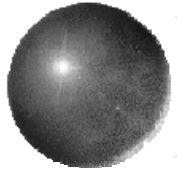


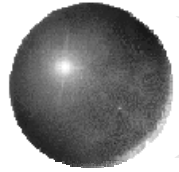
Demand Forecasting for Managing Logistics Requirements





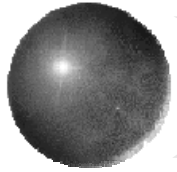
Key Considerations

- Forecasts drive the planning, operation, and control of entire logistics chain
- Good forecasts can lead to
 - Reduced inventory costs.
 - Increased customer satisfaction
 - Lower overall personnel costs



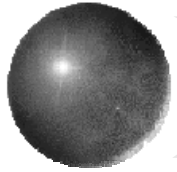
Forecasting Management Tools

- Forecasting managerial approach
- Forecasting performance measurement
- Forecasting techniques
- Forecasting system



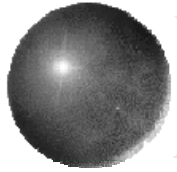
Definition

- Demand vs Sales
- Demand forecasting vs Demand Planning vs Demand Management
- Sales forecasts vs Sales plan vs Sales Targets
- Bill-to-customer (Sold-to-customer) vs Ship-to-customer
- Independent Demand, Dependent Demand, and Derived Demand



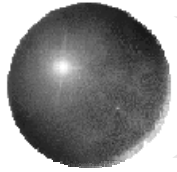
Definition

- **Demand Forecasting:** The prediction, projection or estimation of expected demand over a specified future time period.
- **Demand Planning:** uses the demand forecast (statistical forecast) as the base for its plan and provides direction on how the forecasts will be consumed through the business. Demand Planning allows you to make accurate customer demand predictions, leverage historical product performance, manage inventory replenishment with forecasting, and see how price changes affect product gross margins.
- **Demand Management:** The function of recognizing all demands for goods and services to support the market place. It involves prioritizing demand when supply is lacking. Proper demand management facilitates the planning and use of resources for profitable business results.



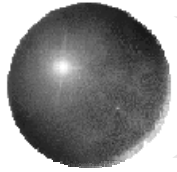
Elements of Forecasts

- Forecasts level: product family, product groups, product items
- Customer group (type, region, zone, individual)
- Time horizon
- Time bucket
- Time interval

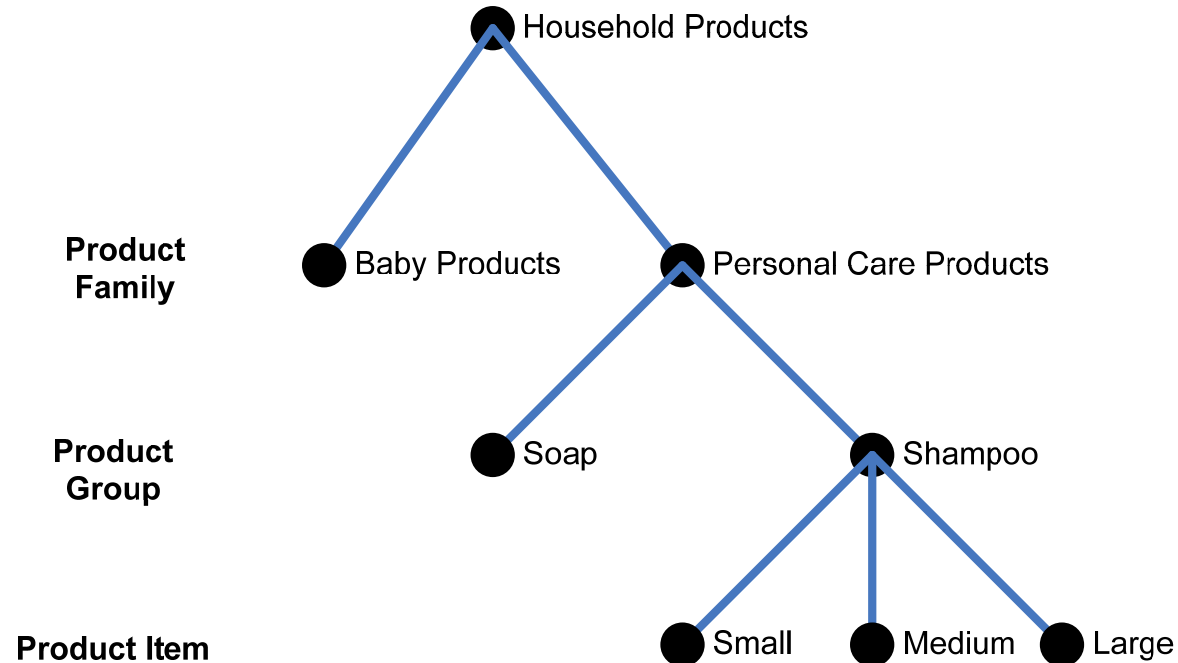


A Hypothetical Business Case

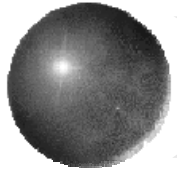
- The BU is a company manufacturing and distributing household products to a network of retailers located all over Thailand.
- The company operates two plants, one in Samutprakarn and one in Lumpoon.
- The two plants have the same type of machines, meaning that both plants can produce exactly the same product items.
- About 50% of raw materials are available in Thailand while the remaining must be imported by sea from the US requiring procurement lead time of approx. 2 months.
- The products can be categorized into two major product families.



Finished Goods

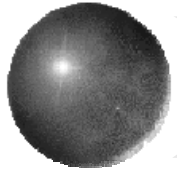


- How many units of each product item must be produced at each plant the following week?
- How many trucks do we need to prepare for delivery products from plants to retailers?

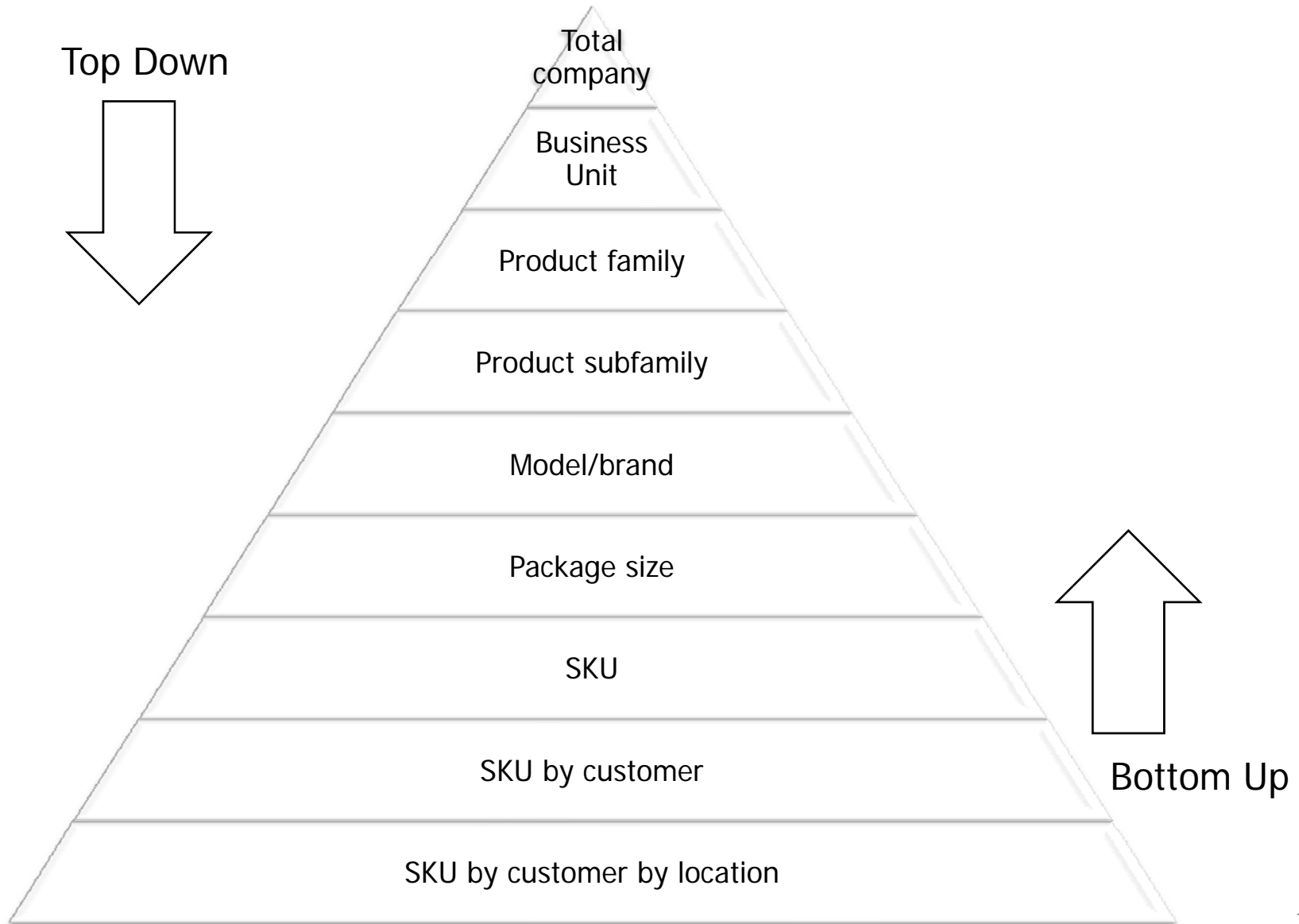


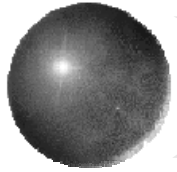
Planning Levels

	Time horizon	Time bucket	Product	Customer
Strategic	<i>> 1 year</i>	<i>year, month</i>	<i>family</i>	<i>region</i>
Tactical	<i>3 months-1 year</i>	<i>month, week</i>	<i>group</i>	<i>zone</i>
Operational	<i>1 week-1 month</i>	<i>week, day</i>	<i>item</i>	<i>zone, individual</i>



