

SMOOTHIE: Interactive Time--Series Analysis

by Richard S. Barr and James Collins

SMOOTHIE is an interactive program for time--series data that permits the application of several forecasting models to a set of data. The user can apply single and double exponential smoothing, moving average, trend, arithmetic mean, and complete decomposition methods to a given data series.

Running SMOOTHIE

Prepare a data file using a text editor and the instructions below. To execute the program, type the following at the DOS prompt:

SMOOTHIE filename

where *filename* is the name of the data file. If *filename* is omitted, operating instructions are displayed.

Data File Organization

The data file contains a set of time--series data in free format. That is, it consists of a series of observed values for a single variable, taken at uniform time intervals, given in chronological order, and separated by blanks or on separate lines.

The following example file will be used below to illustrate the use of the program, and is assumed to be in the file named MYFILE.

```
13.1 12 15.8 11.4 14 15.3 17.6 13 15.2 16.4 19.2
14.7 15.6 15.5 17.2 16.7 16.8 16.5 17.4 14.4 17.0
19.4 19.2 16.7
```

There are 25 observations of a variable, given in time-series order.

Program Operation and Report Interpretation

In the sections that follow, user input will be shown in **underlined boldface**. To process the above data file, we enter:

SMOOTHIE myfile

The initial screen displays:

```
*** SMTHIE: INTERACTIVE TIME--SERIES FORECASTING ***
by RichOoard S. Barr and Jim Collins
```

```
Processing data file  smoothie.dat
24 observations were read
How many observations to use in the mean error calculation  (enter
0 for the maximum possible)? 5
```

The user is asked to enter the number of observations to be used in calculating cumulative error values, such as mean squared error (MSE). Since the models result in varying numbers of historical error terms, one may wish to use a subset in computing cumulatives, if the values are to be compared across models. We have asked that only the most recent five error values be used.

*** SMOOTHIE: INTERACTIVE TIME--SERIES FORECASTING ***

The following forecasting models are available:

- Moving average
- Exponential smoothing (single)
- Smoothing with trend (double)
- Trend
- Arithmetic mean
- Decomposition

Select model by typing the first letter, or ESC to quit:

Any of the six models listed may be applied to the dataset. A model is selected by typing its first letter, such as "M" for moving average.

Each model type results in a different forecast methodology and set of reports. The output for each model as applied to our dataset is given below.

NOTE: To prevent reports from scrolling off of the screen before viewing by the user, output pauses at the end of each full screen. This condition is indicated by a "&" symbol, and the user may press any key to continue.

M, Moving Average Forecasts

Moving average forecasting is selected at the main menu by the "M" key. The user is then asked to enter the number of periods to be used in the averaging process. In our example, we will perform a 3--period moving average.

*** MOVING AVERAGE METHOD ***

Number of periods for your moving average: 3

*** SUMMARY REPORT ***			
Period Number	Actual Observn	Forecast for Next Period	Error (Forecast-- Actual)
-----	-----	-----	-----
1	13.100		
2	12.000		
3	15.800	13.633	
4	11.400	13.067	-2.233
5	14.000	13.733	0.933
6	15.300	13.567	1.567
7	17.600	15.633	4.033
8	13.000	15.300	-2.633
9	15.200	15.267	-0.100
10	16.400	14.867	1.133
11	19.200	16.933	4.333
12	14.700	16.767	-2.233
13	15.600	16.500	-1.167
14	15.500	15.267	-1.000
15	17.200	16.100	1.933
16	16.700	16.467	0.600
17	16.800	16.900	0.333
18	16.500	16.667	-0.400
19	17.400	16.900	0.733
20	14.400	16.100	-2.500
21	17.000	16.267	0.900
22	19.400	16.933	3.133
23	19.200	18.533	2.267
24	16.700	18.433	-1.833

*** FORECAST ERROR MEASURES ***

	Specified	Maximum
Number of periods	5	21
Mean squared error (MSE)	5.075	4.249
Mean absolute error (MAD)	2.127	1.714
Mean absolute pct error (MAPE)	12.318	10.666
Mean error/Forecast bias	0.393	0.371

E, Single Exponential Smoothing

When "E" is chosen from the main menu, and a smoothing constant (α) of 0.5 is selected, the following reports result.

