Introduction to Operations Management
运营管理概论

2- Forecasting

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Why forecast ?

- To reduce uncertainty in the future
- To facilitate a company in taking control of operations
- To anticipate and manage change
- To increase communication and integration of planning teams
- To anticipate inventory and capacity demands and manage lead times
- To project costs of operations into budgeting processes
- To improve competitiveness and productivity through decreased costs and improved delivery and responsiveness to customer needs

Without forecast, it would be chaos

Forecasts depend upon what is to be achieved

For strategic business plan

market and economy

- Long term horizon : 2 to 10 years
- Low level of details
- Reviewed yearly or quarterly

For production planning

budget, labor, long lead time things

- Mid term horizon : 1 to 3 years
- By group or family of products
- Reviewed monthly

For Master Production Scheduling

detailed production activity

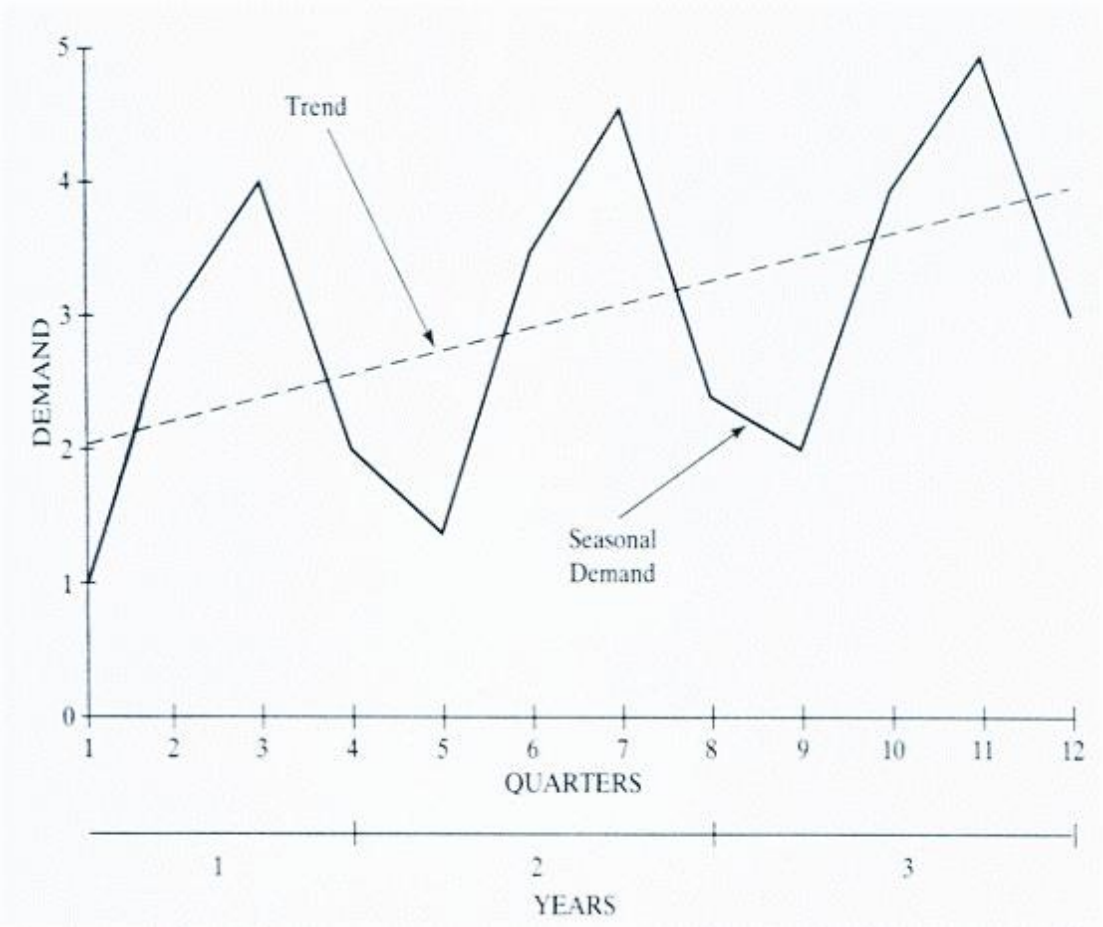
- Short term horizon : 1 to 12 month
- By Item
- Review weekly

How to describe demand ?

