FORECASTING METHODS

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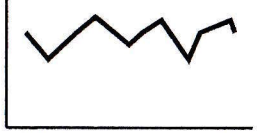
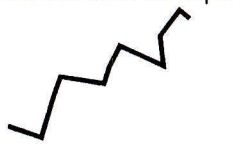
Types of Data:

No Trend Component
No Season Component



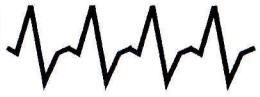
10) Naive
11) Simple Moving Average
12) Weighted Moving Average
13) Exponential Smoothing

Trend Component
No Season Component



7) Regression
14) Double Exponential Smoothing

No Trend Component
Season Component



Trend Component
Season Component

5) Multiplicative Desomposition

Qualitative Methods:

1 DELPHI METHOD - Iterative group process continues until a consensus is reached. There are 3 types of people: Decision Makers, Staff, and Respondents.

2 CONSUMER MARKET SURVEY - A process of asking consumers about their purchasing plans. What they say and what they do are often different.

3 JURY OF EXECUTIVE OPINION - Each sales person projects sales, as they generally know what the consumer wants. These projections are then gathered and combined at national level.

4 SALES FORCE COMPOSITE - Estimates from individual salespersons are reviewed for reasonableness, then aggregated.

MEASURING ACCURACY A_t = Actual value F_t = Forecasted value
$E_t = A_t - F_t$ = forecast Error $E'_t = A_t/F_t$ = relative Error RSFE = $SUM(E_t)$
$ME = SUM(E_t)/n$ = Mean Error $MAD = SUM(|E_t|)/n$ = Mean Absolute Dev.
$MSE = SUM(E_t^2)/n$ = Mean Squared Error SD of forecast errors = SQRT(MSE)
MAPE = SUM(100*[absolute error/actual])/n
TRACKING SIGNAL = Cummulative Error/MAD
TS > 0 means Demand > Forcast TS < 0 means Demand < Forecast

Quantitative Methods:

5 MULTIPLICATIVE DECOMPOSITION
$A_t = T_t * S_t * C_t * R_t$
We must break down the past data to isolate components above.
You will only need to worry about the Trend (T) and Seasonsal (S)
Chart Headings:
(1) Season -> Determined from question
(2) Year -> Determined from question
(3) Period -> Numbered Sequentially
Even # of s (4) Actual Demand - Given
(5) MA -> i. Your first MA calculation will appear in **period i = # seasons/2**
Even # of s ii. MA for period "i" = Average of actual for the first set of seasons.
Odd # of s (6) CMA -> For period "i+1" = Average of the MA from Periods "i" and "i+1"
(6) CMA -> For period "(#s +1)/2 = Average of first set of seasons.
(7) Calculate Actual / CMA for each period -> (4)/(6)
(8) SI -> For period #1 take the average off all values in Column 7 that have a season that is the same as period #1. Repeat this for all periods.
(9) Adj SI = for period "n" = $SI_n/Average(SI_1+SI_2+...+SI_m)$, where m is number of seasons. Only use this column if normalization is needed.
(10) Deseasonalized Demand -> Actual / Adj SI = (4)/(9)
(11) Trend -> Run a regression analysis with Period (3) as the predictor and Des. Demand (10) as the response.
Trend = Constant from output + Period (3)* Coefficient from output
(12) **Forecast = Adj SI * Trend = (9)*(11)**

7 LINEAR REGRESSION
Regression Equation -> F_t = intercept + slope*t
R^2 -> Coefficient of Determination - Compares Variation with regression line to variation without regression line.
-> Determines how effective the model is. Must be between 0 and 1
Total Variation (SST) = Explained Variation (SSR) + Residual (SSE)
R^2 = Explained Variation(SSR)/Total Variation(SST)
R^2 >= 0.8 -> Good Predictor R^2 <= 0.25 -> Poor Predictor
R^2 between 0.25 and 0.8 -> Moderate Predictor
Coefficient of Correlation = r = +/- SQRT(R^2)
r -> must be between -1 and 1. If negative, then we have an inverse relationship in the model
s -> Standard Error of the model = SQRT(MSE)
Coefficient = slope = $F_t - F_{t-1}$ **Intercept = F_1 - slope**
MANUAL REGRESSION
$b = [(SUM(x_i*y_i) - (n*\bar{x}*\bar{y})] / [(SUM(x_i^2) - n*\bar{x}^2)]$
$a = \bar{y} - b*\bar{x}$ $\bar{x}$ = avg of time periods $\bar{y}$ = average of the actual

10 NAIVE FORECAST
- demand in the next period will be the same as demand in the most recent period. This method is cost effective and efficeint.

