

Time Series and Forecasting





Time Series and its Components

A **TIME SERIES** is a collection of data recorded over a period of time (weekly, monthly, or quarterly), that can be used by management to compute forecasts as input to planning and decision making. It usually assumes past patterns will continue into the future.

Components of a Time Series

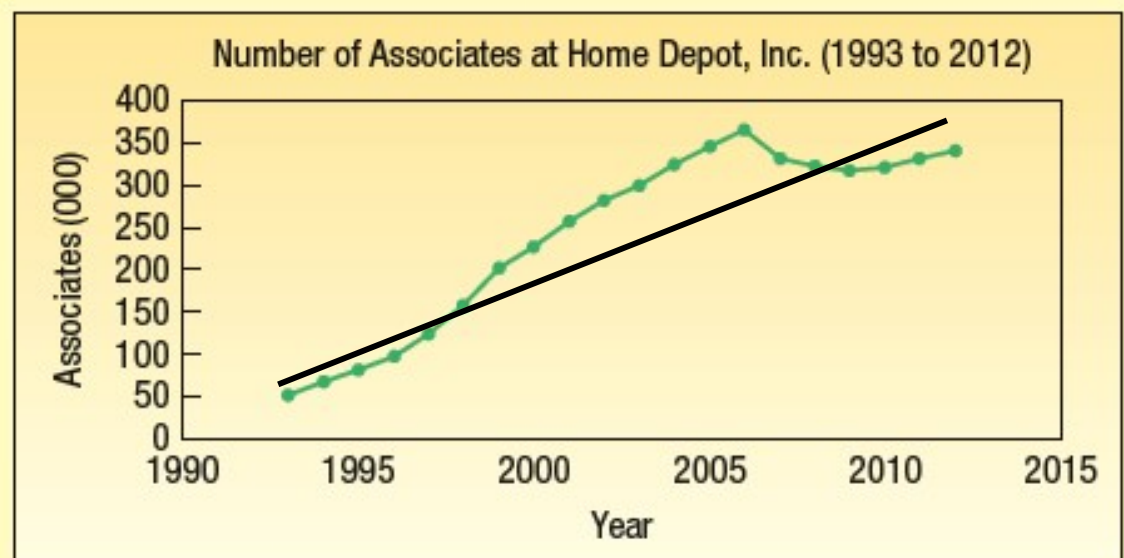
- **Secular Trend** – the smooth long term direction of a time series
- **Cyclical Variation** – the rise and fall of a time series over periods longer than one year
- **Seasonal Variation** – Patterns of change in a time series within a year which tends to repeat each year
- **Irregular Variation** – residuals and exogenous shocks

Secular Trend – Example

SECULAR TREND The smoothed long-term direction of a time series.

