EXERCISES IN FORECASTING IV

THE ANALYSIS OF A SEASONAL TIME SERIES: US Money Stock

The Object of the Exercise

The object of this exercise is to learn how to analyse a time series which contains a regular seasonal cycle. The series in question comprises 132 observations on the money supply in the United States over the period Jan. 1960 to Dec. 1970. The series is to be found within the `DEMO` data directory which accompanies *MESOSAUR* on the `J` drive. Part of the exercise will involve regressing the de-trended version of the money-supply series upon a set of sequences generated by harmonically related sine and cosine functions. Since the money supply is observed monthly, the annual cycle spans 12 time periods. The fundamental frequency is therefore 30° per period and the harmonic frequencies are the integer multiples of 30° up to the Nyquist frequency of 180°. Thus, in addition to the values of the sine and cosine functions $\cos(30°t)$ and $\sin(30°t)$, we require the values for the functions with frequencies of 60°, 90°, 120°, 150° and 180° per period. A set of prefabricated sine and cosine functions at these various frequencies will be found in the file `DUODEC.TXT` which resides in the `TXTDATA` subdirectory of the `MOREDATA` directory on the `F` drive.

Configuring Mesosaur and Reading the Data

The program is invoked by typing `meso,` and the first act is to configure the program. Respond to the prompt

```
Default data directory [G:\DATA]:
```

by typing

```
J:\APPS\MESO
```

This will direct *MESOSAUR* to look for the `DEMO` data directory. In response to the prompt

```
Default import directory [G:\IMPEX]:
```

you should type

```
F:\MOREDATA\TXTDATA
```

This will direct *MESOSAUR* to look for the `TXTDATA` sub-directory which contains the file `DUODEC.TXT`.

Once you are within the program, you should proceed to read the requisite data via the **I/O** menu. First you should read the contents of the file

DUODEC.TXT via the **Import->** command. The arrow indicates that this command has a sub-menu. Select the command and type <Return> to enter the sub-menu. Then select **ASCII File** and type <Return>. You will be presented with a dialogue box into which you must enter the name of the file to be imported. You will notice that *MESOSAUR* is already looking into the F:\MOREDATA\TXTDATA directory as it was instructed to do in the process of configuration.

You may now proceed to enter the name DUODEC.TXT. This can be done either by typing the filename or else by selecting it from the menu which is presented to you when you type <Ctrl-F>. When you press <Return> you will be confronted with a further dialogue box in which you may specify the Time Interval, i.e. the unit of time, and the Initial Time. In this case, the time units are months and the initial date is Jan. 1960. Once these details have been entered, you should press <F-10>. This will take you back to the upper level of the program where you will see evidence of the fact that the data has been read into *MESOSAUR.*

The next step is to enter the data on the U.S. money supply. Go to the **I/O** menu and issue the **File** command which can be done by typing <Ctrl-F>. You will see the DEMO directory displayed within the DATA FILE DIRECTORY. Press <Insert> to obtain the local menu and **Open** the DEMO directory. Use the cursor keys to locate and to highlight the MONEY-U.S.A. file. Press <Insert> to obtain the local menu again and **Read** the file. Then return to the upper level of *MESOSAUR.*

De-trending the Money Supply

The money supply data is displayed as the last item in the list of variables. Be certain that this is the highlighted item. The first stage in the analysis of this data is to plot it. The relevant **Plot** command is to be found within the **Visual Analysis** menu. What you will see is a saw-tooth pattern superimposed upon a rising trend. The first object is to model the trend. This is accomplished easily by fitting a quadratic or "parabolic" function to the data. The method has been described already in Exercise I.

Go to the **Models** menu under which you will find the **Univariate Models** sub-menu. Select the **Trend** option. Press the space bar until the trend which you wish to fit is displayed. Press <Insert> to obtain the local menu and then issue the **Go** command. You will be presented with a summary of the regression results including the values of the three coefficients and an indication of their significance. Notice that the value of R^2 is a high one, which signifies that most of the variation in the money supply is the result of a simple process of monotonic growth.

To see some further aspects of the regression results, you might use some of the commands of the local regression menu which is accessed by typing

<Insert>. Amongst these are the **Trend Plot** and the **Residual Autocorrelation Function**. Before leaving this level of the program, you should issue the **Store and Exit** command within the local menu. This saves the series which have been generated in the course of the regression analysis.

