ON THE MEASUREMENT OF SEASONAL VARIATIONS

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1. The study of seasonal variations in Finland

As short-term national income calculations are made for periods of less than one year, the analysis and elimination of seasonal variations form an almost indispensable stage of the preparation of this information for use in economic analyses. It is scarcely necessary to elaborate the reasons for this.[1]

In Finland the seasonal variations have been more intensively studied during the last two years. This work has been performed principally by the Bank of Finland Institute for Economic Research. Two main lines have been followed in experimenting with different methods of analysis: that of studying the short-term changes in the seasonal variations by means of econometric models constructed to explain the changes, and that of analysing a number of time series by a "standard method" programmed for electronic computers.

2. The study of seasonal variations by means of regression analysis

The seasonal variations in industrial production in Finland

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1. Cf Seasonal Adjustment on Electronic Computers, OECD publications, 1961, p. 14.

have been examined since 1960[1], with the view, not only of measuring the average or normal seasonal variation, but also of explaining their short-term changes from year to year. These changes, termed specific seasonal variations, have been explained as deriving from weather conditions (temperature and rainfall, and the ice conditions on the Finnish coasts), and from business cycle variations in industrial production.

In the 1930's some interest was displayed in the specific seasonal variations. MENDERSHAUSEN, for instance, made an investigation into the dependence of the seasonal variations in Central European building industry upon meteorological factors and cyclical movements in the same industry.[2] However, in general only the normal seasonal variations have been eliminated in the construction of business cycle indicators, although it is known that the presence of, for instance, random fluctuations caused by exceptional weather conditions makes it more difficult to observe and project the cyclical development. During the last few years some attempts have been made at measuring the oscillations caused by meteorological factors.[3]

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1. A preliminary report was published in No. 8, 1961 of the Bank of Finland Monthly Bulletin: PERTTI KUKKONEN Seasonal Fluctuations in Industrial Production in Finland, and by the same author a slightly more comprehensive one in Series A 1962: I of Publications issued by the Bank of Finland Institute for Economic Research, "Teollisuustuotannon volyymin lyhytaikaiset vaihtelut suhdanneanalyysin kannalta" (in Finnish) and "Kortfristiga fluktuationer i industriproduktionens volym ur konjunkturanalytisk synpunkt" (in Swedish).

2. HORST MENDERSHAUSEN Eliminating Changing Seasonals by Multiple Regression Analysis, The Review of Economic Statistics, November 1939, s. 171-177; see also Methods of Computing and Eliminating Changing Seasonal Fluctuations, Econometrica, July 1937.

3. See "Experience in the Application of Regression Computing to the Seasonal Adjustment of Statistical Time-Series", Monthly Reports of the Deutsche Bundesbank, August 1961, p. 22.

In the analysis of the volume of Finnish industrial production, the volume index of industrial output per working day - a time series adjusted for calendar variations - was used as the basic series. By means of data concerning the length of working time for each day of 1959 in the various groups of industry, a working-time coefficient had been calculated for each group of industry and for total industry. Coefficients had been calculated for each month of the period concerned, January 1950 - April 1961, and by division of the original volume index by these coefficients a series adjusted for calendar variations was obtained. From this series the effect of work stoppages, which were comparatively numerous in Finland in the 1950s, was eliminated, insofar as relevant statistics were available. The series now obtained will here be denoted by Y, its trend-cycle component by T, the normal seasonal component by P_1, the specific seasonal component by P_2 and the rest component by ε. A multiplicative model was used, and the decomposition was carried out employing the following formula:

$\text{Log } Y = \text{Log } T + \text{Log } P_1 + \text{Log } P_2 + \text{Log } \varepsilon$. Before decision was taken in favour of the multiplicative model, experiments were made with an additive model, but the former was found to be more realistic. By a preliminary analysis an approximate value T′ was computed for the trend-cycle component[1], and the other components were then obtained from models of the following type:

$$\text{Log } Y_{mt} - \text{Log } T'_{mt} = b_m + f_m t' + \sum_i d_{(i)m} S_{(i)mt} + \varepsilon'_{mt} ,$$

where t stands for years (t′= t - 1955) and m for months; $b_m + f_m t'$ represents the logarithm of the normal seasonal component