The number of employees at Home Depot from 1993 to 2012

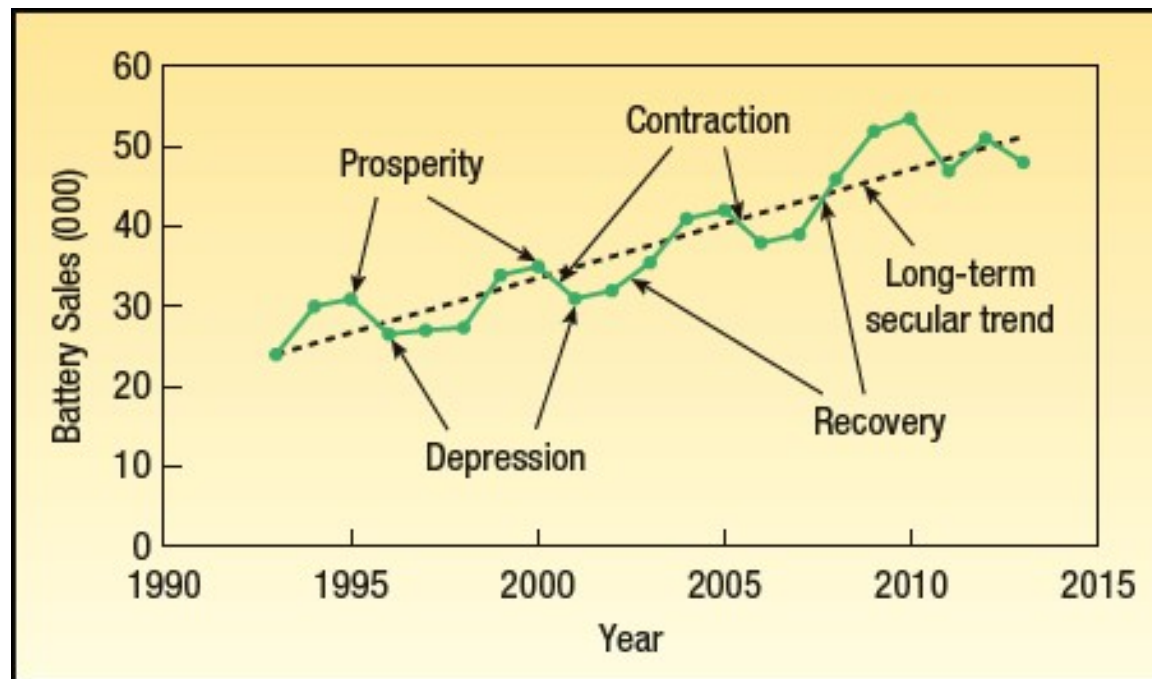
Year	Associates	Year	Associates
1993	50.6	2003	298.8
1994	67.3	2004	323.1
1995	80.8	2005	344.8
1996	98.1	2006	364.4
1997	124.4	2007	331.0
1998	156.7	2008	322.0
1999	201.4	2009	317.0
2000	227.3	2010	321.0
2001	256.3	2011	331.0
2002	280.9	2012	340.0



Cyclical Variation – Sample Chart

CYCLICAL VARIATION The rise and fall of a time series over periods longer than 1 year.

The annual unit sales of batteries sold by National Battery Retails Inc. from 1991 to 2010

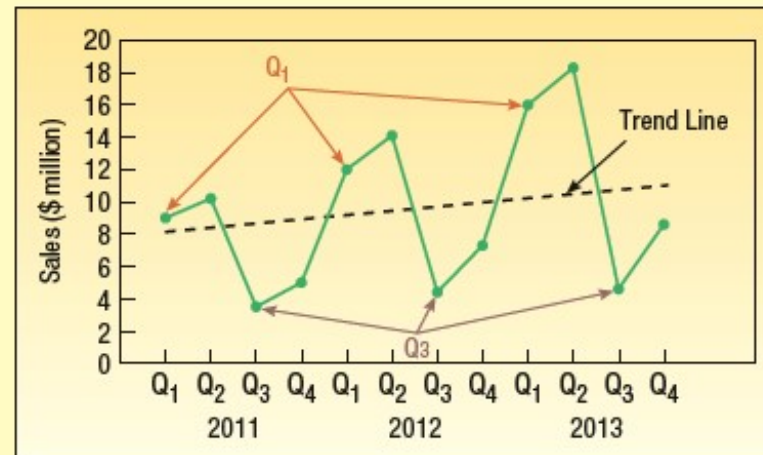


Seasonal Variation – Sample Chart

SEASONAL VARIATION Patterns of change in a time series within a year. These patterns tend to repeat themselves each year.