1. Patterns

2. Stability

3. Dependence



Demand patterns

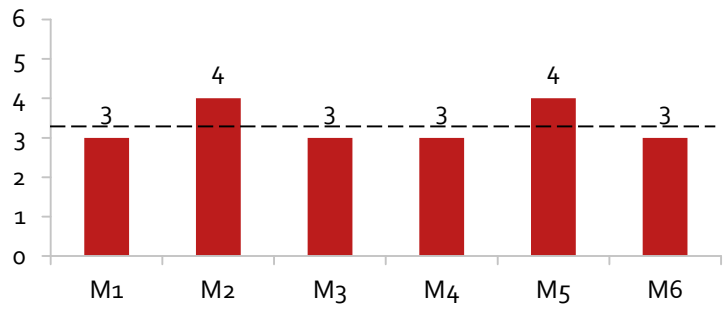
Trend	• A steady pattern increasing from year to year • Can be linear, geometric, exponential…
Seasonality	• Can be the result of the weather, holiday seasons… • Can occur on a yearly, weekly or even daily basis (restaurant)
Random variation	• Occur on a random basis • When many factors affect demand • Can usually be measured, (see tracking the forecast)
Cycle ("Conjoncture")	• *Over a span of several years and even decades* • *Job for economists, beyond the scope of this presentation*

Demand stability

- The shapes of the demand patterns for some products or services change over time whereas others do not.

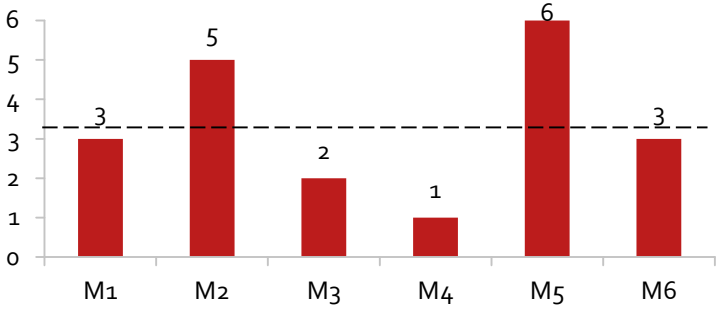
Stable pattern

- Pattern that retain the same general shape (whatever price conditions, …)



Dynamic pattern

- Dynamic changes that can affect the trend, seasonality, or randomness of the actual demand

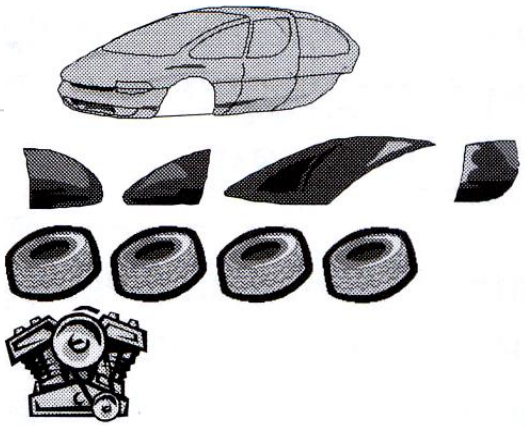


The more stable the demand, the easier it is to forecast

Demand dependence

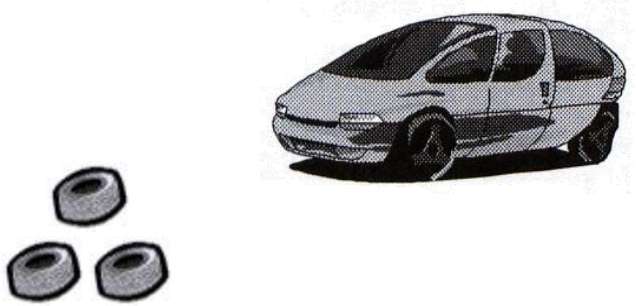
Dependent demand

- When the demand for the item is derived from that of a second item
- Requirements for dependent demand items need not be forecasted but are **calculated** from that of the independent demand item.



