1-1-1993

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Working Paper 93-0801*

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Abstract

Early exponential smoothing techniques did not adjust for seasonality and trend. Later Holt and Winters developed methods to include these factors but they require the arbitrary choice of three smoothing constants α, β and γ. Our technique requires only alpha and an estimate of trend and seasonality as done for decomposition analysis. Since seasonality and trend are relatively constant why keep reestimating them - just include them. Moreover this technique is easy to perform on a standard spreadsheet. We show an example of the effectiveness of this method with spreadsheet output and graphics.

A Simple Method to Adjust Exponential Smoothing Forecasts for Trend and Seasonality

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Simple exponential smoothing is excellent for situations where there are no patterns in the data such as long run upward or downward trend effects or seasonal patterns where there are certain highs or lows repeated at the same time each year. More sophisticated methods of exponential smoothing are offered by Holt and Winters. Holt's linear exponential smoothing recognizes the presence of trend. Using an additional weight, β, a smoothed value of trend is found. This trend is then combined in the standard smoothing equation (Wheelwright and Makridakris, pp. 66-69). In the early sixties Winters developed a system that would deal with both seasonality and trend. A weight for seasonality, γ, is used and seasonal factors are multiplied by the forecasts that already combine exponential smoothing and trend. The Winters method constantly updates seasonal and trend factors (Hanke and Reitsch, pp. 258, 266 and Tersine, pp 57-67). These methods require the arbitrary choice of three constants α, β, γ, and constant updates of seasonality and trend. Since seasonality and trend are relatively constant patterns, they generally will not need continuous updates. Therefore, it may be more effective to estimate seasonality and trend as done in the decomposition method and combine these estimates with simple exponential smoothing. Moreover, these estimates can be made using simple spreadsheet representation and capabilities.

To use this simple method, first estimate a linear trend equation using regression analysis and 3-10 years of data previous to the years you want to predict. The trend factor called T will be the slope of this trend equation. Next compute either quarterly or monthly seasonality by averaging each of the 4 quarters or each of the 12 months and dividing them by the average for the quarters (Tables) or the months. Finally, the set of resulting numbers are adjusted to total to 4 or 12. This set of numbers provides the seasonal index, S_t. Now we choose an exponential smoothing constant α and use the following three equations:

(1) $F_t^* = \frac{\alpha D_t}{S_t} + \frac{(1-\alpha)F_t}{S_t}$ deseasonalized forecast computed at the end of period "t"

(2) $F_t^* + T$ trend added to deseasonalized forecast at the end of period "t"

(3) $S_{t+1}\left(F_t^* + T\right) = F_{t+1}$ seasonalized forecast for next period (t+1)

t	=	end of the current time period
F_t	=	forecast value for current period
F_t^*	=	deseasonalized forecast computed at the end of the current period (t)
α	=	smoothing constant
S_t	=	seasonal factor for current period
S_{t+1}	=	seasonal factor for period to which we forecast (t+1)
T	=	trend factor
D_t	=	actual value for the current period
F_{t+1}	=	forecast value for next period adjusted for seasonality and trend

We will now demonstrate this method using data for retail sales (billions of dollars) of general merchandise in the U.S. from 1983 to 1987 to develop the trend value, T, and the quarterly seasonal pattern in the form of four index numbers. A comparison of our forecast with that of a simple exponentially smoothed forecast of these expenditures will be made from 1988 through 1992. Using regression analysis for the first 5 years we get the following linear trend equation:

$$\hat{Y} = 29.8455 + 0.94970\ X$$

so our value for T is 0.94970.

The seasonal pattern derived from the 1983-1987 data is:
Q1 = 0.7446, Q2 = 0.9451, Q3 = 0.9280, and Q4 = 1.3824.

This information was derived from using the spreadsheet package Lotus 1-2-3, Version 2.4. Utilization of the command series, / *Data Regression*, resulted in this information:

Constant		**29.8446**
Std Err of Y Est		9.01009
R Squared		0.29101
No. of Observations		20
Degrees of Freedom		18
X Coefficient(s)	**0.94970**	
Std Err of Coef.	0.34939	

and then developing the seasonal pattern resulted in the subsequent table:

DETERMINATION OF SEASONAL PATTERN:
(Using quarterly averages of the original data.)

	Q1	Q2	Q3	Q4
1983	24.80	31.53	31.65	47.90
1984	27.85	35.75	34.63	52.46
1985	29.84	37.57	36.83	54.35
1986	32.01	39.99	39.56	57.67
1987	33.74	43.31	42.08	62.83
Avg	29.65	37.63	36.95	55.04

Overall Quarterly Average: 39.8175

S	0.7446	0.9451	0.9280	1.3824

(The body of the table is the original data. The Overall Quarterly Average is the grand mean of the original twenty quarters. The seasonal indices, S, are computed by dividing each quarter's average by the Overall Quarterly Average.)

To get our forecast for the second quarter of 1988, these calculations are made. We have assumed a smoothing constant (α) of 0.3. It is important to try different values of α to determine the best one for your data.