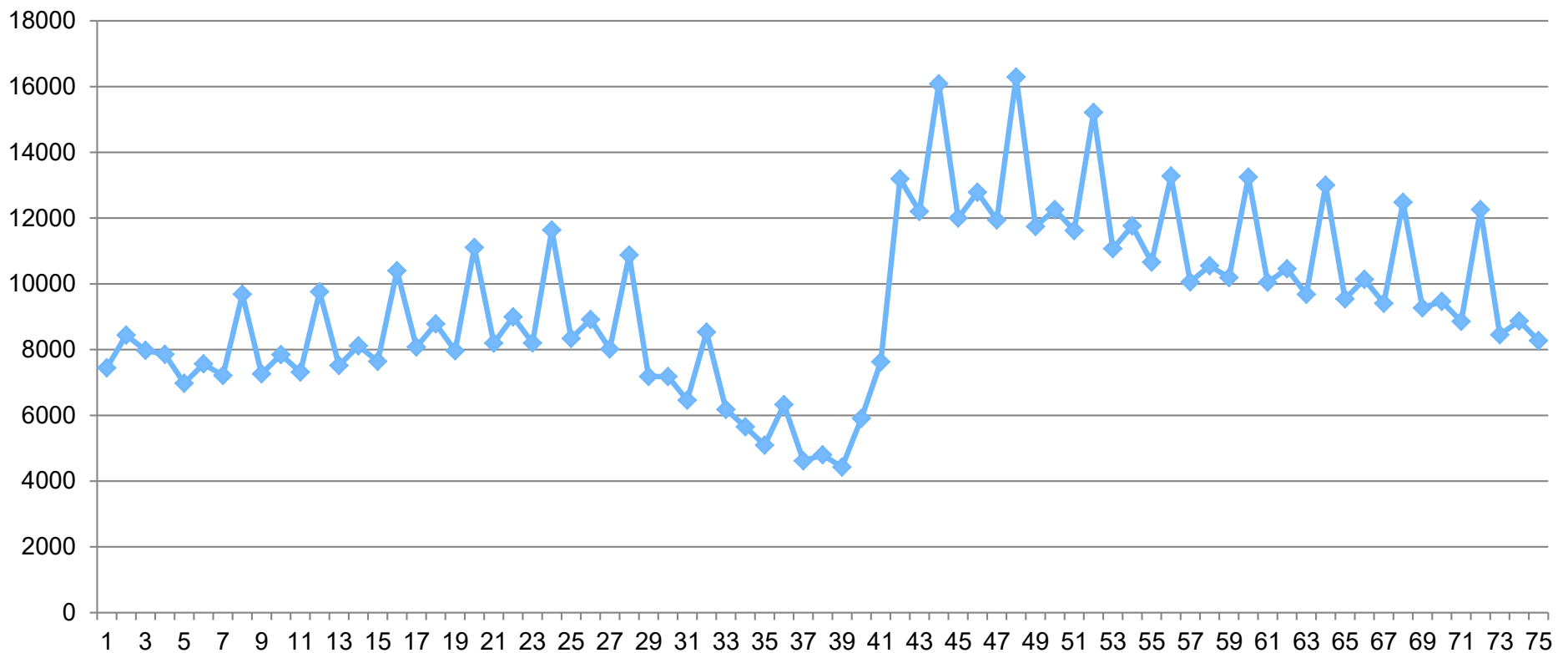
Quarterly sales of Hercher Sporting G Inc, a Chicago area sporting goods company specializes in selling baseball and softball equipment to high schools, colleges and youth leagues.

Year	Quarter	Code	Sales (mil)
2011	Q ₁	1	9.0
	Q ₂	2	10.2
	Q ₃	3	3.5
	Q ₄	4	5.0
2012	Q ₁	5	12.0
	Q ₂	6	14.1
	Q ₃	7	4.4
	Q ₄	8	7.3
2013	Q ₁	9	16.0
	Q ₂	10	18.3
	Q ₃	11	4.6
	Q ₄	12	8.6