Independent demand

- When it is not related to the demand for any other product or service.
- **Only independent demand items need to be forecasted.**
- Usually end items or finished goods but should also include inter-company transfers



Principles of forecasting

1. Forecasts are usually wrong.
   Errors are inevitable and must be expected
2. Every forecast should include an estimate of error
3. Forecasts are more accurate for families or groups
4. Forecasts are more accurate for nearer time periods
   Reducing lead-time will improve forecast accuracy

General methods of Forecasting

Qualitative

Based on intuitive or judgmental evaluation

- General business trends, end of life or new products
- Delphi method : panel of experts giving their opinion on what is likely to happen
- Rarely appropriate in the industry

Quantitative

Based on computational projection of numeric relationship

- Mostly used in the industry

Extrinsic

Based on external pattern from information outside the company

- Product correlated to an activity in another field
- Even better, correlated to an indicator that prevail from demand
- For macro (business, production) rather than micro planning (end items)

Intrinsic

Based on historical patterns of the data itself from company data

- Based on the assumption that **what happened in the past will probably happen in the future**
- Mostly used in the industry

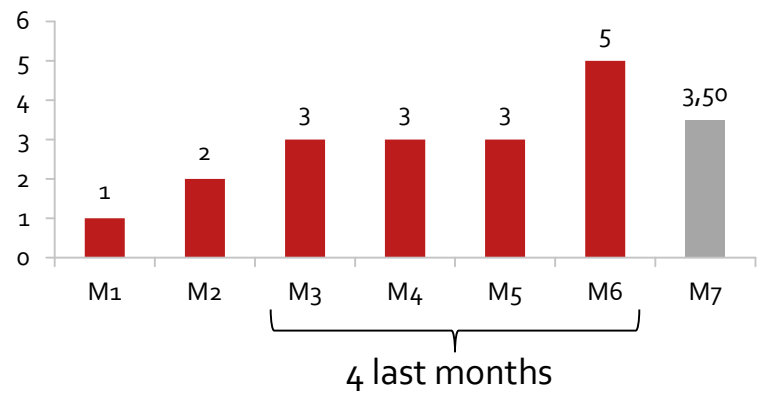
Forecast is only as good as the data on which it is based

Record data in the same terms as needed for the forecast	• Data type according to forecast purpose (demand or shipment data ?) • Data period same as forecast period (weeks / quarters / months)
Record the circumstances	• Events that may have influenced the period (promotions, market events, price changes, …) • …
Record the demand separately for different customer groups	• Distinguish customers ordering batch or detail • …

Good predictions requires good information

Intrinsic techniques for forecasting (1/2)

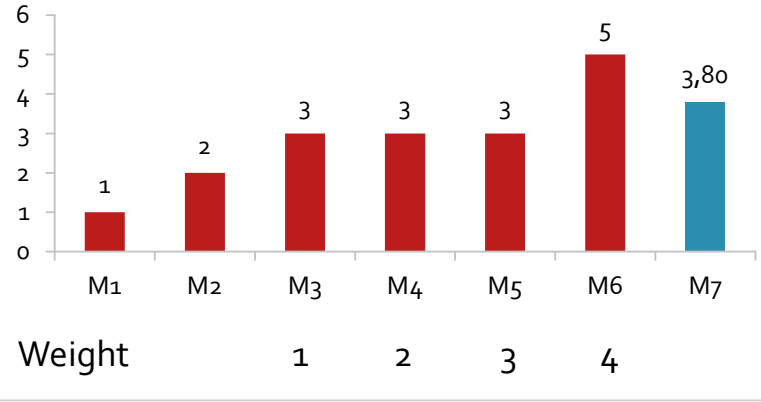
Moving average



For **stable demand** with little trend/seasonality

- ↗ number of periods : ↗ lag to follow trend
- ↘ number of periods : ↗ reaction to random fluctuations