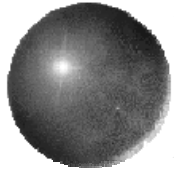
Product Aggregation





Forecasting Requirements

	Marketing	Finance	Production	Logistics
Needs	<i>Annual plans for promotional efforts and pricing</i>	<i>Projecting cost and profit levels</i>	<i>Planning facility development and production runs</i>	<i>Planning facility development and distribution operation</i>
Level	<i>Product or product line</i>	<i>Corporate, division, product line</i>	<i>Product item</i>	<i>Product by location</i>
Horizon	<i>Annual</i>	<i>1-5 years</i>	<i>1-3 years, 1-6 months</i>	<i>Annual, monthly, daily, weekly</i>
Interval	<i>Monthly or quarterly</i>	<i>Monthly or quarterly</i>	<i>Monthly or weekly</i>	<i>Monthly, weekly, or daily</i>

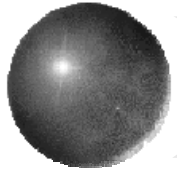


Who Should Be Taking Up the Forecasting Functions ?

TABLE 1
SUMMARY OF PROS AND CONS OF PUTTING
THE FORECASTING FUNCTION IN EACH TYPE OF DEPARTMENT

Department	Objectivity	Business Understanding	Quantitative Skills	Organizational Skills
Standalone Forecasting	Objective, but not impacted by demand	No direct contact with customers	High Level	High level of discipline
Marketing	Objective, but some bias from performance goals	Very good understanding of future customer needs	Low Level	Moderate level of discipline
Production, Operations, and Logistics	Objective and impacted by demand	Little direct contact with customers	High Level	High level of discipline
Sales	Bias from sales goals and commissions	Highest level of contact with customers	Low Level	Less interest in running structured, routine processes
Finance	Objective, but some bias from budgeting and not impacted by demand	No direct contact with customers	High Level	High level of discipline
Strategic Planning	Objective, but not impacted by demand and view is too long-term	No direct contact with customers	High Level	High level of discipline

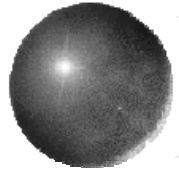
Source: WHERE SHOULD THE FORECASTING FUNCTION RESIDE? BY Larry Lapide, AMR Research



Forecasting Managerial Approach

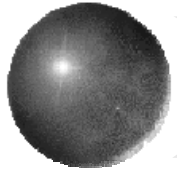
How we organize and how we efficiently and effectively conduct the business of developing and using sales forecasts

- Independent form
- Concentrated form
- Negotiated form
- Consensus form



Forecasting Techniques

- Expert judgment or Qualitative forecasting
- Causal Methods i.e. regression analysis
- Historical Projection Methods i.e. smoothing methods



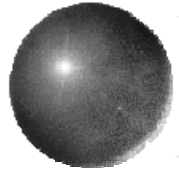
Expert Judgment

Advantage

- Ability to predict changes in sales patterns
- Allow decision-makers to incorporate rich data consisting of their intuition, experience, and expert judgement

Disadvantage

- Inability to process large amount of complex information
- Political factors
- To justify rather than to understand
- Influence of moods & emotion



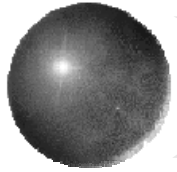
Expert Evaluation Techniques

Jury of executive opinion: powerful member will dominate the discussion & dispersion of forecasting accountability

Delphi method: not willing to seek additional information

Sales Force Composite: lack of training, political pressures between trade partners

Market Research

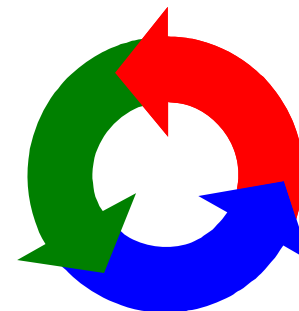


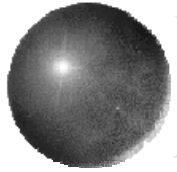
Causal Methods

- Regression Analysis

$$Y = a_0 + a_1X_1 + a_2X_2 + \dots$$

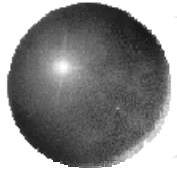
- Causal relation between X's and Y
- Effects of external factors
- Long-term and aggregate forecasts





Regression

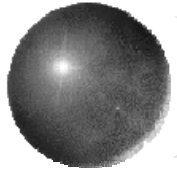
Year	Annual sales of umbrellas (10,000 units)	Rainfall (inches)	Per capita income (10,000 baht)
2000	14	7	6
2001	15	7	8
2002	16	5	10
2003	17	4	12
2004	20	3	15
2005	21	3	17
2006	24	1	20



Regression

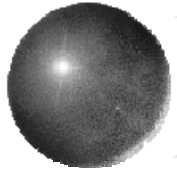
- Effect of Rainfall and Income factors

$$\text{Sales} = 7.357 + 0.186 \text{ Rainfall} + 0.795 \text{ Income}$$



Regression

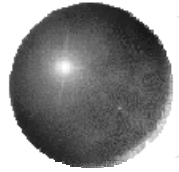
Year	Annual sales of umbrellas (10,000 units)	Rainfall (inches)
2000	14	7
2001	15	7
2002	16	5
2003	17	4
2004	20	3
2005	21	3
2006	24	1



Regression

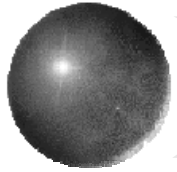
- Effect of Rainfall only

$$\text{Sales} = 24.884 - 1.573 \text{ Rainfall}$$



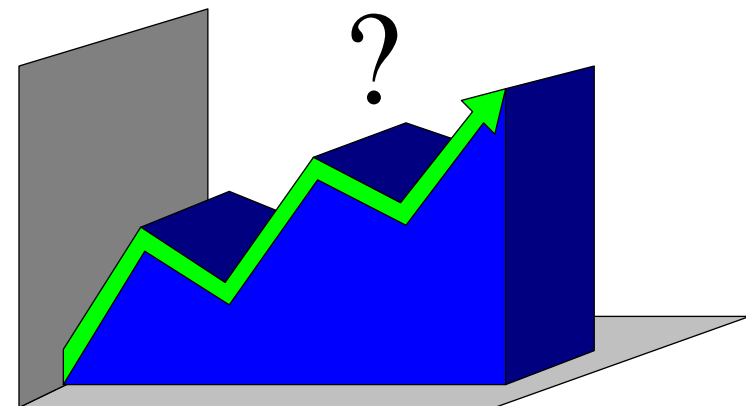
Historical Projection Methods

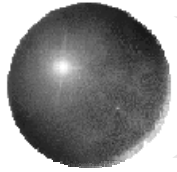
- Availability of a large amount of historical sales data
- Existing demand patterns will continue in the future
- Short-range forecasting