1. In the preliminary analysis a constant multiplicative seasonal component was calculated on the basis of ratios to centered 12-month moving average, and was eliminated, exept for November and December, where a linearly time-conditioned change in normal seasonal variations was also eliminated. Estimate T′ was computed from the adjusted series by a 15-term smoothing formula, which is proposed by MACAULAY and which gives approximately the same results as the well-known SPENCERs 15-term formula.

(in month m of year t), $\sum_i d_{(i)m} S_{(i)m}$ the logarithm of the specific seasonal component, and ε'_{mt} the logarithm of the rest component. The parameters of the model, b_m, f_m and $d_{(i)m}$, were computed by the least squares method, separately for the models of each month. The number of parameters which had to be estimated was 4 or 5, depending on the model, while the number of observations available for the estimation was only 11 or 12, which causes some difficulties in the interpretation of the results.

In the majority of months the normal seasonal variation was approximately constant; in the models for these months the parameter for the normal seasonal variation was b_m. In the models for July, August, November and December the term $f_m t'$ was included to represent the change in the normal seasonal variation.

The variables (S_i) employed to explain the specific seasonal variations are: changes in spare capacity (including the labour force), the monthly average temperature and rainfall (both in the form of monthly deviations from the average for the whole period), and the length of the periods when the harbours are closed to represent the influence of the ice conditions on the coasts, which affect the transports of the Finnish exporting industries in particular. The last-mentioned variable was included only in the models for January, February and March. In the April model, the January-March averages of the temperature variable and the ice variable were included for the purpose of explaining the fluctuations which occur in the early spring, and have a direction opposite to that of the fluctuations during the winter months. In other months only the immediate effects of weather variations could be taken into consideration, although there are some indications that also more generally, after a great weather fluctuation there will be a countereffect. The observations were so few in number that the countereffects could not be analyzed in this study.

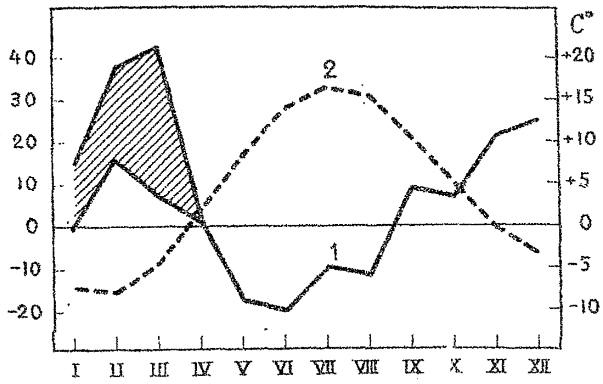
The amplitude of the seasonal variations of industrial production have been found to vary according to the phase of the cyclical movement: it is less during upswing and boom periods than during periods of downswing. According to the hypothesis adopted in the analysis, this is because, when there is less spare capacity, it is more profitable to concentrate the increase in production to months with a normally low output than to spread it evenly over the whole year, or place it to the months of the seasonal peak. By this means the additional costs for increased overtime or shift work etc. are partly avoided, although admittedly stocking costs may at the same time increase to some extent. The estimates of the coefficients for variables for the spare capacity do not contradict the hypothesis.

The random weather variations have been found to influence the volume of industrial production mainly in such a manner that production is partly shifted to the months most favourable as regards weather conditions, and in a minor degree in such a manner that these variations actually raise (or arrest) production. The latter phenomenon may occur when random weather variations very strongly affect the use of some products, for instance the consumption of fuel in winter and of cooling drinks in summer.