Deseasonalized forecast:

$$\frac{36.13\,(.3)}{0.7446} + \frac{35.49904079(.7)}{0.7446} = 14.55680900 + 33.37272167 = 47.92953070 \qquad (1)$$

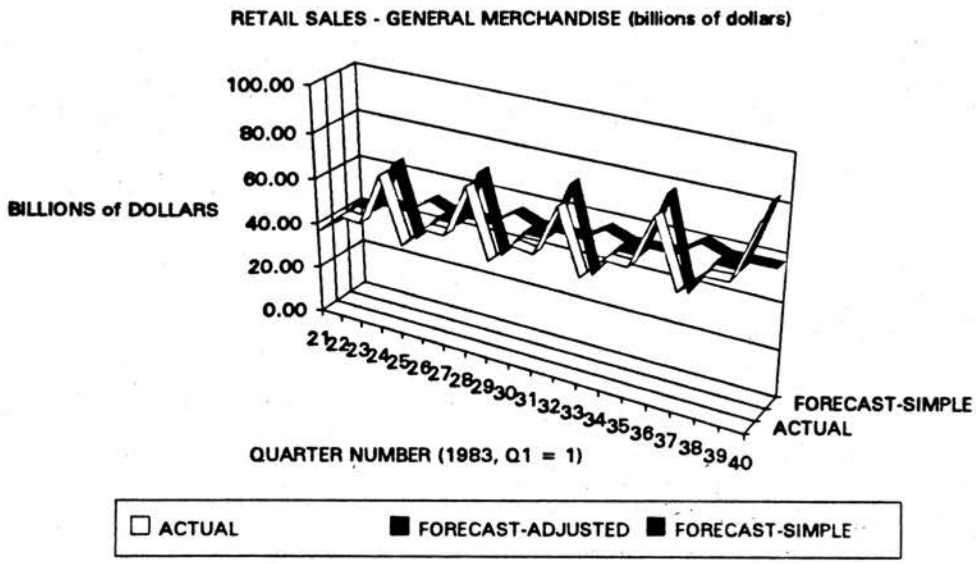
Deseasonalized forecast + trend: 47.92953070 +0.94970 = 48.87923746 (2)

Re-seasonalized for Quarter 2: (48.87923746)(0.9451) = 46.19576733 or 46.1958 (3)

For Quarter 2 of 1988 we have predicted 46.1958 billion dollars would be spent in the U.S. on general merchandise.

In order to demonstrate the effectiveness of the model relative to an analogous simple smoothing model using the same smoothing constant (α=0.3), the remaining quarters in the data will be predicted and the forecasts from each compared for accuracy by examining the resulting Mean Absolute Deviations (MAD). As we can see, the simple smoothing is relatively accurate for quarters 2 and 3 but produces large errors for quarters 1 and 4. (See Tables 1 and 2.)

The chart below depicts the actual data along with the forecast using adjustments for trend and seasonality, as well as the forecast for the simple exponential smoothing model.



The Mean Absolute Deviation (MAD) for the model using trend and seasonal adjustments was 2.08, while the simple smoothing model forecast yielded a MAD of 8.93. Both models were developed using $\alpha = 0.3$ and an initial smoothed value equal to the last unadjusted smoothed value for the first five year period. As we can see by studying the graphs and the mean absolute deviation, this system makes a simple but much improved prediction for data which includes seasonal and trend information. Moreover, we have to make only <u>one</u> arbitrary decision which is the level of α.

Table 1: RETAIL SALES in the U.S. – GENERAL MERCHANDISE (billion of dollars)
Simulation of 20 Quarters and Forecast for Last 20 Quarters
Using Seasonal and Trend Adjustments

Smoothing Constant:	0.3
Assumed Change (Trend):	0.94970
Initial (Seed) Forecast:	33.9700

(Initial F is mean of 1st four quarters.)

