LECTURE 8 OUTSOURCING AND PLANNING

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LEARNING OBJECTIVES FOR TODAY

Outsourcing

- The Bullwhip effect
- Double marginalization and supply chain coordination

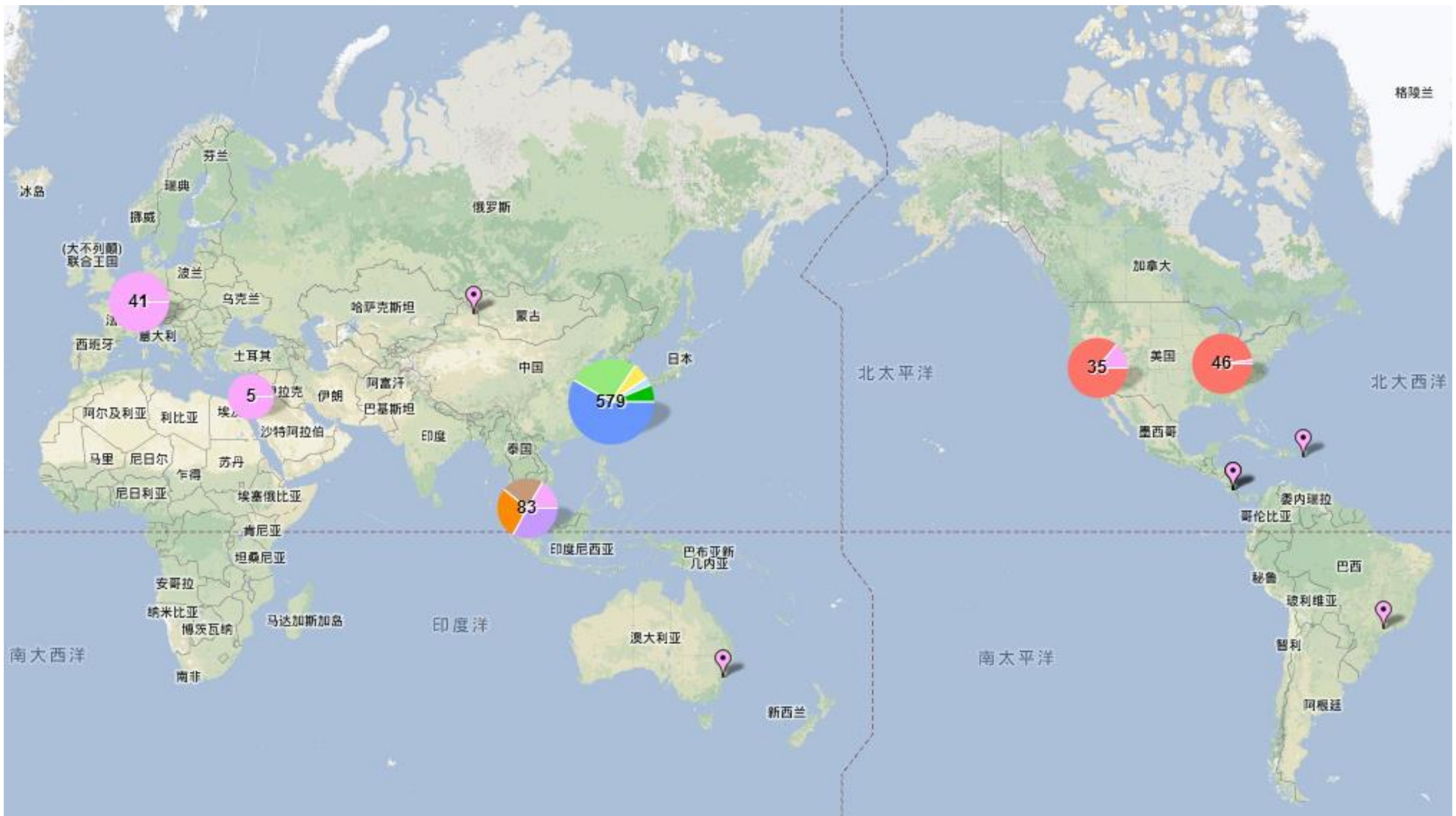
Forecasting techniques

Aggregate planning

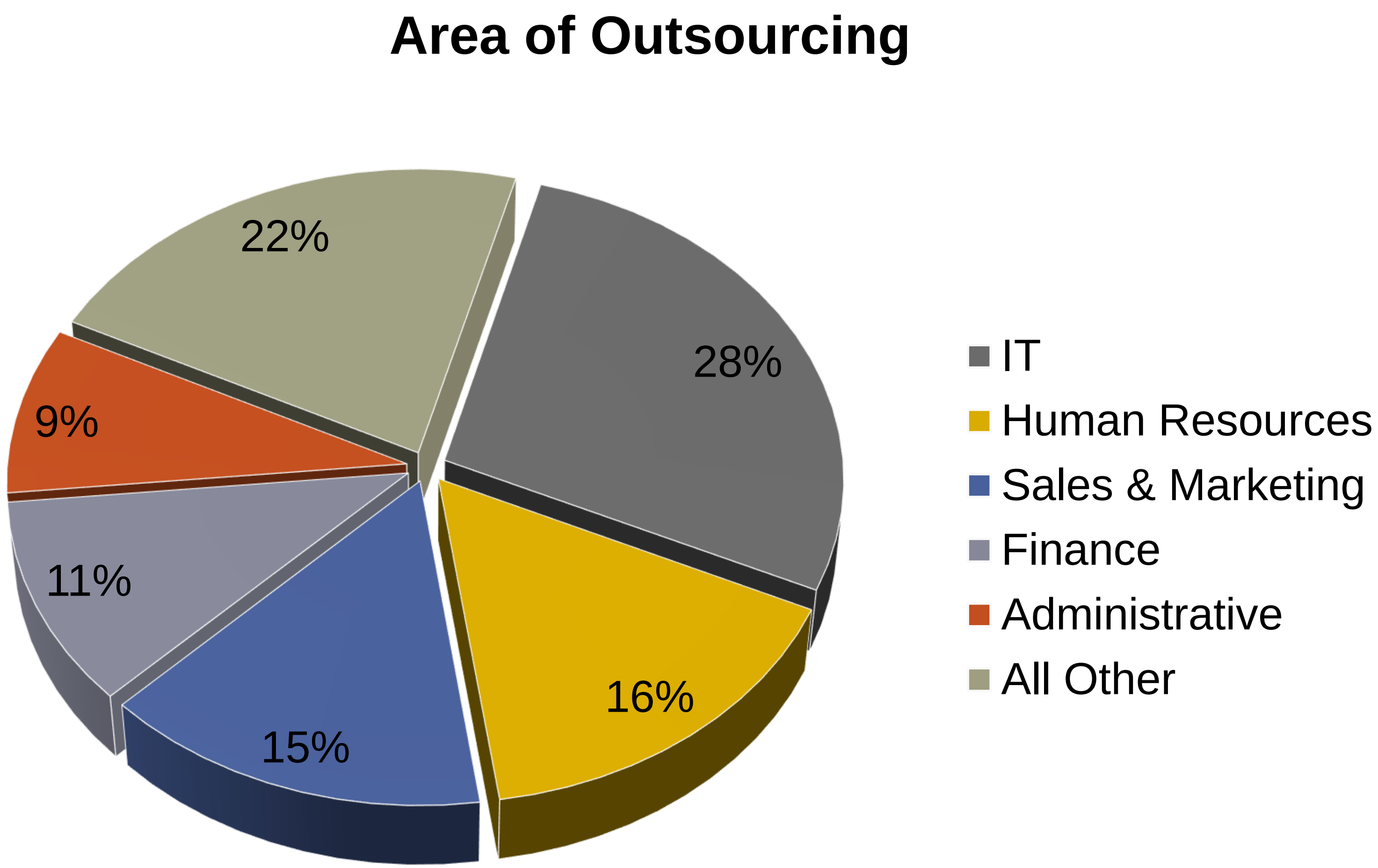
OUTSOURCING (外包)

Outsourcing is defined as moving a firm's internal activities and decision responsibility to outside providers