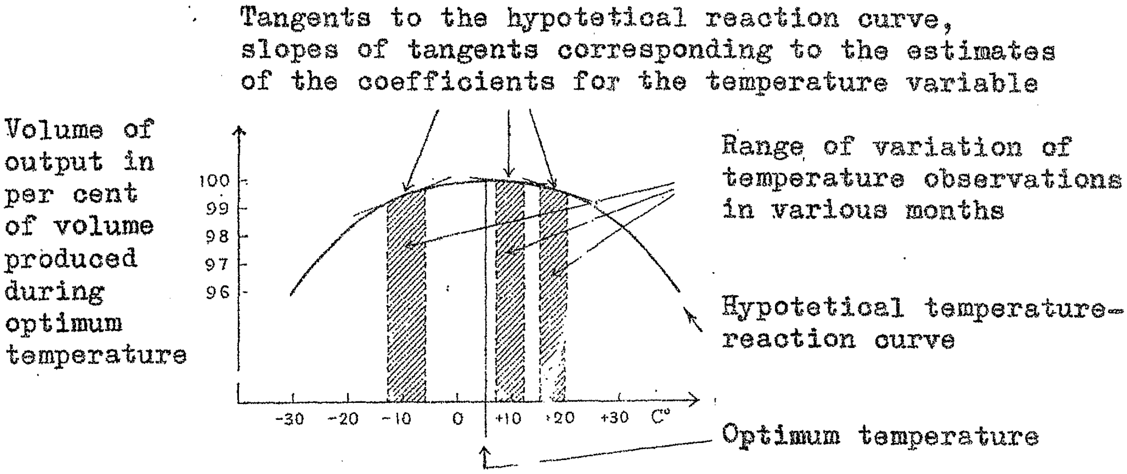
The direction of the effect of random variations in temperature could be hypothesized in advance only for the winter months. On the basis of common experience and earlier investigations it was expected that output would fall off during months colder than normal and increase during months milder than normal. The results of the analysis supported this hypothesis (graph 1 on page 6). During the summer months the tendency was found to be the opposite one. It was considered justified to combine these results into a hypothetical curve for the immediate effect of the temperature, i.e. a curve representing an assumed optimum temperature, from which deviations in either direction deteriorate conditions of production and reduce output. This curve and the method of determining the effect of the temperature variable are illustrated in graph 2 on page 6. The plausibility of this kind of reaction curve becomes more apparent, when we consider the effects of very extreme temperature variations.

Graph 1. 1. Estimates of the coefficients for the temperature variable and the ice variable (shaded area) multiplied by the standard deviations of the variables (left-hand scale)

2. Average temperature during the various months of the years 1950 - 1960 (right-hand scale)

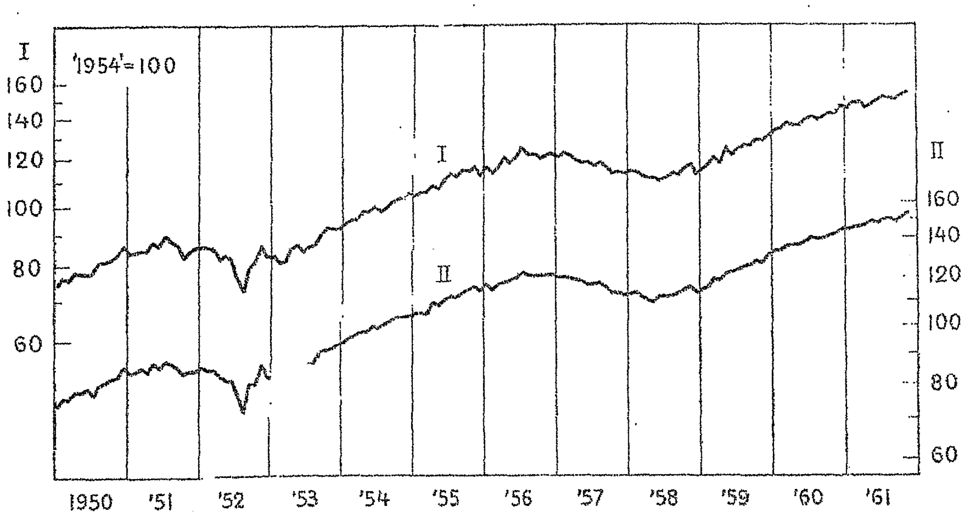


Graph 2. Schematic representation of the pattern of reaction to temperature and its measurement



