PERENCANAAN & PENGENDALIAN PRODUKSI

TIN 4113

Pertemuan 2

- **Outline:**
  - Metode Peramalan:
    - Moving Average & Weighted Moving Average
    - Exponential Smoothing
    - Double Exponential Smoothing (Holt's)
    - Winter's Method for Trend & Seasonal Problems
  - *Error Forecast*
    - MAD, MSE, MAPE, MFE atau Bias
- **Referensi:**
  - Elsayed, A. Elsayed. *Analisis and Control of Production System*, Prentice Hall International, 1994.
  - Tersine, Richard J., *Principles of Inventory and Materials Management*, Prentice-Hall, 1994.
  - Vollman, et al. Manufacturing Planning & Control System, McGraw-Hill, 1997.
  - Pujawan, Demand Forecasting Lecture Note, IE-ITS, 2011.

Example of Simple Moving Average

Week	Demand	3-Week	6-Week
1	650		
2	678		
3	720		
4	785	682.67	
5	859	727.67	
6	920	788.00	
7	850	854.67	768.67
8	758	876.33	802.00
9	892	842.67	815.33
10	920	833.33	844.00
11	789	856.67	866.50
12	844	867.00	854.83

Example of Exponential Smoothing

– Exponential smoothing and a constant model are being used for forecasting. The smoothed average at the end of period zero was 80. The actual demand in period 1 was 104. The smoothing constant is 0,1. What is the forecast for period 2 made at the end of period 1?

1. Apa pengaruh jumlah variasi produk terhadap penerapan PPIC pada perusahaan tersebut?

2. Divisi perencanaan produksi dari penerbit buku Pearson memiliki data sales sebagai berikut (dalam 1000 unit):

	Tahun			
	4	5	6	7
Penjualan*	21	18	20	17

Perusahaan mempertimbangkan untuk menggunakan metode exponential smoothing dengan konstanta = 0.2 untuk melakukan forecast. Diasumsikan bahwa perkiraan penjualan pada tahun ke-3 adalah 20.000 unit buku. Lakukan forecast untuk tahun ke-5 hingga tahun ke-7. Apakah metode tersebut lebih tepat jika dibandingkan dengan metode Moving Average? (Analisa ME, MAD, dan MSE-nya).

1. Jelaskan mengapa pada metode Exponential Smoothing disarankan menggunakan nilai α sebesar $0 < \alpha < 0{,}5$?
2. Jelaskan karakteristik dan kondisi penggunaan masing-masing error forecast, bias, dan tracking signals dalam melakukan justifikasi metode peramalan.
3. Tunjukkan bahwa pada metode Moving Avearge dan Exponential Smoothin akan memiliki error yang sama pada saat $\alpha = \frac{2}{N+1}$.
4. Diketahui data permintaan secara berturut-turut sebagai berikut: 12, 10, 18, dan 20.
   a. Lakukan peramalan dengan dua metode yang berbeda untuk menentukan jumlah permintaan 2 periode ke depan. Definisikan dan tentukan data-data pendukung yang diperlukan untuk metode yang akan anda gunakan. (Tingkat kesulitan metode dan ketepatan jawaban akan mempengaruhi bobot nilai).
   b. Lakukan analisa untuk menentukan metode manakah yang paling sesuai untuk data tersebut. Jelaskan alasannya.

Simple Time Series Models

- Moving Average (Simple & Weighted)
- Exponential Smoothing (Single)
- Double Exponential Smoothing (Holt's)
- Winter's Method for Seasonal Problems

Simple Moving Average

- Forecast F_t is average of n previous observations or actuals D_t:

$$F_{t+1} = \frac{1}{n}(D_t + D_{t-1} + \cdots + D_{t+1-n})$$

$$F_{t+1} = \frac{1}{n}\sum_{i=t+1-n}^{t} D_i$$

- Note that the n past observations are equally weighted.
- Issues with moving average forecasts:
  - All n past observations treated equally;
  - Observations older than n are not included at all;
  - Requires that n past observations be retained;
  - Problem when 1000's of items are being forecast.