Weighted average

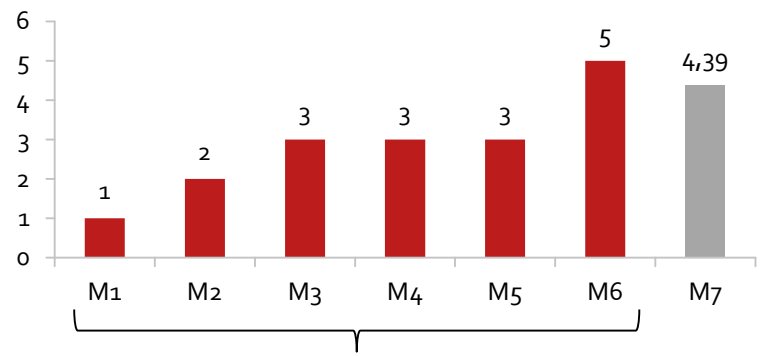


For **stable demand** with little trend/seasonality

- Can give more weight to the newest months or the oldest months

Intrinsic techniques for forecasting (2/2)

Exponential smoothing

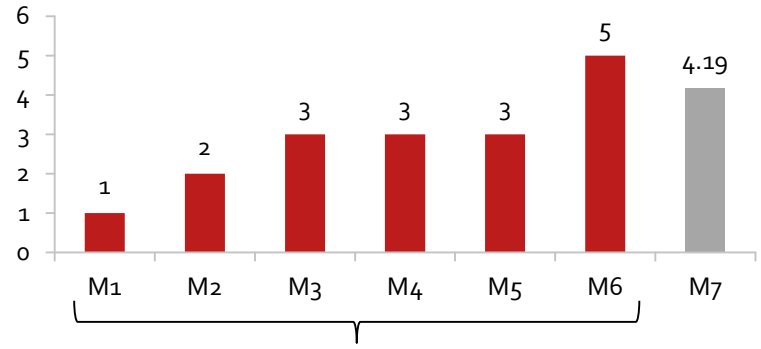


- Formerly the most used method for short term forecast (because less data needed)
- Similar results than a moving average :

$$P_n = \alpha D_{n-1} + (1-\alpha)P_{n-1}$$

- $\alpha \to 1$: ↗ influence of recent months
- $\alpha \to 0$: ↗ influence of older months