Time Series Forecasting Techniques

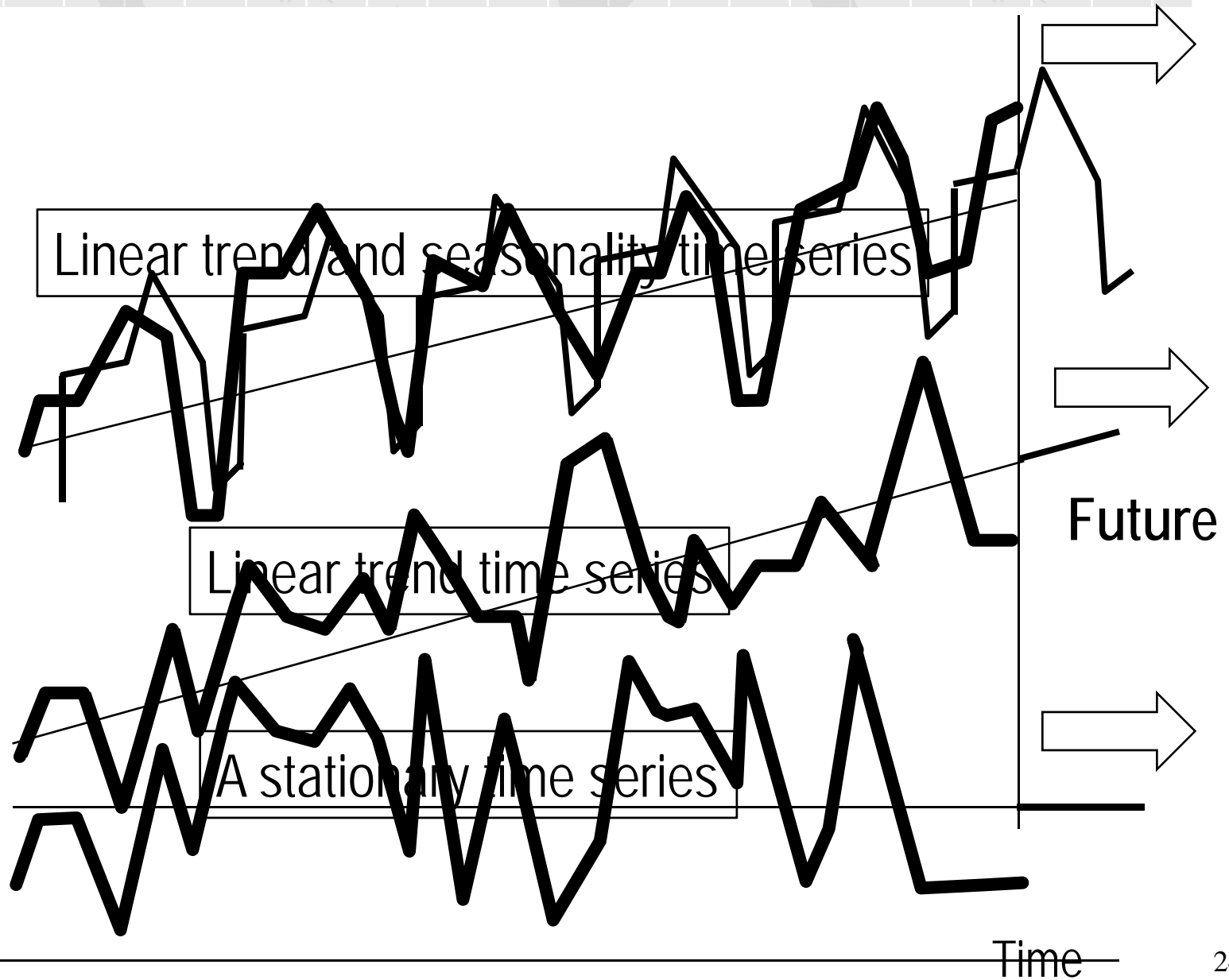
- Endogenous techniques: look at only the patterns of actual sales history
- Four basic time-series pattern
 - Level
 - Trend
 - Seasonality/Cycles
 - Noise

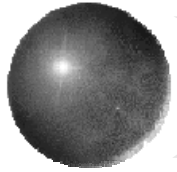




Components of a Time Series

Time series value





Stationary Forecasting Models

- In a stationary model the mean value of the time series is assumed to be constant.
- The general form of such a model is

Where:

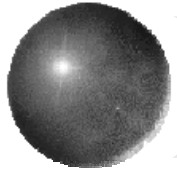
$$y_t = \beta_0 + \varepsilon_t$$

- The values of ε_t are assumed to have a mean of 0.

y_t = the value of the time series at time period t .

β_0 = the unchanged mean value of the time series.

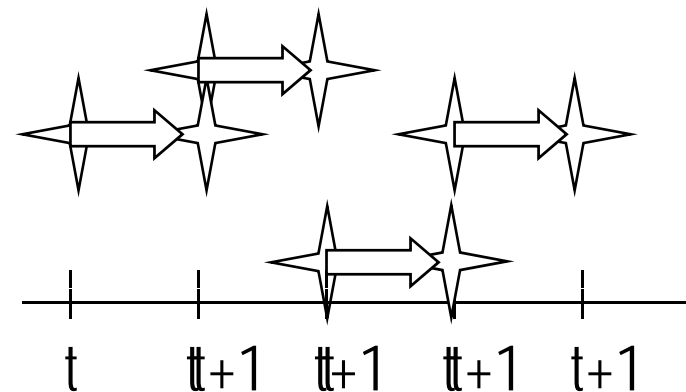
ε_t = a random error term at time period t .

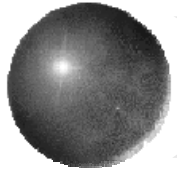


Moving Average Methods

- The last period technique (Naïve technique)
The forecast for the next period is
the last observed value

$$F_{t+1} = A_t$$



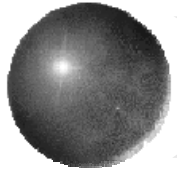


Moving Average Methods

- The moving average method

The forecast is the average of the last n observations of the time series.

$$F_{t+1} = \frac{\sum_{i=t-n+1}^t A_i}{n} = \frac{A_t + A_{t-1} + \dots + A_{t-n+1}}{n}$$



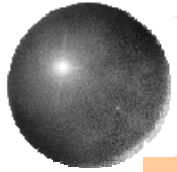
Moving Average Methods

- The weighted moving average method

More recent values of the time series

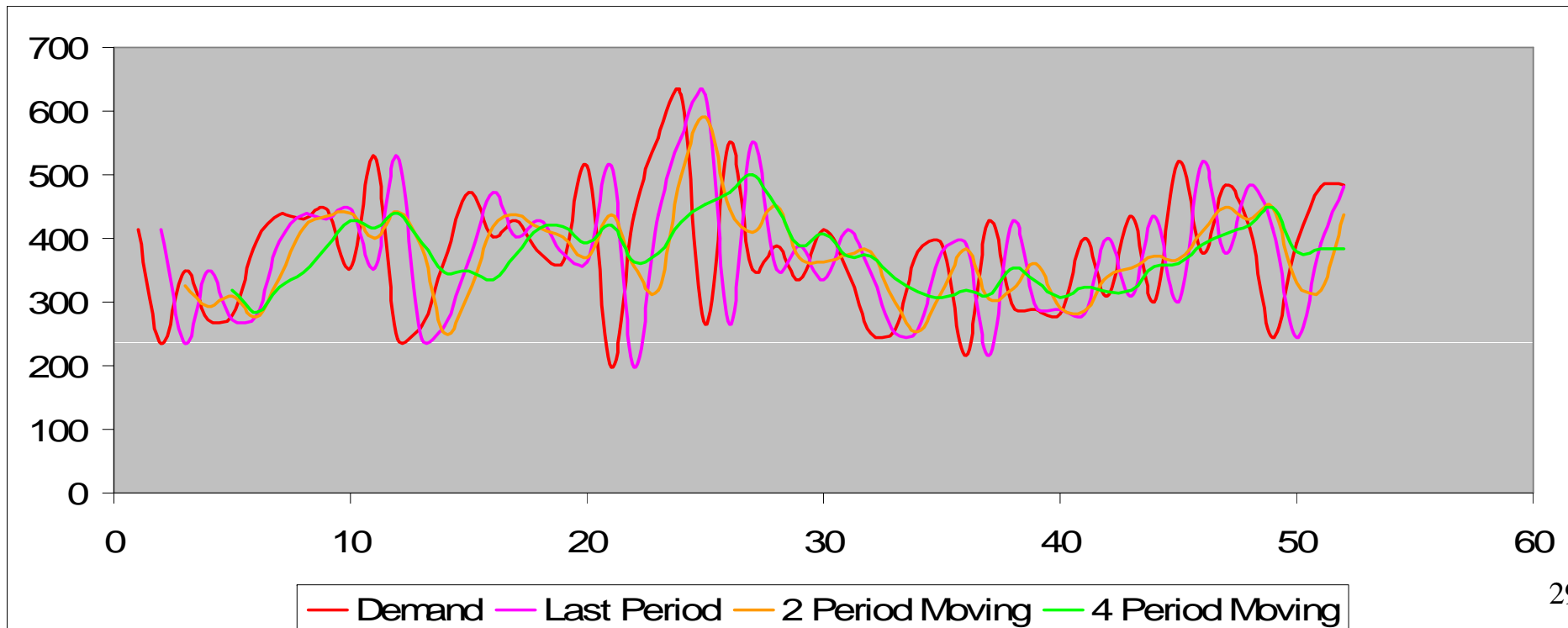
get larger weights than past values when performing the forecast.

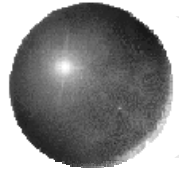
$$F_{t+1} = \frac{\sum_{i=t-n+1}^t w_i A_i}{n}$$
$$= \frac{w_t A_t + w_{t-1} A_{t-1} + \dots + w_{t-n+1} A_{t-n+1}}{n}$$



Example

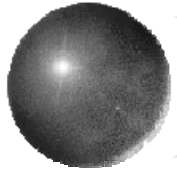
Week	Demand	Last Period	2 Period Moving	4 Period Moving
1	415			
2	236	415.0		
3	348	236.0	325.5	
4	272	348.0	292	
5	280	272.0	310	317.8
6	395	280.0	276	284.0
7	438	395.0	337.5	323.8
8	431	438.0	416.5	346.3
9	446	431.0	434.5	386.0
10	354	446.0	438.5	427.5
11	529	354.0	400	417.3
12	241	529.0	441.5	440.0





The Exponential Smoothing Technique

- This technique is used to forecast stationary time series.
- ***All*** the previous values of historical data affect the forecast.



