated and becomes more pronounced towards the end of the year.

As a result of either cumulative reporting of sub-annual data or the use of a biased PPI (or a combination of either factors) the indices of industrial production compiled in some transition countries display a distinct surge in production at the end of the year such as that illustrated in the graph on page 9 above. The "seasonal pattern" displayed is in fact not a true reflection of actual changes in the volumes of output. Series displaying this characteristic pattern are not suitable for the seasonal adjustment techniques described in subsequent Sections and have been excluded from the list of transition countries whose series have been adjusted in this paper.

2.5 Compilation of indices

An essential requirement for monitoring short-term fluctuations in indices continually over time (i.e. between months or quarters and between series) is that the indices used must be calculated using base year volumes and prices, and have the same base year.

In the past, prices in transition countries were officially fixed by the State. However, these prices were also used in compiling the official price indices. Also, more of the increase in prices was attributed to quality change than was justified in terms of the improved utility of the products. This under-statement of price rises led to an over-statement of quantities when volume measures, such as indices of production, were derived by dividing current price data by price indices.

Another problem affected index numbers in volume terms because they were calculated as current-weighted index numbers, that is as ratios of current production at current prices to base-year production valued at current prices. The problem with this type of index is that comparisons between any two periods, except the base period, do not accurately reflect the change between the two periods.

Index number compilation was also affected by the reclassification of state enterprises from one sector to another in such a way that comparisons between different periods were invalidated.

2.6 Time period

Data are used determine the pattern of behavior of some variable based on historical observations. The various time series approaches to forecasting are methodologies for using data in this fashion. The minimum length of the time series required for seasonal adjustment by different modes are:

- five times the length of the seasonal pattern for the main frame versions of X11 and X11-ARIMA; and

- three times the length of the seasonal pattern for the PC versions of X11-ARIMA and X12-ARIMA.

Increasing the length of the time series will generally increase the accuracy of estimation, but not necessarily in direct proportion to the amount of data. One of the problems with particularly long time series is that frequently the pattern changes with time and using a longer time span may in fact give less accurate results than using only the minimum number of data necessary (see Section 5 below).

3. PRE-PROCESSING OF DATA PRIOR TO SEASONAL ADJUSTMENT

In many situations it is necessary to pre-process or adjust the data after they have been collected, but before they are used for monitoring and analysing short-term fluctuations in economic time series. A number of the most common types adjustments are outlined in this Section.

3.1 Calendar adjustment

Many monthly time series contain variations which result from the weekly/monthly cycle in the daily data. Such variations include:

- different lengths of months;
- number of Saturdays and Sundays in a month;
- official holidays and regional official holidays;
- differences in the importance of certain working days.

These may obscure important movements in the series and should be adjusted for. This type of adjustment is often refereed to as *trading day adjustment* and in particular effects retail sales series.

A special case of trading day adjustment is *working day adjustment*. This type of adjustment is performed on production data. The adjustment is made by finding the average number of working days for each period in the series and to adjust the raw data so that it reflects actual values comparable to a standard period.

3.2 Outlier adjustment

Variation due to *moving holidays* is not corrected for in the calendar adjustment and must be treated separately. This type of variation is not removed by seasonal adjustment which only removes fluctuations which regularly occur every period. The correction is performed by use of both external and internal evidence, i.e. usually derived from the irregular factors computed in the seasonal adjustment process.

Variations due to *special events*, e.g. the effect of a severe strike, should be adjusted for in order not to interfere with the estimation of the seasonal factors performed in the next step.

3.3 Re-adjustment (REGARIMA)

Regression models for automatic estimation of trading day variation are incorporated in all standard seasonal adjustment programs, i.e. X11, X11-ARIMA and X12-ARIMA. Models for estimating the effect of moving holidays such as Easter are part of the programs X11-ARIMA and X12-ARIMA.

In addition, the X12-ARIMA program includes combined regression and ARIMA models for identification and correction of the following different types of outliers:

- *additive outliers*: which affect only one observation in the time series;
- *level shifts*: which increase or decrease all observations from a point in time onward by some constant amount; and

- *temporary ramps*: which allow for a linear increase or decrease in the level of the series over a specified time span

3.4 Extension of original series (ARIMA models)

The ARIMA (Auto-Regressive Integrated Moving Average models) part of X11-ARIMA and X12-ARIMA was incorporated into X11 in order to make it possible to extend the original series. The program will automatically select one ARIMA model (on conditions that certain criteria are fulfilled), estimate the parameters of the model and produce backcasts and forecasts on the original series. The reason for prolonging the series by one year at both ends is to make it possible to apply moving averages which have symmetric weights over the whole span of the series. This procedure will produce seasonal estimates which are less prone to revisions as new data are added to the series.

The default values for automatic model selection may be changed by the user in the X12-ARIMA program so that the model may be accepted by the automatic modelling procedure. In addition, the program includes a module for use in specified ARIMA models.

4 SEASONAL ADJUSTMENT

4.1 Model

Before seasonal adjustment is carried out it is necessary to determine the model of the series. All standard programs for seasonal adjustment (X11, X11-ARIMA and X12-ARIMA) include two basic models:

- multiplicative; and

- additive seasonal adjustment.

To determine the model to use it is necessary to examine the behavior of the components (TC, S and I) of the series. For example:

- the series is *multiplicative* when the seasonal component (S) is proportional to the trend-cycle component (TC);

- the series is *additive* when the seasonal component (S) is independent of the trend-cycle component (TC).

In addition to these two basic models, X12-ARIMA includes a third very useful model for certain series, i.e. a pseudo-additive seasonal adjustment.

- the *pseudo-additive* model is considered when some periods have extremely small values (for example, due to vacations or climate) and the remaining months appear to have multiplicative seasonality.

The structural behavior of the time series needs to be closely investigated. A wrong model may seriously distort the seasonal adjustment results for the years at both ends of the series. The following simple tests may be used to determine the structural behavior of the series:

- Examination of the relationship between the seasonal amplitude (S) and the trend-cycle (TC). This involves plotting the original series and examining whether a relationship exist between the seasonal amplitude and the trend-cycle. If the relationship is difficult to see, set out annual seasonal amplitudes against annual trend-cycle estimates. The slope of the line gives a first indication of the structure of the series, i.e. a positive slope indicates a multiplicative relationship while an additive model is indicated by a horizontal line in the case of a time series with a positive trend.

- Comparison of seasonal adjustment diagnostics for different model applications. This involves comparing F-statistics for stable seasonality (S) and the relative contribution of the irregular (I) variation to the total variation in the original series.

4.2 Estimation of trend-cycle, seasonal and irregular components

An important feature of seasonality is that the phenomenon repeats itself with certain regularity every year. At the same time the pattern of seasonality may evolve over the years. The method for seasonal adjustment applied by the majority of statistical agencies is based on moving average techniques. The three basic programs for seasonal adjustment in use (X11, X11-ARIMA and X12-ARIMA) follow an iterative estimation procedure where:

- the trend-cycle (TC) is estimated first;

- the seasonal component (S) next; and

- the irregular component (I) is derived as a residual.

The programs carry out the decomposition into trend-cycle, seasonal and irregular components by applying a number of weighted moving averages.

The main steps in the programs applying the moving average technique to produce seasonally adjusted series (multiplicative model) are as follows:

Phase I

1. A centered 12-term moving average[2] is calculated to obtain a *preliminary estimate of the trend-cycle* (TC). The ratio between the original series and the 12-term moving average is computed as a *first estimate of the seasonal-irregular component* (SI);

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[2]. A centered 12-term moving average (MA) is obtained by taking an additional 2-term moving average of the 12-term moving average:

MA=1/24(X1+2X2+2X3+.......+2X11+2X12+X13) i.e. with half weights for the first and last terms in the average. This MA is used in order to place the values opposite a month in the original series i.e. the first value is placed opposite the 7 month in the data being

2. A weighted 5-term moving average[3] is applied to the seasonal-irregular component (SI) of each month separately to obtain a *preliminary estimate of the seasonal factors* (S);

3. The seasonal-irregular ratios (SI) are divided by the adjusted preliminary seasonal factors (S) to obtain a *first estimate of the irregular component* (I);

4. *Extreme values*[4] of the irregular component are removed or adjusted;

5. A *preliminary seasonally adjusted series* is obtained by dividing the original series by seasonal factors (S) corrected for extreme values and adjusted with a centered 12-term moving average;

Phase II

6. A Henderson moving average[5] is applied to the preliminary seasonally adjusted series to obtain a *second estimate of the trend-cycle* (TC). The length of the Henderson filter is determined by the irregular to trend-cycle ratio. The original series is divided by the resulting trend-cycle estimate to give a *second and final estimate of the seasonal-irregular ratios* (SI)[6];

7. A weighted moving average, the specification depending on the global seasonal-irregular ratios (SI), is applied to each month's seasonal-irregular ratio separately to obtain a second and *final estimate of the seasonal factors* (S)[7]. These factor values are projected out one year by multiplying each month's factor for the last year by 3, and subtracting the factors for the corresponding months of the preceding year and dividing the results by 2. This procedure gives *one-year ahead forecast seasonal factors;*

8. To obtain the *final seasonally adjusted series*, the original series is divided by the second estimate of the seasonal factors (S) adjusted with a centered 12-term moving average.

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averaged. End values lost because of centered MA are replaced with corresponding values of the following or preceding year.

[3]. End values lost because of the 5-term moving average are set equal to the average of the two following values

[4]. Extreme values outside +/- 2 standard deviations (default value) are replaced by taking the average of the values for the preceding and following period.

[5]. The Henderson moving average produces an estimate of the trend-cycle, where this trend-cycle is assumed to follow a parabola over an interval of short duration.

[6]. SI ratios of each year are adjusted to have a mean of 100 if a multiplicative model is used and a mean of 0 if an additive model is used.

[7]. Fixed seasonal factors are obtained by averaging SI ratios for each month or quarter over all years and moving seasonal factors are obtained by calculating a moving average of SI ratios for each month or quarter along successive years.

4.3 Seasonal adjustment diagnostics

A set of statistical tests are incorporated into the seasonal adjustment part of the different programs for seasonal adjustment. These tests are used to assess the quality of the original series and the reliability of the seasonal adjustment. A brief description of some of the different test statistics for quality assessment available in X11-ARIMA and X12-ARIMA are provided below.

- F-test for the presence of stable seasonality

  This test is based on a one-way analysis of variance of the SI ratios (differences). The F-ratio is a quotient of the variance due to seasonality, i.e. “between months or quarters” to the residual variance due to the irregulars.

- F-test for the presence of moving seasonality

  The moving seasonality test is based on a two-way analysis of variance on the SI ratios (differences). The F-ratio is the quotient between the “between years” variance and the residual variance and tests for the presence of moving seasonality described by gradual changes in the seasonal amplitude.

- Combined test for the presence of identifiable seasonality

  This test combines the two previous tests with the Kraskal-Wallis Chi-squared test.

- Months (quarters) for cyclical dominance (MCD or QCD)

  The number of months or quarters over which a change in the seasonally adjusted series must move in a given direction before it can be reasonably certain that the trend-cycle component of the series has also moved in the same direction.

- Average duration of run

  The average number of consecutive monthly or quarterly changes in the same direction for the different components of the series is calculated to determine if a particular component is auto-correlated.

- Relative contribution of the different components to the total variance in the series

- Quality control statistics

A set of monitoring statistics (M1 to M10) are combined to produce a final overall quality assessment statistics (Q). The monitoring statistics include measures related to the amount and nature of the irregular and seasonal components. The irregular influence is measured by the variance, relative contribution of the irregular component to the total variance in the series and the relationship between the irregular and trend-cycle component as measured by the MCD or QCD statistics. The variation in the seasonal component is only measured by the size of the year-to year variation and the average linear movement calculated for the whole series and for recent years.

4.4 Direct or indirect adjustment

A special option to test the seasonal adjustment of composite series is included in the X11-ARIMA and X12-ARIMA programs. The option performs both direct and indirect seasonal adjustment of composite series.

- *Direct seasonal adjustment* consists of making the composite of the unadjusted component series and then seasonally adjusting the composite series.

- *Indirect seasonal adjustment* consists of first seasonally adjusting the component series and then the aggregation of the seasonally adjusted composite series.

In order to decide whether the composite series should be seasonally adjusted using either the direct or indirect procedure, the smoothness of the resulting seasonally adjusted series is tested with two different measures:

- the first measure (R1) is based on the sum of squares of the first difference of the series; and

- the second measure (R2) which is calculated as the sum of squares between the series and the associated trend obtained via the Henderson filter.

The first difference for a series removes most of the variations of long periodicity but not variations of shorter periodicity. The R2 measure is preferred to R1 in the case of composite series which are strongly affected by short-term variations.

4.5 Publication policy

The traditional practice in many countries was to run seasonal adjustment at the end or at the start of each calendar year and to use the projected seasonal factors in turn to seasonally adjust each new monthly or quarterly observation. This practice was necessary because of constraints on computer resources. With the advent of powerful PCs this constraint is less valid today.

However, many statistical agencies in OECD countries still adopt this policy. The use of projected seasonal factors does not take into account the latest information in the series, as would be the case if seasonal adjustment was rerun every month or quarter. This practice is commonly referred to as *concurrent adjustment* (current updating) and is used in some OECD countries. One reason for not redoing seasonal adjustment every period is to avoid minor variations in time series which do not add to the analytical usefulness.