Example: Sears Revenue Data

Sears Quarterly Revenue 1995-2013



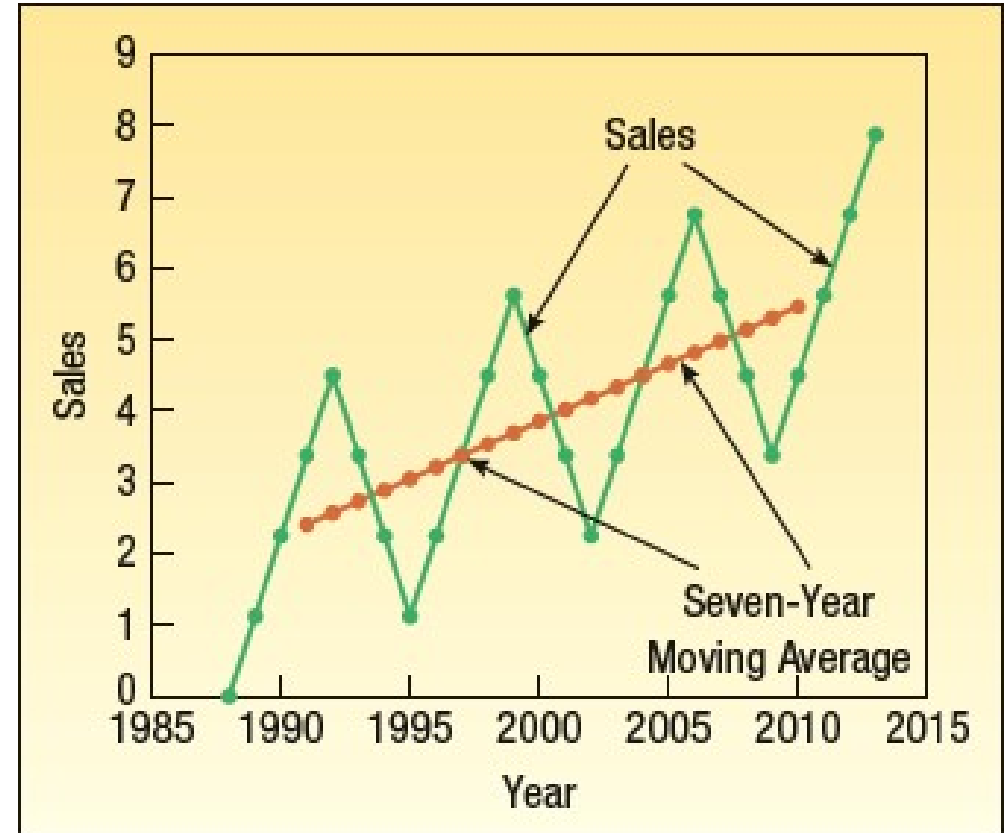


The Moving Average Method

- Useful in smoothing time series to see its trend.
- Basic method used in measuring seasonal fluctuation.
- Applicable when a time series follows a fairly linear trend.