Double Exponential smoothing



- For demand with trend

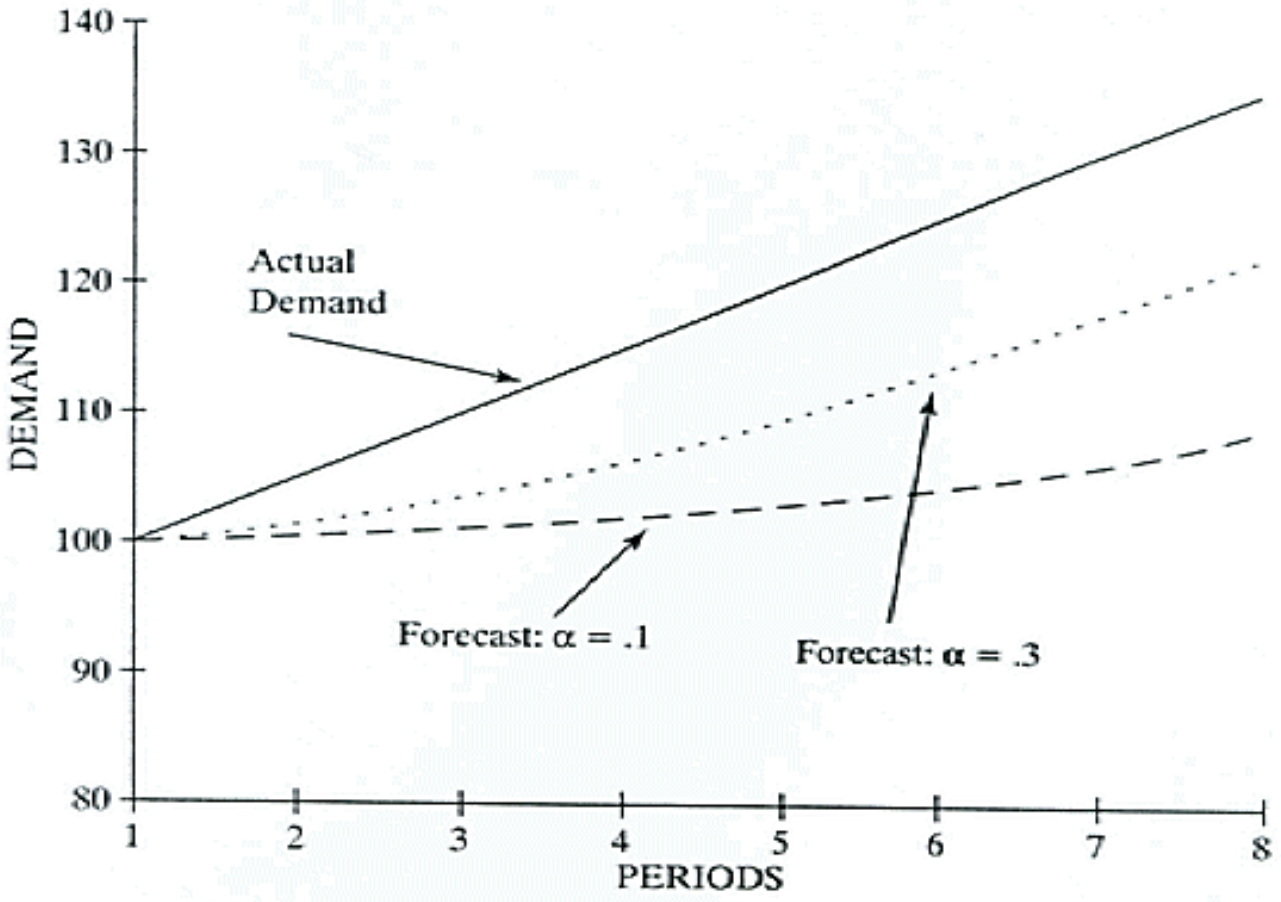
$$P_n = P_{n-1} + T_{n-1}$$

$$P_{n-1} = \alpha D_{n-1} + (1-\alpha)(P_{n-1} + T_{n-1})$$

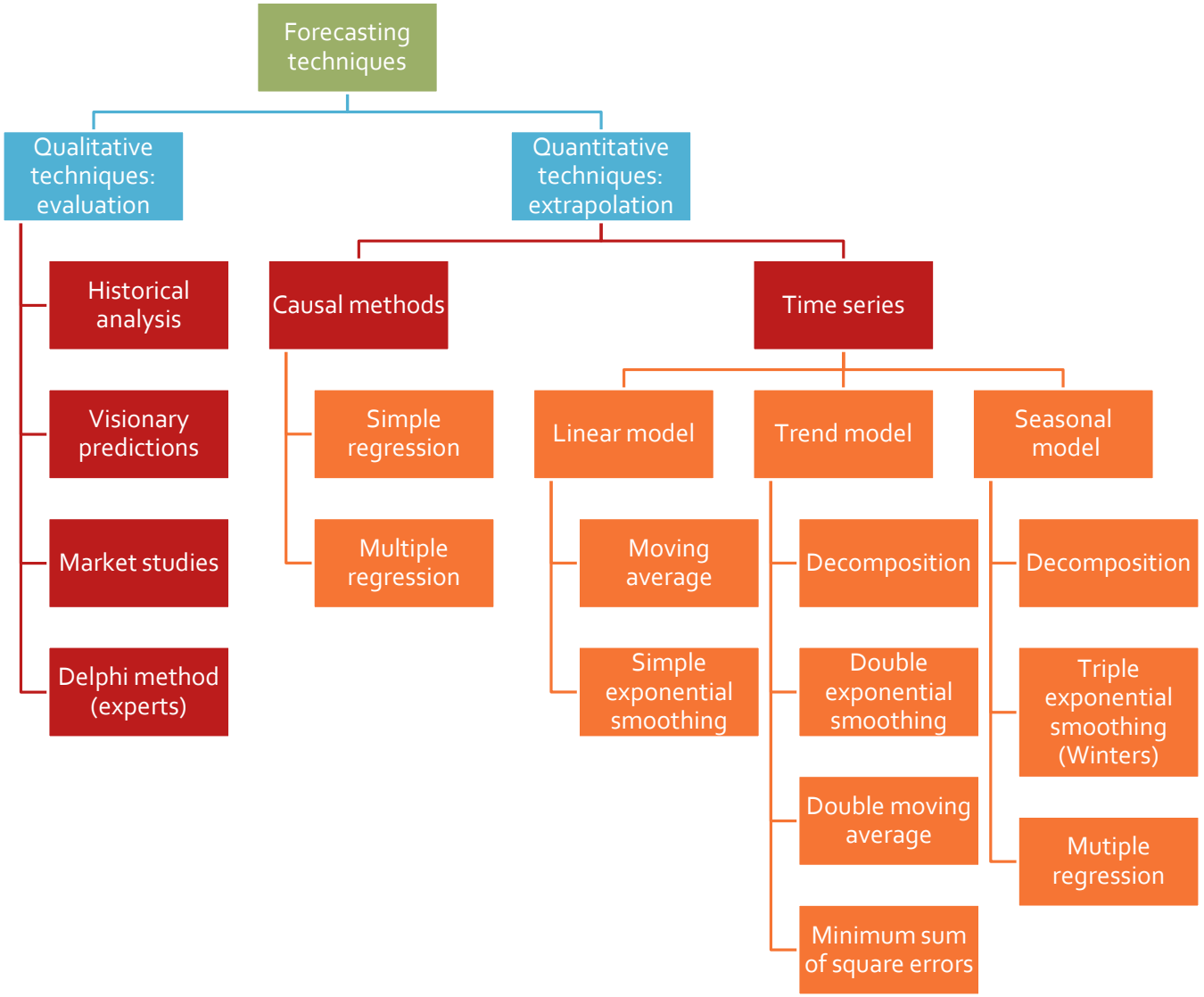
$$T_{n-1} = \beta(P_{n-1} - P_{n-2}) + (1-\beta)T_{n-2}$$