Weighted Moving Average

Forecast is based on n past demand data, each given a certain weight. The total weight must equal to 1.

$$F_{t+1} = (w_t D_t + w_{t-1} D_{t-1} + \cdots + w_{t+1-n} D_{t+1-n})$$

Re-do the above example, using 3 past data, each given a weight of 0.5, 0.3, and 0.2 (larger for more recent data)

Exponential Smoothing

- New Forecast = α (current observation of demand) + (1-α) (last forecast)
- Or

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

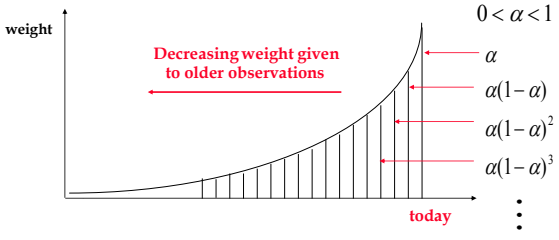
And

$F_{t-1} = \alpha(D_{t-1}) + (1-\alpha)F_{t-2,}$ dst

Sehingga pada model ini, semua data historis terwakili pada forecast terakhir dengan bobot yang semakin kecil (untuk data yang semakin lama)

Exponential Smoothing

- Include all past observations
- Weight recent observations much more heavily than very old observations:



Exponential Smoothing

- Notes:
  - Only 2 values (D_t and F_{t-1}) are required, compared with n for moving average
  - Parameter α determined empirically (whatever works best)
  - Rule of thumb: $\alpha < 0.5$
  - $\alpha = 0.1$ to $\alpha = 0.3$
- Forecast for k periods into future is:

$$F_{t+k} = F_t$$

Persamaan MA dan ES

- Sama-sama mengasumsikan demand bersifat stationary
- Keduanya tergantung pada 1 nilai parameter, N pada MA dan α pada ES.
- Kalau ada trend, kedua-duanya terlambat dalam merespon
- Keduanya akan menghasilkan distribusi error yang sama apabila α = 2 / (N+1)

Perbedaan MA dan ES

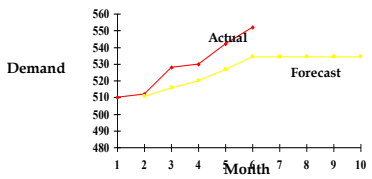
- MA mengakomodasikan lebih banyak data
- ES hanya menyimpan dua data: forecast terakhir dan actual demand terakhir, sedang MA menyimpan N data demand terakhir

Double Exponential Smoothing

- What happens when there is a definite trend?

A trendy clothing boutique has had the following sales over the past 6 months:

1	2	3	4	5	6
510	512	528	530	542	552



Double Exponential Smoothing

- Ideas behind smoothing with trend:
  - ``De-trend'' time-series by separating series from *trend* effects
  - Smooth *series* in usual manner using α
  - Smooth *trend* forecasts in usual manner using β
- Smooth the *series* forecast S_t

$$S_t = \alpha D_t + (1-\alpha)(S_{t-1} + T_{t-1})$$

- Smooth the *trend* forecast T_t

$$T_t = \beta(S_t - S_{t-1}) + (1-\beta)T_{t-1}$$

- Forecast *k* periods into future F_{t+k} with *base* and *trend*

$$F_{t+k} = S_t + kT_t$$

Latihan Soal

(a = 0,1; b = 0,1; S_1 = 40; T_1 = 0)

Periode	Demand	Level	Trend	Forecast
1	47	40	0	40
2	42			40,22
3	16			37,58
4	47			38,39
5	38			
6	34			
7	45			
8	50			
9	47			
10	54			
11	40			
12	43			
13				

Exponential Smoothing w/ Trend and Seasonality

- Apabila kita memiliki data yang mengandung pola trend maupun seasonality, kita menggunakan model ini.
- Prinsipnya, data didekomposisi menjadi 3 bagian:
  - Data dasar
  - Komponen trend
  - Indeks musiman
- Masing-masing kemudian diforecast tersendiri dengan exponential smoothing, kemudian digabung kembali