The Exponential Smoothing Technique

Define:

F_{t+1} = the forecast value for time $t+1$

A_t = actual demand at time t

α = smoothing constant (between 0 and 1)

$$F_{t+1} = F_t + \alpha (A_t - F_t)$$

$$= \alpha A_t + (1 - \alpha) F_t$$

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

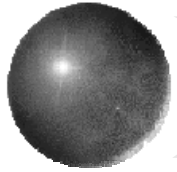
$$F_{t+1} = \alpha A_t + (1 - \alpha) (\alpha A_{t-1} + (1 - \alpha) F_{t-1})$$

$$= \alpha A_t + (1 - \alpha) \alpha A_{t-1} + (1 - \alpha)^2 F_{t-1}$$

$$= \alpha A_t + (1 - \alpha) \alpha A_{t-1} + (1 - \alpha)^2 \alpha A_{t-2} + (1 - \alpha)^3 F_{t-2}$$

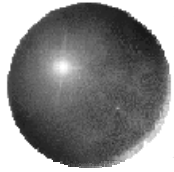
$$= \alpha A_t + (1 - \alpha) \alpha A_{t-1} + (1 - \alpha)^2 \alpha A_{t-2} + (1 - \alpha)^3 \alpha A_{t-3} + \dots (1 - \alpha)^N \alpha A_{t-N}$$

An initial "forecast" is needed to start the process.



The Exponential Smoothing Technique *Smoothing Effect*

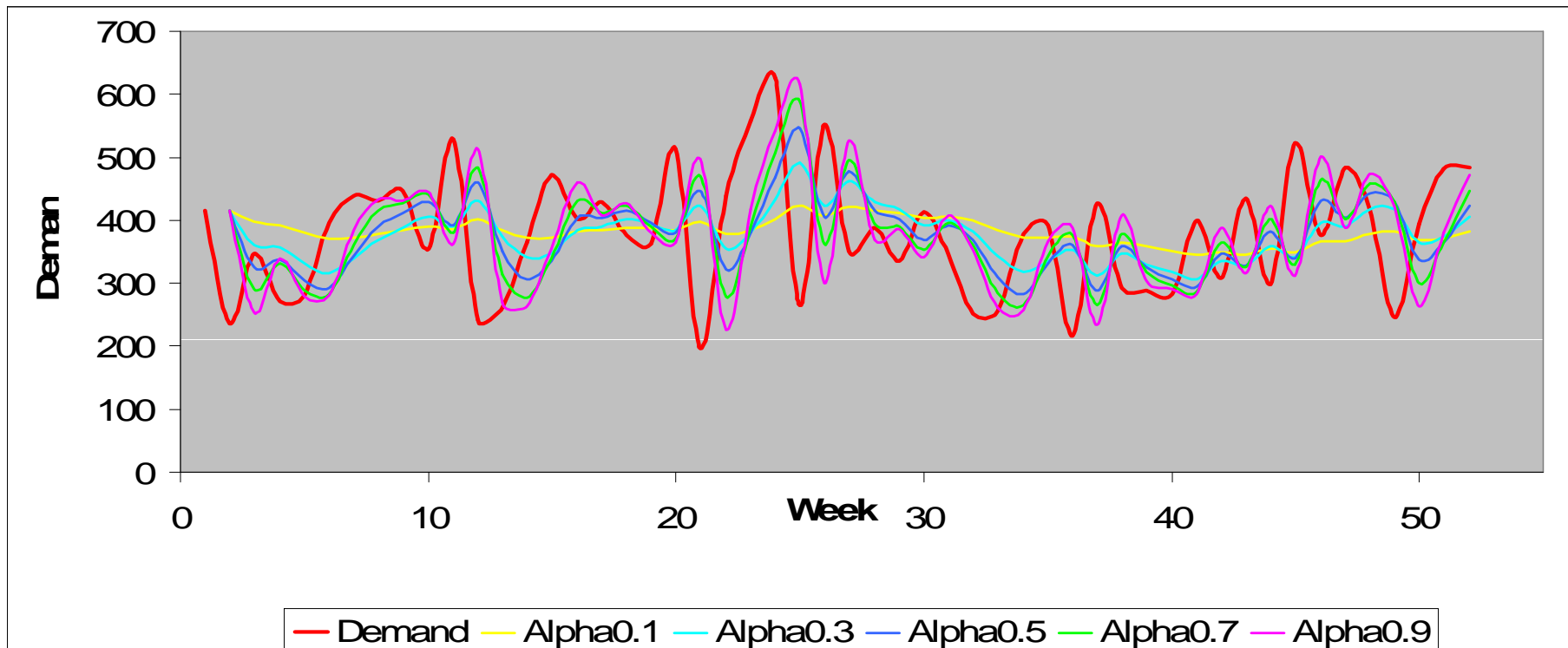
- A small α provides a lot of smoothing.
- A large α provides a fast response to the recent changes in the time series and a smaller amount of smoothing.

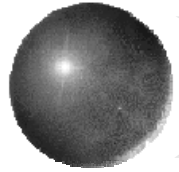


Example

Alpha 0.1 0.3 0.5 0.7 0.9

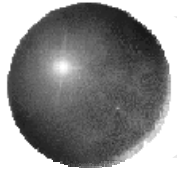
Week	Demand	Alpha0.1	Alpha0.3	Alpha0.5	Alpha0.7	Alpha0.9
1	415					
2	236	415.0	415.0	415	415	415
3	348	397.1	361.3	325.5	289.7	253.9
4	272	392.2	357.3	336.8	330.5	338.6
5	280	380.2	331.7	304.4	289.6	278.7
6	395	370.2	316.2	292.2	282.9	279.9
7	438	372.6	339.8	343.6	361.4	383.5
8	431	379.2	369.3	390.8	415.0	432.5
9	446	384.4	387.8	410.9	426.2	431.2
10	354	390.5	405.3	428.4	440.1	444.5
11	529	386.9	389.9	391.2	379.8	363.1
12	241	401.1	431.6	460.1	484.2	512.4





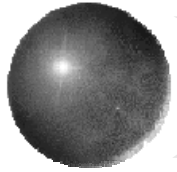
Time Series with Trend & Seasonality

- Time series with Trend:
 - Holt's Model.
- Time series with Trend & Seasonality:
 - Winter's Model.



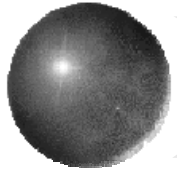
Demand Forecast Applications

Application	Time Horizon		
	Short Term (0–3 months)	Medium Term (3 months– 2 years)	Long Term (more than 2 years)
Forecast quantity	Individual products or services	Total sales Groups or families of products or services	Total sales
Decision area	Inventory management Final assembly scheduling Workforce scheduling Master production scheduling	Staff planning Production planning Master production scheduling Purchasing Distribution	Facility location Capacity planning Process management
Forecasting technique	Time series Causal Judgment	Causal Judgment	Causal Judgment



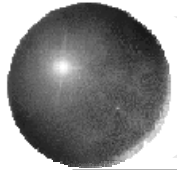
Evaluating the performance of Forecasting Techniques

- Several forecasting methods have been presented.
- Which one of these forecasting methods gives the “best” forecast?



Performance Measures

- Generally, to evaluate each forecasting method:
 - Select an evaluation measure.
 - Calculate the value of the evaluation measure using the forecast error equation
$$e_t = A_t - F_t$$
 - Select the forecast with the **smallest** value of the evaluation measure.



Performance Measures

$$\text{MAD} = \frac{\sum |e_t|}{n}$$

Mean Absolute Deviation

$$\text{MSE} = \frac{\sum (e_t)^2}{n}$$

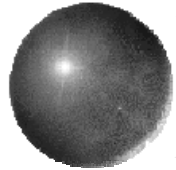
Mean Squared Error

$$\text{MAPE} = \frac{\sum_n |e_t| / A_t}{n} \times 100$$

Mean Absolute Percentage Error

$$\text{BIAS} = \frac{\sum e_t}{n}$$

Bias



Usage Of Forecasting Techniques

Table V. Usage across time horizons (percentage of respondents)

Technique	<= 3 months		3 months to 2 years		> 2 years	
	M&C	PS	M&C	PS	M&C	PS
<i>Qualitative</i>						
Jury of executive opinion	37	4	42	77	38	55
Sales force composite	37	4	36	77	8	21
Customer expectations	25	5	24	38	12	15
<i>Quantitative</i>						
Moving average	24	9	22	45	5	11
Straight-line projection	13	5	16	35	10	10
Exponential smoothing	24	8	17	92	6	16
Regression	14	4	36	69	28	30
Trend line analysis	21	2	28	57	21	22
Simulation	4	1	9	6	10	12
Life cycle analysis	1	1	5	24	12	18
Decomposition	9	2	13	40	5	10
Box—Jenkins time series	5	2	6	19	2	7
Expert systems		1		6		8
Neural networks		2		17		6

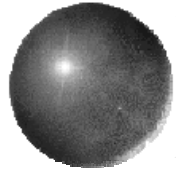
Numbers in italic are statistically different at $\alpha \leq 0.05$.