The general policy in OECD countries is to publish both original and seasonally adjusted data for each series. Smoothing of seasonally adjusted series is only recommended for presentation in diagrams and for analytical purposes.

5. APPLICATION OF X12-ARIMA TO SEASONAL ADJUSTMENT OF INDICES OF INDUSTRIAL PRODUCTION IN TRANSITION COUNTRIES IN CENTRAL AND EASTERN EUROPE AND THE RUSSIAN FEDERATION

5.1 Background

Seasonal adjustment of the industrial production series in transition countries in Central and Eastern Europe (CEEC) and the Russian Federation is affected by two types of problems:

- the sharp contraction in output over the last few years; and
- possible changes in the seasonal pattern caused by changes in structural, institutional and other parameters linked to the transition to a market economy.

The programs used for seasonal adjustment (X11, X11-ARIMA and X12-ARIMA) are based on a decomposition of the original production series into trend-cycle (TC), seasonal (S) and irregular (I) components by means of smooth curves (moving averages). The results of a decomposition of indices of industrial production in Bulgaria, the Czech Republic, Estonia, Hungary, Poland, Romania, the Russian Federation, the Slovak Republic and Slovenia are presented in Charts 1-9 (pages 20-28).

A sharp contraction in output may bias the estimation of the trend-cycle component. Some of the “cycle” may remain in the S-I ratios which may bias the final seasonal adjustment factors and the seasonally adjusted series. To deal with abrupt changes in the trend-cycle a prior-adjustment technique may be used to eliminate values from the original series that exhibit sharp cyclical movements. This links the original series before the break to the original series after the break. Seasonal adjustment is then applied to the new outlier-adjusted (i.e. level corrected) original series.

The seasonal adjustment routine is based on the assumption that the seasonal factors vary gradually over time. If the seasonal pattern has changed abruptly in the past, then for the purpose of seasonal adjustment a single series could be treated as two series, with the program applied separately to the periods before and after the change.

The following procedure is used to test if the seasonal factors have changed after the sharp decline in output over the period 1989-92, and to see if the seasonal pattern has changed. This procedure involves a comparison of the seasonal factors calculated through to 1996 with:

- the factors based on data up to 1990; and
- the factors based on data for the period 1990 to 1996.

The second test is performed in order to see what the difference in adjustment would be if the series were treated as one series or two series, i.e. as a new series after 1990. The two tests are applied to all of above countries with data starting in 1990 or earlier, i.e. all CEEC countries. Consistent time series are only available from 1993 in the case of Estonia and the Russian Federation and the two tests can not be applied to these two countries.

5.2. Adjustment Parameters

Seasonal adjustment has been performed with the following parameters and has been carried out on the following periods in the different transition countries:

Table 3: Seasonal adjustment parameters and time periods

Country	Prior adjustment		Decomposition	Adjustment periods		Trend-cycle break year
	TRD	EAST	Model	Entire period	Transition period	
Bulgaria	Yes	No	Additive	1985-1996	1989-1996	1989
Czech Republic	Yes	Yes	Multiplicative		1990-1996	1990
Estonia	Yes	No	Additive		1993-1996	1991
Hungary	Yes	Yes	Multiplicative	1980-1996	1989-1996	1989
Poland	Yes	Yes	Multiplicative	1985-1996	1988-1996	1988
Romania	Yes	Yes	Multiplicative		1990-1996	1990
Russian Federation	Yes	No	Multiplicative		1993-1996	1991
Slovak Republic	Yes	Yes	Multiplicative		1989-1996	1990
Slovenia	Yes	Yes	Multiplicative	1980-1996	1989-1996	1989

TRD = Trading day regression
EAST = Easter adjustment

The break years indicated refer to years with an abrupt change in the trend-cycle in the series. This change is due to a major drop in output in all of the transition countries listed (see Charts 1-9). The break years indicated for Estonia and the Russian Federation are estimated from annual data and are not covered by the period of available consistent monthly time series data shown in the charts.

The series for the Czech Republic, Romania and the Slovak Republic only cover the transition period and the seasonal adjustment can only be performed on the entire period. The series for The Czech Republic and Romania start both in 1990 and the series for the Slovak Republic starts in l989.

Seasonal adjustment characteristics for all countries based on data over the entire period up to 1996 are set out in Table 4 and the trend-cycle component, seasonal factors and irregular component are shown in Charts 1-9.

Table 4: Quality assessment statistics based on data over entire period up to 1996 (X12-ARIMA)

Country	ARIMA model auto	Disturbance from irregular component		Identifiable seasonality		Changes in seasonal component over: All periods		End periods		Over all accept-ed
		VAR	MCD	Stable	Mov	Size	Lin	Size	Lin	
Bulgaria	Yes	No	3	Yes	No	**Yes**	No	**Yes**	**Yes**	Yes
Czech Republic	Yes	No	4	Yes	No	No	No	No	No	Yes
Estonia	**No**	**Yes**	4	Yes	No					Yes
Hungary	Yes	No	6	Yes	No	No	No	No	No	Yes
Poland	Yes	No	4	Yes	**Yes**	No	No	No	No	Yes
Romania	Yes	No	3	Yes	No	No	No	No	No	Yes
Russian Fed.	**No**	**Yes**	1	Yes	No					Yes
Slovak Republic	Yes	No	8	Yes	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**
Slovenia	**No**	**Yes**	6	Yes	No	No	No	**Yes**	**Yes**	Yes

Auto = Automatic ARIMA model identification
VAR = Variance, relative contribution of the irregular component to the total variance in the series
MCD = The number of months it takes the change in the trend-cycle to surpass the amount of change in the irregular component
Mov = Moving seasonality
Size = The size of the fluctuations in the seasonal component
Lin = The linear movement in the seasonal component

The quality assessment statistics based on X12-ARIMA output reveal the following points:

- Only one country, the Slovak Republic, is rejected on the overall scoring for acceptable seasonal adjustment. The series is rejected due to bad test results on the assessment concerning changes in the seasonal component over the entire period as well as over recent years. The results indicate too large changes in both the size of the fluctuations and the average linear movement in the seasonal component. In addition, the results indicate moving seasonality and disturbance from the irregular component, measured by the relationship between the irregular and trend-cycle component as indicated by the Months for Cyclical Dominance (MCD) statistics.

- Two countries, Bulgaria and Slovenia, accepted on the overall scoring, fail on the test results concerning changes in the seasonal component over all and/or end period. In the case of Slovenia the results also indicate a disturbance from the irregular component as measured by the variance, i.e. the relative contribution of the irregular component to the total variance in the series. Disturbance from the irregular component is also indicated for Estonia and the Russian Federation.

- The Czech Republic, Hungary, Poland and Romania are accepted on all test results. However, the results for Poland indicate moving seasonality.

- The automatic forecasting option included in the X12-ARIMA seasonal adjustment program is able to identify an ARIMA model for all countries except Estonia, the Russian Federation and Slovenia. In the case of Estonia and the Russian Federation the relatively short period of data presented prevents the identification of an ARIMA model.

Four of above five countries, namely Bulgaria, Poland, the Slovak Republic and Slovenia show bad test results on one or more of the quality assessment statistics analyzed and will be evaluated further below. However, the Czech Republic, Hungary and Romania are included in this evaluation for comparison purposes.

Quality assessment statistics based on data over the period up to 1990 for all of these countries with series starting in 1980 or 1985 are provided in Table 3 (excluding the Czech Republic, Romania and the Slovak Republic where the series start in 1989 or 1990). Assessment statistics for the period 1990 to 1996 for all countries are provided in Table 4.

The results based on data up to 1990 (i.e. pre-transition period) show that all countries are accepted on the over-all scoring. No country is rejected on bad test results concerning changes in the seasonal component. The results for Poland indicate moving seasonality and the results for Hungary and Slovenia show disturbance from the irregular component as measured by the relationship between the irregular and trend-cycle component as indicated by the MCD statistics (refer Table 5).

Table 5: Quality assessment statistics based on data over period up to 1990 (X12-ARIMA)

Country	ARIMA model auto	Disturbance from irregular component		Identifiable seasonality		Changes in seasonal component over: All periods		End periods		Over all accepted
		VAR	MCD	Stable	Mov	Size	Lin	Size	Lin	
Bulgaria	Yes	No	2	Yes	No	No	No	No	No	Yes
Hungary	Yes	No	12	Yes	No	No	No	No	No	Yes
Poland	Yes	No	4	Yes	**Yes**	No	No	No	No	Yes
Slovenia	Yes	No	9	Yes	No	No	No	No	No	Yes

See notes to Table 4

The results based on data over the period 1990 to 1996 (i.e. the transition period) show that all countries are accepted on the over-all scoring. No country is rejected on bad test results concerning changes in the seasonal component. However, two countries accepted on the overall assessment fail on one criterion. The results for the Slovak Republic indicate moving seasonality and the results for Slovenia show disturbance from the irregular component as measured by the variance, i.e. the relative contribution of the irregular component to the total variance in the series (refer Table 6 below).

In summary, the results based on data for the different periods suggest the following:

- Seasonal adjustment may be performed on the entire period of available data for Hungary and Poland (i.e. 1980-1996 and 1985-1986, respectively).

- Seasonal adjustment over the period 1990 to 1996 (i.e. the transition period) may be performed in the case of Bulgaria, the Czech Republic, Romania, the Slovak Republic and Slovenia.

- Seasonal adjustment over the period 1993 to 1996 may be performed for Estonia and the Russian Federation.

Table 6: Quality assessment statistics based on data over period 1990 to 1996 or period 1993 to 1996 (X12-ARIMA)

Country	ARIMA model auto	Disturbance from irregular component		Identifiable seasonality		Changes in seasonal component over: All periods		Changes in seasonal component over: End periods		Over all accept-ed
		VAR	MCD	Stable	Mov	Size	Lin	Size	Lin	
Period 1990-1996										
Bulgaria	Yes	No	3	Yes	No	No	No	No	No	Yes
Czech Republic	Yes	No	3	Yes	No	No	No	No	No	Yes
Hungary	Yes	No	3	Yes	No	No	No	No	No	Yes
Poland	Yes	No	3	Yes	No	No	No	No	No	Yes
Romania	Yes	No	4	Yes	No	No	No	No	No	Yes
Slovak Republic	Yes	No	6	Yes	**Yes**	No	No	No	No	Yes
Slovenia	Yes	**Yes**	5	Yes	No	No	No	No	No	Yes
Period 1993-1996										
Estonia	**No**	**Yes**	4	Yes	No					Yes
Russian Federation	**No**	**Yes**	1	Yes	No					Yes

See notes to Table 4

However, the basic question concerning the cause of the indicated changes in the seasonal components if seasonal adjustment is performed on data available over the entire period up to 1996 (i.e. including the trend-cycle break year) has not been answered by the quality assessment statistics. Also, no indication is provided on how to treat series with bad test results. In order to determine these issues further tests are performed in the following two sections.