Exponential Smoothing w/ Trend and Seasonality

- Smooth the *series* forecast S_t

$$S_t = \alpha \frac{D_t}{C_{t-m}} + (1-\alpha)(S_{t-1} + T_{t-1})$$

- Smooth the *trend* forecast T_t

$$T_t = \beta(S_t - S_{t-1}) + (1-\beta)T_{t-1}$$

- Smooth the seasonality forecast C_t

$$C_t = \gamma \frac{D_t}{S_t} + (1-\gamma)C_{t-m}$$

Exponential Smoothing w/ Trend and Seasonality

- Forecast F_t with trend and seasonality

$$F_{t+k} = (S_t + kT_t)C_{t+k-m}$$

Exponential Smoothing w/ Trend and Seasonality

- **Example:**

  The Alpha Corporation has a product with seasonal differences in sales between the halves of the year. Sales in the first half of the year are generally less than for the second half of the year. For this reason they've split sales from the two previous years (7 and 8) into two halves and would like to use these two parts to predict sales in the coming year (9). They also feel there's an upward trend in sales. Sales for the past two years were:

	Year 7	Year 8
First half (F)	100	105
Second half (S)	110	130

  Company executives estimated the trend at the end of year 6 was 5 units per half year (T_{6S}) = 5. The base value at the end of year 6 (B_{6S}) = 95. Seasonal factors were 1.05 and 0.95 for the first and second half of the year, respectively. (Note these factors are set purposely to the opposite of what they should be to demonstrate how they'll be corrected.)

  $$\alpha = 0.3;\ \beta = 0{,}5;\ \gamma = 0{,}5$$

  a. Using a trend and seasonally enhanced model, forecast each of the four half years, sequentially updating the model at the end of each half year.
  b. At the end of year 8 prepare a forecast for each half year in year 9.
  c. Graph values of the updated seasonal factor for each half year.

Forecast Errors

$e_t = F_{t-p,t} - D_t$

Measures of forecast errors:

$$MAD = (1/n)\sum_{i=1}^{n}|e_i|$$

$$MSE = (1/n)\sum_{i=1}^{n}e_i^2$$

$$MAPE = \left[(1/n)\sum_{i=1}^{n}|e_i/D_i|\right]x100\%$$

Mean Forecast Error (MFE or Bias)

$$MFE = \frac{1}{n}\sum_{t=1}^{n}(D_t - F_t)$$

- Want MFE to be as close to zero as possible -- minimum bias
- A large positive (negative) MFE means that the forecast is undershooting (overshooting) the actual observations
- Note that zero MFE does not imply that forecasts are perfect (no error) -- only that mean is "on target"
- Also called forecast BIAS

Tracking Signals

- **Tracking Signal**. Gunanya adalah memonitor apakah forecast kita bias (cenderung naik / turun secara konsisten)

$$\frac{\sum_{i=1}^{n}(\text{Actual demand} - \text{Forecast demand})_i}{\text{MAD}}$$

- -1 ≤ Tracking Signal ≤ +1
- Alternatif lainnya, gunakan MFE (lebih mudah).

Forecast: Comparisons of Methods

- Latihan soal:
  - Pada dua contoh soal di atas (ES with trend dan ES with trend & seasonal):
    - Hitung forecast masing-masing soal dengan menggunakan metode Single ES.
    - Hitung MAD, MSE, MAPE, MFE, dan Tracking Signals masing-masing metode.
    - Analisa dan simpulkan hasil perhitungan yang anda peroleh.

Forecast Menjadi Lebih Penting Jika

- Barang harus ada dulu sebelum pelanggan membutuhkan (producing the product before there is a definite demand)
  - Ini adalah konsep sangat mendasar dari MTS
  - Perusahaan yang memproduksi barang atas dasar MTO tidak **terlalu** tergantung pada ramalan
- Lead time pengadaan / produksi panjang (lebih panjang dari waktu tunggu pelanggan)
  - Industri mobil bisa memperpendek lead time sampai yang bisa ditoleransi oleh pelanggan dengan mengubah sistemnya menjadi assembly to order (ATO)

Pertemuan 3 - Persiapan

- **Tugas Baca**
  - Materi:
    - Perencanaan Aggregate

SAMPAI JUMPA