M&C = Mentzer and Cox (1984)

PS = present study

M&C sample size = 160

PS sample size = 186



Satisfaction With Forecasting Techniques

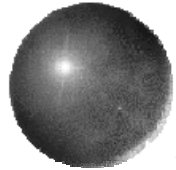
Table IV. Satisfaction

Technique	Sample size		% satisfied		% neutral		% dissatisfied	
	M&C	PS	M&C	PS	M&C	PS	M&C	PS
<i>Qualitative</i>								
Jury of executive opinion	118	131	54	35	24	36	22	29
Sales force composite	112	140	43	34	25	27	32	39
Customer expectations	95	130	45	46	23	32	32	22
<i>Quantitative</i>								
Moving average	112	179	58	40	21	35	21	25
Straight-line projection	93	169	32	28	31	30	37	42
Exponential smoothing	104	172	60	72	19	24	21	4
Regression	99	156	67	66	19	29	14	5
Trend line analysis	40	145	58	48	28	40	15	12
Simulation	65	100	54	50	18	42	28	8
Life cycle analysis	52	99	40	36	20	36	40	18
Decomposition	71	84	55	61	14	28	31	11
Box-Jenkins time series	47	78	30	44	13	45	57	11
Expert systems		66		45		47		8
Neural networks		37		38		49		13

Numbers in italic are statistically different at $\alpha \leq 0.05$.

M&C = Mentzer and Cox (1984)

PS = present study



Accuracy of Forecasting Techniques

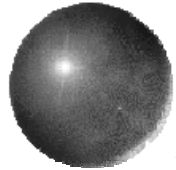
Table VII. Percentage accuracy

Forecast level	<= 3 months		3 months to 2 years		> 2 years	
	M&C	PS	M&C	PS	M&C	PS
Industry	92 (n = 61)	90 (n = 1)	89 (n = 61)	88 (n = 16)	85 (n = 50)	87 (n = 36)
Corporate	93 (n=81)	72 (n=2)	89 (n=89)	90 (n=64)	82 (n=61)	88 (n=42)
Product group	90 (n=89)		85 (n=96)		80 (n=61)	
Product line	89 (n = 92)	90 (n=4)	84 (n = 95)	86 (n = 83)	80 (n = 60)	88 (n=25)
Product	84 (n = 96)	82 (n = 14)	79 (n = 88)	79 (n = 89)	74 (n = 54)	86 (n = 10)
SKU by location		76 (n=17)		75 (n = 58)		87 (n=5)
				M&C 85	PS 84	

M&C = Mentzer and Cox (1984)

PS = present study

¹ Weighted average calculated by weighting each cell accuracy by the number responding.

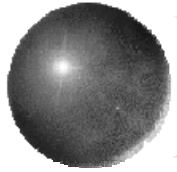


Adopted Measures of Forecast Accuracy

Table VIII. Measures of forecast accuracy

	No. of respondents in present study ¹
Mean absolute percentage error	122 (52%)
Mean absolute deviation	59 (25%)
Mean squared error	23 (10%)
Deviation	9 (4%)
Percentage error	8 (3%)
Forecast ratio	2 (<1%)
Inventory statistic	2 (<1%)
Standard deviation	2 (<1%)
Other	9 (4%)

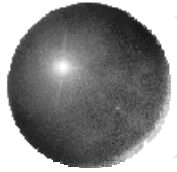
¹*Some* respondents listed more than one measure.



Forecasting Systems

Key Principles

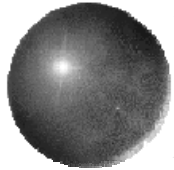
- Sales forecasting system should serve as a communication vehicle between users and developers of forecasts
- The whole business entity operates with a single set of operational numbers.
- Demand manager proposes a demand plan with inputs from various departments that is reviewed for consensus on a continuing basis
 - Integration of forecasting systems with other corporate systems
 - Sophisticated report-generation systems
 - Sophisticated data warehouse systems that allow forecasts to be updated in real time



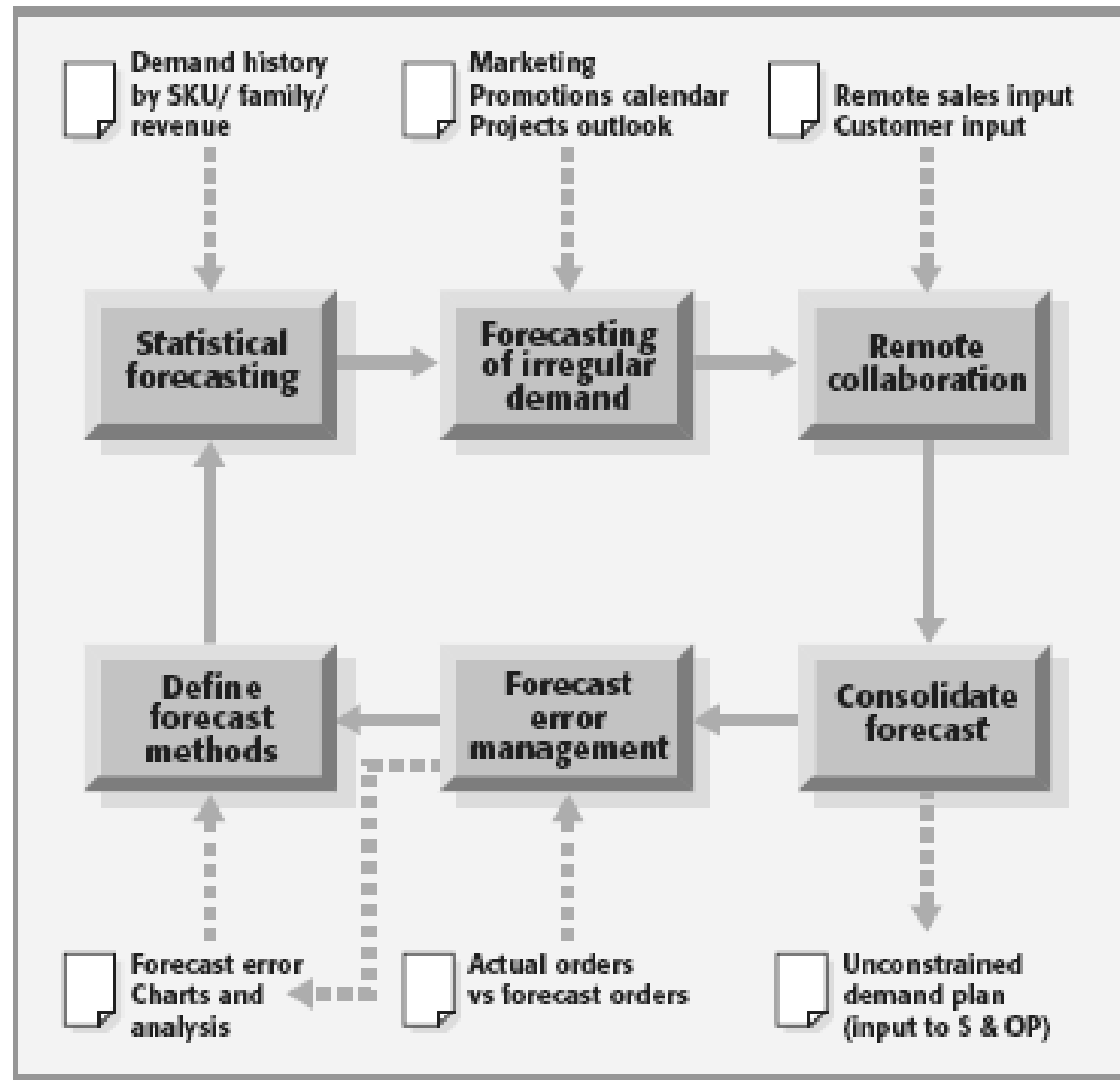
Forecast Improvement Tactics

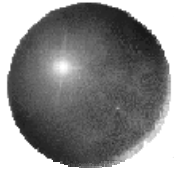
Forecasts are always wrong !!!

- Aim is not to obtain perfect forecasts, but to try the best to improve forecast accuracy & to be systematically concerned with the impacts of the forecast inaccuracy
- Develop forecasting flexibility
- Tracking and Understanding Forecast Errors
- Demand Segmentation
- Understanding of Impacts of Marketing Initiatives
- Incorporate as much causal information and system status through information technologies i.e. POS
- Joint forecasting i.e. CPFR
- Demand Management



