- **Exponential Smoothing uses *all* the time series values to generate a forecast with lesser weights given to the observations further back in time.**

Exponential Smoothing (1 of 2)

- A weighted moving average
  - Weights decline exponentially
  - Most recent observation weighted most
- Used for smoothing and short term forecasting (often one or two periods into the future)

- **Exponential smoothing is actually a way of "smoothing" out the data by eliminating much of the "noise" (random effects).**

Exponential Smoothing (2 of 2)

- The weight (smoothing coefficient) is α
  - Subjectively chosen
  - Range from 0 to 1
  - Smaller α gives more smoothing, larger α gives less smoothing
- The weight is:
  - Low value (closer to 0) for smoothing out unwanted cyclical and irregular components
  - Higher value (closer to 1) for forecasting, especially for smoother time series

Exponential Smoothing Model

1. Obtain the smoothed series:

$$\hat{x}_1 = x_1 \qquad \hat{x}_t = (1-\alpha)\,\hat{x}_{t-1} + (\alpha)x_t \qquad (0 < \alpha < 1;\ t = 2,3,\ldots,n)$$

2. From time *n*, the forecasts of future values are

$$\hat{x}_{n+h} = \hat{x}_n \qquad (h = 1,2,\ldots)$$

where:

$\hat{x}_t$ = exponentially smoothed value for period *t*

$\hat{x}_{t-1}$ = exponentially smoothed value already computed for period *i* − 1

x_t = observed value in period *t*

α = weight (smoothing coefficient), $0 < \alpha < 1$

Exponential Smoothing Example

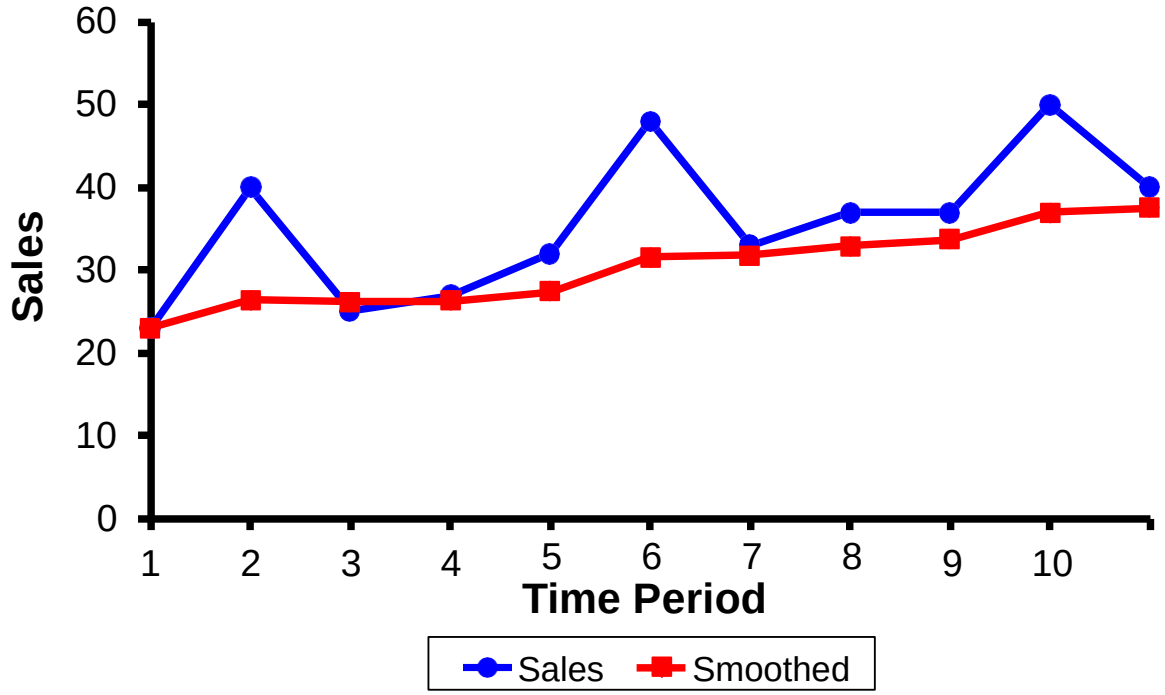
- Suppose we use weight $\alpha = 0.2$ $\hat{x}_t = (1 - 0.2)\hat{x}_{t-1} + 0.2x_t$

Time Period (t)	Sales (X_t)	Forecast from prior period ($\hat{x}_{t-1}$)	Exponentially Smoothed Value for this period ($\hat{x}_t$)
1	23	--	23
2	40	23	(.8)(23)+(.2)(40)=26.4
3	25	26.4	(.8)(26.4)+(.2)(25)=26.12
4	27	26.12	(.8)(26.12)+(.2)(27)=26.296
5	32	26.296	(.8)(26.296)+(.2)(32)=27.437
6	48	27.437	(.8)(27.437)+(.2)(48)=31.549
7	33	31.549	(.8)(31.549)+(.2)(33)=31.840
8	37	31.840	(.8)(31.840)+(.2)(37)=32.872
9	37	32.872	(.8)(32.872)+(.2)(37)=33.697
10	50	33.697	(.8)(33.697)+(.2)(50)=36.958
etc.	etc.	etc.	etc.