Amongst the series which have been generated are LOWER, UPPER, TREND and FORECAST. You can afford to delete all of these from the list of variables using the <Ctrl-D> command. What remains is the RESIDUALS series which will provide the dependent variable for the next stage of the analysis. It is advisable to rename this series so that it will not be confused with the residual series generated by subsequent regressions.

Regressing the Trend-Residuals on the Trigonometrical Series

To rename the RESIDUALS as TRENDRES, you access the **Variable** menu and you issue the **Rename** of <Ctrl-R> command. TRENDRES is now the dependent variable for a trigonometrical regression.

Before running the regression, however, you should investigate the periodogram of TRENDRES. This is done via the **Periodogram** or <Ctrl-G> command in the **Statistics** menu. Once you have noted the details of the resulting graph, you should press <F-10> or <Esc>, and you will be confronted by a list of numbers which are the frequency values, the equivalent periods and the corresponding values of the periodogram ordinates. It is worth glancing at the values of these ordinates since they indicate which of the frequencies are responsible for explaining the largest proportion of the variance of TRENDRES. You will notice, for example, that the ordinate corresponding to the frequency value of 0.0227 and to a period of of 3.6667 years is a prominent one. This corresponds to the first spike on the graph of the periodogram. Other prominent ordinates are found at 12 months, 6 months, 4 months, 3 months, 2.4 months and 2 months, which correspond, of course, to the fundamental frequency of 30° and its harmonics.

You may wish to save the data on the periodogram ordinates to a file which can be read by *EXCEL*. To do so, you must press <Insert> to obtain the local menu and you must issue the command **Print.** You will be confronted by a dialogue box which asks you whether the output should be sent to the printer or to a file. Choose File and supply an intelligible file name such as G:\USPERIOD.DAT. The data will be saved on your G drive for later use.

Now you are ready to conduct a regression analysis. Use the cursor keys to move to the top of the list of variables. The first in the list are t and Cos(0). Neither of these are of any use to us, so they may be deleted via the <Ctrl-D> command. The remaining variables, beginning with cos(30t), may now be selected for inclusion on the RHS of the regression. The variables are marked for inclusion simply by pressing <Return>, which serves to highlight them, and by passing from one variable to the next using the <↓> cursor key. You should select a variable only if, in your judgment, it is liable to contribute significantly

to the explanation of TRENDRES. The significance of its contribution may be judged in advance either from the graph of the periodogram or from the list of the periodogram ordinates. The final variable to be selected is the dependent variable TRENDRES itself.

To run the regression, you access the **Models** menu. Move to the item **<-Multivariate Models** and type <Return>. Then select **Regression** and type <Return> again. You will be confronted by the **Multiple Regression Menu.** You should be able to accept the default settings which you will find already entered in the menu. There will be no harm in including a constant term in the regression provided that Cos(0) has not been included in the list of regressors. If it has been included, then the regression will certainly fail. To run the regression, type <Insert> to obtain the local menu and then <G> for **Go.** You will be presented with a summary of the regression results including the values of the coefficients and an indication of their significance.

If you have included all of the trigonometrical series on the RHS of the regression, then you will find that some of the regression coefficients are barely significant. Therefore, they might be excluded from a further regression analysis. You will also find that the value attributed to the constant term, if you included one in your regression, is vanishingly small.

To see some further aspects of the regression results, you might use some of the commands on the local regression menu which is accessed by typing <Insert>. Before returning to the upper level of *MESOSAUR,* you should issue the command **Store and Exit** or <Ctrl-S>. You might also wish to save the display of results to an ASCII file. This can be done via the **Print** command which is used in the same way as previously when the periodogram ordinates were saved to a file.

When you return to the upper level of the program, you will find that several new variables have been generated. You might wish to inspect some of these variables by plotting them. By plotting REGRESSION, for example, you will see the estimated version of the TRENDRES series. You may have seen it plotted already in conjunction with the actual TRENDRES series whilst you were exploring the commands of the local regression menu.

Select the RESIDUALS series and plot it. Also inspect its periodogram and its autocovariance function, which you can do using the relevant commands under the **Statistics** menu. You will find that there are some low-frequency motions remaining in the RESIDUALS series. These motions correspond more-or-less to those which were represented in the periodogram of TRENDRES by the low-frequency peak corresponding to the 3.6667-year period. You might care to speculate about whether these low-frequency fluctuations represent real features of economic activity or whether they are merely the artifacts of our data processing. If they do correspond to recognisable influences upon the money stock, then they might be worthy of statistical modelling.