Demand Forecasts System





Forecasting Group

Worldwide Sales

Marketing

Upper management

Download demand history into program

Develop forecasts using program

Send forecasts to sales

Review forecast

Incorporate sales changes

Send forecasts to marketing

Review forecast

Incorporate marketing changes

Send forecasts to management

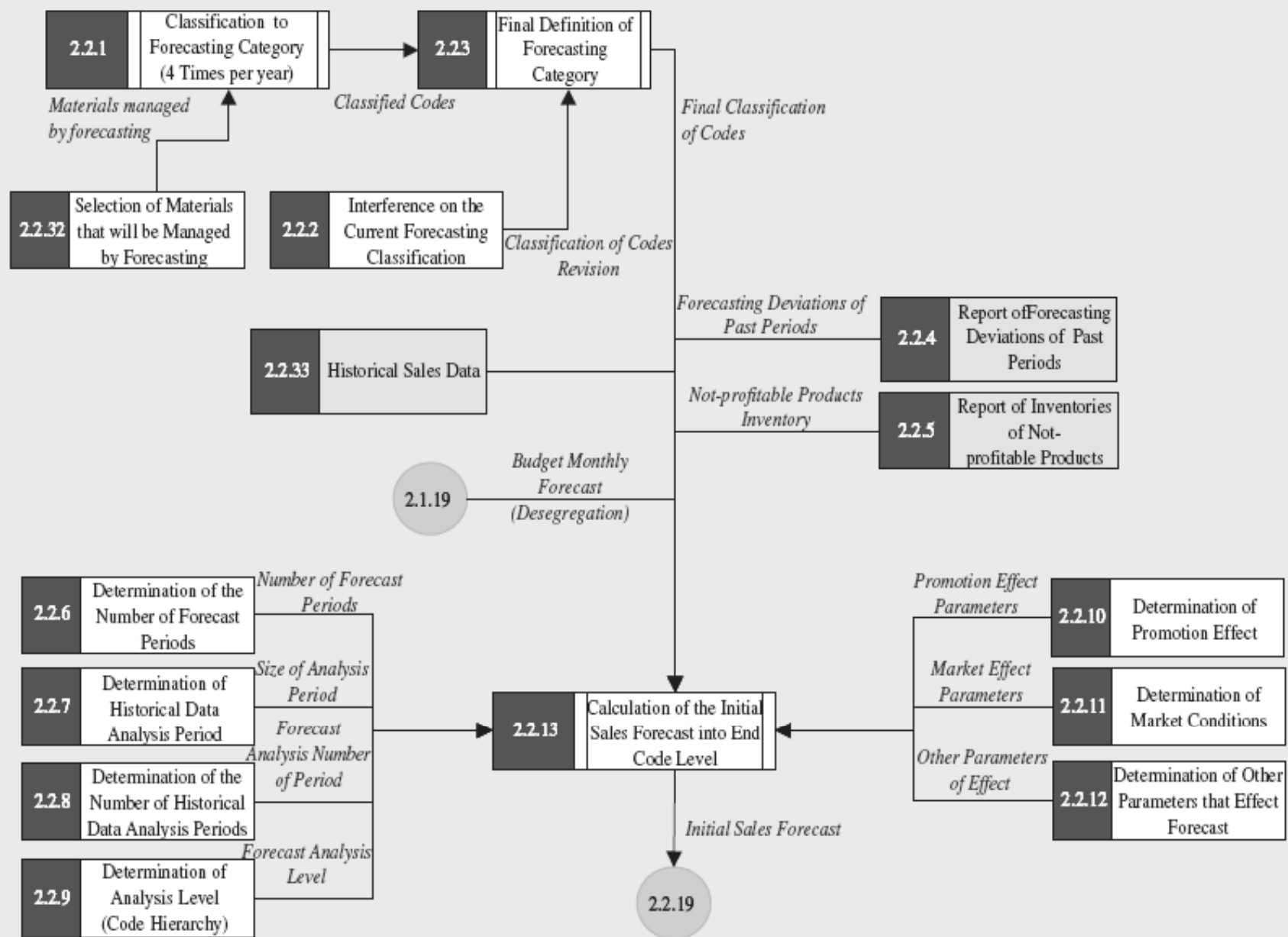
Review forecast

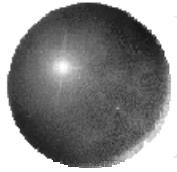
Incorporate management changes and relase to planning

Forecasting Process

MARKETING

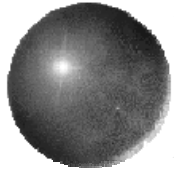
2.2 Sales Forecasting (U 2)



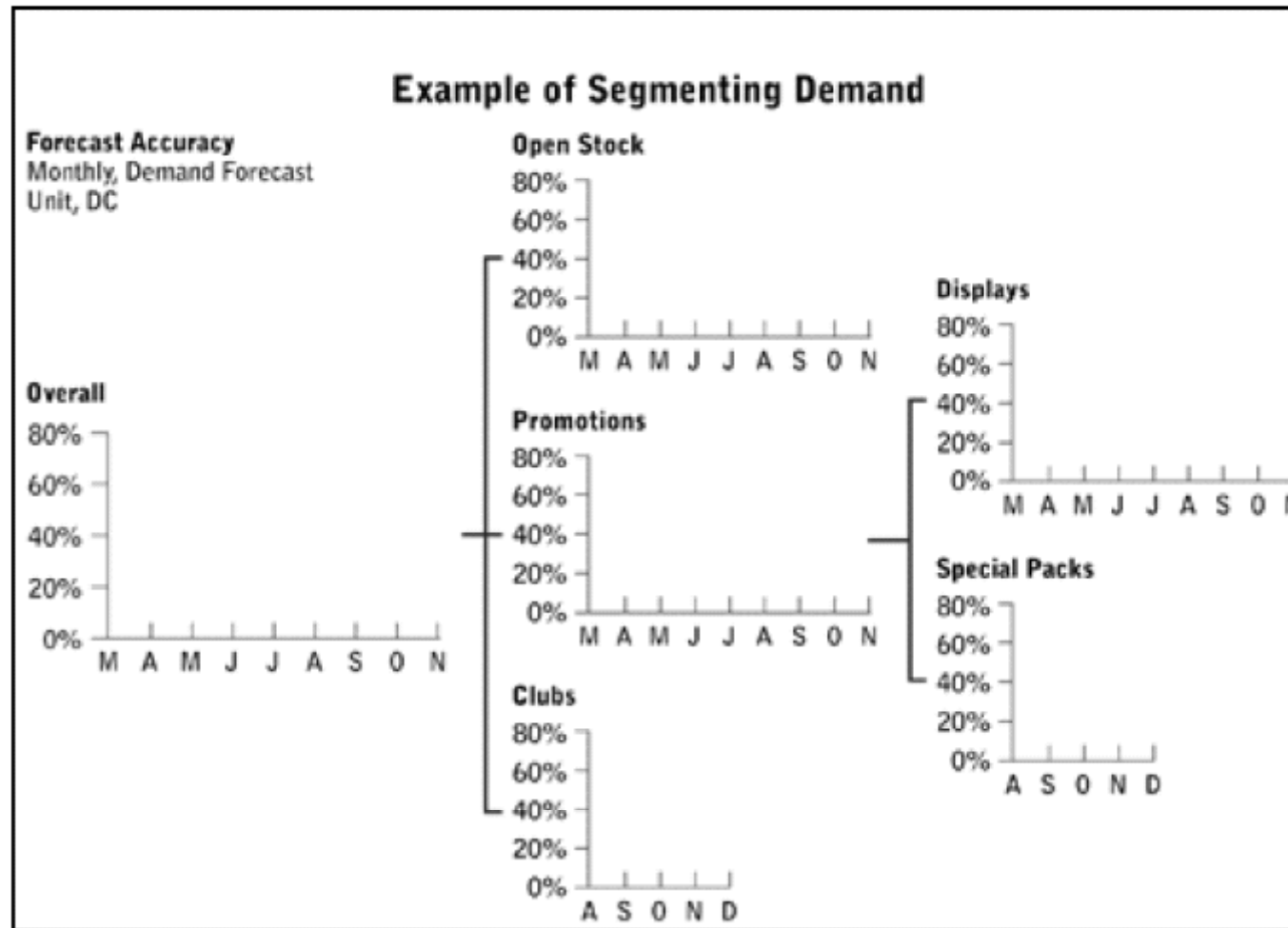


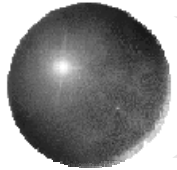
Investment in Demand Forecasting Process

- A well-designed system requires 1-2 hour per month of marketing and sales professionals' time
- Investment in a full-time demand manager(s) is needed
- About 2-3 hours per month is required of senior sales and marketing executives
- Investment in forecasting system