CHART 1 DECOMPOSITION OF INDUSTRIAL PRODUCTION
BULGARIA

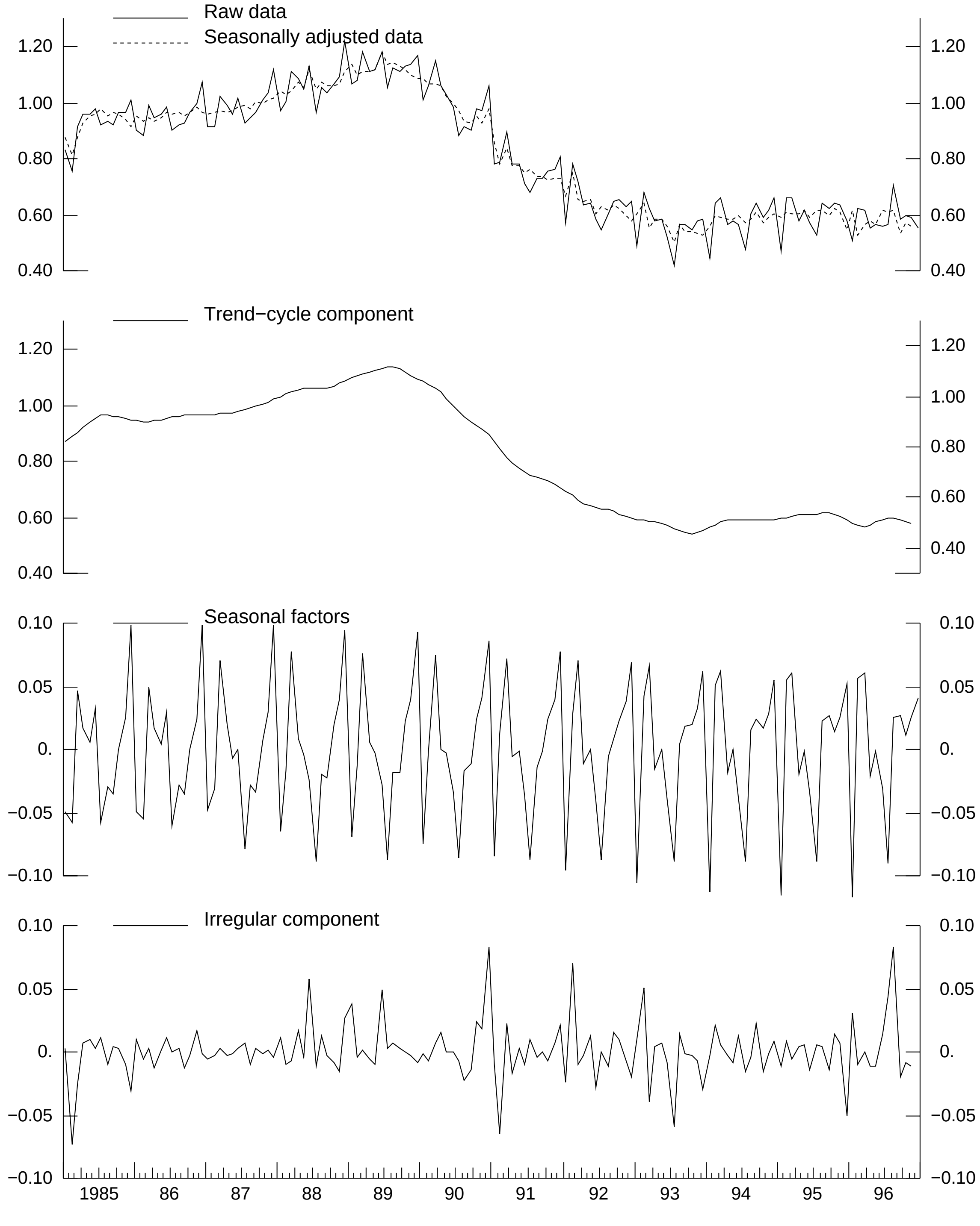


CHART 2 DECOMPOSITION OF INDUSTRIAL PRODUCTION
CZECH REPUBLIC

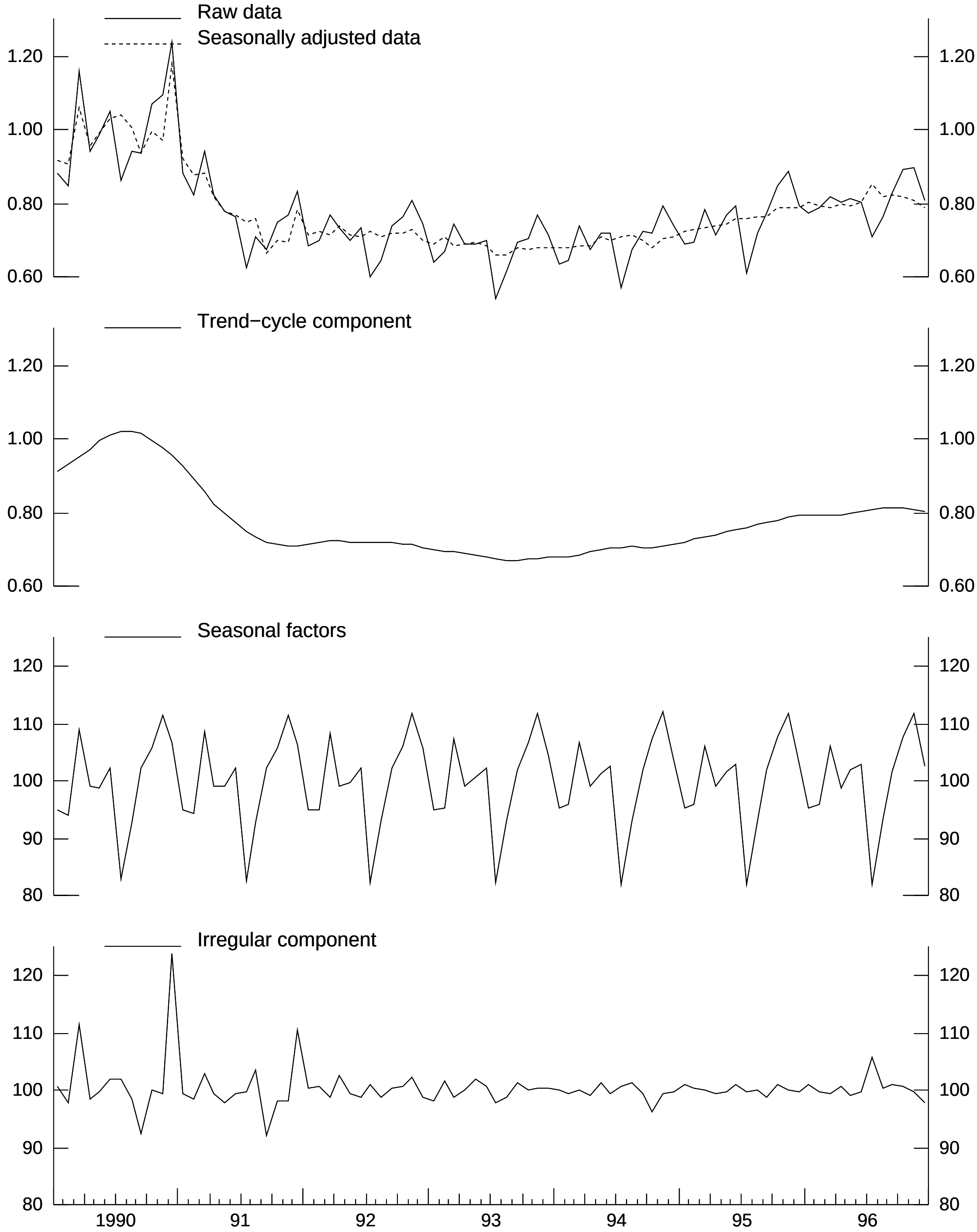


CHART 3 DECOMPOSITION OF INDUSTRIAL PRODUCTION
ESTONIA

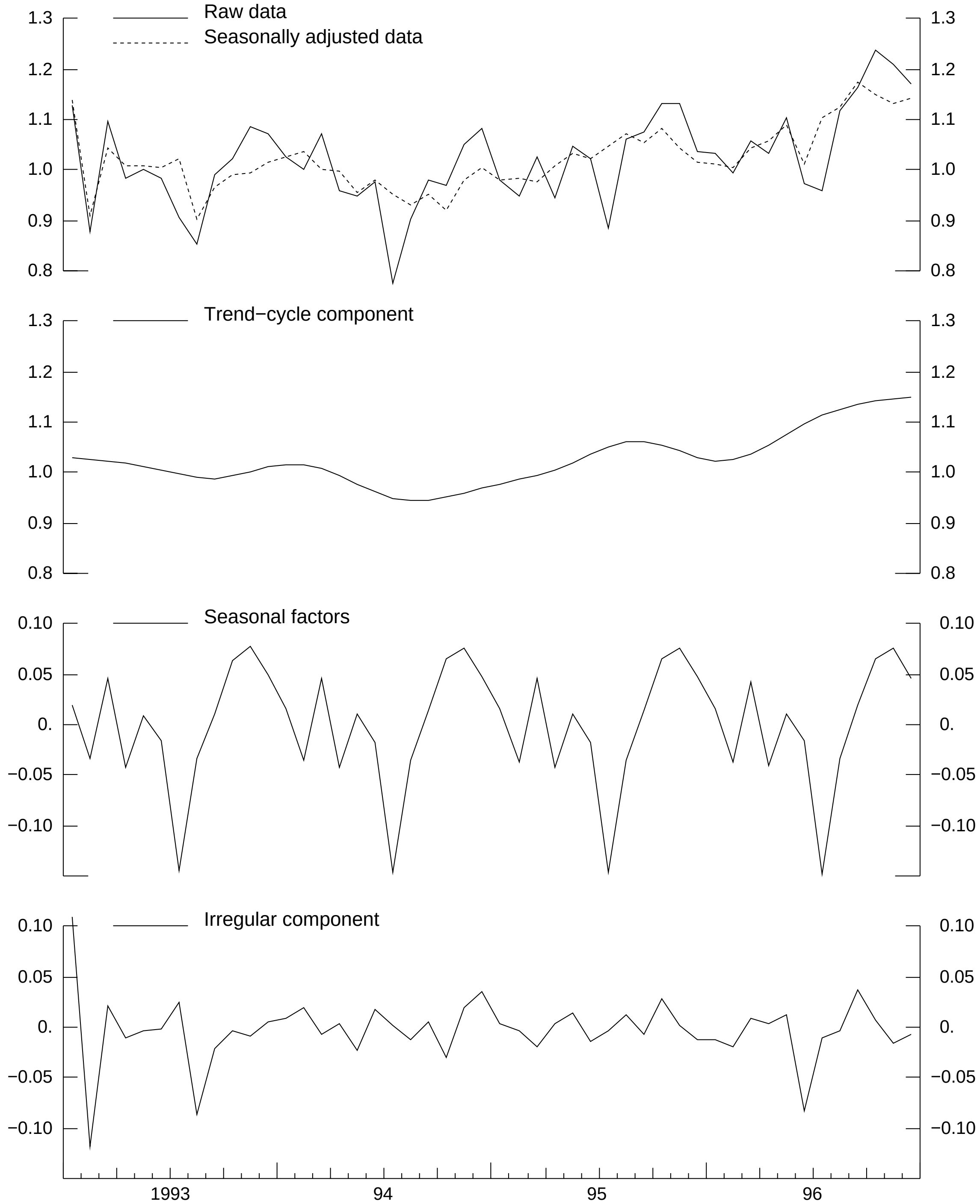


CHART 4 DECOMPOSITION OF INDUSTRIAL PRODUCTION
HUNGARY

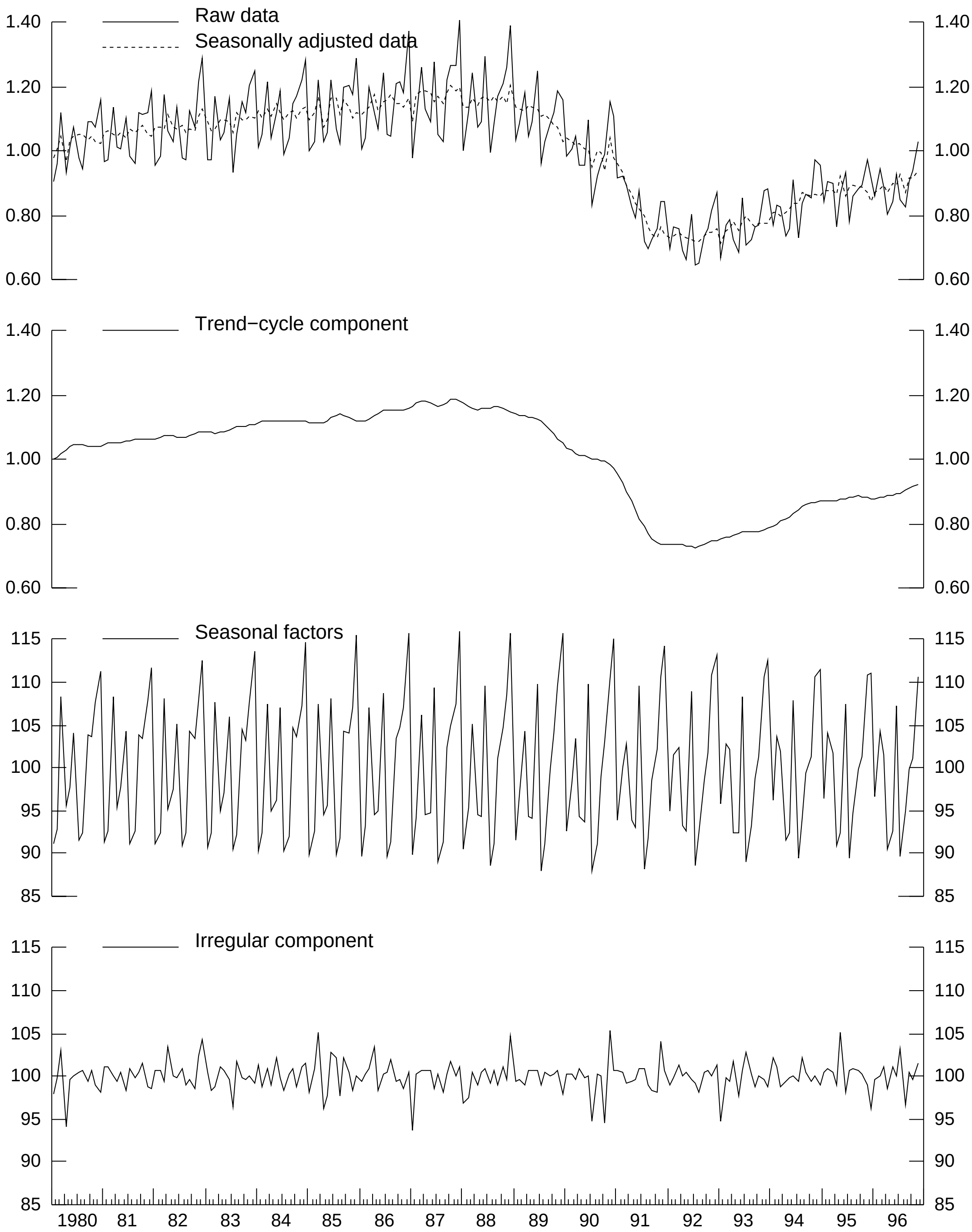


CHART 5 DECOMPOSITION OF INDUSTRIAL PRODUCTION
POLAND

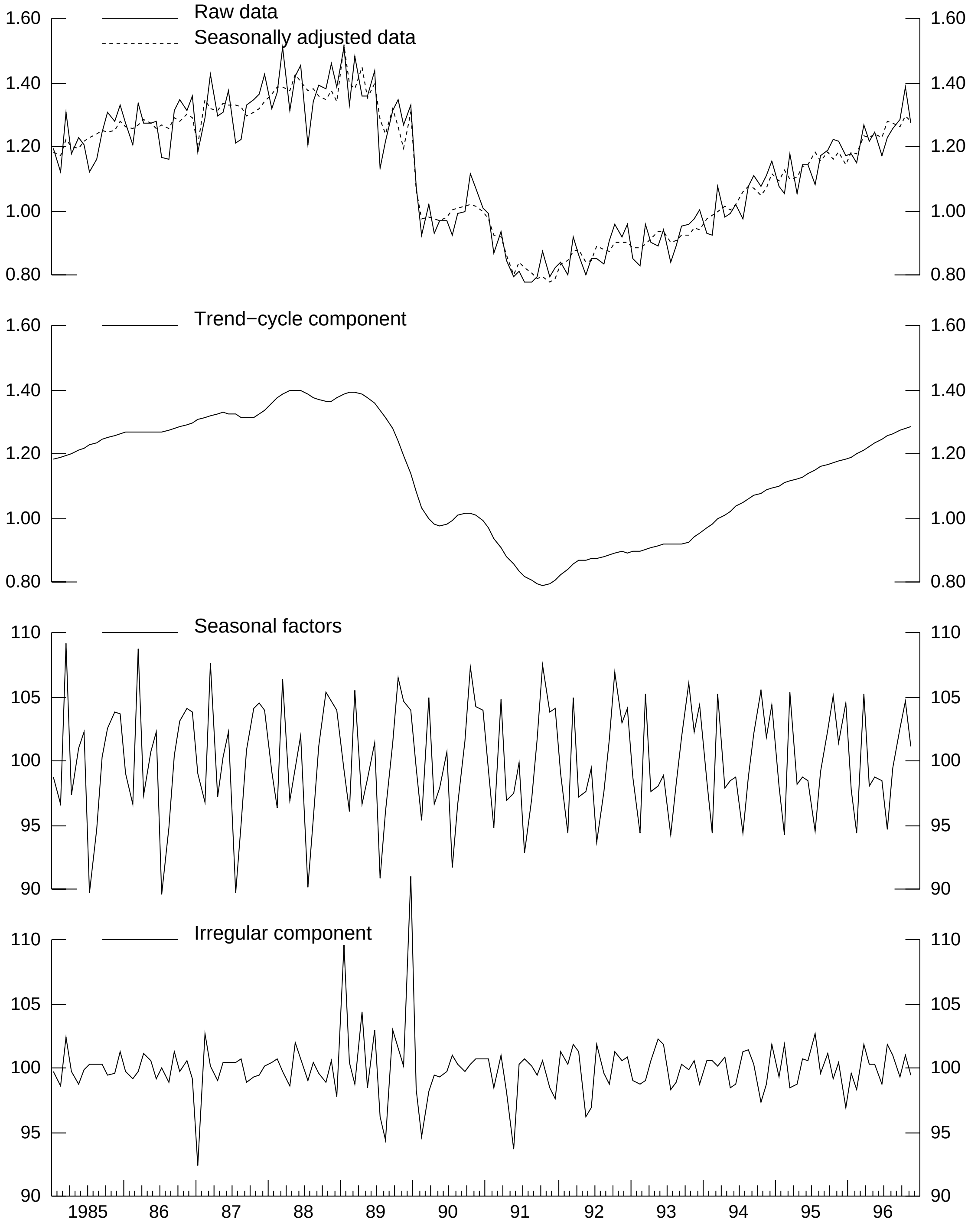


CHART 6 DECOMPOSITION OF INDUSTRIAL PRODUCTION
ROMANIA

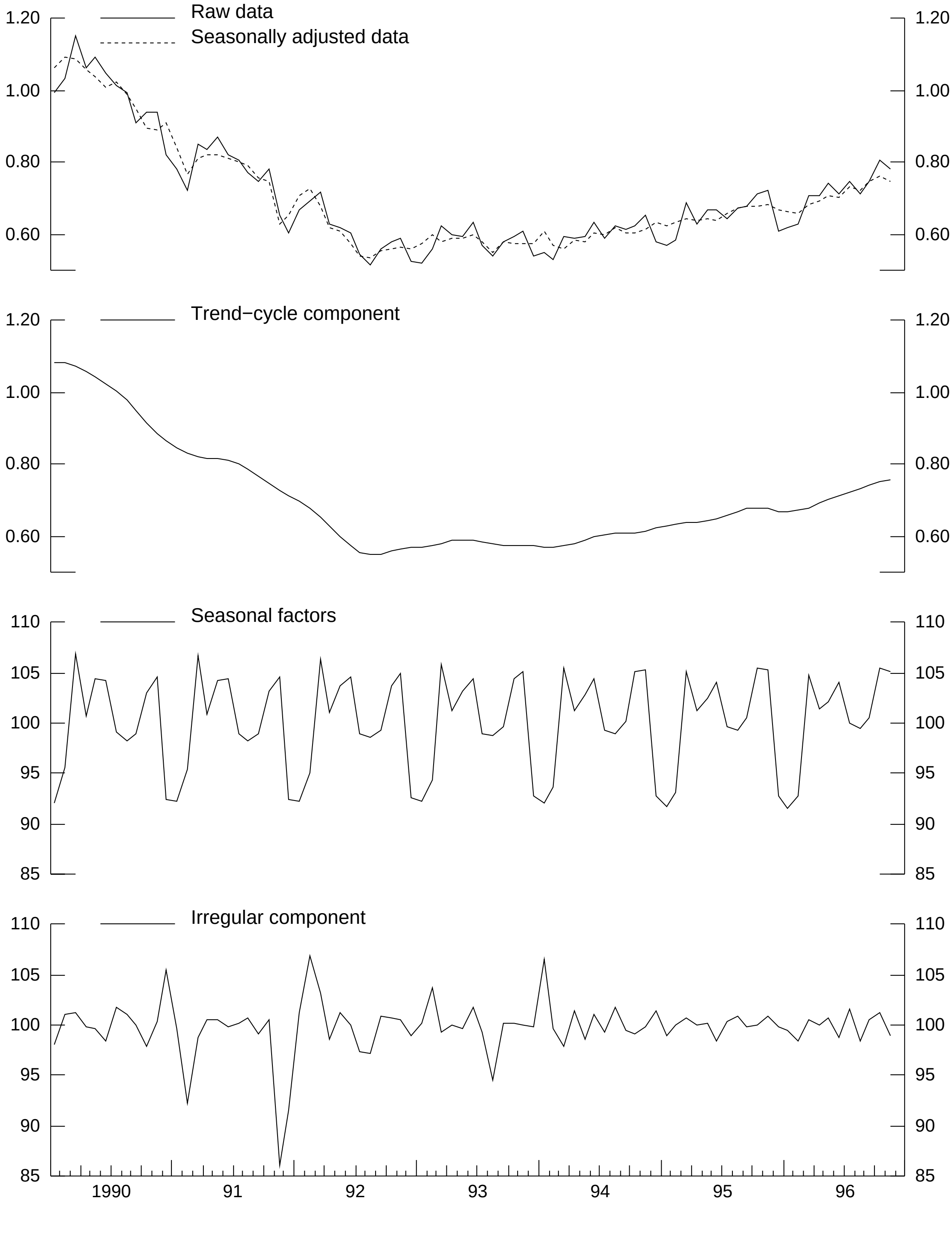


CHART 7 DECOMPOSITION OF INDUSTRIAL PRODUCTION
RUSSIAN FEDERATION

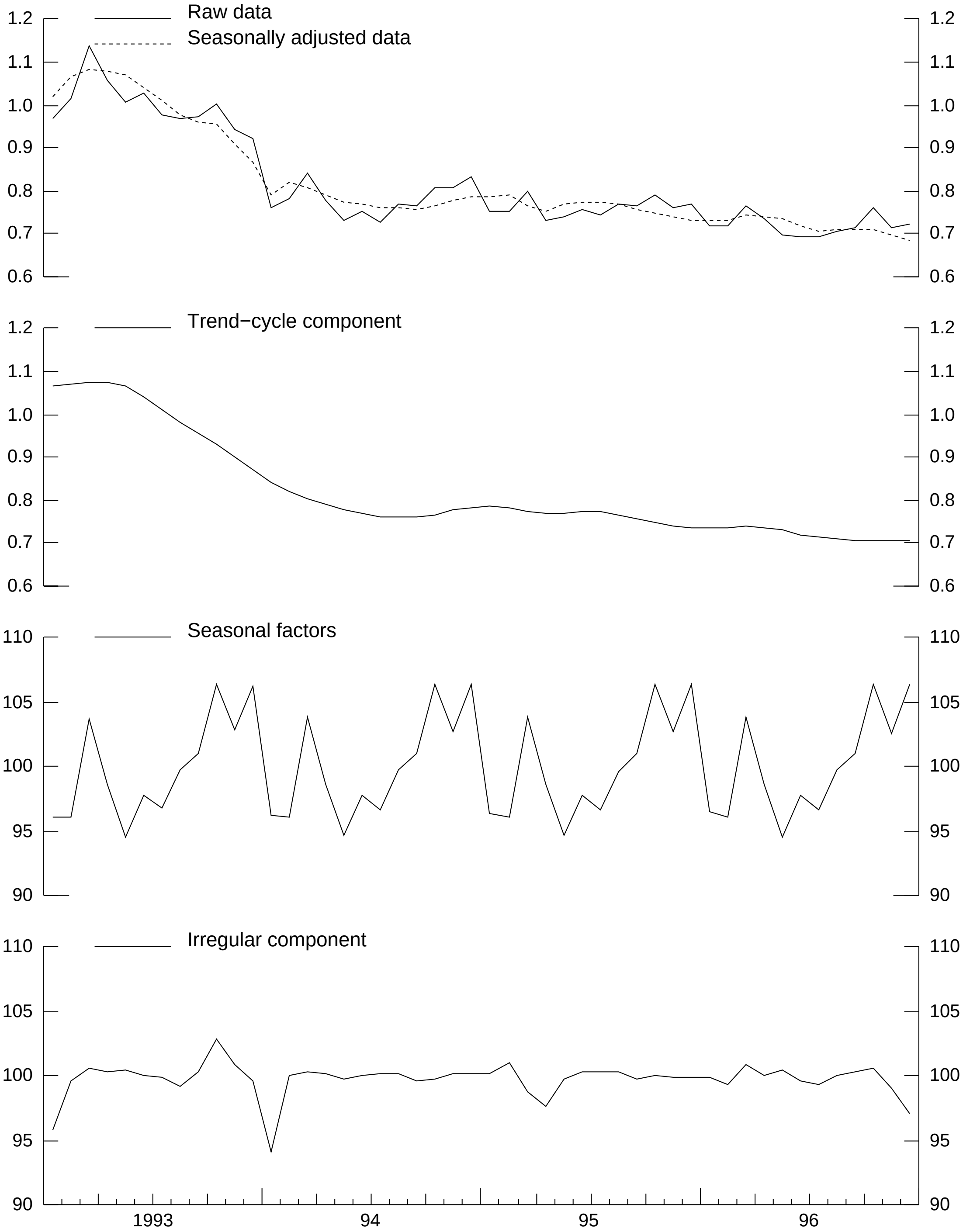


CHART 8 DECOMPOSITION OF INDUSTRIAL PRODUCTION
SLOVAK REPUBLIC

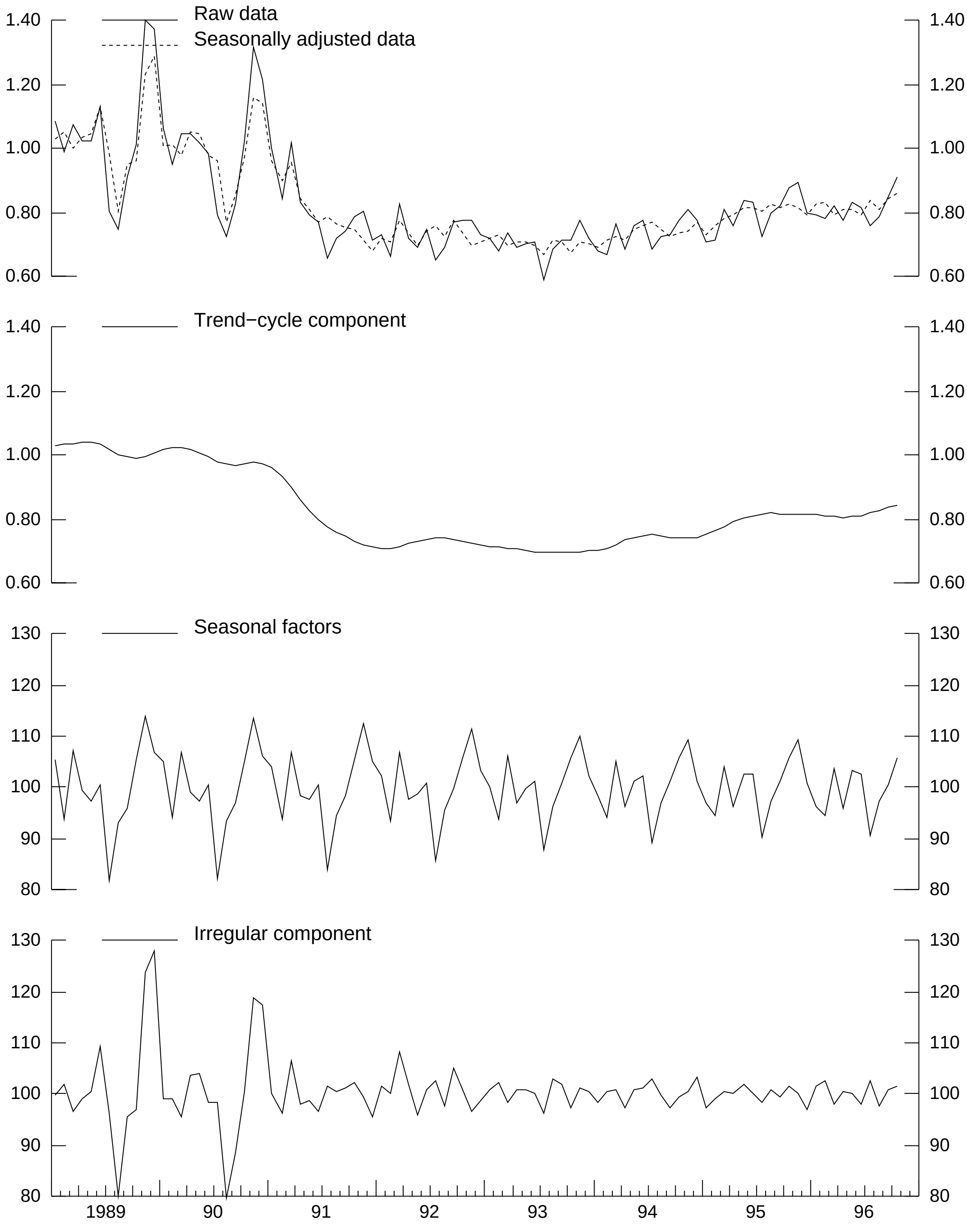
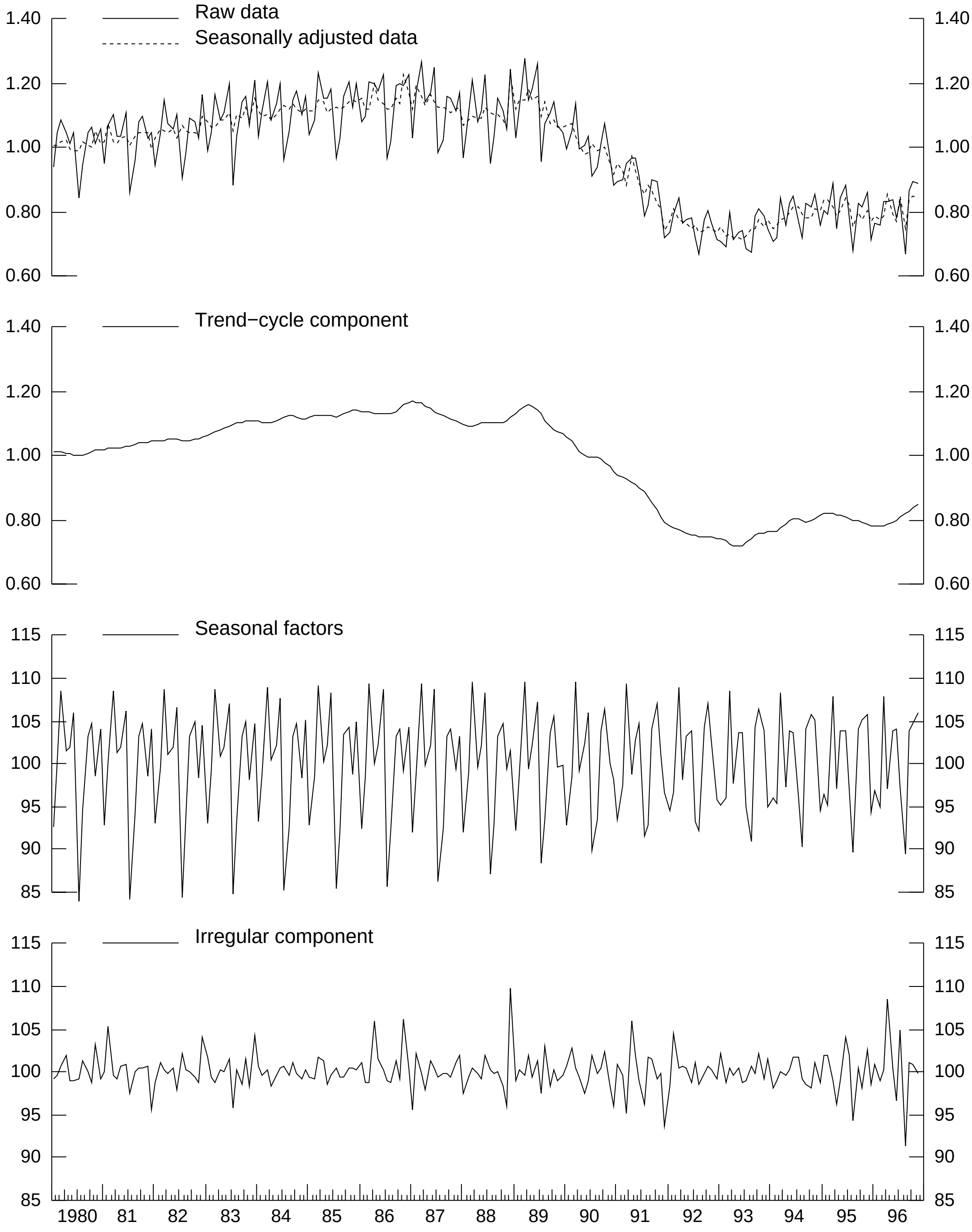


CHART 9 DECOMPOSITION OF INDUSTRIAL PRODUCTION
SLOVENIA



5.3. Test 1 : Comparison of Seasonal Factors for the Period Before 1990

Seasonal factors based on data up to 1988 or 1989, depending on the break point in the trend-cycle, and data based on factors over the entire period up to 1996 are plotted in Charts 10 to 13 (top) for countries with data available back to 1980 or 1985 (excluding the Czech Republic, Romania and the Slovak Republic where the series start in 1989 or 1990 and Estonia and the Russian Federation where the series start in 1993 - refer to Table 5). A qualitative assessment of the differences between the two sets of seasonal factors is set out in Table 7.