$\hat{x}_1 = x_1$ since no prior information exists

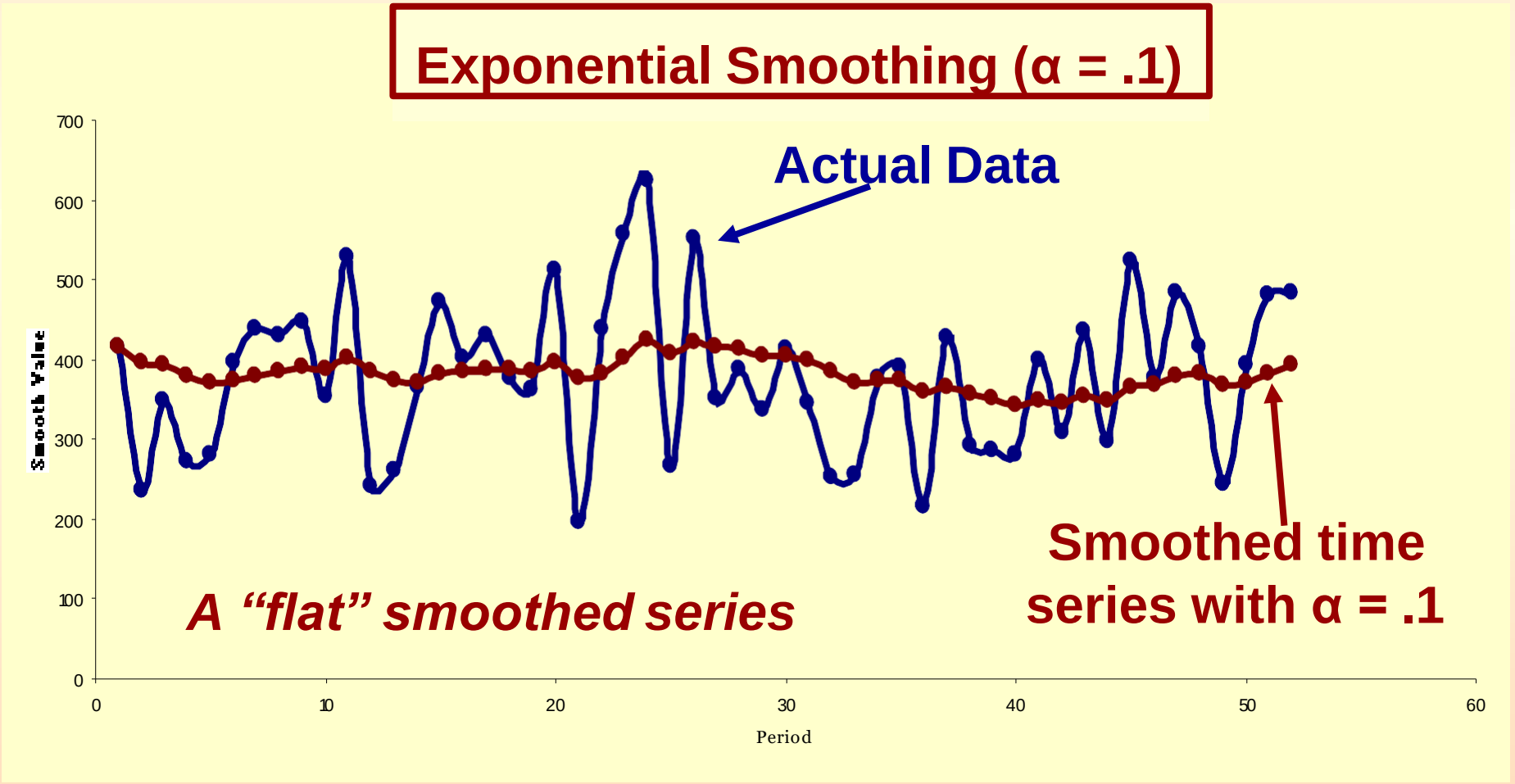
Sales vs. Smoothed Sales

- Fluctuations have been smoothed
- Note: the smoothed value in this case is generally a little low, since the trend is upward sloping and the weighting factor is only 0.2