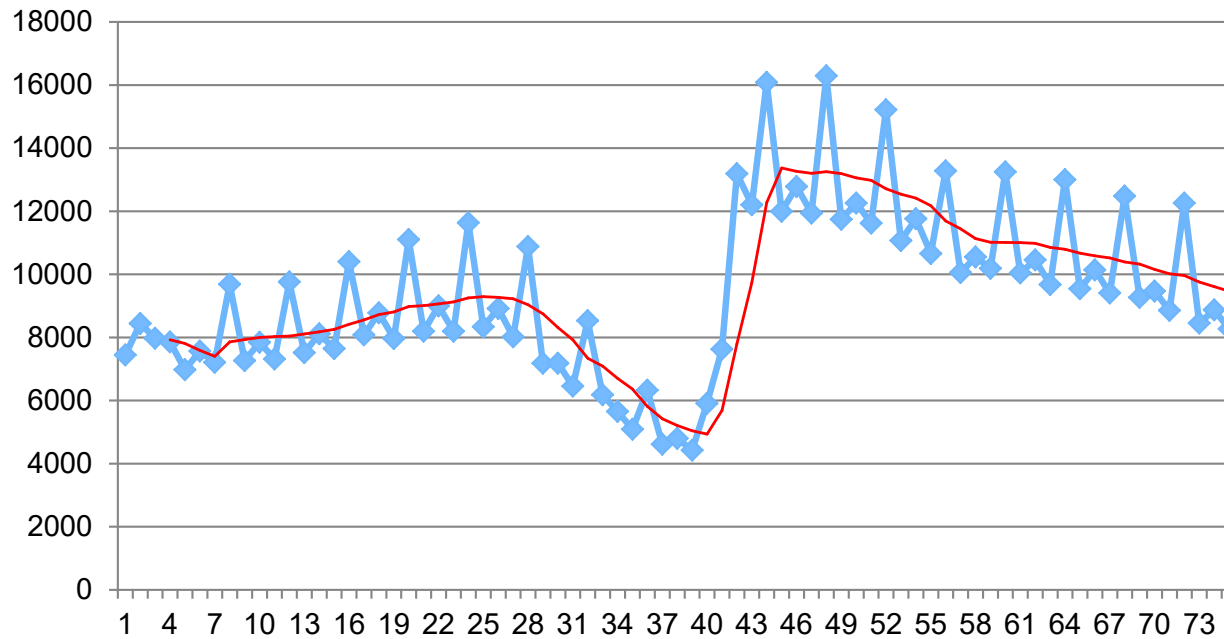
Moving Average Method - Example

Year	Sales (\$ Mil)	Seven-Year Moving Total	Seven-Year Moving Average
1988	1		
1989	2		
1990	3		
1991	4	22	3.143
1992	5	23	3.286
1993	4	24	3.429
1994	3	25	3.571
1995	2	26	3.714
1996	3	27	3.857
1997	4	28	4.000
1998	5	29	4.143
1999	6	30	4.286
2000	5	31	4.429
2001	4	32	4.571
2002	3	33	4.714
2003	4	34	4.857
2004	5	35	5.000
2005	6	36	5.143
2006	7	37	5.286
2007	6	38	5.429
2008	5	39	5.571
2009	4	40	5.714
2010	5	41	5.857
2011	6		
2012	7		
2013	8		



Example: Sears Revenue Data

Sears Quarterly Revenue 1995-2013



Format Trendline

Trendline Options

Line Color

Line Style

Shadow

Glow and Soft Edges

Trend/Regression Type

- Exponential
- Linear
- Logarithmic
- Polynomial Order: 2
- Power
- Moving Average Period: 4

Trendline Name

- Automatic: 4 per. Mov. Avg. (Revenue)
- Custom:

Forecast

Forward: 0.0 periods

Backward: 0.0 periods

Set Intercept = 0.0

Display Equation on chart

Display R-squared value on chart

Close

Linear Trend

- The long term trend of a time series may approximate a straight line.


LINEAR TREND EQUATION

$$\hat{y} = a + bt$$

[18-1]

where:

- \hat{y} , read *y*, hat, is the projected value of the *y* variable for a selected value of *t*.
- a* is the *y*-intercept. It is the estimated value of *y* when $t = 0$. Another way to put it is: *a* is the estimated value of *y* where the line crosses the *y*-axis when *t* is zero.
- b* is the slope of the line, or the average change in \hat{y} for each increase of one unit in *t*.
- t* is any value of time that is selected.