(NB : for seasonality, see triple smoothing)

Influence of α parameter in the exponential smoothing method



Choose wisely, and compare several techniques



If you had to remember one thing regarding forecast methodologies

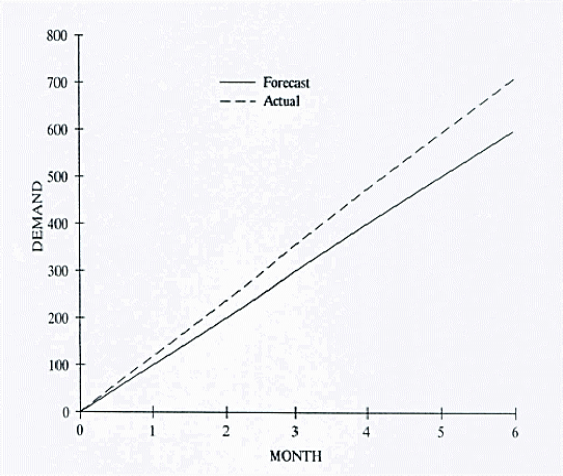
What is important is not the formula

but the understanding you have from it

- Think about Supply Chain Manager needs
- Use a measure/methodology which is meaningful and useful for SCM

Tracking the forecast error

Forecast error is the difference between **actual demand and forecast demand**



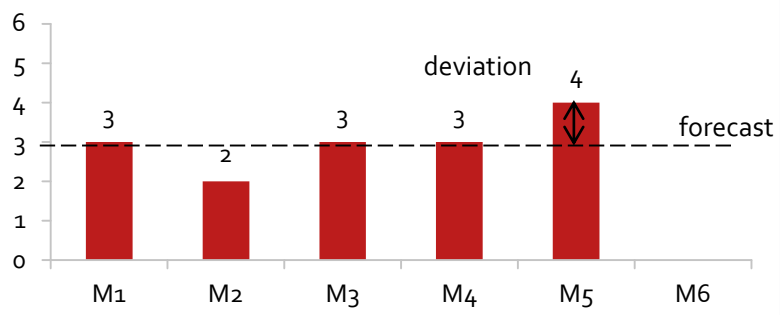
It can have 2 origins :

Bias ("Distorsion")	Random variation
▪ Systematic error in which the actual demand is consistently above or below the forecast demand ▪ Cumulative actual demand varies from the cumulative forecast ▪ When bias exists, forecast should be changed to improve its accuracy	▪ Should not be considered in forecast, and have no impact on forecast adjustment