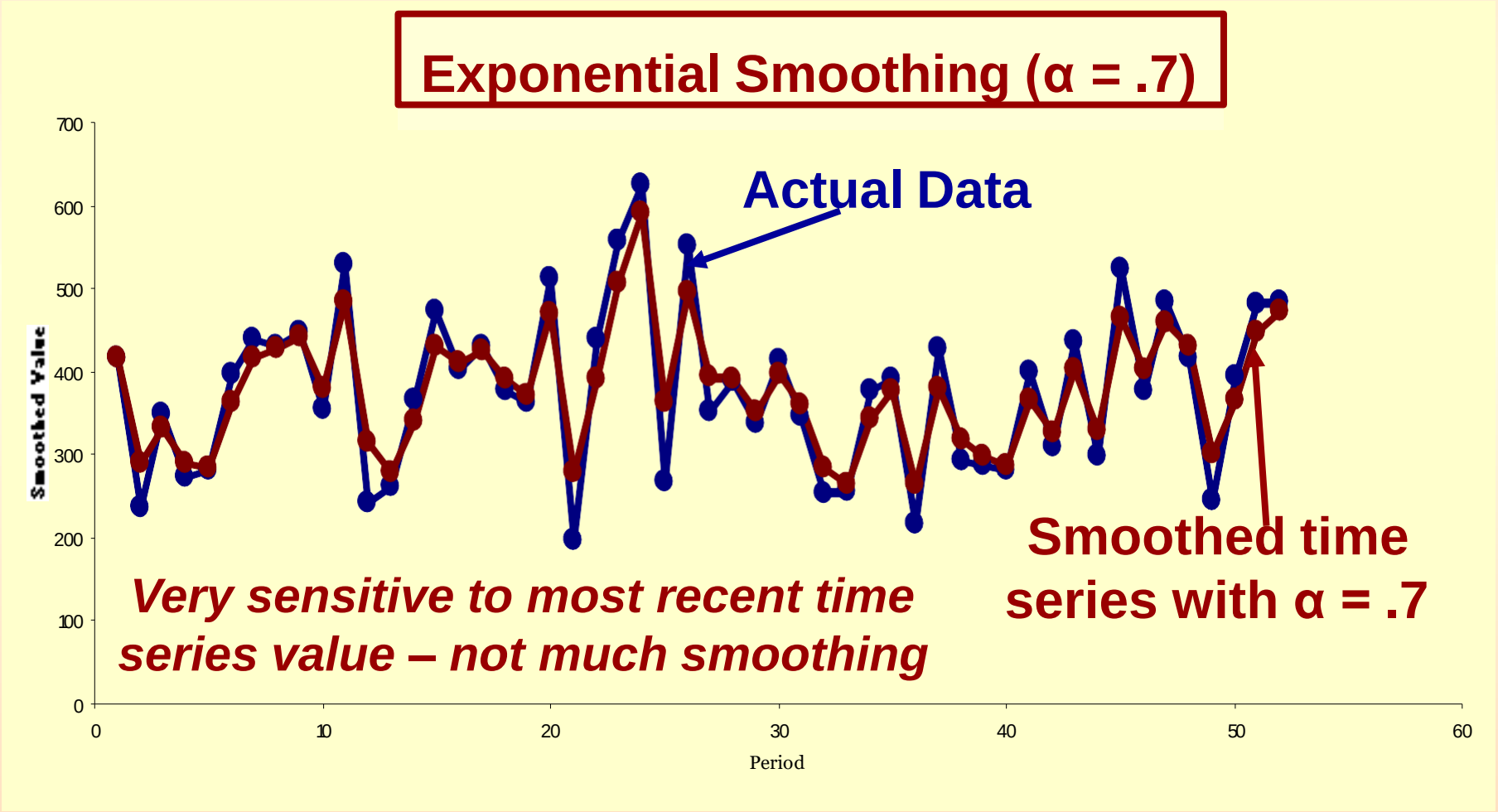
How Much Smoothing Is There?

- **We said the lower the value of α, the more "smooth" the time series will become.**



What About Larger Values of α?

- **Here is the "smoothed" series for α = .7:**



Forecasting Time Period (t + 1)

- The smoothed value in the current period (t) is used as the forecast value for next period (t + 1)
- Standing at time n, we obtain the forecasts of future values, X_{n+h} of the series

$$\hat{x}_{n+h} = \hat{x}_n \quad (h = 1, 2, 3...)$$

Exponential Smoothing in Excel

- Use Data / Data Analysis / exponential smoothing
  - The "damping factor" is $(1-\alpha)$