In summary, for all tested countries the differences between the two sets of seasonal factors mainly seem to be related to the abrupt change in the trend-cycle over the period 1988-1992. This affects the factors in diminishing degree over the last few years, i.e. 1987, 1988 and 1989.

A drastic change in the seasonal pattern does not seem to have occurred in any country. However, a strong but gradual change in the seasonal pattern over the period 1985-1989 is apparent in Bulgaria (refer Chart 1 with factors plotted over the entire period). However, the series for Bulgaria seems to be affected by a change in the trend-cycle over the last three to four years, which makes it difficult to separate the two forces.

Table 7: Changes in seasonal factors over the period 1985-1989: Factors based on data up to 1988/89 compared to factors based on data over the entire period up to 1996

Changes in seasonal factors probably due to:

Country	Break in trend-cycle					Drastic new pattern				
	1985	1986	1987	1988	1989	1985	1986	1987	1988	1989
Bulgaria	No	No	**Yes**	**Yes**	**Yes**	No	No	No	No	No
Hungary	No	No	No	**Yes**	**Yes**	No	No	No	No	No
Poland	No	No	No	**Yes**		No	No	No	No	
Slovenia	No	No	No	**Yes**	**Yes**	No	No	No	No	No

The above results indicate that the seasonal factors for these countries may be biased after 1990 if the factors are estimated from data over the entire period. However, since the break in trend-cycle may be the main factor behind this bias for most countries further tests are necessary due to the fact that the break in the trend-cycle is spread over the period 1988-92 across the countries. In addition, the length of the break period and the drop in the level of series differ between each country.

To test the effect of the estimation of the seasonal factors when the series are affected by an abrupt break in the trend-cycle, the series for the above countries (accepted on the overall score) are adjusted over a longer time span which includes part of the break period. The importance of the choice of time period for comparison of seasonal factors when the series contains a break in the trend cycle is tested for Hungary, Poland and Slovenia with data up to 1990 (i.e. one or two more years of data) and in the case of Bulgaria with data up to 1992 (i.e. three years of more data). The choice of time period is dictated by the length of the break period and the size of the drop in the level of the series.

The new factors, estimated on a period including part of the break period, i.e. up to 1990 (for Hungary, Poland and Slovenia) and up to 1992 (for Bulgaria) and factors based on data for the entire period up to 1996 are plotted over the period 1985-1989 in Charts 10-13 (bottom).

The results show that the changes in the seasonal factors are significant compared to the case when the factors are only estimated on data for the period before the break in the trend-cycle, i.e. Charts 10-13 (top). In addition, the results show that the new factors correspond much better or are close to identical compared to the factors estimated over the entire period up to 1996. These results confirm that the main change in the seasonal factors is due to the abrupt break in the trend-cycle.