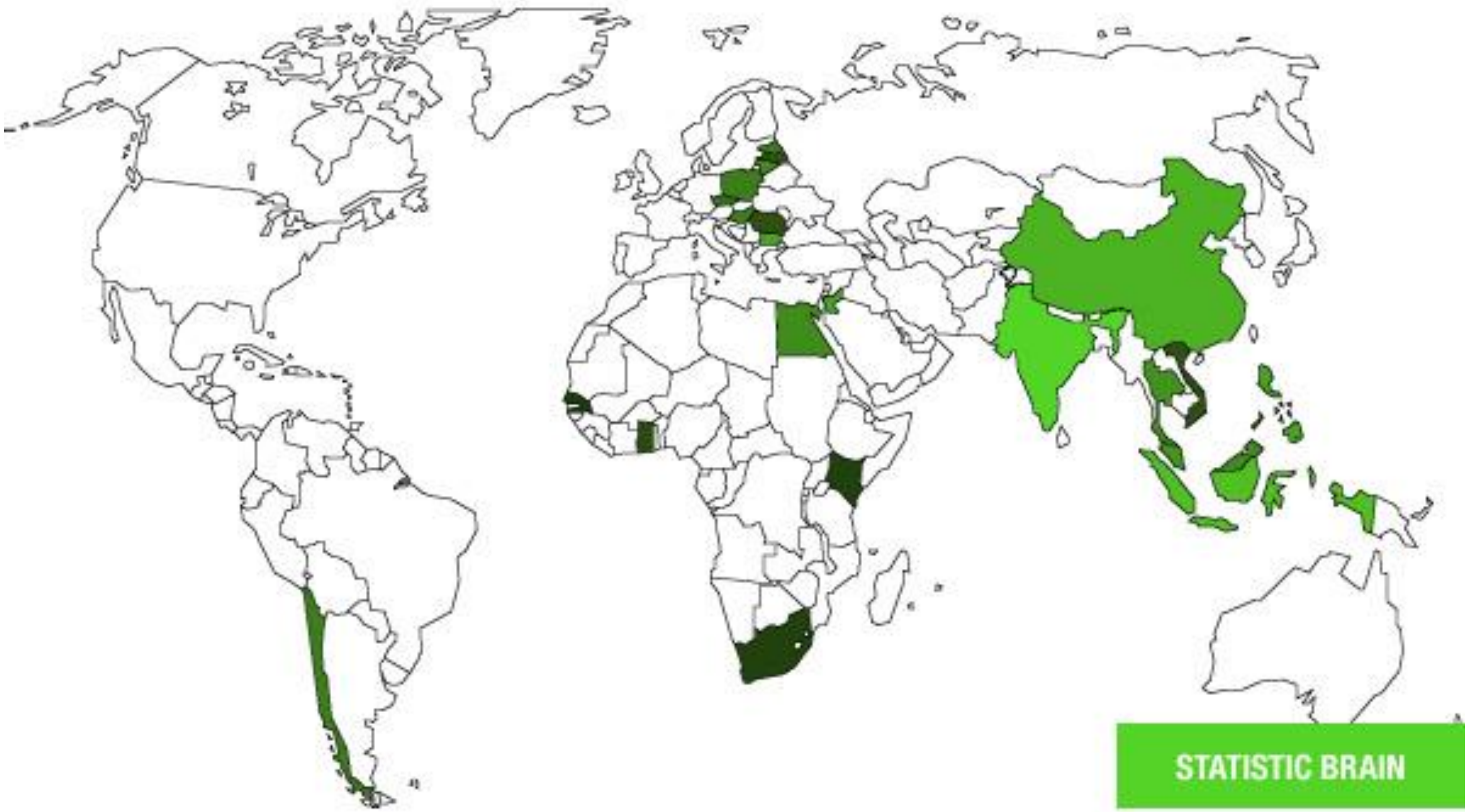
APPLES' GLOBAL SUPPLIERS



FACTS AND FIGURES



OUTSOURCING DESTINATIONS



REASONS FOR OUTSOURCING

Financially Driven Reasons

- Improve return on assets by reducing inventory
- Generate cash by selling low-return entities
- Gain access to new markets, particularly in developing countries
- Reduce costs through a lower cost structure
- Turn fixed cost into variable cost

Improvement-Driven Reasons

- Obtain expertise, skills and technologies that are not otherwise available
- Improve risk management
- Acquire innovative ideas
- Improve credibility and image by associating with superior providers

REASONS FOR OUTSOURCING

Organizationally Driven Reasons

- Improve effectiveness by focusing on what the firm does best.
- Increase flexibility to meet changing business conditions, demand for products and services
- Increase product and service value by improving response to customer needs

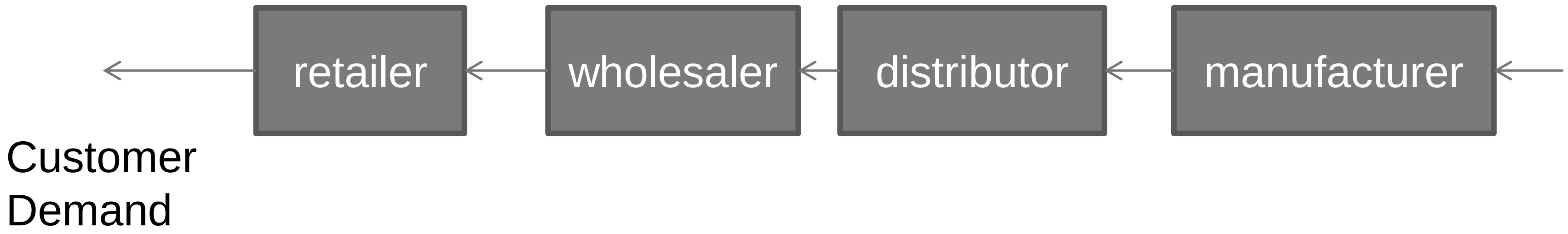
CAPABILITY SOURCING AT 7-ELEVEN

- **Founded 1927 in Texas, US and acquired by Ito-Yodako in 1998**
- **53,000 stores mainly in Asia and US**
- **Before 1991, 7-Eleven was most vertically integrated**
- **For a while, 7-Eleven owns the distribution network, and even the cows that the produced the milk!**

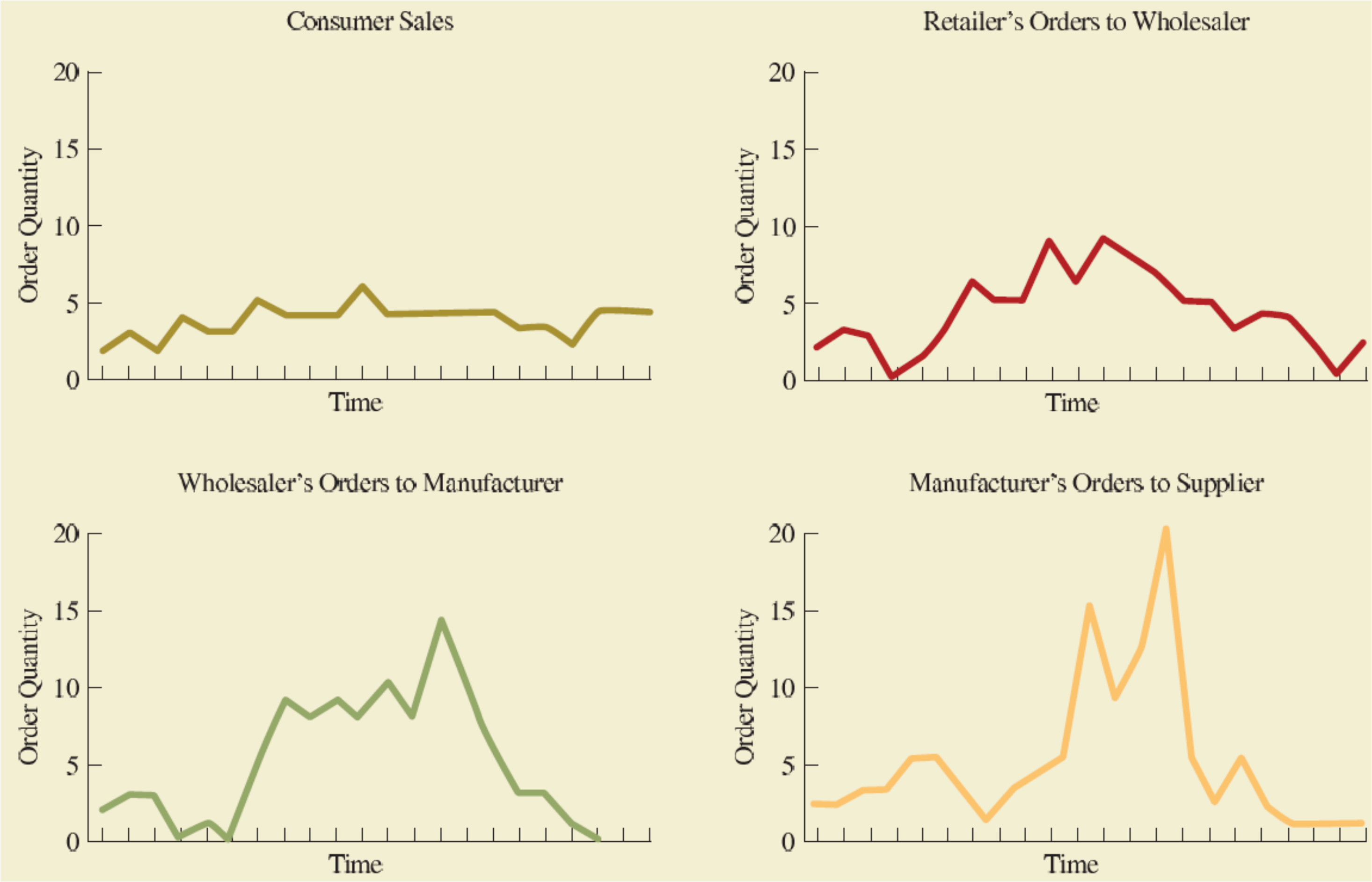
CAPABILITY SOURCING AT 7-ELEVEN

Activity	Outsourcing strategy
Gasoline	Outsourced distribution of fuel. Maintain control over pricing and promotion
Snack foods	Frito-lay distributes products directly to the store. 7-Eleven makes critical decisions about order and shelf placement
Prepared foods	Joint venture with E.A. Sween: a direct-store delivery operation that supplies 7-Eleven stores twice a day
Specialty products	Worked with Anheuser-Busch on special NASCAR and Major League Baseball promotions
Data analysis	Rely on outside vendor to maintain and format purchasing data while keep them proprietary.