The difficulty is to detect whether a variance is due to bias or random variation…

Measuring forecast error using the Mean Absolute Deviation

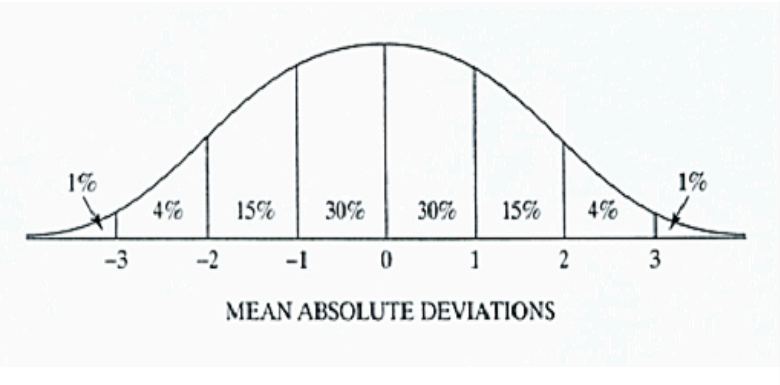
Definition of MAD



$$\text{MAD} = \frac{\sum |deviation|}{number\ of\ observations}$$

$$\text{MAD} = \frac{0 + 1 + 0 + 0 + 1}{5} = 0.4$$

Use of MAD

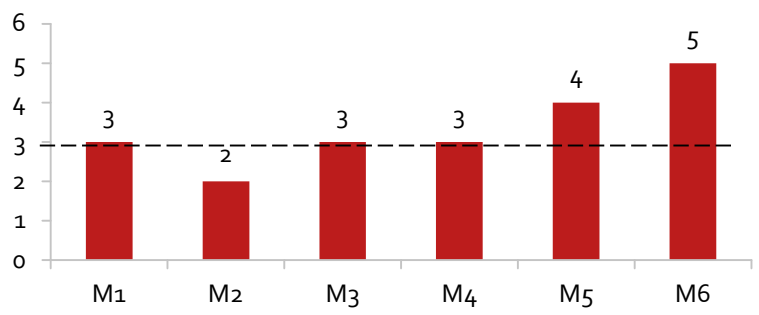


From statistics we know that, for a normal distribution, the error will be within:

- ± 1 MAD of the average ~ 60% of the time
- ±2 MAD of the average ~ 90% of the time
- ±3 MAD of the average ~ 98% of the time.

Distinguish bias from random variation using Tracking signal

Use of tracking signal



$$\text{Tracking signal} = \frac{\sum forecast\ errors}{MAD}$$

$$\text{Tracking signal}_{M6} = \frac{-1+1+2}{0.4} = 5$$

Trigger can be used with tracking signal to decide whether a forecast should be reviewed

- Example : if tracking signal above 4 or under -4

Forecast system design issues

- Determine information that needs to be forecasted
- Assign responsibility for the forecast
- Set up forecast system parameters
- Select forecasting models and techniques
- Collect Data
- Test models
- Record actual demand
- Report accuracy
- Determine root cause of variance
- Review forecasting system for improved performance
- Spot exceptional cases

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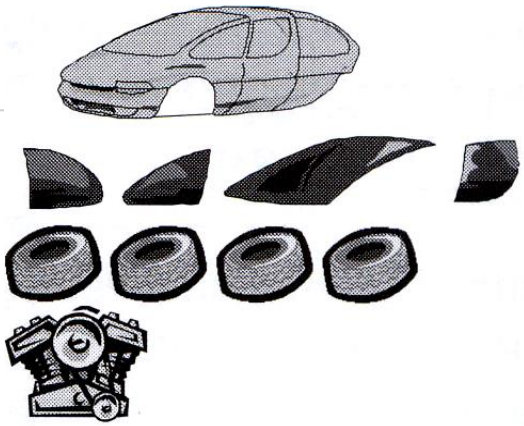

Effective use of dependent demand inventory models requires the following

1. **Master production schedule**
2. **Specifications or bill of material**
3. **Inventory availability**
4. **Purchase orders outstanding**
5. **Lead times**