CHART 10 COMPARISON OF SEASONAL FACTORS 1985−1989
BULGARIA

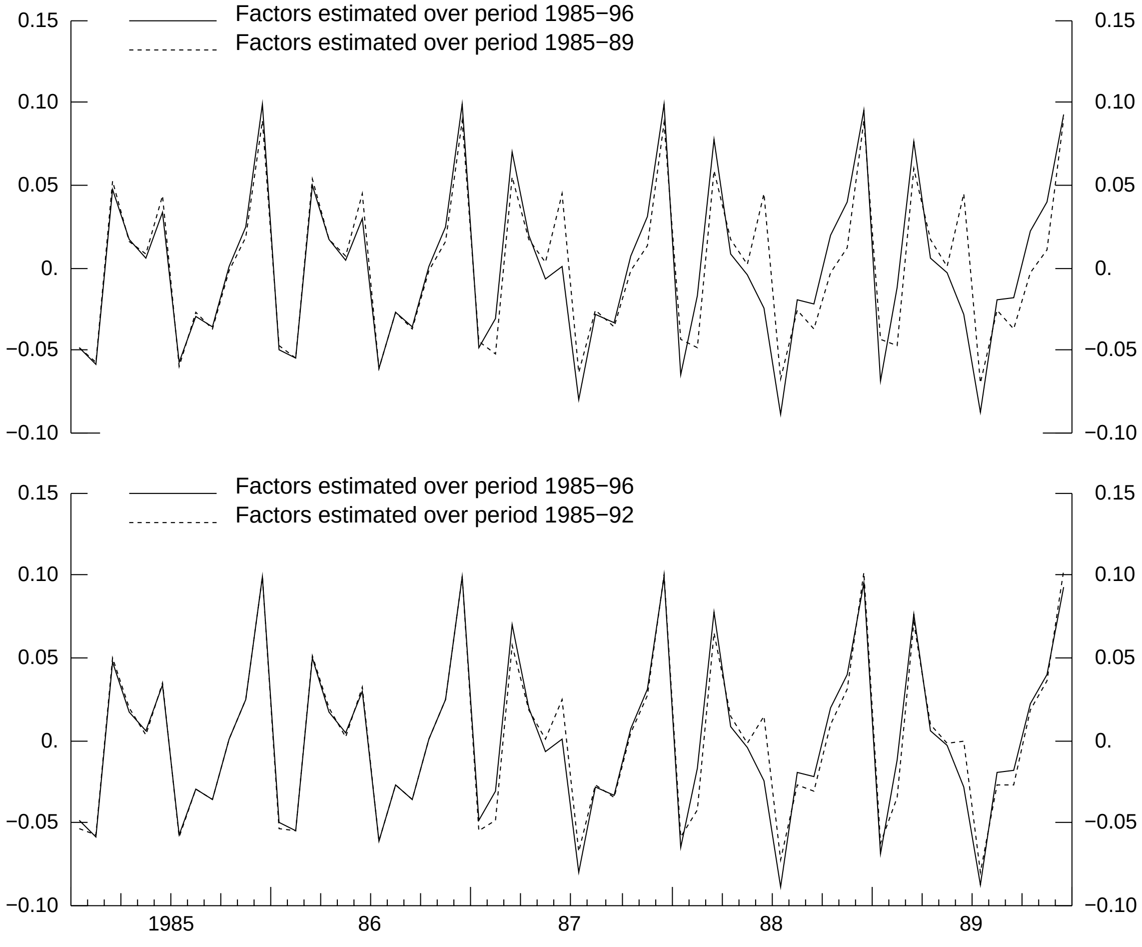


CHART 11 COMPARISON OF SEASONAL FACTORS 1985−1989
HUNGARY

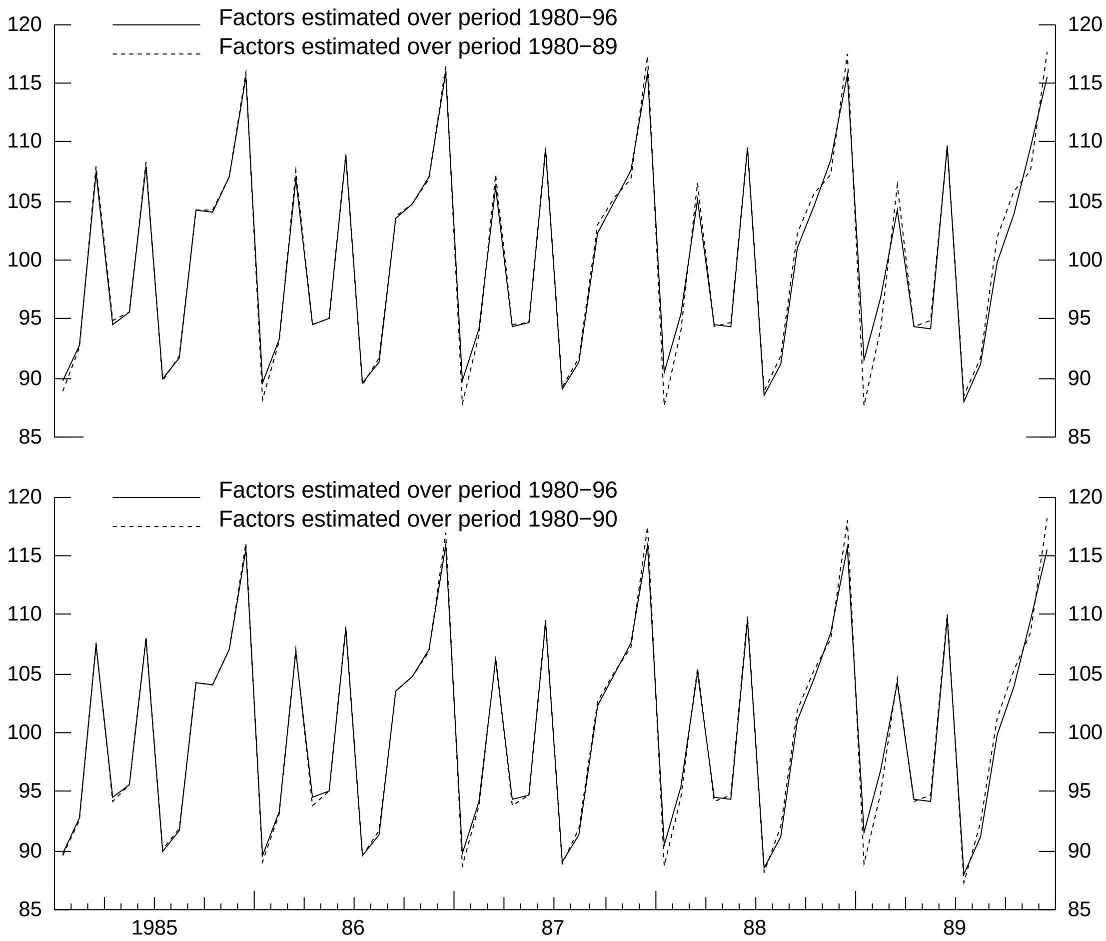


CHART 12 COMPARISON OF SEASONAL FACTORS 1985−1989
POLAND

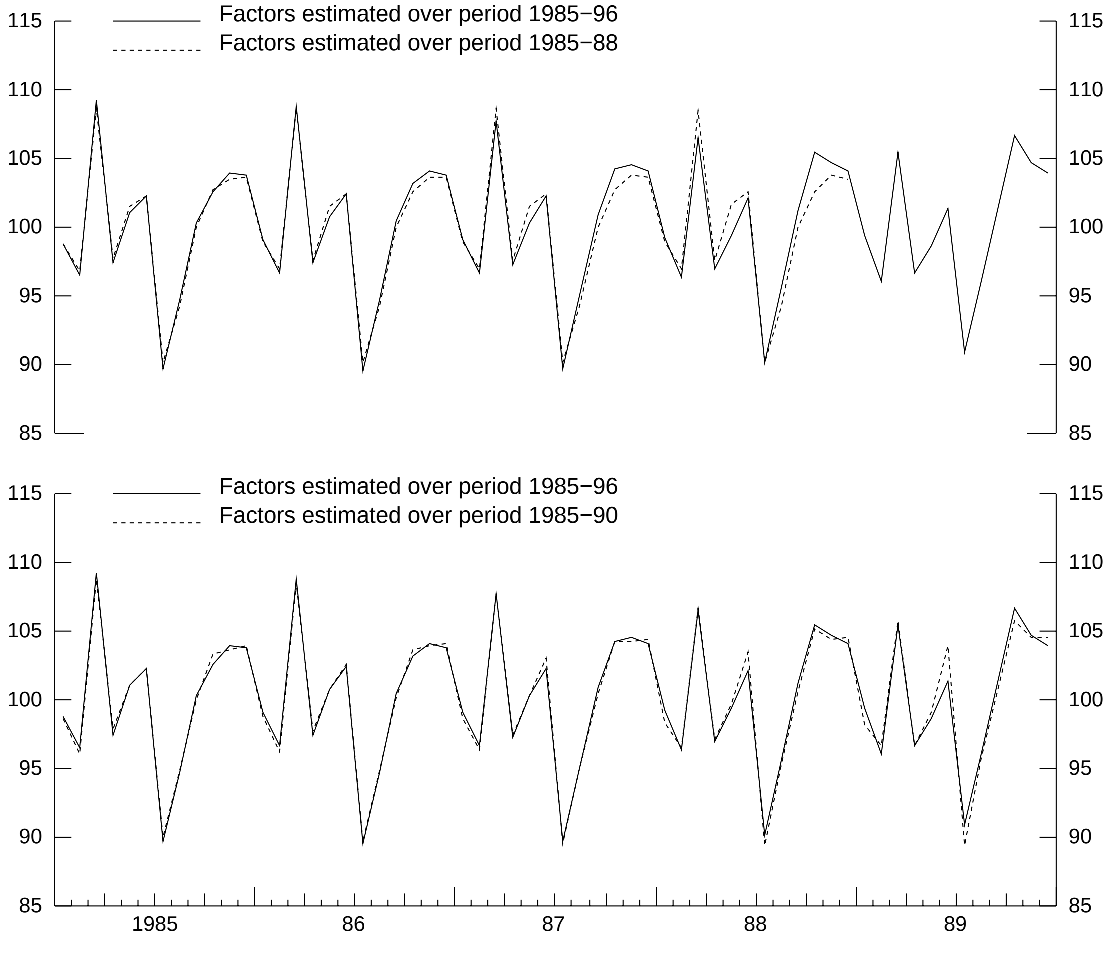
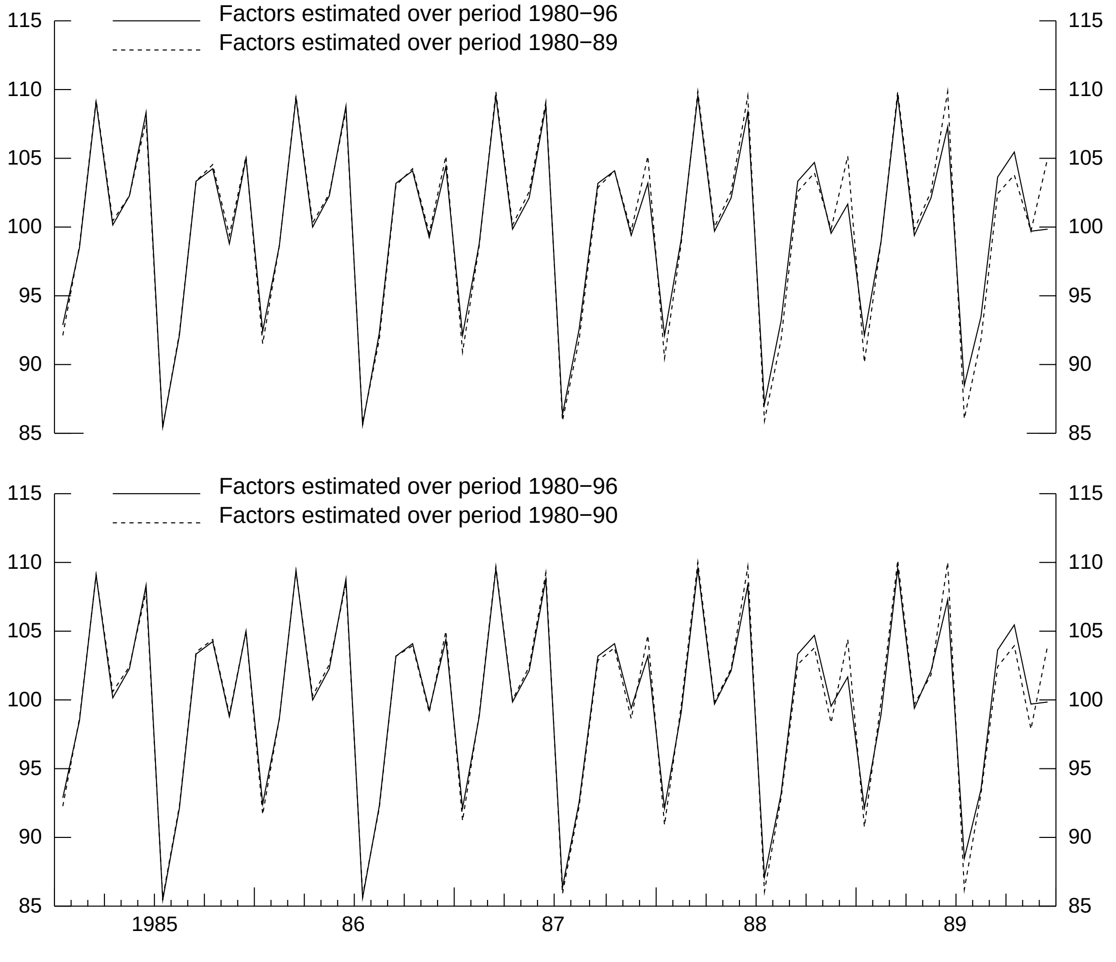


CHART 13 COMPARISON OF SEASONAL FACTORS 1985−1989
SLOVENIA



5.4. Test 2: Comparison of Seasonal Factors Over the Period 1990-1996

Seasonal factors based on data for the period 1990-96 or 1991-96 (depending on start date of series), i.e. transition period, and factors based on data for the entire period up to 1996 are plotted in Charts 14-20 (top) for all countries investigated, i.e. excluding Estonia and the Russian Federation where the series start in 1993. A summary of the assessment of the differences between the two sets of seasonal factors is set out below in Table 8.

As mentioned above this test will show the difference in adjustment between a one-period approach and a two-period approach concerning adjustment over the period 1990-96. The two-period option would be the obvious choice if a drastic change in the seasonal pattern occurred after 1990.

The results show that the differences between the two sets of seasonal factors are mainly caused by the break in the trend-cycle which supports the results of the first test. In addition, the effect of the break is reversed compared to the first test which is logical for corrections before and after the break. For example, compare Chart 14 with Chart 10.

The only country with an observed change in the seasonal pattern in the first test, namely Bulgaria, also shows some trace of this effect over the period after 1990 but to a much lesser extent. The results for Poland show a different seasonal pattern over the period 1990-93 which may be explained by the mini-cycle during 1990-91 affecting the seasonal factors estimated over the period 1990-96.

Table 8: Changes in seasonal factors over the period 1990/1991-1996
Factors based on data for the period 1990/1991-1996 compared to factors based on data over the entire period up 1996

Changes in seasonal factors probably due to:

Country	Break in the trend-cycle						
	1990	1991	1992	1993	1994	1995	1996
Bulgaria	**Yes**	**Yes**	**Yes**	No	No	No	No
Czech Rep.		**Yes**	**Yes**	No	No	No	No
Hungary	No	No	No	No	No	No	No
Poland	**Yes**	**Yes**	No	No	No	No	No
Romania		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Slovak Rep.	**Yes**	**Yes**	No	No	No	No	No
Slovenia	**Yes**	**Yes**	No	No	No	No	No
	Drastic new pattern						
Bulgaria	No	No	No	No	No	No	No
Czech Rep.		No	No	No	No	No	No
Hungary	No	No	No	No	No	No	No
Poland	No	No	No	No	No	No	No
Romania		No	No	No	No	No	No
Slovak Rep.	No	No	No	No	No	No	No
Slovenia	No	No	No	No	No	No	No

The difference between the two sets of factors for all countries seems however to be dominated by the break in the trend-cycle which slightly distorts the estimation of the seasonal factors for 1990 and 1991 in all countries with series starting in I989 or earlier, except Hungary, as well as 1992 in the case of Bulgaria.

The series for the Czech Republic and Romania start in 1990 and show a slight difference between the two sets of factors for 1991 and 1992 in the case of the Czech Republic, and a more pronounced difference for the whole period 1991-1996 in the case of Romania which is explained by the continued decline in output until mid-1992 and the short period of available data.

All countries investigated show a break in the trend-cycle in 1990 or earlier. However, the sharp decline in output after 1990 in all countries may affect the estimation of seasonal factors over the 1990-96 period in all of them if the seasonal factors are estimated from data which include the break period. To reduce this effect the series for all countries are adjusted for the period 1991-1996 or 1992-1996 (depending on start date of series) and the new factors estimated on data for this period are compared to factors estimated from data over the entire period up to 1996.

The new factors, excluding part of the break period (i.e. 1991-1996 or 1992-1996) and factors based on data for the entire period up to 1996 are plotted in Charts 14-20 (bottom).

The results show that changes are significant between the two sets of seasonal factors, i.e. Charts 14-20 (top) for Bulgaria, Poland, Romania and the Slovak Republic. The new factors correspond less to the factors estimated for the entire period up to 1996 for the above countries with the exception of Romania. However, as noted above, the result for Romania is very much affected by the continued decline in output until mid-1992 and the short period of available data . These results indicate that the main cause of the change in the seasonal factors is the break in the trend-cycle. This supports the findings in the first test.