THE BULLWHIP EFFECT



THE BULLWHIP EFFECT



THE BULLWHIP EFFECT

- Fluctuations in orders increase as they move up the supply chain from retailers to wholesalers to manufacturers to suppliers
- Distorts demand information within the supply chain, where different stages have very different estimates of what demand looks like
- Results in a loss of supply chain coordination
- Examples: Proctor & Gamble (Pampers), HP

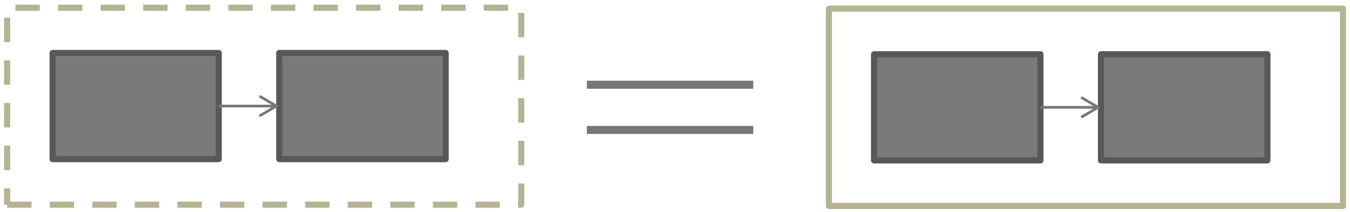
LACK OF COORDINATION MAY…

- **Cause the manufacturing cost, inventory cost to increase**
- **Cause product availability to decrease (service level decrease)**
- **Worsen relationships across the supply chain**
- **Decrease supply chain's profitability**

A SIMPLE SUPPLY CHAIN COORDINATION MODEL

Ideal scenario: a central planner manages the supply chain

Coordination: Although operated independently, a coordinated supply chain behaves like a centralized supply chain



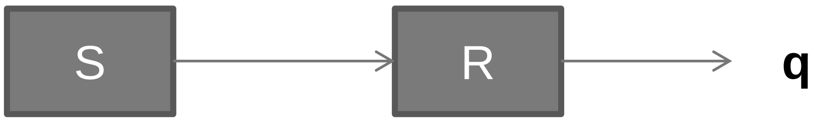
Coordinated supply chain

Centralized supply chain

CENTRALIZED SUPPLY CHAIN

- **One supplier and one retailer**
- **Market demand q = 30-p**

- **Cost: c = 10**
- **Profit = p q – c q**

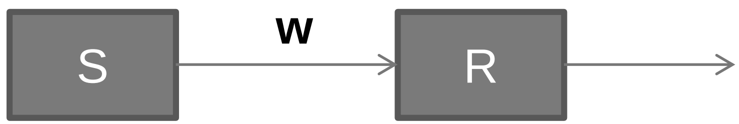


CENTRALIZED SUPPLY CHAIN

- Optimal p = 20
- Optimal q = 10
- Optimal profit = 100
- Benchmarking!

DISTRIBUTED SUPPLY CHAIN

- **Supplier determines the wholesale price w while the retailer determines the retail price p**



$q = 30 - p$

- **Stackelberg game:**
  - Supplier: leader
  - Retailer: follower

- **Retailer’s profit = $(p - w)\,q$**
- **Supplier’s profit = $(w - c)\,q$**

DISTRIBUTED SUPPLY CHAIN

- **Given supplier's wholesale price w,**
  - Retailers' optimal price = (30 + w) / 2
  - Retailer's optimal quantity = (30 – w) / 2
- **If the supplier can anticipate the retailer's decision, he should optimize (w – c) (30 – w) / 2**
  - The optimal w = 20
  - The optimal p = 25
  - The optimal q = 5
  - Supplier's profit = 50
  - retailer's profit = 25
- **The supply chain profit is reduced by 25! (Double marginalization)**

COORDINATION CONTRACT

- **Revenue sharing contract**
  - The retailer shares a portion of its revenue with the supplier
- **Example:**
  - The retailer and the wholesaler negotiate that the wholesaler shares 20% of the revenue and the wholesale price is 13
  - Optimal p = 23.1
  - Optimal q = 6.9
  - Retailer’s profit = 37.8
  - Supplier’s profit = 52.4
  - The double marginalization effect is reduced.

SUMMARY

- Reasons for outsourcing
- Bullwhip effect
- Double marginalization

WEATHER FORECAST

SUPPLY FORECAST OF PRIMARY ENERGY

World supply of primary energy in the Reference Case

	Levels *mboe/d*			Growth *% p.a.*	Fuel shares *%*		
	2010	2020	2035	2010–35	2010	2020	2035
Oil	81.2	89.7	100.2	0.8	32.2	30.0	26.3
Coal	69.8	84.9	104.0	1.6	27.7	28.4	27.2
Gas	54.8	69.0	99.8	2.4	21.7	23.1	26.0
Nuclear	14.3	16.0	21.6	1.7	5.7	5.4	5.7
Hydro	5.8	7.4	10.1	2.3	2.3	2.5	2.6
Biomass	24.4	28.0	35.2	1.5	9.7	9.4	9.2
Other renewables	1.8	3.6	10.7	7.5	0.7	1.2	2.8
Total	**251.9**	**298.6**	**381.7**	**1.7**	**100.0**	**100.0**	**100.0**

FORECAST FOR OIL DEMAND

Long-term oil demand outlook in the Reference Case *mb/d*

	2012	2015	2020	2025	2030	2035
OECD	**46.0**	**45.2**	**44.2**	**43.1**	**41.8**	**40.4**
Developing countries	**37.8**	**41.1**	**46.6**	**51.8**	**57.0**	**62.1**
India	3.7	4.0	5.0	6.2	7.6	9.3
China	9.7	10.8	12.7	14.4	16.0	17.5
Eurasia	**5.0**	**5.3**	**5.5**	**5.7**	**5.8**	**6.0**
World	**88.9**	**91.6**	**96.3**	**100.7**	**104.6**	**108.5**

WHAT IS FORECASTING?

A statistical estimate of future developments, that can be used to plan current activities:

- It is a statement about future outcomes (not observed yet)
- Demand, expenditure, profit, stock price, crime rate, etc
- Both qualitative and quantitative methods

WHY DO WE FORECAST?

The future is impossible to completely control but good forecasting prepares us for what may happen

By forecasting, we can take action to influence the vision of the future offered by operations managers

- What is the demand for jackets in the next season?
- How many individuals want Pumpkin flavored coffee?

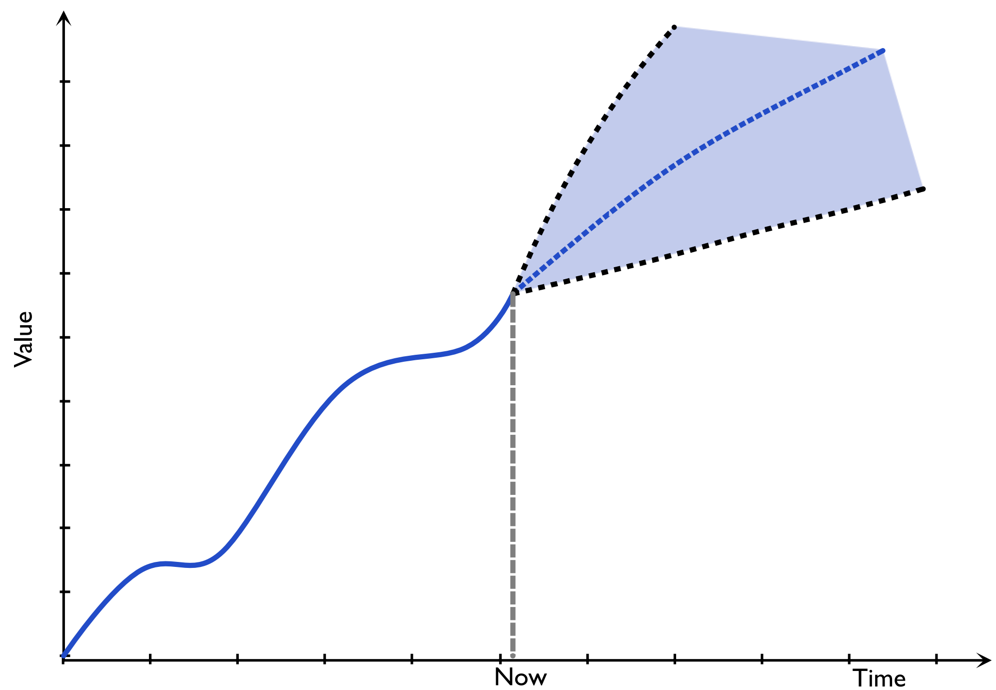
We need a model, data and then appropriate interpretation

FORECAST PRINCIPLES

Forecasts are always wrong and should always include some measure of error

The longer the horizon, the larger the error

Method should be chosen based on need and context



TYPES OF FORECAST

Qualitative Techniques (定性)

- Forecasting techniques based on expert opinions and intuition. Typically used when there are no data available.

Quantitative Techniques (定量)

- Using statistical methods. Typically used when there are sufficient data
- Big data…

QUALITATIVE TECHNIQUES

Market Research

- Collects customer data in a variety of ways (surveys, interviews, etc.) to know about the market. This is typically used to forecast new-product sales.

Panel Consensus

- Forecasts are developed through open meetings with free exchange of ideas from all levels of management and individuals

Historical analogy

- Ties what is being forecast to a similar product.

COMPONENTS OF DEMAND

Average Demand for the Period (平均量)

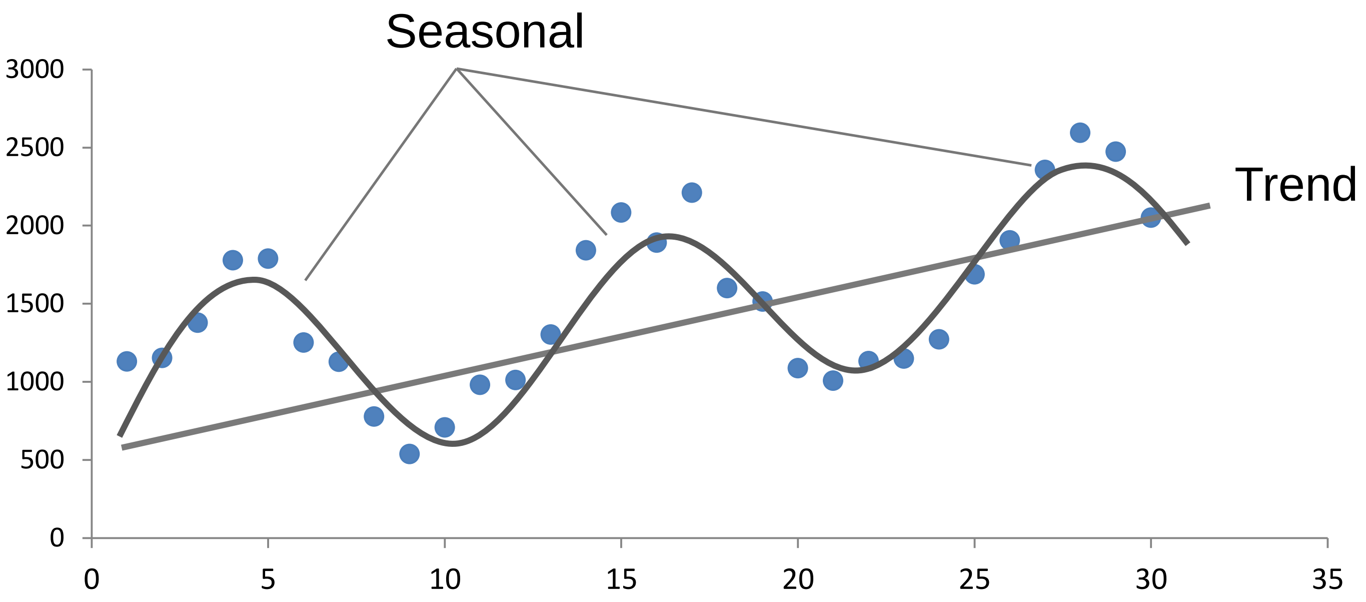
Trends (趋势)