Graph 3. Seasonally adjusted series of the volume of industrial production in Finland

I Adjusted for normal seasonal variations
II Adjusted for normal and specific seasonal variations
(log. scale)



When we move from the usual open air temperature region (-30° - $+30^{\circ}$ C in Scandinavian countries) to the levels $+40^{\circ}$ - $+50^{\circ}$ C or to -40° - -50° C or to even more extreme temperatures, it is very likely that production conditions become more and more unfavourable, even at an accelerating pace. This confirms the form of the reaction curve discussed above.

The optimum temperature can be estimated at about + 5°C, which is the approximate annual average temperature in Finland. This finding, together with the a priori conclusions drawn from corresponding temperature-reaction patterns in other climatic conditions, gives rise to the following theoretical reflections of a more general nature.

Human beings living in the different climatic zones have probably adapted themselves to the prevailing temperatures in such a way that their working capacity is highest when the temperature moves around the average, and falls off when the temperature is higher or lower than average. Also, production techniques are in many cases developed so as to be most effective in conditions of average temperature. Further, it is likely that these zone optima have on optimum, that is to say, there are latitudes which, as regards temperature, are more favourable for industrial production than are the more northerly or southerly latitudes. This fact of economic geography is probably comparatively well known. In this connection it is not a question of short-term reactions to temperature variations, as it was in the reaction curve discussed above.

The temperature-reaction curve, calculated on the basis of monthly random variations, can also be used for explaining that part of the normal seasonal variation which is caused by the regular temperature variation that depends on the seasons of the year but is not directly measurable, because it has not proved possible to quantify the effect of other factors influencing the normal seasonal variations, such as customs and institutional factors.

The effects of random variations in rainfall are likely to be even more difficult to determine, but it seems possible that a rain-reaction curve corresponding to the temperature-reaction curve could also be constructed. Nevertheless, the effects of rain and temperature are not likely to be independent of each other.

In the foregoing presentation, several important points have been ignored, such as the construction of the weather variables from the values recorded at different meteorological observation stations, the non-linear nature of the functions involved, and so on. The aim has been to show that there exist some possibilities of constructing models to explain short-term changes in the seasonal variations, and of building up a theory on the pattern of reaction to temperature, the most important factor causing seasonal variations in production series, a theory that would permit measuring of seasonal variations by procedures other than just "mechanical" ones. However, an analysis of this type demands a high degree of exactness of the basic time series, and requires a set of data with the aid of which the calendar component can be eliminated. As not nearly all of the series employed, for example in the national income calculations meet these requirements recourse must often be had to more mechanical procedures in eliminating the seasonal.

3. A standard programme for the analysis of seasonal variations

A thorough analysis of the short-term fluctuations by the above described method by necessity entails much work for the elimination of the calendar variations and the choice of the form of, and the explanatory variables for, the model to be used, although the calculations proper on an electronic computer take little time. The number of series to be analysed in this way can be raised but slowly. For this reason, and for the reasons mentioned above, another method is required by which seasonally adjusted series can be produced in large numbers; these analyses will, of course, be less thorough, which tends to restrict the usability of the results.

In 1962 a standard method of analysis by an Elliot 803 computer was planned and programmed in the Bank of Finland

Institute for Economic Research. In designing the method and programme great help was derived from the accounts of experiences gained in other countries of such methods, described in the OECD publication "Seasonal Adjustment on Electronic Computers."