11
SIMPLE MOVING AVERAGE:
$F_t = (A_{t-1} + A_{t-2} + ... + A_{t-n})/n$
-If past data is stable (unstable), use a high (low) value for n

Disadvantages: Increasing `n` causes forecast to be less sensitive to change, Not good for forecasting trend, Requires a great deal of historical data

12
WEIGHTED MOVING AVERAGE:
$F_t = w_1*A_{t-1} + w_2*A_{t-2} + ...$
$+ w_n*A_{t-n}$,
where $w_1+w_2+...+w_n = 1$
-Most recent periods have highest weights
Disadvantages: Same as #11

13 EXPONENTIAL SMOOTHING
- Requires a smoothing constant "α", which is chosen subjectively
-If data is stable (unstable) choose α closer to 0 (1)
$F_t = F_{t-1} + \alpha*(A_{t-1} - F_{t-1})$
where $(0<=\alpha<=1)$
Re-arrage the formula to get:
$F_t = \alpha*A_{t-1} + (1 - \alpha)*F_{t-1}$
$F_t = \alpha*A_{t-1} + \alpha*(1-\alpha)*A_{t-2} + \alpha*(1-\alpha)^2*A_{t-3} + \alpha*(1-\alpha)^3*A_{t-4} ...$

14 EXPONENTIAL SMOOTHING WITH TREND ADJUSTMENT (Double Exponential Smoothing)
- α must be between 0 and 1 - β must be between 0 and 1
Forecast including trend (FIT_t) = exponentially smoothed forecast (F_t) + exponentially smoothed trend (T_t)
Step 1 - Smooth the Data:
$F_t = \alpha*A_{t-1} + (1-\alpha)*FIT_{t-1}$
Step 2 - Smooth the Trend:
$T_t = \beta*(F_t - F_{t-1}) + (1-\beta)*T_{t-1}$
Step 3 - Calculate the New FIT:
$FIT_t = F_t + T_t$

Variables:
F_t = exponentially smoothed forecast of the data series in period t
T_t = exponentially smoothed trend in period t
A_t = actual demand in period t
α = smoothing constant for the average
β = smoothing constant for the trend

AGGREGATE PLANNING

LEVEL STRATEGY
- Maintain a constant workforce and production rate, use inventories and backorders to accomodate fluctuations in demand
- Workforce strategy will be defined in the question. It may require only regular time production, or it may require a combination of regular production, overtime and subcontracting.

Fomula to calculate production rate per period:
Production rate/period =
(Total demand for all periods - Beg Inv. + Required End Inv.) / # periods

Fomulas:
Beg Inv. = Ending inventory from previous period - Backorders (previous period)
(If beginning inventory is negative, you have a backorder)
Ending Inventory = Beg Inv. + Reg. Production + Overtime + Sub + Part time - Demand
(Ending inventory can not be nagative, if it is enter "0")
Backorders = Demand - Beg Inv. - Reg. Production - Overtime - Sub - Part time
(Backorder can not be nagative, if it is enter "0")
Sub Units = Demand - Production - Beg Inventory
Overtime Units = Demand - Production - Beg Inventory

Notes:
- You cannot have an ending inventory and a backorder in the same period
- If you are asked to calculate the minimum number of workers to ensure no backorders, you must do trial and error by increasing and decreasing the number of workers and recaculating the aggregate plan.

MIXED STRATEGY
- The question will specify the strategy that will be used to create an aggregate plan. This can be a combination of regular production, overtime, subcontracting, part time, ending inventories, backorders, etc.