Year	Qtr	t	Actual Y	Seasonal Index S	Deseas Smooth Average A*	Deseas Forecast +Trend F+T	Next Qtr Forecast w/Seas (F+T)*S	Absolute Error
1983	1	1	24.80	0.7446				
	2	2	31.53	0.9451	35.1688	36.1185		
	3	3	31.65	0.9280	35.5146	36.4643	33.5179	
	4	4	47.90	1.3824	35.9200	36.8697	50.4083	
1984	1	5	27.85	0.7446	37.0296	37.9793	27.4532	
	2	6	35.75	0.9451	37.9335	38.8832	35.8942	
	3	7	34.63	0.9280	38.4133	39.3630	36.0836	
	4	8	52.46	1.3824	38.9386	39.8884	54.4154	
1985	1	9	29.84	0.7446	39.9444	40.8941	29.7009	
	2	10	37.57	0.9451	40.5516	41.5013	38.6490	
	3	11	36.83	0.9280	40.9572	41.9069	38.5132	
	4	12	54.35	1.3824	41.1295	42.0792	57.9321	
1986	1	13	32.01	0.7446	42.3523	43.3020	31.3322	
	2	14	39.99	0.9451	43.0053	43.9550	40.9247	
	3	15	39.56	0.9280	43.5573	44.5070	40.7903	
	4	16	57.67	1.3824	43.6701	44.6198	61.5265	
1987	1	17	33.74	0.7446	44.8277	45.7774	33.2239	
	2	18	43.31	0.9451	45.7920	46.7417	43.2643	
	3	19	42.08	0.9280	46.3226	47.2723	43.3763	
	4	20	62.83	1.3824	46.7256	47.6753	65.3493	
1988	1	21	36.13	0.7446	47.9295	48.8792	35.4990	0.6310
	2	22	44.69	0.9451	48.4013	49.3510	46.1958	1.5058
	3	23	43.86	0.9280	48.7246	49.6743	45.7977	1.9377
	4	24	67.13	1.3824	49.3401	50.2898	68.6697	1.5397
1989	1	25	38.43	0.7446	50.6864	51.6361	37.4458	0.9842
	2	26	47.82	0.9451	51.3246	52.2743	48.8013	0.9813
	3	27	47.44	0.9280	51.9282	52.8779	48.5106	1.0706
	4	28	70.70	1.3824	52.3574	53.3071	73.0984	2.3984
1990	1	29	41.35	0.7446	53.9749	54.9247	39.6925	1.6575
	2	30	50.17	0.9451	54.3726	55.3223	51.9093	1.7393
	3	31	49.14	0.9280	54.6114	55.5611	51.3391	2.1991
	4	32	71.26	1.3824	54.3572	55.3069	76.8076	5.5476
1991	1	33	44.23	0.7446	56.5351	57.4848	41.1815	3.0485
	2	34	54.08	0.9451	57.4058	58.3555	54.3289	0.2489
	3	35	53.67	0.9280	58.1991	59.1488	54.1539	0.4839
	4	36	76.50	1.3824	58.0057	58.9554	81.7673	5.2673
1992	1	37	48.75	0.7446	60.9102	61.8599	43.8982	4.8518
	2	38	57.50	0.9451	61.5540	62.5037	58.4638	0.9638
	3	39	57.78	0.9280	62.4315	63.3812	58.0034	0.2234
	4	40	83.33	1.3824	62.4506	63.4003	87.6181	4.2881

(Shaded area is forecast for last five years by quarter.)

MAD = 2.0784

Source: U.S. Department of Commerce, Economics and Statistics Administration Office of Business Analysis, *National Trade Data Bank*, July 1993

Table 2: RETAIL SALES in the U.S. (1983–1992)
THE SIMPLE SMOOTHING MODEL

Smoothing Constant:	**0.3**
Initial Value:	**46.7256**

(Initial A is same as adjusted model.)

Year	Qtr	t	Actual Y	Smoothed Average A	F	Absolute Error
1983	1	1	24.80			
	2	2	31.53			
	3	3	31.65			
	4	4	47.90			
1984	1	5	27.85			
	2	6	35.75			
	3	7	34.63			
	4	8	52.46			
1985	1	9	29.84			
	2	10	37.57			
	3	11	36.83			
	4	12	54.35			
1986	1	13	32.01			
	2	14	39.99			
	3	15	39.56			
	4	16	57.67			
1987	1	17	33.74			
	2	18	43.31			
	3	19	42.08			
	4	20	62.83	46.7256 <– – –initial value		
1988	1	21	36.13	43.5469		
	2	22	44.69	43.8898	43.5469	1.1431
	3	23	43.86	43.8809	43.8898	0.0298
	4	24	67.13	50.8556	43.8809	23.2491
1989	1	25	38.43	47.1279	50.8556	12.4256
	2	26	47.82	47.3356	47.1279	0.6921
	3	27	47.44	47.3669	47.3356	0.1044
	4	28	70.70	54.3668	47.3669	23.3331
1990	1	29	41.35	50.4618	54.3668	13.0168
	2	30	50.17	50.3742	50.4618	0.2918
	3	31	49.14	50.0040	50.3742	1.2342
	4	32	71.26	56.3808	50.0040	21.2560
1991	1	33	44.23	52.7355	56.3808	12.1508
	2	34	54.08	53.1389	52.7355	1.3445
	3	35	53.67	53.2982	53.1389	0.5311
	4	36	76.50	60.2588	53.2982	23.2018
1992	1	37	48.75	56.8061	60.2588	11.5088
	2	38	57.50	57.0143	56.8061	0.6939
	3	39	57.78	57.2440	57.0143	0.7657
	4	40	83.33	65.0698	57.2440	26.0860

MAD=	8.9336183

(Shaded area is forecast for last five years by quarter.)

Source: U.S. Department of Commerce, Economics and Statistics Administration Office of Business Analysis, *National Trade Data Bank*, July 1993

REFERENCES

Hanke, Joe and Reitsch, J. , *Business Forecasting*, Boston: Allyn and Bacon, 1981, pp. 249-258.

Makridakis, S. and Wheelwright, S.C., *Forecasting Methods for Management*, 1989, Fifth Edition, New York: Wiley, pp. 76-87.

Sobol, M. G. and Starr, M., *Introduction to Statistics for Executives*, New York: McGraw Hill, 1993, Chapter 11.

Tersine, R. J., *Principles of Inventory and Materials*, Management 1988, 3rd ed., New York: North Holland. pp. 57-67.

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