Segmenting Demand



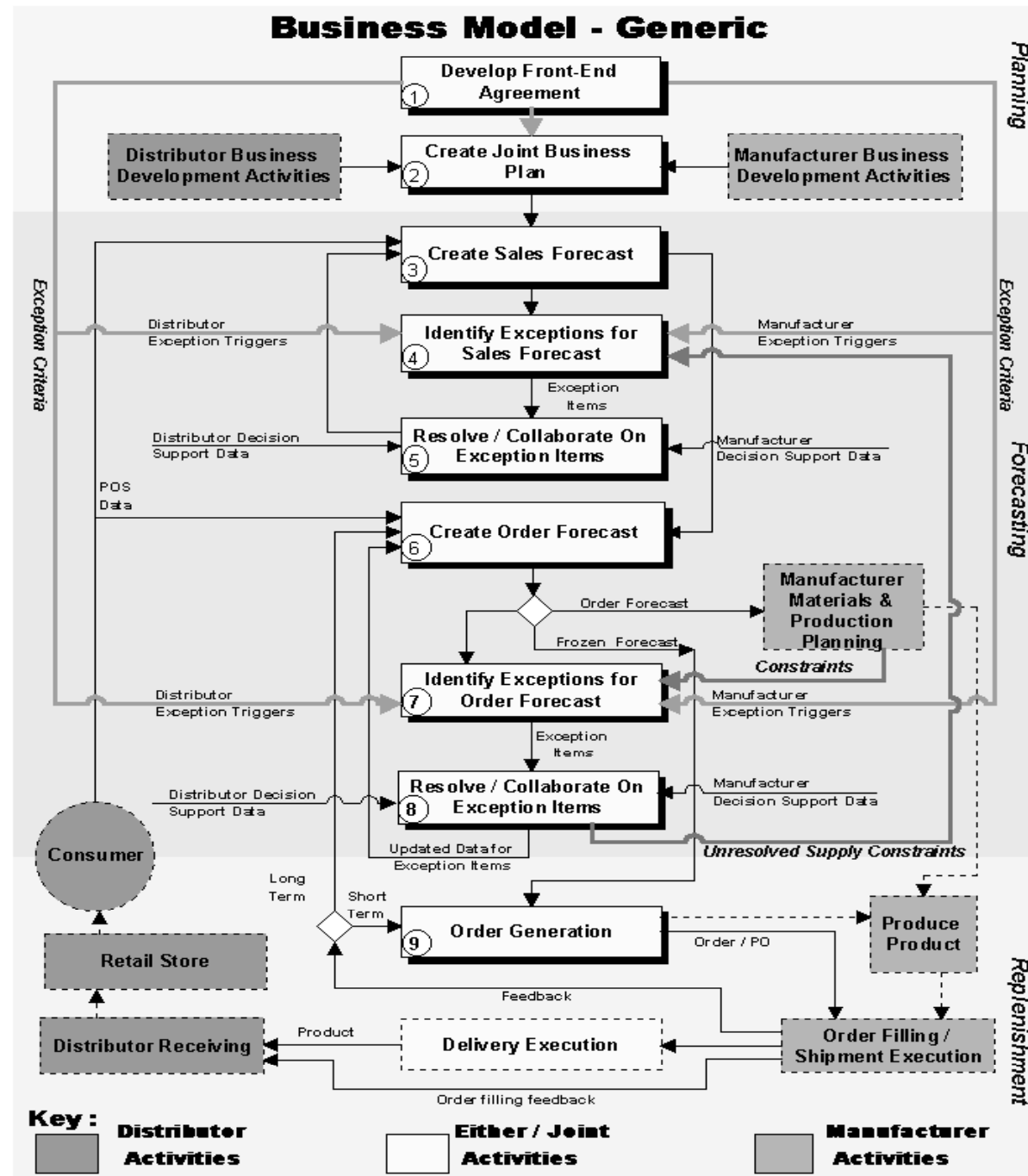


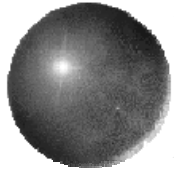
Collaborative Planning, Forecasting and Replenishment (CPFR)

- a web-based standard that enhances VMI and CR by incorporating joint forecasting
- parties exchange electronically a series of written comments and supporting data
- coordinate joint forecasts by concentrating on differences in forecast numbers
- systems need to be designed to allow data verification and ensure standard practices of coordination



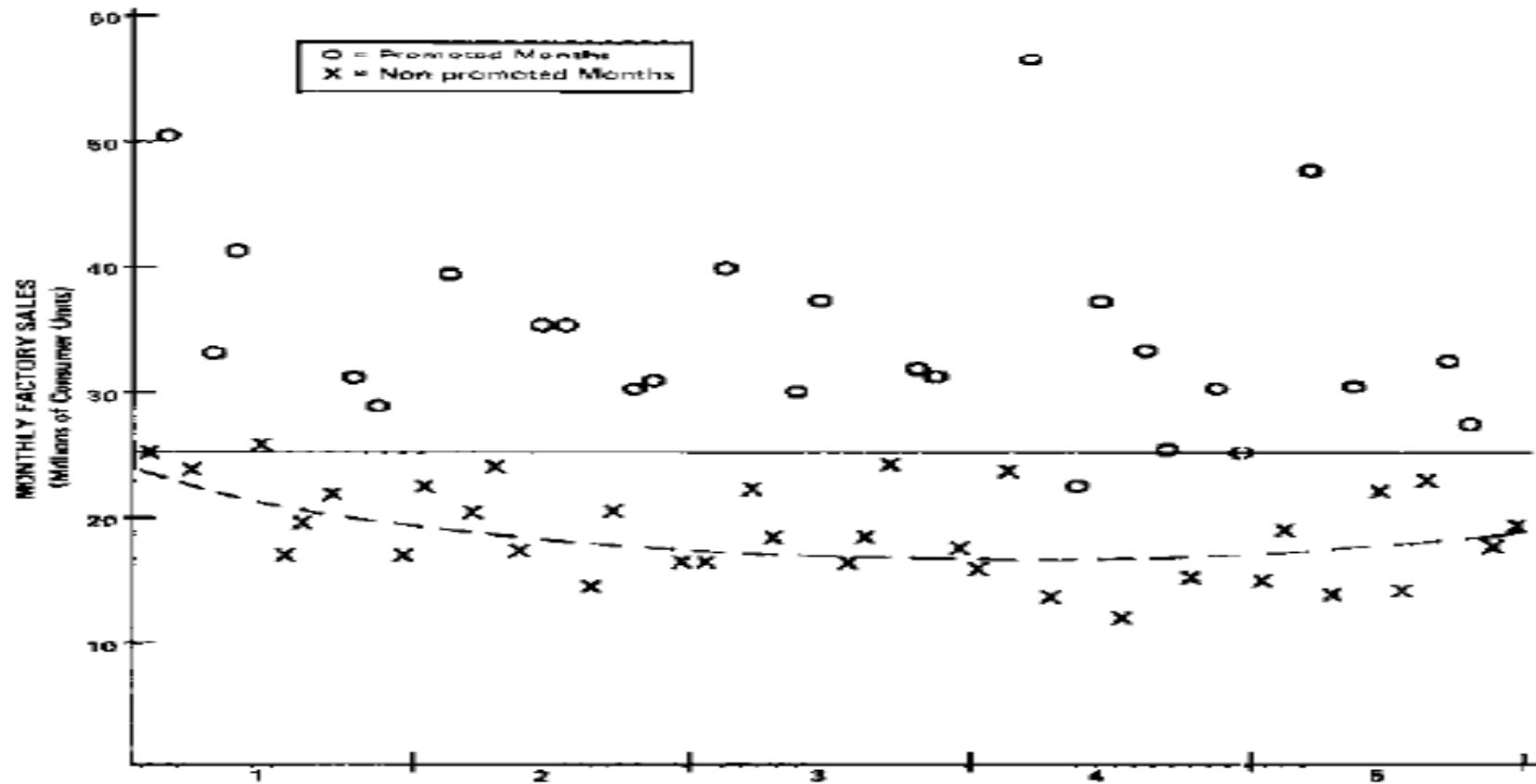
Collaborative Planning, Forecasting and Replenishment (CPFR)

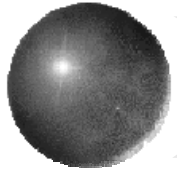




Promotion on Sales

Figure 1
FACTORY SALES BY MONTH
Years 1-5





Promotion on Sales

Figure 5
FACTORY SALES BY MONTH
Years 1-8

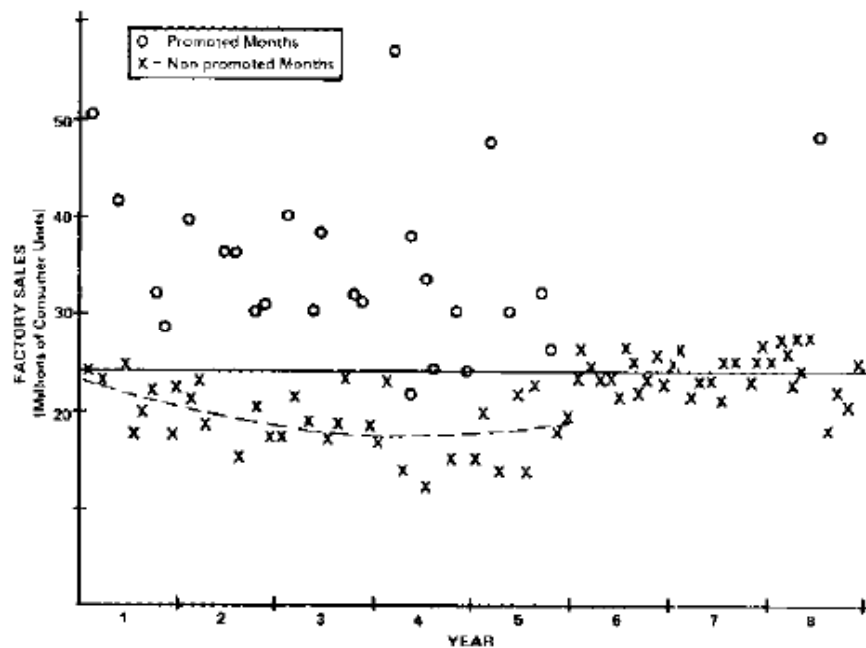
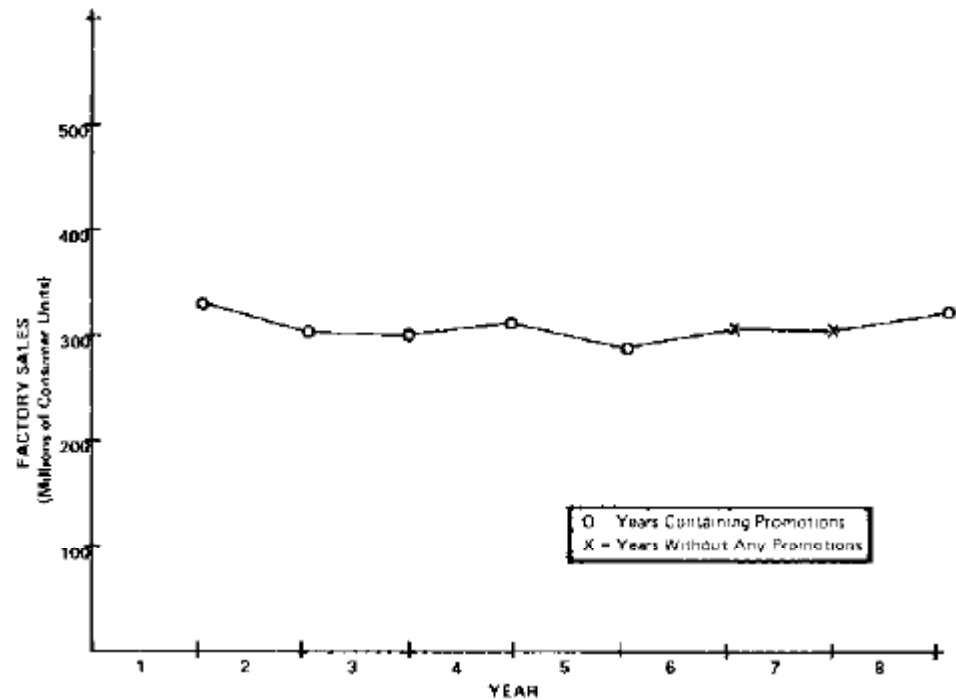
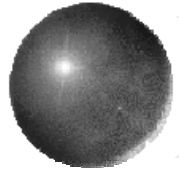