The method is of the 'ratio to moving average' type, and in the main resembles the Bureau of Census Method II.[1] The decomposition is made employing the formula

$$Y = T \cdot P \cdot \mathcal{E},$$

where Y stands for the basic time series, T for the trend-cycle component, P for the normal seasonal component and $\mathcal{E}$ for the residual (irregular) component. The normal seasonal component is allowed to change slowly. The estimation procedure is iterative, as in Method II, but the iterations are increased by one run to correct the estimate for the trend-cycle component after correcting the extreme values for the irregular component.[2]

Another difference and, as it is hoped, an improvement in comparison with the Bureau of Census Method II is in the formula for extrapolating the end values of the trend-cycle component. In Method II the series to be smoothed is at first extrapolated $\underline{k}$ terms ahead (if $\underline{2k+1}$ is the number of terms in the smoothing formula) by the average of 4 last observations of the series. When there is a rising or falling trend at the end of the series, this extrapolation method tends to underestimate the change in the trend-cycle component.

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1. See JULIUS SHISKIN Electronic computer seasonal adjustments, test and revisions of U.S. Census Methods, p. 80-150 in the publication of OECD: Seasonal adjustment on electronic computers, Paris 1961, and JULIUS SHISKIN and HARRY EISENPRESS Seasonal Adjustments by Electronic Computer Methods, Journal of the American Statistical Association 1957, p. 415-449.

2. This improvement has been proposed by SHISKIN himself, cf. his Electronic computer seasonal adjustments, test and revisions of U.S. Census Methods, p. 109.

In the standard method under discussion, the trend-cycle component is extrapolated by means of such a weighted average of the <u>2k+1</u> last observations as corresponds to the fitting of a cubic by means of least squares to these last observations. Last <u>k</u> values of the cubic are used as extrapolation of the trend-cycle component. If the amplitude of the irregular component is relatively large, 2 or 3 last values of the series are substituted by their average before fitting the cubic. This procedure mitigates the effect of large values of the irregular component in the last values of the cubic. It causes the same kind of underestimation of changes in the trend-cycle component as does the extrapolation procedure in Method II, but the bias is less marked.

The programme is planned so as to give the widest possible scope for use in the following respects:

1) The number of time units in one period of oscillation may vary between 2 and 31. Thus analyses can be made of quarterly or monthly series and, if so desired, of semiannual or weekly series, or even of daily variations during the month.

2) The weighted moving averages can be freely chosen for each series, the weights being read into the memory of the computer from a special paper tape, which may contain a great number of different weighting procedures. The weights required for extrapolation of moving averages at the ends of the series can also be freely chosen for each series from among the weights on the tape. This makes it possible, for instance, to apply more efficient smoothing procedures for series with a great irregular component, and less efficient ones in other cases.

3) The processing of a time series may be started and stopped at any point of time, not necessarily at the beginning, or end, of a period of the oscillation (generally a year).

4) The extent of the printing of results can be regulated within the limits of given alternatives.

5) In programming the method the calculations were split into many sub-routines. Thus, each of the two smoothing procedures needed was made into a separate sub-routine, similarly

their extrapolation procedures and the tabulation of the results. This makes it easy to change the programme, if needed.

To date, some 200 economic time series have been analysed using this programme. These include the principal quarterly series of the national income calculations. The experience gained of the analyses of series for production volumes is that in many cases, and particularly in respect of construction and forest industry, the elimination of merely the normal seasonal variation does not produce a sufficiently regular series; regular in the sense that the irregular component would be small enough to allow of easy observation of the cyclical development within the sector concerned.

As was mentioned in connection with the discussion of the analysis of industrial production, the irregular component can possibly be reduced by analysis and elimination of variations due to the calendar and to work stoppages, and of the specific seasonal variations caused by business cycle influence and weather conditions. Anyway, the series adjusted for normal seasonal variations make it easier to observe and study the cyclical movement and can also be used as one check on short-term national income calculations.