CHART 14 COMPARISON OF SEASONAL FACTORS 1990−96
BULGARIA

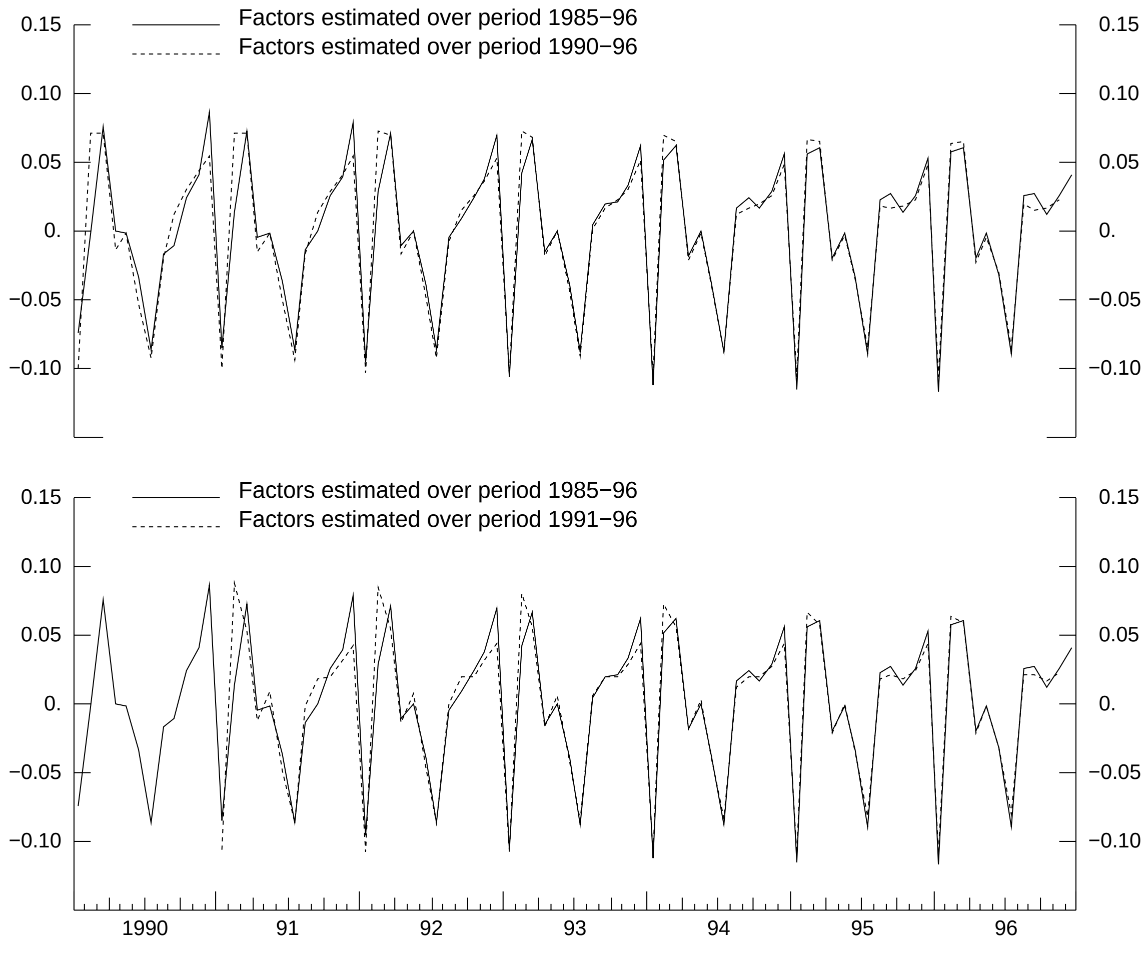


CHART 15 COMPARISON OF SEASONAL FACTORS 1990−1996
CZECH REPUBLIC

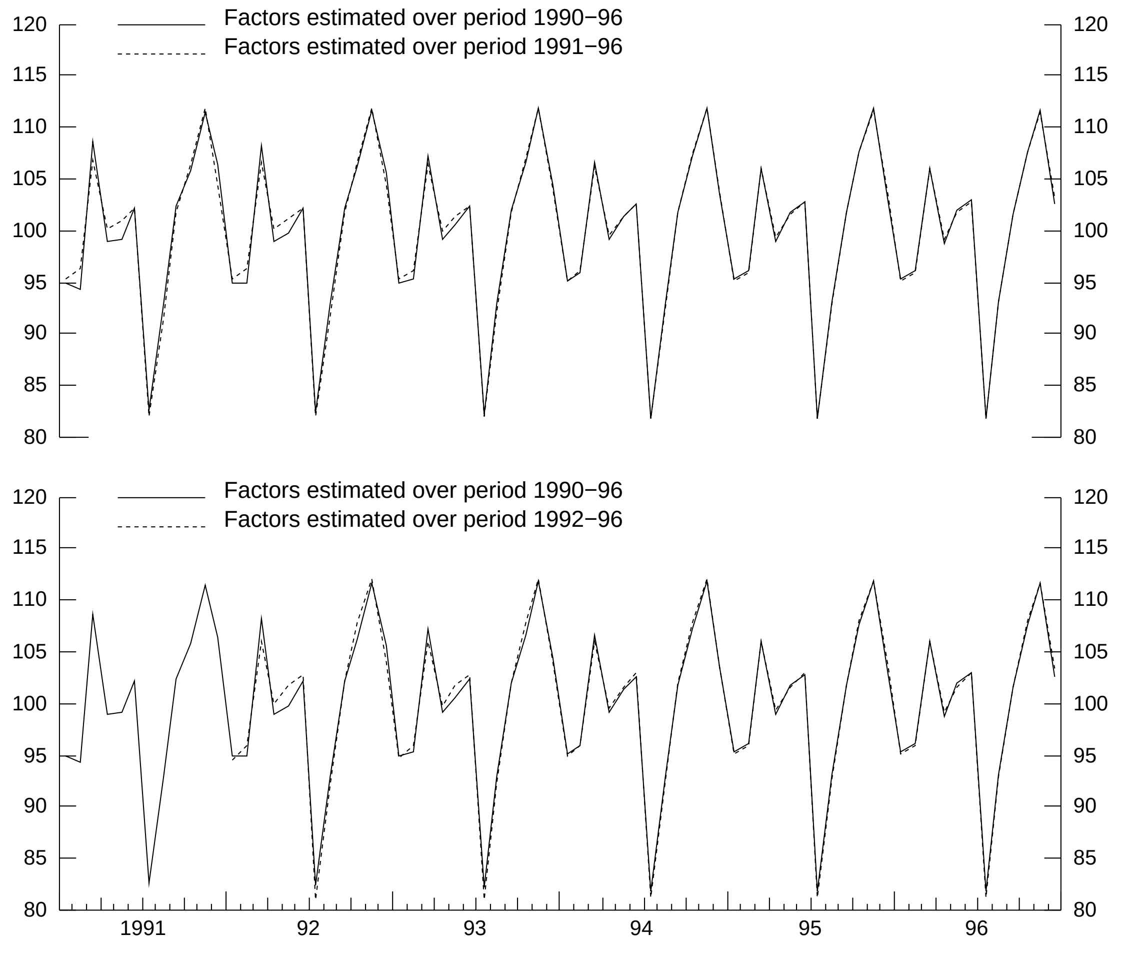


CHART 16 COMPARISON OF SEASONAL FACTORS 1990−96
HUNGARY

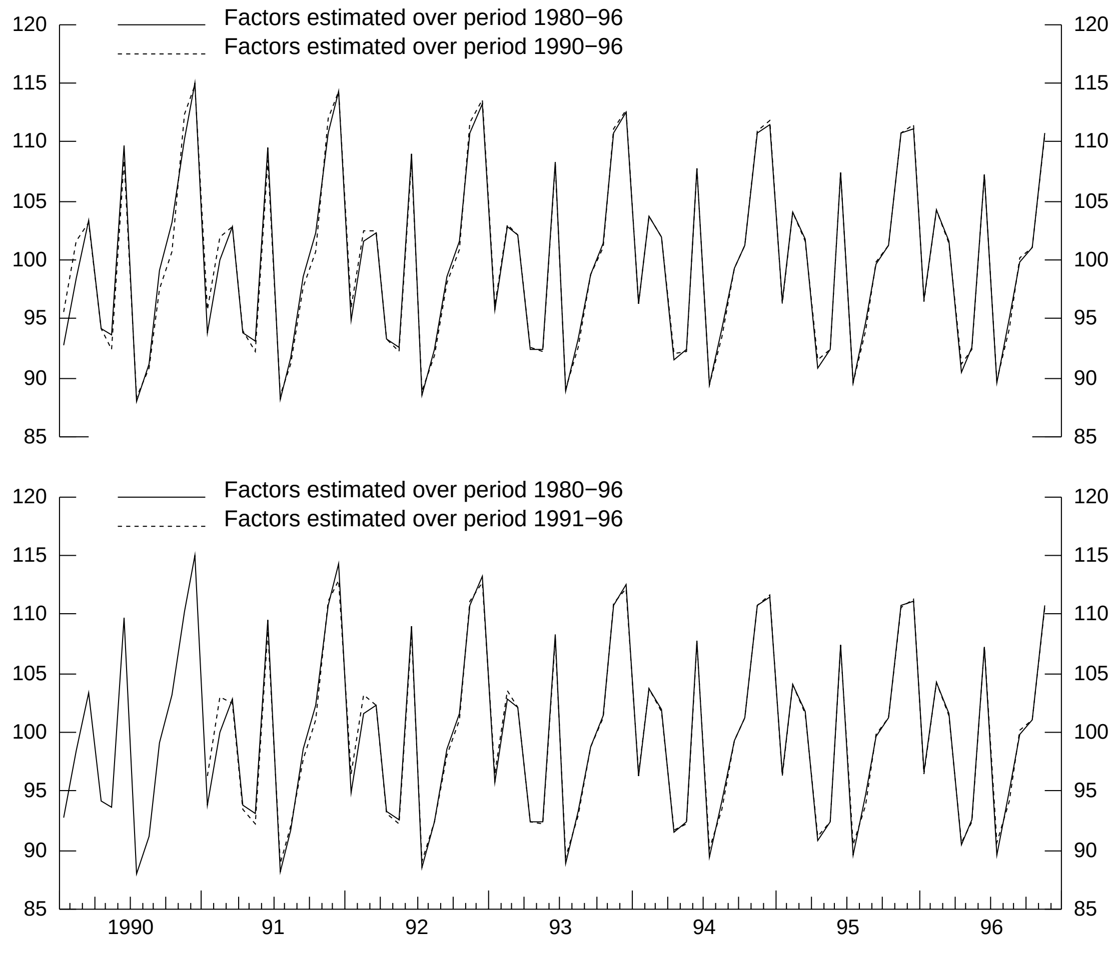


CHART 17 COMPARISON OF SEASONAL FACTORS 1990−1996
POLAND

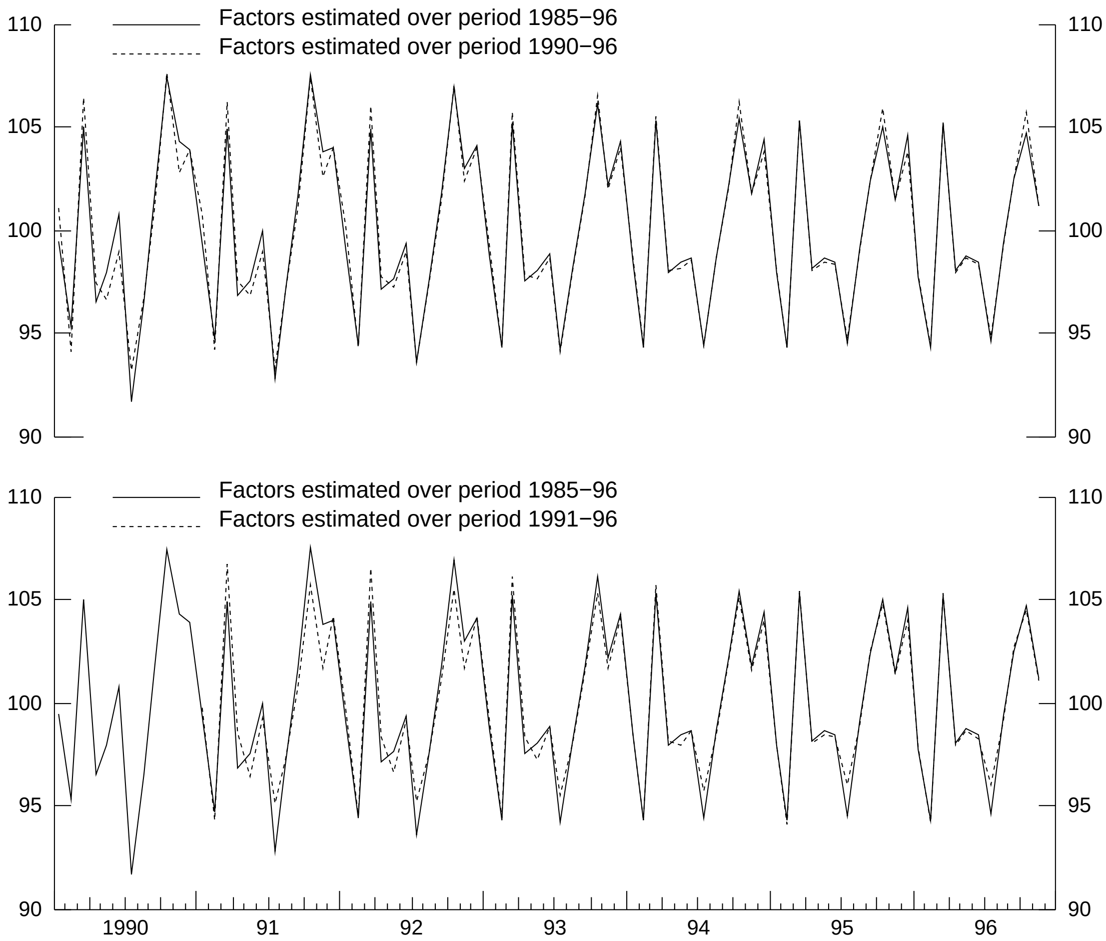


CHART 18 COMPARISON OF SEASONAL FACTORS 1990−1996
ROMANIA

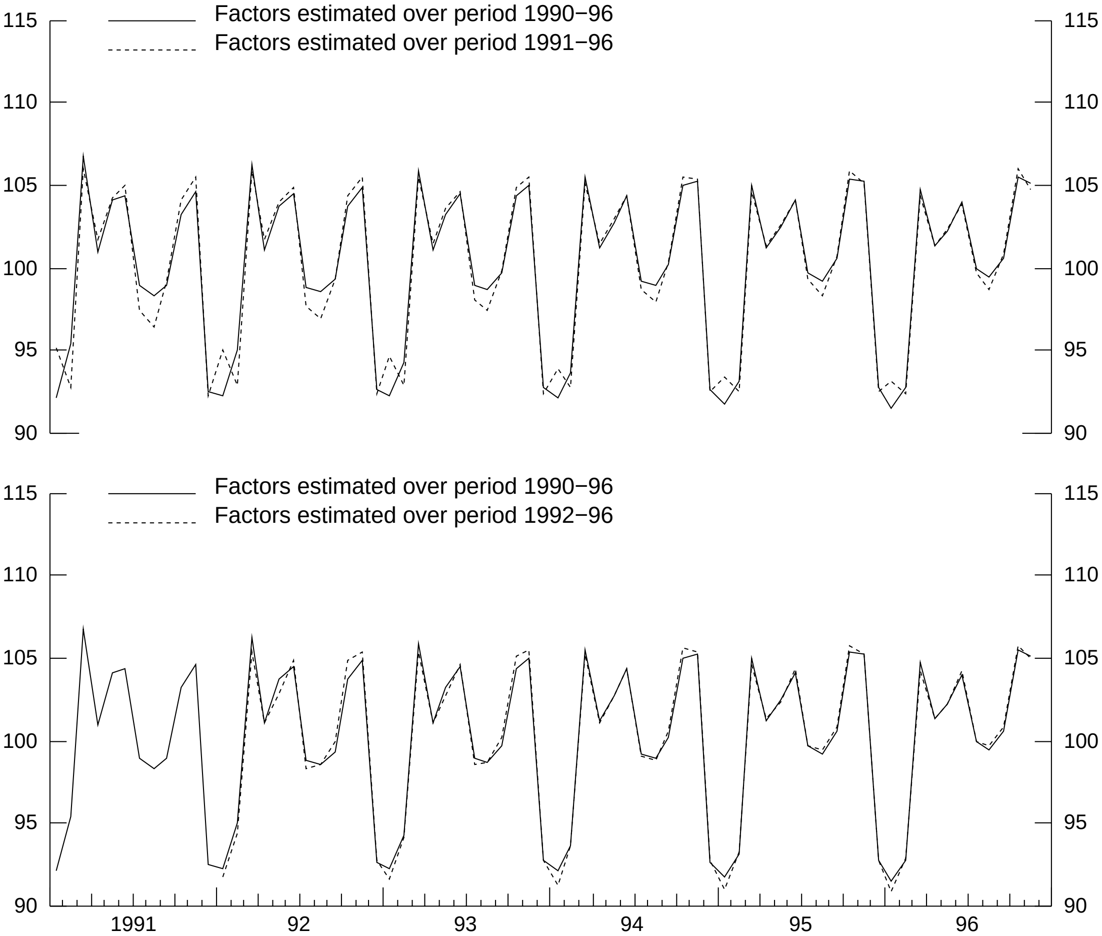


CHART 19 COMPARISON OF SEASONAL FACTORS 1990−1996
SLOVAK REPUBLIC

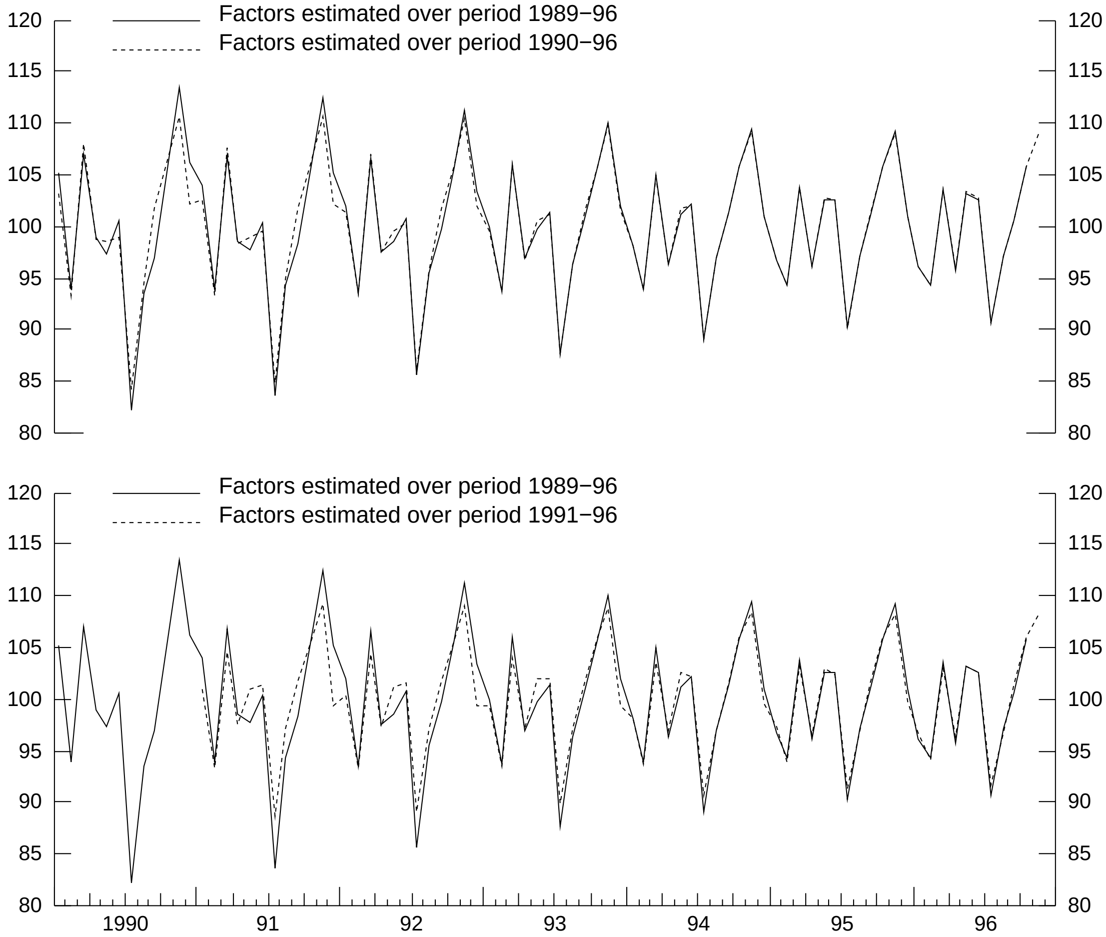
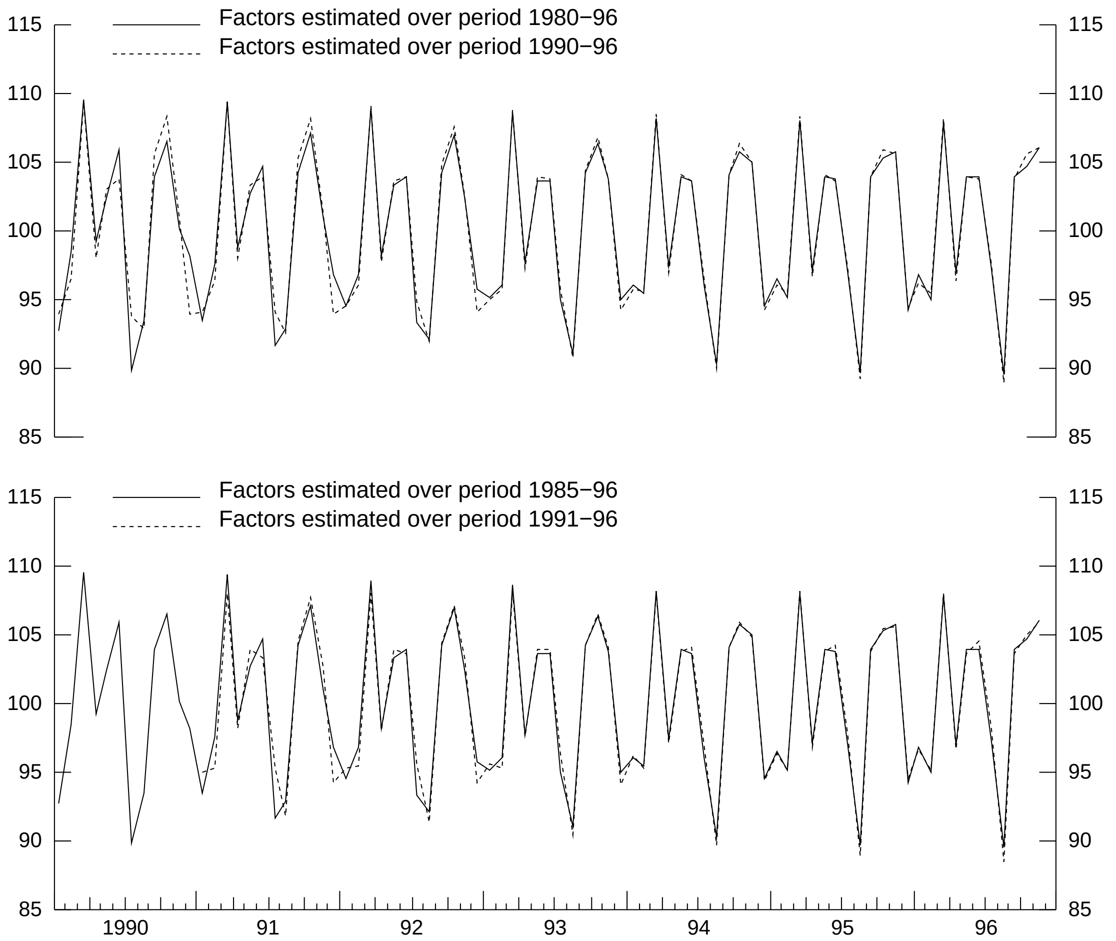


CHART 20 COMPARISON OF SEASONAL FACTORS 1990−1996
SLOVENIA



5.5. Conclusions

The findings of these results may be summarized as follows:

- The break in the trend-cycle over the period 1988-91 is the main factor disturbing the estimation of the seasonal factors.

- A drastic change in the seasonal pattern is not apparent in any of the countries investigated.

- A gradual change in the seasonal pattern is present in a few countries, but the effect seems to be less important than the break in the trend-cycle.

- The findings suggest that the best method to deal with the bias in the estimation of the seasonal factors is to correct the series in some way over the period that is affected by the break in the trend-cycle.

- The results of the assessment statistics in Section 5.2 and of Tests 1 and 2 suggest the following concerning seasonal adjustment at present:

  1. seasonal adjustment may be performed on the entire period of available data for Hungary and Poland;

  2. seasonal adjustment over the period 1990-1996, the transition period, may be performed in the case of Bulgaria, the Slovak Republic and Slovenia;

  3. seasonal adjustment over the period 1993-1996 may be performed for Estonia and the Russian Federation.