*** EXPONENTIAL SMOOTHING (SINGLE) ***

What smoothing constant do you wish to use ($0 < \alpha \leq 1$)? 0.5

*** SUMMARY REPORT ***

Period Number	Actual Observn	Forecast for Next	Error (Forecast-
-----	-----	-----	-----
1	13.100	13.100	
2	12.000	12.550	-1.100
3	15.800	14.175	3.250
4	11.400	12.788	-2.775
5	14.000	13.394	1.212
6	15.300	14.347	1.906
7	17.600	15.973	3.253
8	13.000	14.487	-2.973
9	15.200	14.843	0.713
10	16.400	15.622	1.557
11	19.200	17.411	3.578
12	14.700	16.055	-2.711
13	15.600	15.828	-0.455
14	15.500	15.664	-0.328
15	17.200	16.432	1.536
16	16.700	16.566	0.268
17	16.800	16.683	0.234
18	16.500	16.591	-0.183
19	17.400	16.996	0.809
20	14.400	15.698	-2.596
21	17.000	16.349	1.302
22	19.400	17.874	3.051
23	19.200	18.537	1.326
24	16.700	17.619	-1.837

*** FORECAST ERROR MEASURES ***

	Specified	Maximum
Number of periods	5	23
Mean squared error (MSE)	4.575	4.063
Mean absolute error (MAD)	2.022	1.694
Mean absolute pct error (MAPE)	11.864	10.863
Mean error/Forecast bias	0.249	0.393

S, Smoothing with Trend (Double)

Double exponential smoothing uses both a smoothing constant, α , but a trend emphasis constant, β . Both values are between 0 and 1.

*** EXPONENTIAL SMOOTHING WITH TREND (DOUBLE) ***

What DATA smoothing constant do you wish to use ($0 \leq \alpha \leq 1$)? 0.5

What TREND smoothing constant do you wish to use ($0 \leq \beta \leq 1$)? 0.6

Forecast using $18.340528 + 0.094073 * (\text{number of periods beyond } 24)$

*** SUMMARY REPORT ***

Period Number	Actual Observn	Forecast for Next Period	Error (Forecast- Actual)
-----	-----	-----	-----
1	13.100	13.100	
2	12.000	12.220	-1.100
3	15.800	14.754	3.580
4	11.400	12.815	-3.354
5	14.000	13.501	1.185
6	15.300	15.034	1.799
7	17.600	17.720	2.566
8	13.000	15.347	-4.720
9	15.200	15.217	-0.147
10	16.400	16.106	1.183
11	19.200	18.879	3.094
12	14.700	16.762	-4.179
13	15.600	15.805	-1.162
14	15.500	15.185	-0.305
15	17.200	16.329	2.015
16	16.700	16.763	0.371
17	16.800	17.041	0.037
18	16.500	16.867	-0.541
19	17.400	17.391	0.533
20	14.400	15.255	-2.991
21	17.000	16.011	1.745
22	19.400	18.605	3.389
23	19.200	19.981	0.595
24	16.700	18.435	-3.281

*** FORECAST ERROR MEASURES ***

	Specified	Maximum
Number of periods	5	23
Mean squared error (MSE)	6.919	5.568
Mean absolute error (MAD)	2.400	1.907
Mean absolute pct error (MAPE)	14.250	12.445
Mean error/Forecast bias	-0.109	0.014

T, Trend

Forecasting with a trend line only involved fitting a simple regression line to the observed points, using the period number as the independent variable.