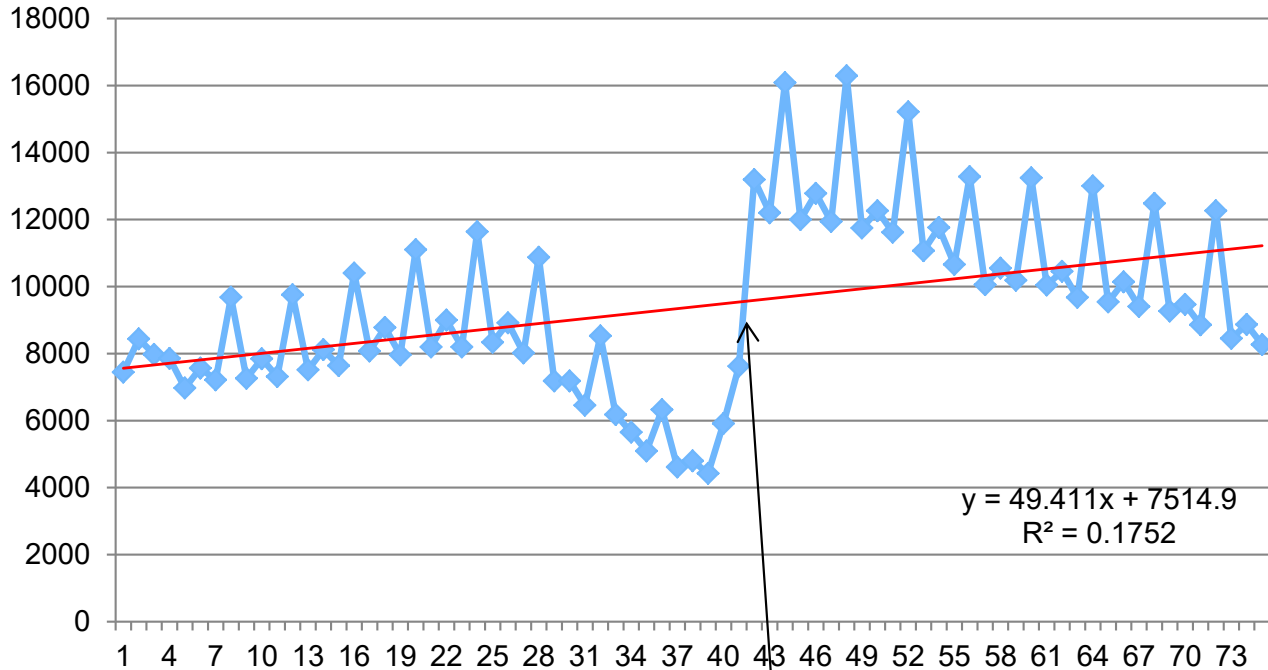


Linear Trend – Using the Least Squares Method, Regression Analysis, and Excel

- Use the least squares method in Simple Linear Regression to find the best linear relationship between the times series and time.
- Code time (t) and use it as the independent variable. That is, let t be 1 for the first year, 2 for the second, and so on.

Linear Trend Plot

Sears Quarterly Revenue 1995-2013



Structural Break

Format Trendline

Trendline Options

Trend/Regression Type

- Exponential
- Linear
- Logarithmic
- Polynomial Order: 2
- Power
- Moving Average Period: 4

Trendline Name

- Automatic: Linear (Revenue)
- Custom:

Forecast

Forward: 0.0 periods

Backward: 0.0 periods

Set Intercept = 0.0

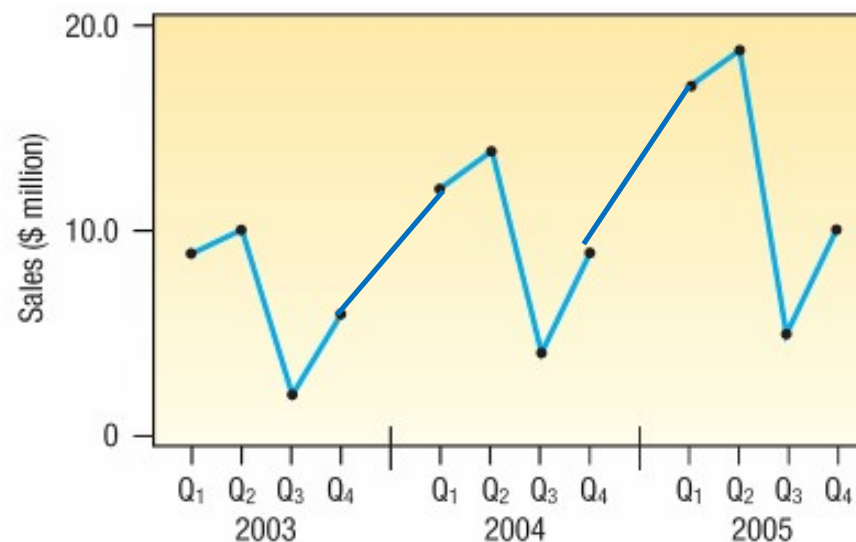
Display Equation on chart

Display R-squared value on chart

Close

Seasonal Variation

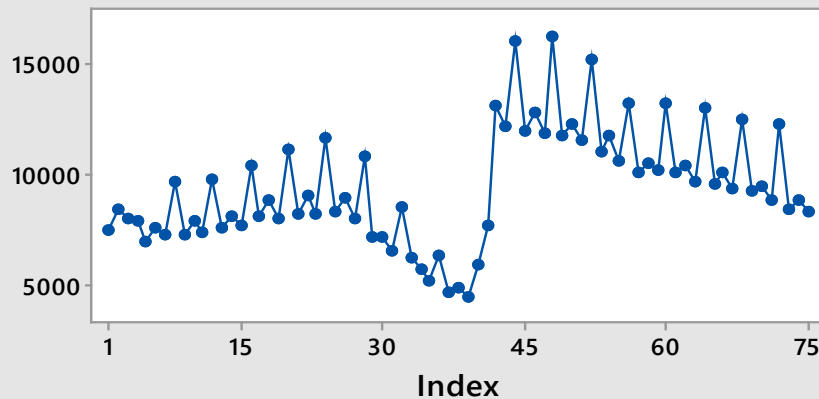
- One of the components of a time series.
- Seasonal variations are fluctuations that coincide with certain seasons and are repeated year after year.
- Understanding seasonal fluctuations help plan for sufficient goods and materials on hand to meet varying seasonal demand.
- Analysis of seasonal fluctuations over a period of years help in evaluating current sales.