  4. the results of Tests 1 and 2 indicate that the estimation of the seasonal factors is affected by the break in the trend-cycle, and an outlier correction (level shift) of the original series over the break period should be applied before seasonal adjustment is performed. This correction can be made by the REGARIMA module in the X12-ARIMA program. If seasonal adjustment is performed on the entire period of available data (i.e. 1980/1985 to 1996) such a correction should be considered for all countries, except Hungary, where data is available covering a long time period..

  5. if the period before 1990 is of less interest, all countries with available data before this date may be adjusted over the period starting in 1990. However, the break in the trend-cycle will affect the series after 1990 as well, but to a lesser extent than before the break period. A correction over the break period will improve the estimation of the seasonal factors. This correction should be considered for Bulgaria, Poland and the Slovak Republic.

The above type of analysis, and similar investigations, should be applied to economic time series when large erratic movements over a short period disrupt longer periods of rather stable fluctuations. Such disruptions may be caused by:

- *external events* such as unseasonal weather conditions, natural disasters, strikes, international hostilities and socio-economic changes; and

- *internal factors* such as changes in the sample used to obtain the time series or the classification scheme used to define the time series.

These types of disruptions, in particular those which result in a change in the level of the time series over a longer period, affect the reliability of the seasonal adjustment obtained from X11, X11-ARIMA, X12-ARIMA and other programs based on the moving average techniques. Such disruptions also make it difficult to identify ARIMA models for forecasting the time series. However, it is frequently possible to model such disruptions in time series by means of REGARIMA models included in the X12-ARIMA program.