Seasonal Influence (季节性)

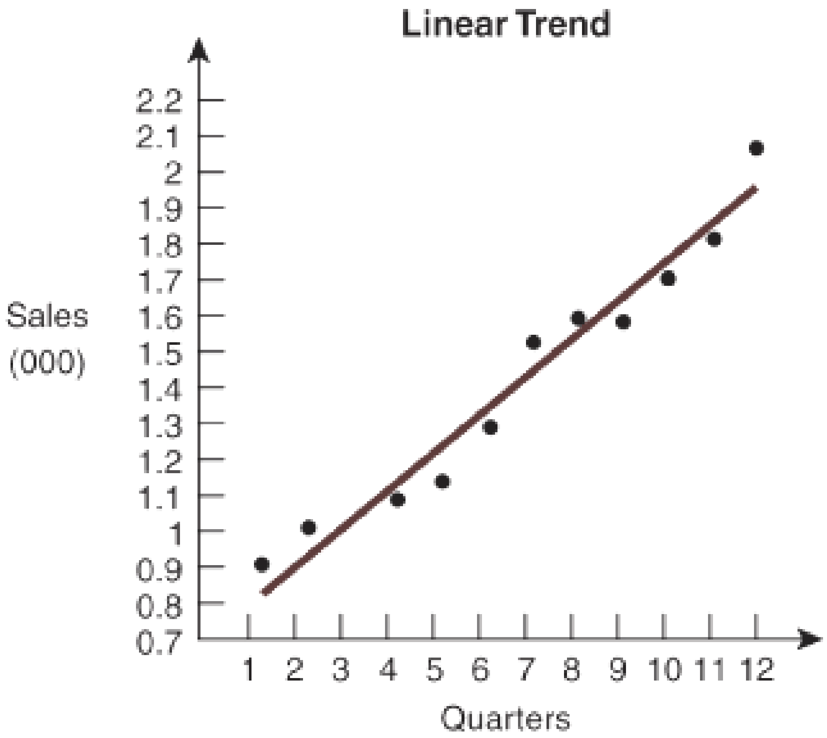
Autocorrelation (自相关)

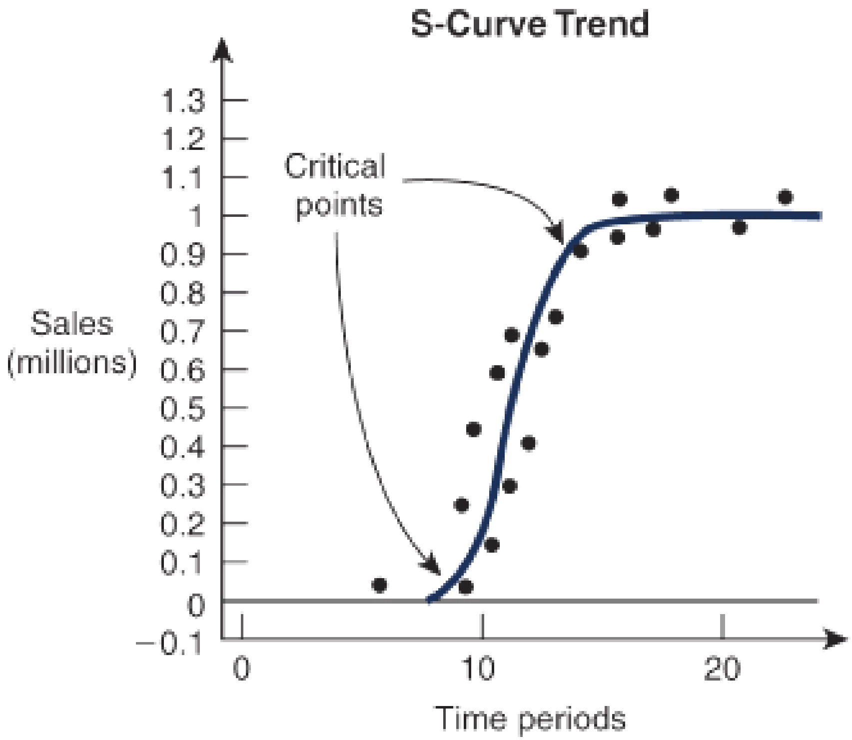
Random Variations (其他随机因素)

HISTORICAL DEMAND WITH TREND AND SEASONAL COMPONENTS



TYPES OF TRENDS





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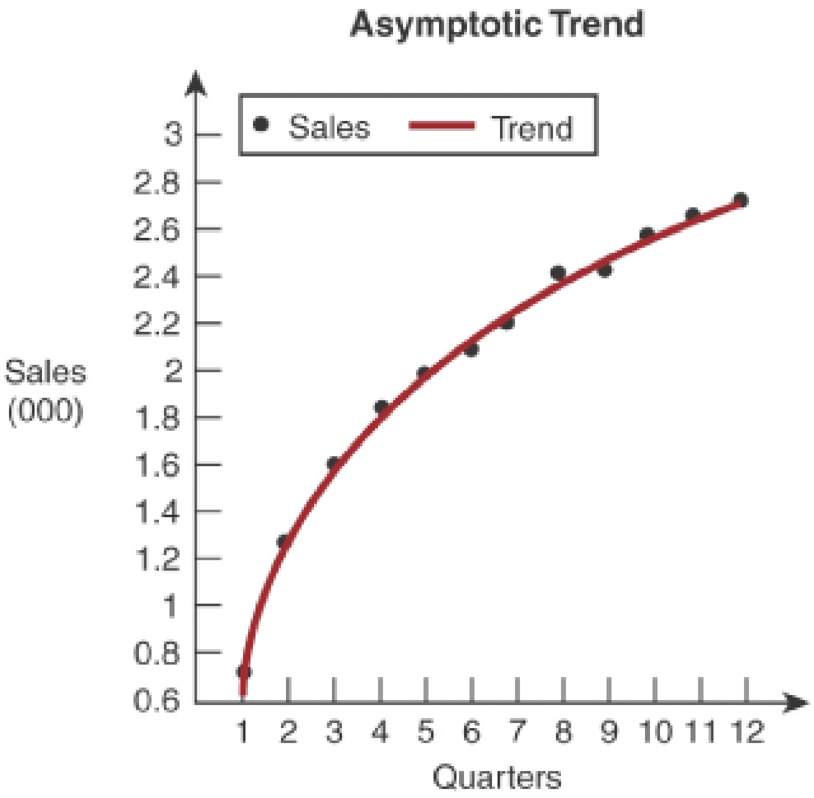
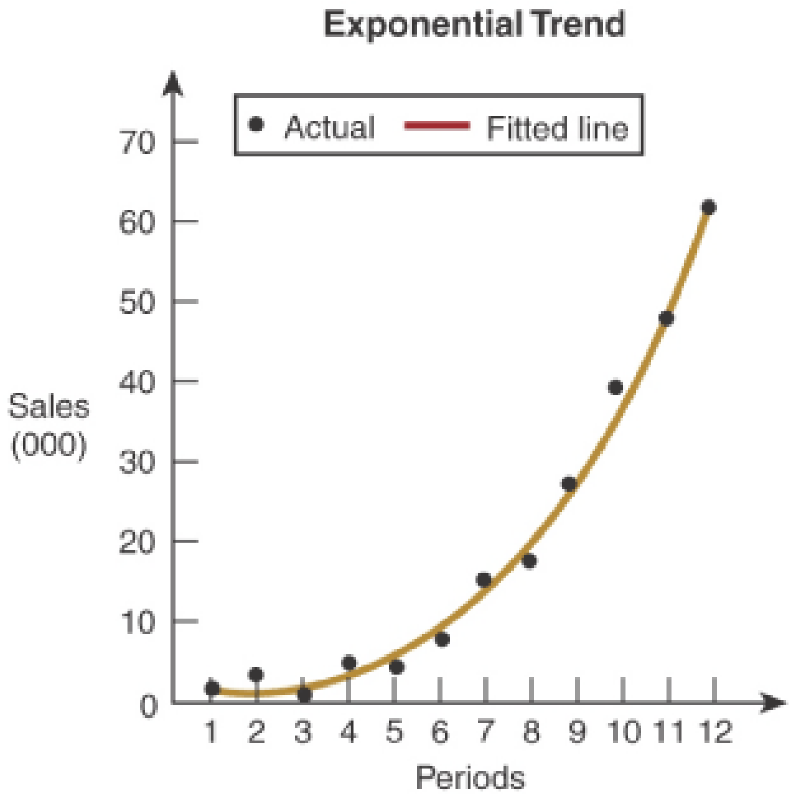




TIME SERIES METHOD: SIMPLE MOVING AVERAGE

- **Average over a given number of time periods that is updated by replacing the data in the oldest period with that in the most recent period.**

$$F_t = \frac{A_{t-1} + A_{t-2} + \cdots + A_{t-n}}{n}$$

F_t = Forecasted sales for period *t*
A_{t-1} = Actual sales in period *t* -1
n = Number of periods in the moving average