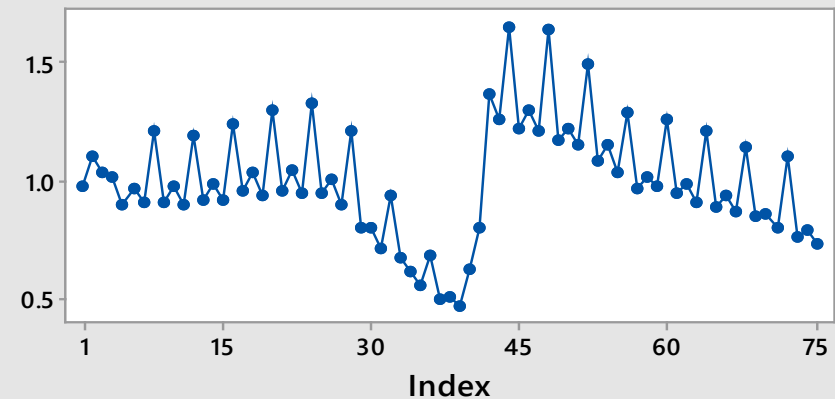
Seasonally Adjusted and Detrended Data

Component Analysis for Revenue
Multiplicative Model

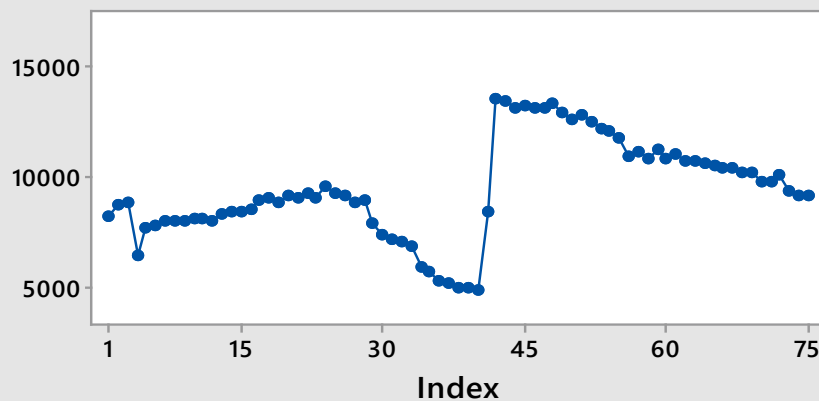
Original Data



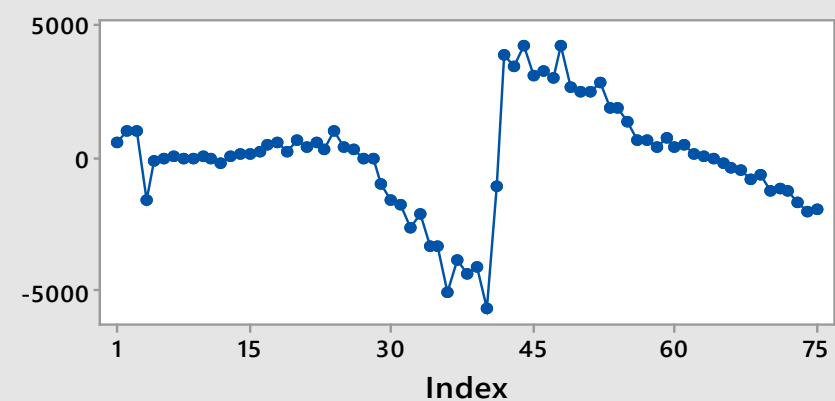
Detrended Data



Seasonally Adjusted Data



Seas. Adj. and Detr. Data





Example: Sears Revenue Data

- The merger of Kmart and Sears closed on March 24, 2015.
- The company expected consistent quarters of decline ever since.
- The Sears CEO Eddie Lampert's penny-pinching ways could have been the major reason for the decline, according to some critics.
 - "In 2010, Lampert's capital expenditure on store improvements was roughly 1 percent of sales. Compare that to Macy's, which is 2.5 percent, and Walmart's 8.8 percent of sales."
 - "In February, he (Lampert) flummoxed the industry by hiring an IBM veteran with no retail experience to run Sears and Kmart."
- Source: "Not so fast, Eddie" by Jamens Covert, New York post, May 22, 2015