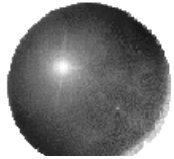
Figure 6
FACTORY SALES BY YEAR
Years 1-8





New Products: Merchandise Test

- A large specialty women's apparel retailer with net sales in 1993 exceeding \$1 billion and with more than 1000 stores dispersed throughout the U.S.
- When this retailer conducts a merchandise test, they select 25 stores whose total sales are closest to average store sales for the chain.
- Product tests are conducted at these stores, usually one year prior to full introduction.



New Products: Merchandise Test

Figure 1 : Predicted Vs Actual Sales For 125 Style/Colors of 1993 Knit Tops Using 1 Representative Store

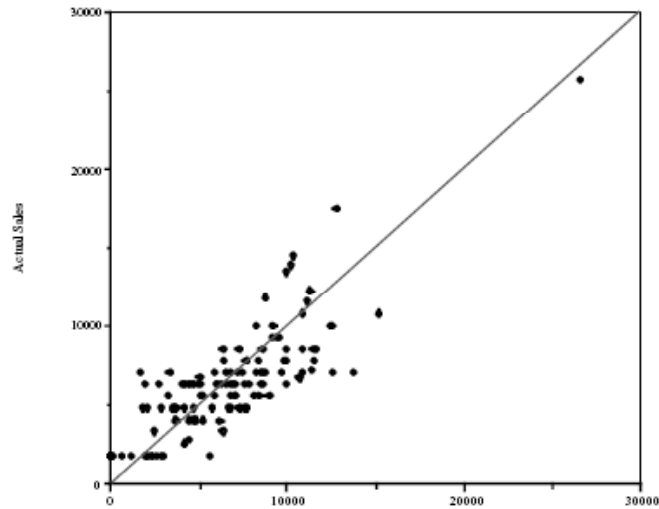


Figure 2 : Predicted Vs Actual Sales For 125 Style/Colors of 1993 Knit Tops Using 5 Representative Stores

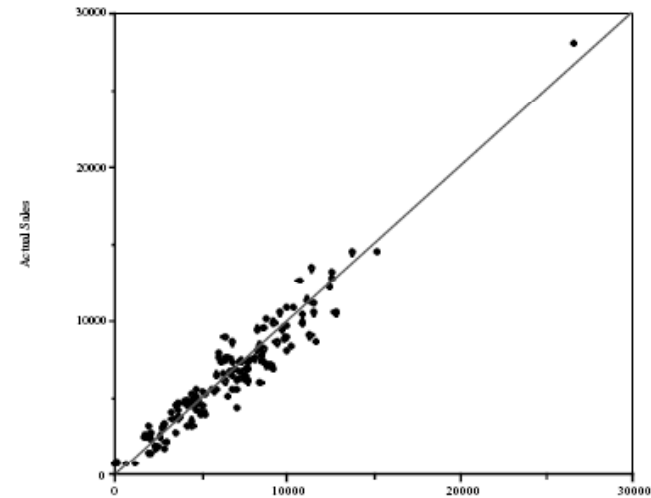


Figure 3 : Predicted Vs Actual Sales For 125 Style/Colors of 1993 Knit Tops Using 10 Representative Stores

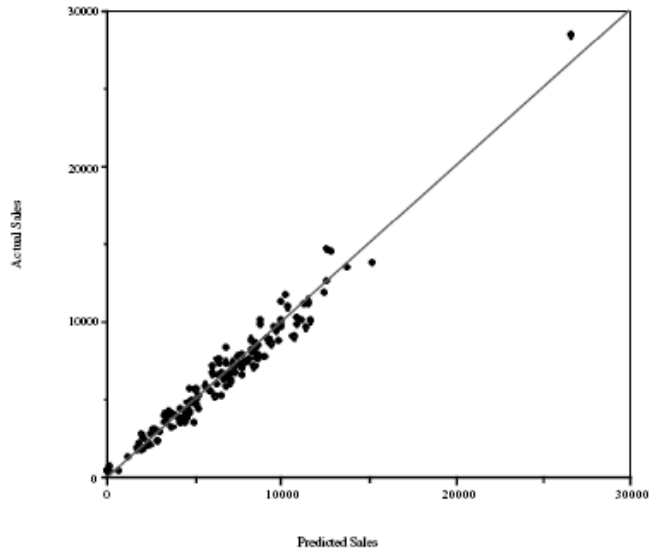
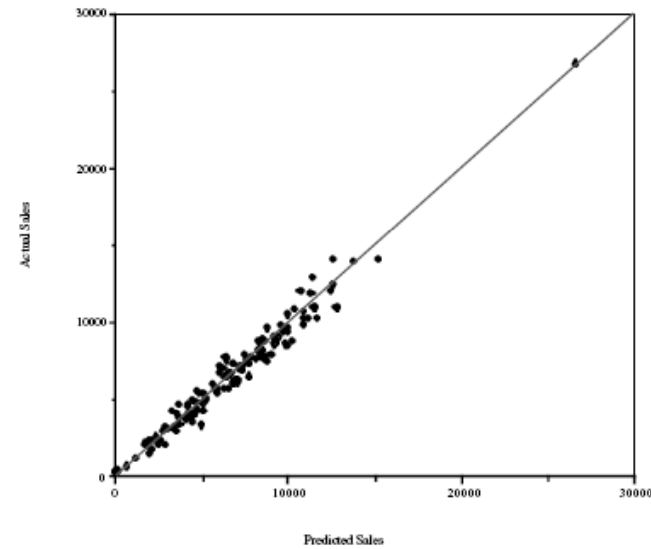
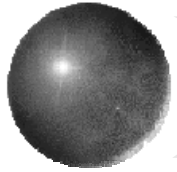


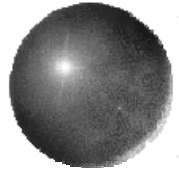
Figure 4 : Predicted Vs Actual Sales For 125 Style/Colors of 1993 Knit Tops Using 15 Representative Stores





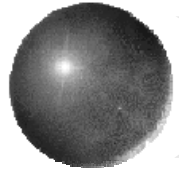
Lack of Alignment

- In the mid-90's, Volvo was faced with a problem when the company found itself with an excessive inventory of green cars in the middle of the year. Eager to get rid of this inventory, the sales and marketing group started aggressively offering special deals, discounts, and rebates on green cars to the distributors. The good news was that the scheme worked, and green cars started to sell. The bad news was that the supply chain planning group, not recognizing that such deals were in place, erroneously thought that customers finally liked green cars. As sales of green cars increased rapidly, they decided to produce even more green cars to meet the seemingly increased demand. The end result was that Volvo was left with a huge inventory of green cars at the end of the year.



Common Mistakes in Forecasting

- Unclear definition of forecast accuracy
- Lack of ongoing and rigorous process of forecast error measurement
- Lack of organizational acceptance of the need for accurate forecast
- Forecasts are developed at a level of detail that is actionable
- Lack of clear organizational ownership of forecasts that are generated
- Lack of clear rewards and incentives for forecast accuracy
- Failure to understand the underlying patterns and the reasons
- Failure to involve senior executives in the forecasting process



Forecasting Management

- Objectives and application of forecasts
- Forecast owners
- Process for reviewing and approving forecasts
- Single set of consistent forecasts
- Sufficient analytical support
- Tracking of forecast performance