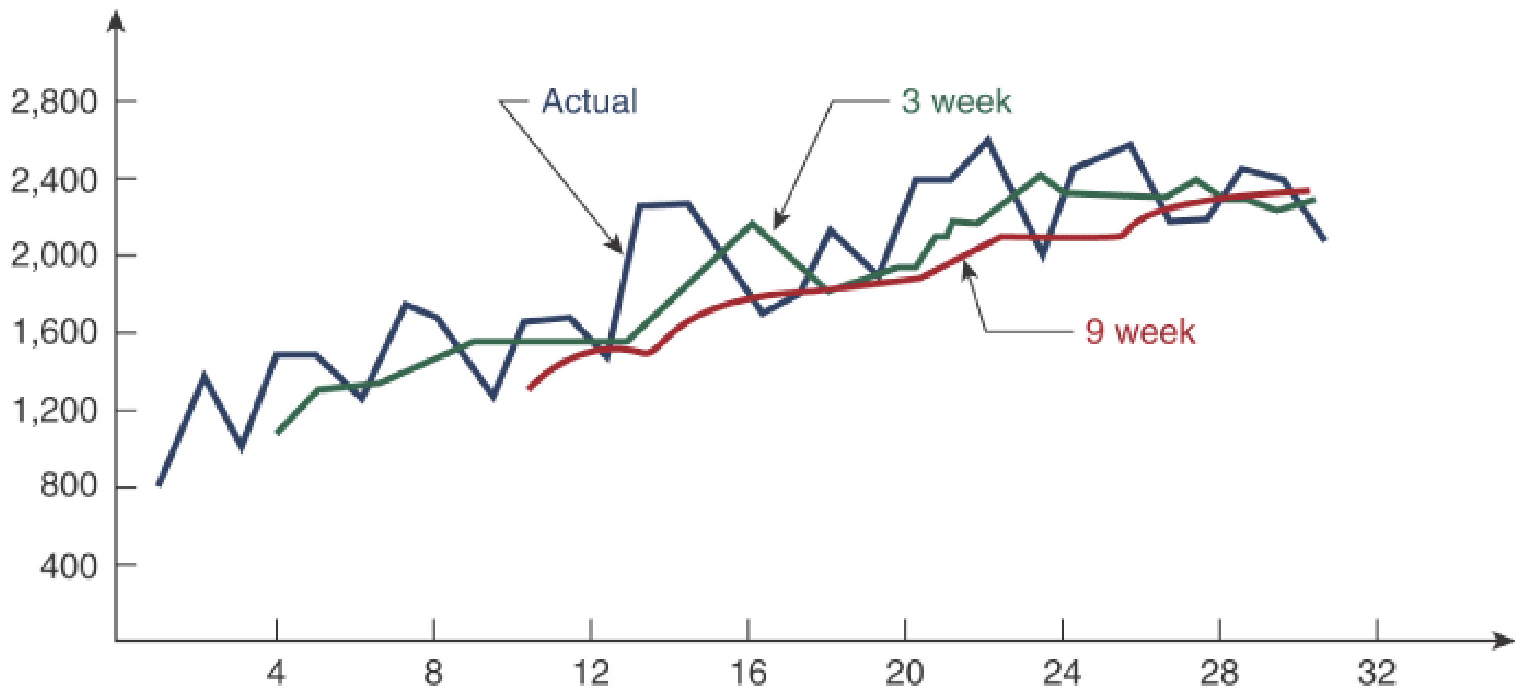
FORECAST DEMAND BASED ON A THREE- AND NINE-SIMPLE MOVING AVERAGE

Week	Demand	Forecast (3 - week)	Forecast (9 - week)
1	800		
2	1,400		
3	1,000		
4	1,500	1,067	
5	1,500	1,300	
6	1,300	1,333	
7	1,800	1,433	
8	1,700	1,533	
9	1,300	1,600	
10	1,700	1,600	1,367
11	1,700	1,567	1,467
12	1,500	1,567	1,500
13	2,300	1,633	1,556
14	2,300	1,833	1,644
15	2,000	2,033	1,733

=SUM(D6:D8)/3

=SUM(D6:D14)/9

THREE- AND NINE-WEEK SIMPLE MOVING AVERAGE FORECAST V.S. ACTUAL DEMAND



TIME SERIES ANALYSIS: HOW MANY PERIODS SHOULD BE USED?

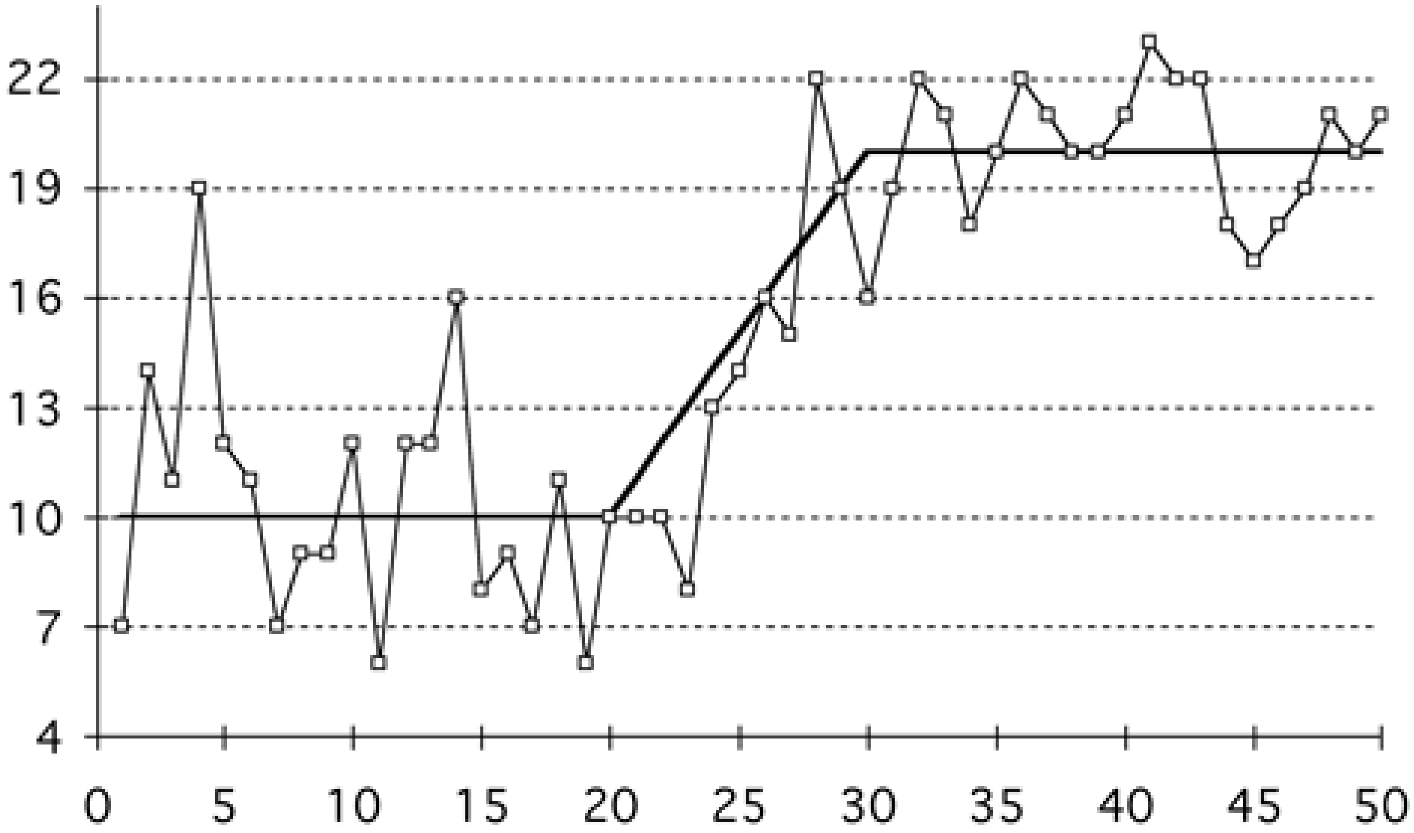
Advantages of more periods:

- More data points give a better estimate
- The effect of randomness is reduced by averaging together a number of observations
    - When there is no trend in the data, using more observations results in a forecast with lower error

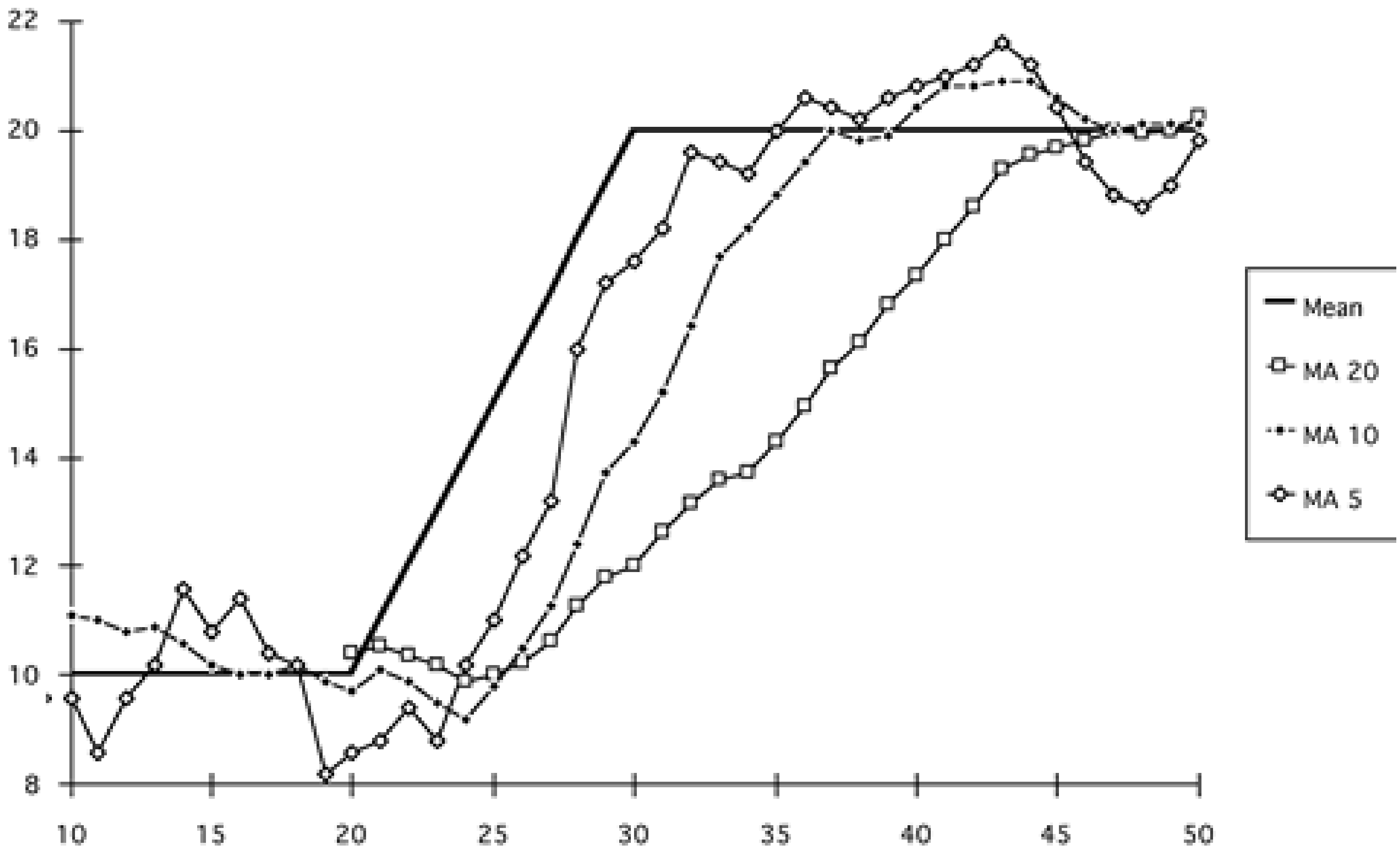
Disadvantages of more periods:

- A large number of observations will cause the moving average to respond slowly to permanent changes
    - When there is a trend in the data, using more observations results in a forecast with higher error
    - Bias

TIME SERIES ANALYSIS: HOW MANY PERIODS SHOULD BE USED?



TIME SERIES ANALYSIS: HOW MANY PERIODS SHOULD BE USED?



TIME SERIES METHOD: WEIGHTED MOVING AVERAGE

- **Simple moving average where weights are assigned to each time period in the average. The sum of all of the weights must equal one.**

$$F_t = w_{t-1}A_{t-1} + w_{t-2}A_{t-2} + \cdots + w_{t-n}A_{t-n}$$

F_t = Forecasted sales for period *t*
A_{t-1} = Actual sales in period *t* -1
w_{t-1} = Weight assigned to period *t* -1
n = Number of periods in the moving average

TIME SERIES METHOD: EXPONENTIAL SMOOTHING

- **We use weights $\boldsymbol{w_{t-1} = \alpha, w_{t-2} = \alpha(1-\alpha), w_{t-3} = \alpha(1-\alpha)^2}$, … indefinitely.**
- $F_t = \boldsymbol{\alpha} A_{t-1} + \boldsymbol{\alpha(1-\alpha)} A_{t-2} + \boldsymbol{\alpha(1-\alpha)^2} A_{\boldsymbol{t-3}} \ldots$

$$= \boldsymbol{\alpha A_{t-1} + (1-\alpha)(\alpha A_{t-2} + \alpha(1-\alpha) A_{t-3} + \cdots)}$$

$$= \boldsymbol{\alpha A_{t-1} + (1-\alpha) F_{t-1}}$$

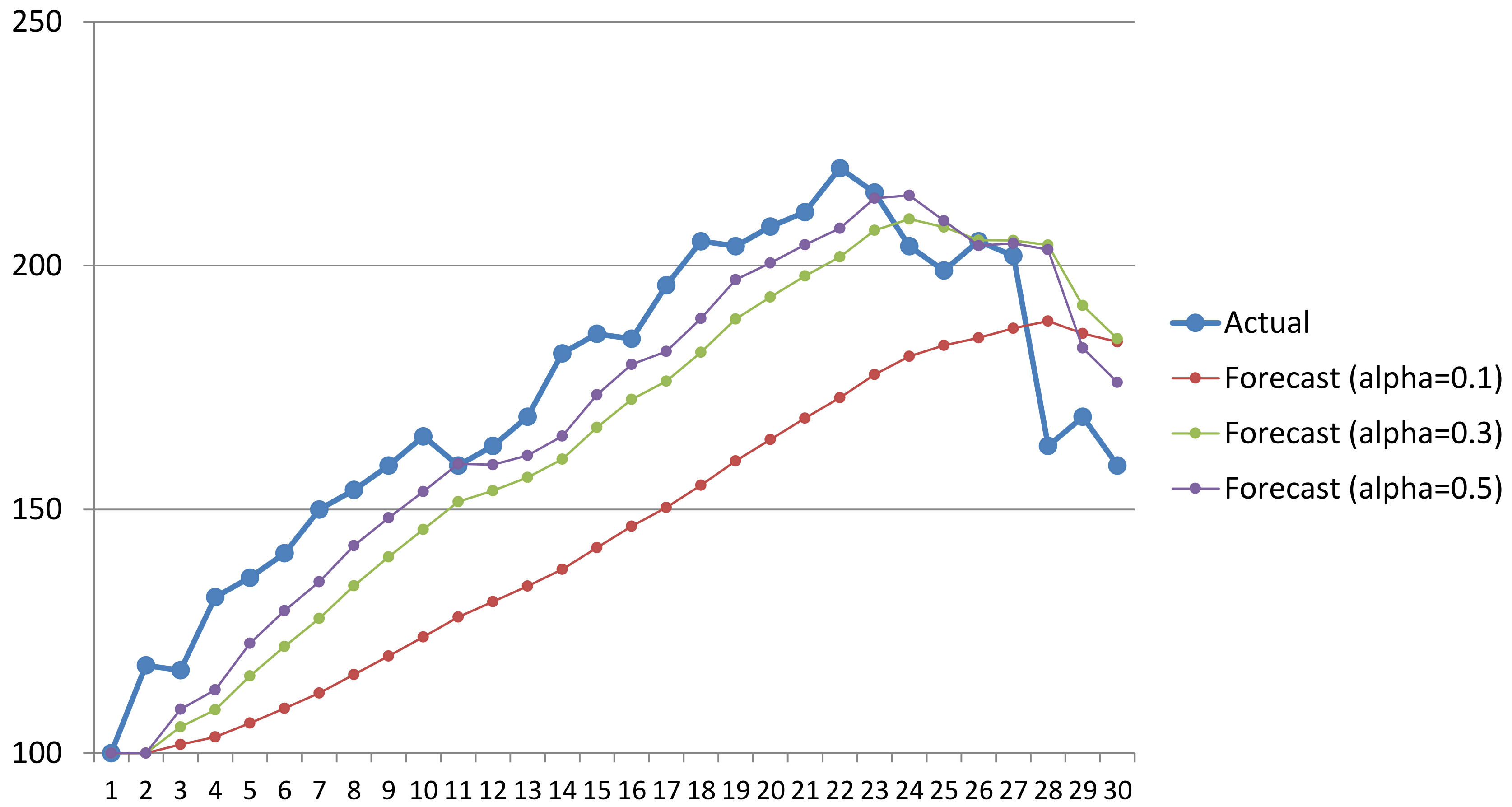
$$= \boldsymbol{F_{t-1} + \alpha(A_{t-1} - F_{t-1})}$$

F_t = Forecasted sales for period *t*
A_{t-1} = Actual sales in period *t* -1
F_{t-1} = Forecasted sales for period *t* -1
α = Desired response rate, or smoothing constant

TIME SERIES METHOD: EXPONENTIAL SMOOTHING

- **Exponential Smoothing Constant Alpha (α)**
  - A value between 0 and 1 that is used to minimize the error between historical demand and respective forecasts
  - Small α means the forecast is less responsive to the latest observation. So use small values for α if demand is stable and larger value if demand is fluctuating.

EXPONENTIAL SMOOTHING FORECASTS VERSUS ACTUAL DEMANDS



EXPONENTIAL SMOOTHING

- Simplicity (only one parameter)
- Little computation is required
- Limited use of historical data
- Lagged forecast when there is a trend

EXPONENTIAL SMOOTHING WITH TREND

- **Forecast with a Trend Constant δ to correct for lagging behind a trend**

$$FIT_t = F_t + T_t$$
$$F_t = FIT_{t-1} + \alpha(A_{t-1} - FIT_{t-1})$$
$$T_t = T_{t-1} + \delta(F_t - FIT_{t-1})$$

F_t = The exponentially smoothed forecast for period t

T_t = The exponentially smoothed trend for period t

FIT_t = The forecast including trend for period t

FIT_{t-1} = The forecasting including trend made for the prior period

A_{t-1} = The actual demand for the prior period

α = Smoothing constant

δ = Smoothing constant

FORECASTING ERRORS

Source of Error

- Projection of past trends into the future
- Bias errors
  - Consistent mistakes, wrong relationships, wrong trend line, errors in shifting seasonal demand, undetected trends
- Random errors
  - Unexplainable variations

MEASUREMENT OF ERRORS

- **MAD (mean absolute deviation) 平均绝对偏差**
  - Average forecasting error based on the absolute difference tween actual and forecast demands.

$$\text{MAD} = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n}$$

- **MAPE (mean absolute percentage error) 平均绝对百分比误差**
  - Measure the error relative to the average mean

$$\text{MAPE} = \frac{\text{MAD}}{\text{Average Demand}}$$

MEASUREMENT OF ERRORS

Month	Demand Forecast	Actual	Deviation	Abs. Dev.
1	1000	950	-50	50
2	1000	1070	+70	70
3	1000	1100	+100	100
4	1000	960	-40	40
5	1000	1090	+90	90
6	1000	1050	+50	50