*** LEAST--SQUARES TREND LINE ***

Trend equation: $T = 13.352174 + 0.198826 * t$

Sample coefficient of determination (R--squared) = 0.433809

*** SUMMARY REPORT ***

Period Number	Actual Observn	Forecast for Next Period	Error (Forecast- Actual)
1	13.100	13.100	
2	12.000	10.900	-1.100
3	15.800	16.333	4.900
4	11.400	12.750	-4.933
5	14.000	13.620	1.250
6	15.300	14.860	1.680
7	17.600	16.786	2.740
8	13.000	15.546	-3.786
9	15.200	15.731	-0.346
10	16.400	16.313	0.669
11	19.200	17.715	2.887
12	14.700	17.192	-3.015
13	15.600	17.069	-1.592
14	15.500	16.935	-1.569
15	17.200	17.275	0.265
16	16.700	17.408	-0.575
17	16.800	17.528	-0.608
18	16.500	17.551	-1.028
19	17.400	17.753	-0.151
20	14.400	17.313	-3.353
21	17.000	17.437	-0.313
22	19.400	17.973	1.963
23	19.200	18.389	1.227
24	16.700	18.323	-1.689

*** FORECAST ERROR MEASURES ***

	Specified	Maximum
Number of periods	5	23
Mean squared error (MSE)	3.910	5.225
Mean absolute error (MAD)	1.709	1.810
Mean absolute pct error (MAPE)	10.350	12.075
Mean error/Forecast bias	-0.433	-0.282

A, Arithmetic Mean

The average of all previous observations can be used as a forecast, as follows.

*** ARITHMETIC MEAN AS A FORECAST ***

The overall mean of Y is 15.837500

*** SUMMARY REPORT ***			
Period Number	Actual Observn	Forecast for Next Period	Error (Forecast- Actual)
-----	-----	-----	-----
13.100	13.100		
2	12.000	12.550	-1.100
3	15.800	13.633	3.250
4	11.400	13.075	-2.233
5	14.000	13.260	0.925
6	15.300	13.600	2.040
7	17.600	14.171	4.000
8	13.000	14.025	-1.171
9	15.200	14.156	1.175
10	16.400	14.380	2.244
11	19.200	14.818	4.820
12	14.700	14.808	-0.118
13	15.600	14.869	0.792
14	15.500	14.914	0.631
15	17.200	15.067	2.286
16	16.700	15.169	1.633
17	16.800	15.265	1.631
18	16.500	15.333	1.235
19	17.400	15.442	2.067
20	14.400	15.390	-1.042
21	17.000	15.467	1.610
22	19.400	15.645	3.933
23	19.200	15.800	3.555
24	16.700	15.837	0.900

*** FORECAST ERROR MEASURES ***

	Specified	Maximum
Number of periods	5	23
Mean squared error (MSE)	6.519	5.164
Mean absolute error (MAD)	2.208	1.930
Mean absolute pct error (MAPE)	12.177	11.761
Mean error/Forecast bias	1.791	1.437

D, Decomposition

Time--series decomposition separates the observations into four components: trend, seasonal, cyclical, and irregular/random. The multiplicative model is of the form: $Y_t = T_t S_t C_t I_t$. The user can then assemble a forecast for a future period by estimating its cyclical

10

SMOOTHIE

13	15.600	15.978	0.979	1.001	15.648	-0.048
14	15.500	16.156	1.017	0.990	16.426	-0.926
15	17.200	16.335	1.135	1.004	18.535	-1.335
16	16.700	16.513	0.869	1.010	14.355	2.345
--	-----	-----	-----	-----	-----	-----
17	16.800	16.692	0.979	1.008	16.348	0.452
18	16.500	16.870	1.017	0.982	17.152	-0.652
19	17.400	17.049	1.135	0.956	19.345	-1.945
20	14.400	17.227	0.869	0.969	14.975	-0.575
--	-----	-----	-----	-----	-----	-----
21	17.000	17.406	0.979	0.992	17.047	-0.047
22	19.400	17.584	1.017	1.012	17.878	1.522

Forecast based on trend and seasonal only

Mean squared error for periods 3 through 22 = 1.040293

*** INTERACTIVE FORECASTING ***

Period to forecast or 0? 30

Cyclical index to use or 1 to ignore? 1

Forecast =	Trend	*	Seasonal	Index	*	Cyclical	Index	19.329
=	19.012	*	1.017	*	1.000			

Period to forecast or 0? 0

Exiting SMOOTHIE

To exit the system, press the Escape key from the main menu.