Fomulas:
Production = Must be derived from the strategy give in the question
Beg Inv. = Ending inventory from previous period - Backorders (previous period)
(If beginning inventory is negative, you have a backorder)
Ending Inventory = Beg Inv. + Reg. Production + Overtime + Sub + Part time - Demand
(Ending inventory can not be nagative, if it is enter "0")
Backorders = Demand - Beg Inv. - Reg. Production - Overtime - Sub - Part time
(Backorder can not be nagative, if it is enter "0")
Sub Units = Demand - Production - Beg Inventory
Overtime Units = Demand - Production - Beg Inventory

Notes:
- You cannot have an ending inventory and a backlorder in the same period

CHASE, LEVEL, MIXED FORMULAS
- You will need to figure out the number of units 1 worker can make in 1 period
- # Workers required = Production / (Units per worker per period) -> Round up
- To calculate costs, simply multiply reg production, overtime, subcontracting, overtime, backlogs, hire fire by is applicable cost given in the question.

CHASE STRATEGY
- Hire and Fire as needed to accommodate fluctuations in demand
- Ending inventory will be "0" unless otherwise specified in the question
- Usually no overtime, subcontracting, backorders

Fomulas:
Production = Demand - Beg Inv. + Required Ending Inventory
Beg Inv. = Ending Inventory from the previous period
Ending Inventory = Beg Inv. + Production - Demand

TRANSPORTATION METHOD
-hiring/firing not an option for this method
Lowest Cost Approach
1) Identify the costs for each cell
2) Identify the cell with the lowest cost
3) Allocate as many units as possible to the lowest cost sell,
4) Move to the next lowest cost and allocate units
5) Repeat #3 until all units have been allocated

Total Cost = SUMPRODUCT(#units for cell*Cost for cell)

CHART HEADINGS
Rows -> Production Periods
- Beginning Inventory
- Periods 1 to n -> Regular/Overtime/Subcontracting
- Total Required (Demand)

Columns -> Sales Periods
- Periods 1 to n
- Ending Inventory
- Unused Capacity
- Total Capacity

CONTROL CHARTS
(FORECASTING)
UCL = 0 + 2*SD
LCL = 0 - 2*SD
Centerline = "0"

- The number of SD will be defined in the question.
- Graph the errors along the x-axis.

MAD	≈ Std Error	C.Interval
± 1 MAD	± 0.8 σ	60 %
± 2 MAD	± 1.6 σ	90 %
± 3 MAD	± 2.4 σ	98 %
± 4 MAD	± 3.2 σ	100 %

GRAPHICAL METHOD
- Trial and Error approach
- Prepare Aggregate plans using the Level Strategy , Chase Strategy , Mixed Strategy and compare the total costs.

MATHEMATICAL METHODS
- Transportation Method of Linear Programming
- Management Coefficient Model
- Linear Decision Rule
- Simulation

PREFERENCE THRESHOLDS
1) Idle vs Building Inventory - Compare the cost of sitting idle each month to the cumulative cost of building inventory. Best to build a table.
2) Idle vs H/F = Hire and Fire cost / Idle cost per hour -> Tells you number of hours someone can remain idle before it is better to fire and hire.
3) Inventory Building vs H/F - Compare the cost of Hire/Fire to the cumulative cost of building inventory. Best to build a table.
4) Overtime vs Subcontracting - Make a direct comparison of the per unit costs.
5) Overtime vs Backlogs - Direct comparison of the costs per unit.
6) Overtime vs H/F = Divide the H/F cost by the incremental hourly overtime rate. - > Tells you the number of hours of overtime that can be used before it is better to hire and fire. (incremental = overtime rate - reg rate)
7) Overtime vs H/F = Divide the H/F cost by the incremental overtime cost per unit. - > Tells you the number of units that can be made in overtime before it is better to hire and fire. (incremental = overtime cost - reg cost)
8) Subcontracting vs Backlogs - Direct comparison of the costs per unit.
9) Subcontracting vs H/F - divide the total cost of H/F by the incremental cost of subcontracting. -> Tells us the number of units that can be subcontracted before it become preferable to hire and fire.
Incremental cost = Subcontracting cost per unit - Regular time cost per unit.
10) Backlog vs H/F - Compare the monthly cost of backlogs to the cost to H/F

LINEAR PROGRAMMING
- Define variables for Reg production (r1, r2...), Overtime (o1, o2...), Sub (s1, s2...) and Ending Invtory (i1, i2...)
- Min Costs = Cost Reg*(r1 + r2 +...) + Over Cost*(o1 + o2 +...) + Sub Cost*(s1 + s2 + ...) + Inv Cost*(i1 + i2 +...)
- Define a constraint for each period -> Demand = Beg Inv + Reg Prod + Overtime + Sub - Ending Inv