MAD = (50+70+100+40+90+50) / 6 = 66.7

Average Demand = (950+1070+1100+960+1090+1050) / 6 = 1056

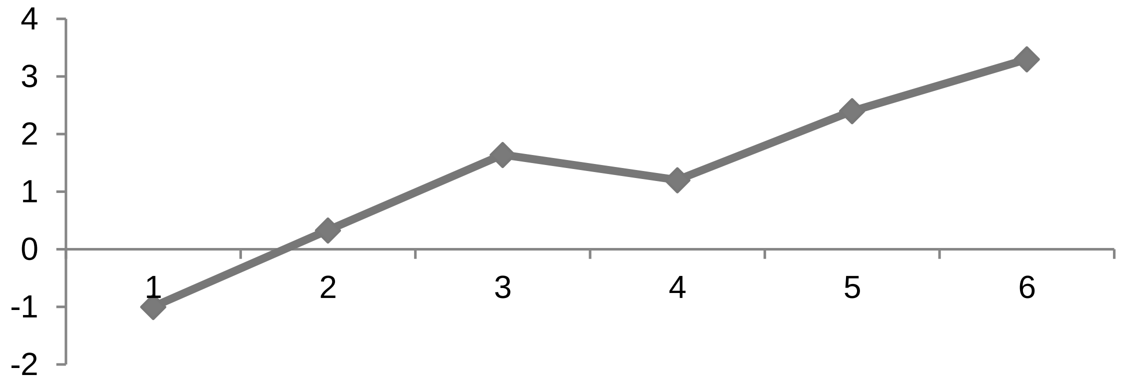
MAPE = MAD / Average Demand = 6.3%

MEASUREMENT OF ERROR

- **Tracking Signal**
  - a measurement of error that indicates if the forecast is staying within specified limits of the actual demand.
  - Tracking Signal = RSFE / MAD
  - RSFE = Running sum of forecast errors 累计预测误差

MEASUREMENT OF ERROR

Month	Demand Forecast	Actual	Deviation	RSFE	Abs. Dev.	Sum of Abs. Dev.	MAD	Tracking Signal
1	1000	950	-50	-50	50	50	50	-1
2	1000	1070	+70	+20	70	120	60	0.33
3	1000	1100	+100	+120	100	220	73.3	1.64
4	1000	960	-40	+80	40	260	65	1.2
5	1000	1090	+90	+170	90	350	70	2.4
6	1000	1050	+50	+220	50	400	66.7	3.3



CAUSAL MODEL: LINEAR REGRESSION ANALYSIS

- **Examples of causal relationship:**
  - A tall dad causes a tall son
  - Hot weather causes sales of air conditioner

- **Linear Regression: A forecasting technique that assumes that the relationship between the dependent and independent variables is a straight line:**

$$\boldsymbol{Y = aX + b}$$

Y = Dependent variable to be solved for
a = Y intercept
b = Slope of the XY relationship
X = Independent variable

ESTIMATION OF LINEAR REGRESSION MODEL

- **Let $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$ be the data points for the two variables X and Y.**
- **Define**

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

$$S_{xy} = n\sum_{i=1}^{n} x_i y_i - (\sum_{i=1}^{n} x_i)(\sum_{i=1}^{n} y_i) = n\sum_{i=1}^{n} x_i y_i - n^2\bar{x}\,\bar{y}$$

$$S_{xx} = n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2 = n\sum_{i=1}^{n} x_i^2 - n^2\bar{x}^2$$

ESTIMATION OF LINEAR REGRESSION MODEL

- Then

$$b = \frac{S_{xy}}{S_{xx}}$$

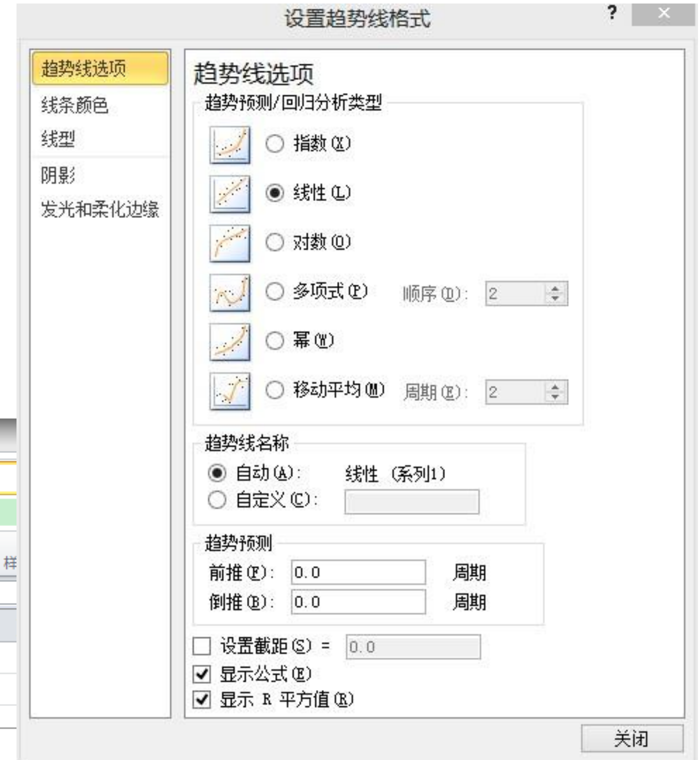
$$a = \overline{y} - b\overline{x}$$

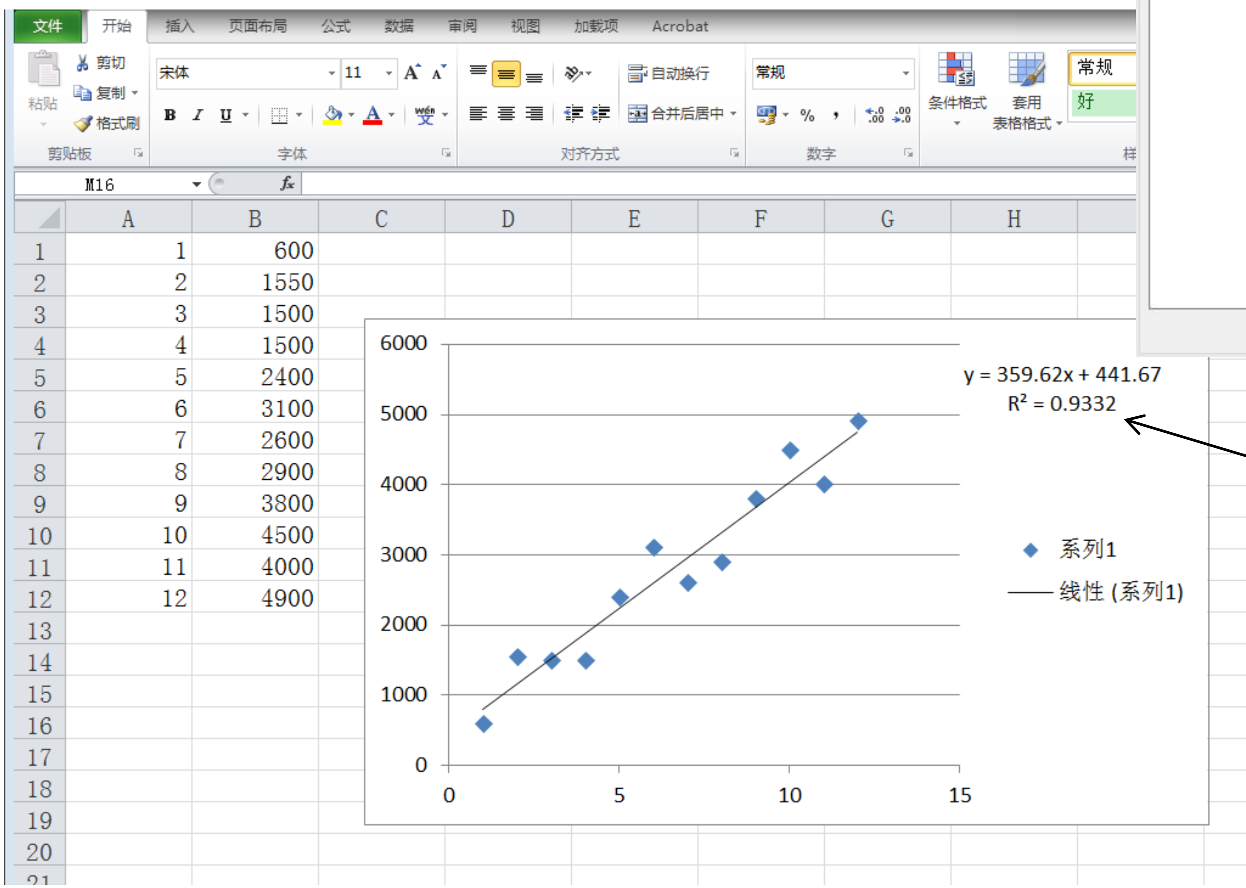
EXAMPLE

Quarter	Sales	Quarter	Sales
1	600	7	2600
2	1550	8	2900
3	1500	9	3800
4	1500	10	4500
5	2400	11	4000
6	3100	12	4900

We want to forecast the sales of the 15th Quarter

USING EXCEL





	A	B
1	1	600
2	2	1550
3	3	1500
4	4	1500
5	5	2400
6	6	3100
7	7	2600
8	8	2900
9	9	3800
10	10	4500
11	11	4000
12	12	4900

R^2 is the goodness of the model, R^2 =1 represents perfect fitting

Forecast for the sales of 15th quarter = 359.62 x 15 + 441.67= 5835

MULTIPLE REGRESSION

- **There is one dependent variable and multiple independent variables**

$$Y = a_1X_1 + a_2X_2 + \cdots a_nX_n + b$$

MISCELLANEOUS ON FORECASTING

- **Robustness v.s. Accuracy.**
- **Advanced Techniques of forecasting**
  - Machine learning

HOW DO WE FORECAST? DIFFUSION MODELS

Forecasting the adoption of new products is particularly hard

- There may be no historical information available

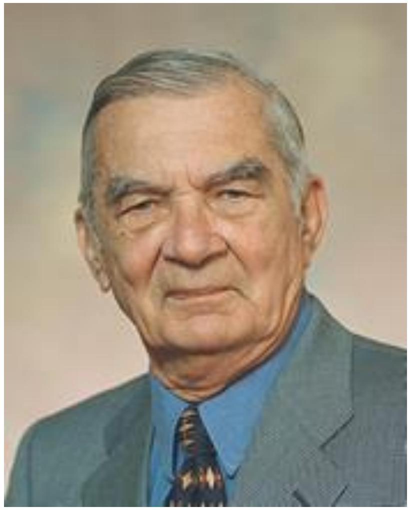
The sales patterns of new products typically go through three phases

- Rapid growth
- Maturity
- Decline

Diffusion models can be a good parametric approach to estimate the demand trajectory of a new product over time

THE BASS DIFFUSION MODEL

- Is a model for adoption of new products (consumer durables)
- One of the 10 most influential papers of “Management Science” in the last 50 years
- Widely used in marketing and strategy
- We will build the model from first principles



Frank Bass

KEY IDEA

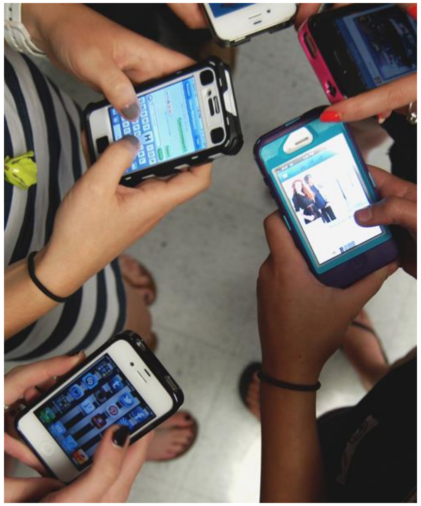
Consumers may have two types of behavior:

Innovators

- Early adopters
- Not influenced by other individuals
- Driven by advertisement or some other external effect

Imitators

- Influenced by other buyers
- Word of mouth
- **Network effects**



BASS DIFFUSION MODEL FORMULATION

There is an initial pool of *M potential adopters*

n_t is the number of *adopters in period t*

N_t is the *cumulative number of adopters* up to period *t*

In each period *t* the *remaining potential adopters* ($M-N_{t-1}$):

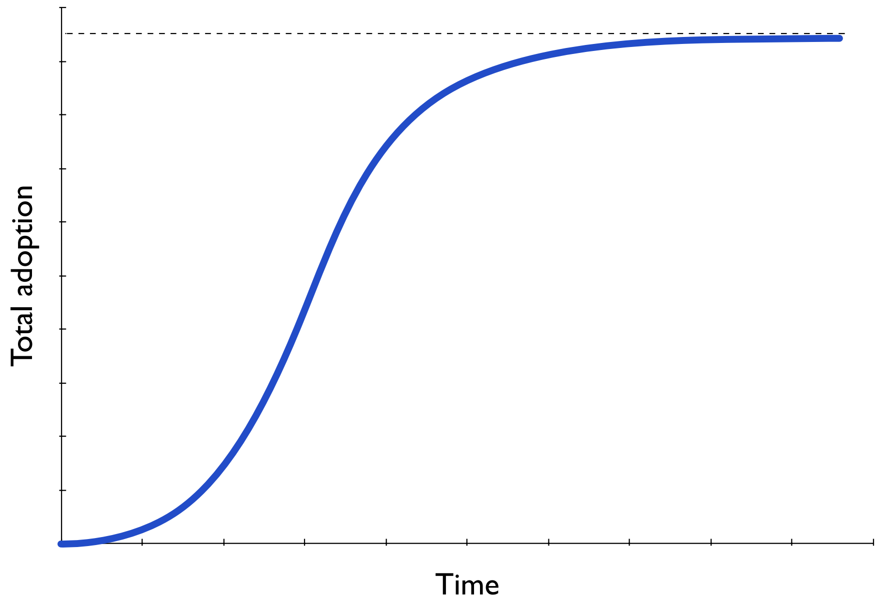
- Coefficient of innovation, ***innovation effect***: **p**
- Coefficient of Imitation ***q.***
- ***Imitation effect*** is influenced by current adopters ***N_{t-1}/M,***

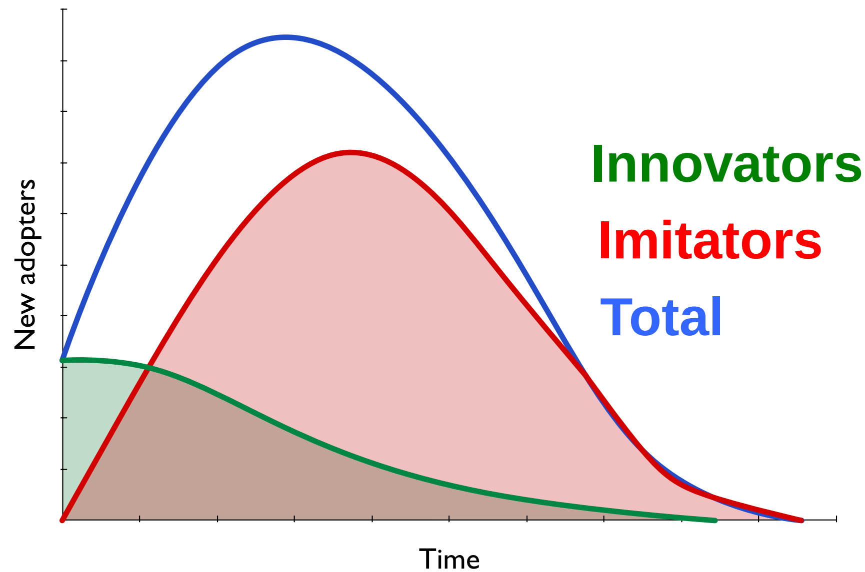
$$n_t = \left(p + q\frac{N_{t-1}}{M}\right)(M - N_{t-1})$$

$$N_t = N_{t-1} + n_t, \quad N_0 = 0$$

GRAPHICAL RESULT AND INTERPRETATION

The following are typical trajectories of the Bass model

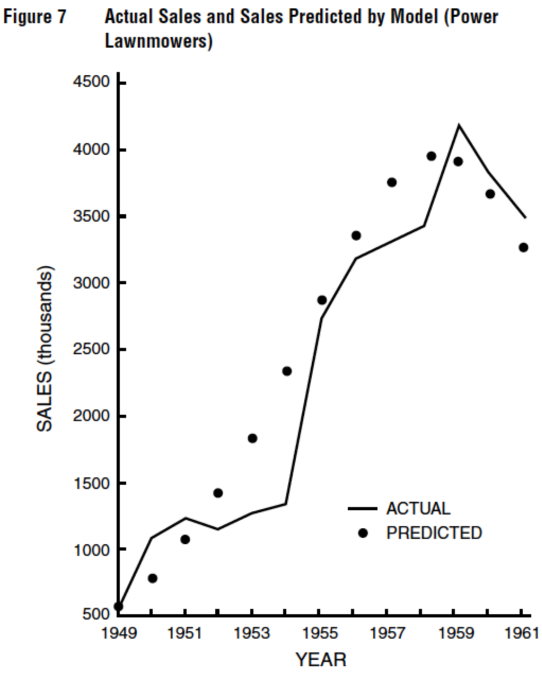


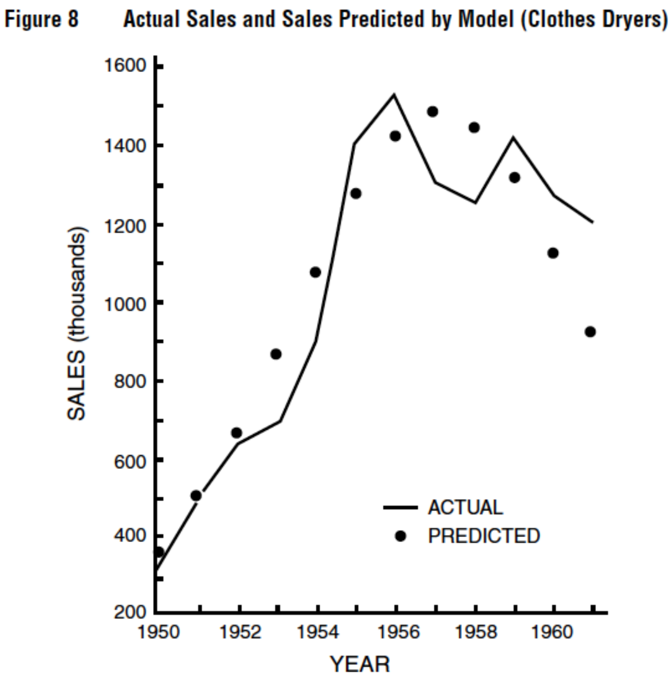


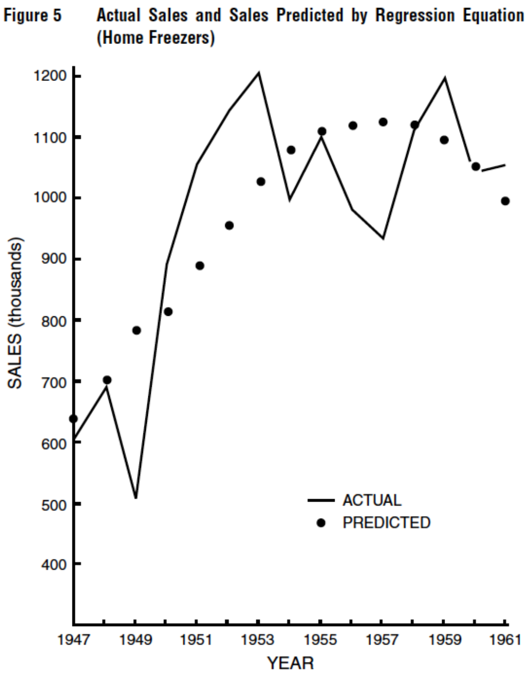
Does it capture the sales trajectory of a new product?

What about the behavior *innovators* and *imitators*?

BASS MODEL EXAMPLES







**Source:* Bass, Frank M. "A new product growth for model consumer durables", *Management Science, January 1969, Volume 15, Number 5, pp. 215–227*

SUMMARY

- **Qualitative and quantitative techniques for forecasting**
- **Time Series Methods:**
  - Simple moving average
  - Weighted moving average
  - Exponential smoothing
  - Exponential smoothing with trend
- **Causal Methods:**
  - Linear regression
- **Diffusion Model**
  - Bass Model