Introduction to Operations Management

Lecture_ Forecasting_2

Slack and Brandon Jones (10th Ed) – pp. 358-368

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RECAP

Why forecast?

Time Series forecasts

- Moving averages
- plus **Trend** (when relevant)
- plus '**Seasonality**' (when relevant)

Exponential smoothing

Suppose:
1) Don’t want to make an arbitrary decision on *n*
2) And don’t want to give old and recent values equal influence.

Then:
1) Take average of all past observations (for algebraic explanation)
2) But reduce contributions as go back in time

To forecast demand for the next period:
- Weightage (α) assigned to the actual demand of the current period;
- Weightage ($1 - \alpha$) assigned to forecast previously calculated for the current period.
- Recent observations are given more relevant to predict future

Exponential smoothing

Algebraic formulation

- So procedure is to calculate…

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

Where F_{t+1} = forecast for the next period
F_t = forecast of the current period
A_t = actual demand of current period
α = smoothing constant ($0 < \alpha < 1$)

- When haven't got previous forecast use actual

Exponential smoothing

Year	Demand
2017	63.3
2018	62.5
2019	67.7
2020	66
2021	67.2
2022	68.4

To use this, we work forward from our first data in 2017:

- At the end of 2017 we knew the demand was 63.3
- We needed a forecast for 2018:

- $F(2018) = \alpha A(2017) + (1-\alpha)F(2017)$

We didn't have a forecast for 2017, so we would have used the actual demand

Suppose we use $\alpha = 0.3$

Then F(2018) = 0.3 x 63.3 + 0.7 x 63.3 = 63.3

Exponential smoothing

- Now at the end of 2018 we knew demand had actually been 62.5
- We needed a forecast for 2019:
- F(2019) = αA(2018) + (1- α)F(2018)

We had a forecast for 2018 calculated as 63.3

- So F(2019) = 0.3 x 62.5 + 0.7 x 63.3 = 63.06
- Then at the end of 2019 we knew demand was actually 67.7
- We needed a forecast for 2020 based on this:

I.e. F(2020) = 0.3 x 67.7 + 0.7 x 63.06 = 64.452

If we carry on like this we find

- F(2021) = 64.9164,
- F(2022) = 65.60148
- F(2023) = 66.4

$$F_2 = \alpha A_1 + (1 - \alpha) F_1$$

Year	Demand A_t	Forecast F_t	$\alpha = 0.3$
2017	63.3	63.3	Use $F_1 = A_1$
2018	62.5	63.3	(0.3*63.3) + (0.7*63.3)
2019	67.7	63.06	(0.3*62.5) + (0.7*63.3)
2020	66	64.45	(0.3*67.7) + (0.7*63.06)
2021	67.2	64.92	
2022	68.4	65.6	
2023		66.44	

Exponential smoothing

Choice of smoothing constant

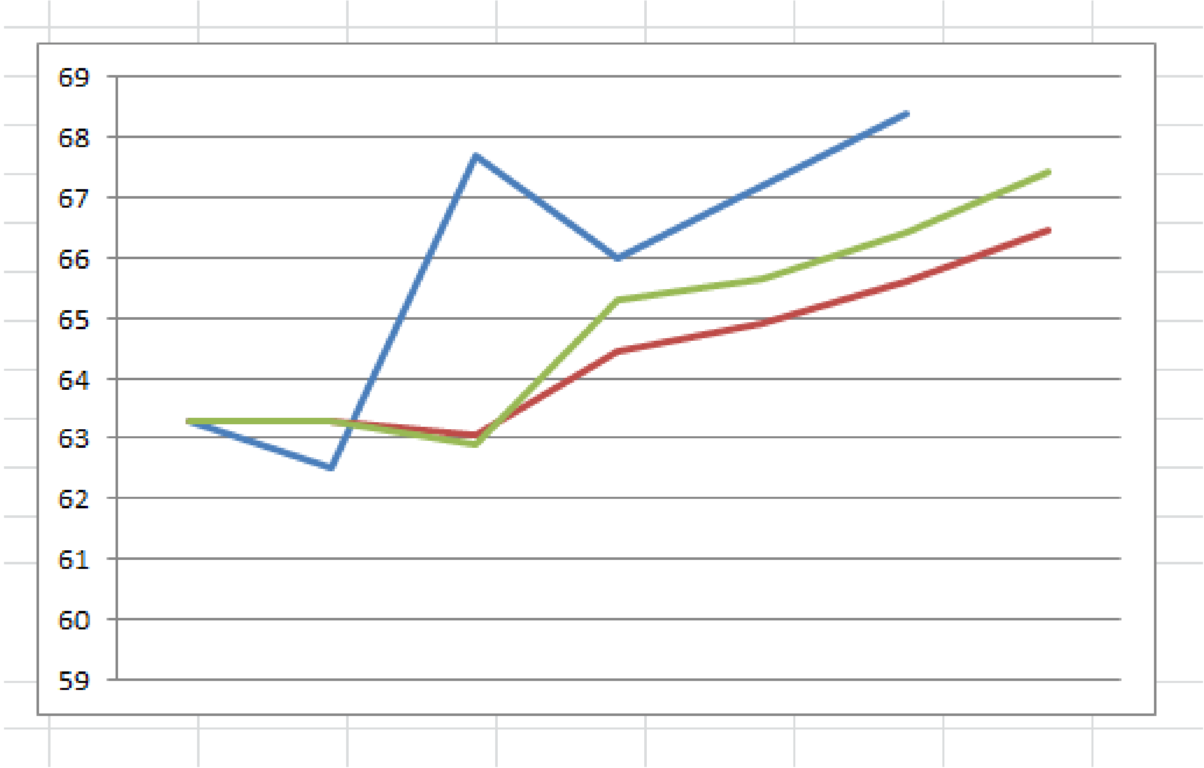
- If zero then *F* never changes
- If 1 then *F(next period)* is actual demand (current period) lagged by 1 period
- Usually fixed between 0.1 and 0.3
- Small value implies slow response to demand
- High value implies quick response to demand

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

Question

Which line corresponds to 1) the demand, 2) the forecast with smoothing constant 0.3, 3) the forecast with smoothing constant 0.5?

A) Red, Green, Blue
B) Green, Blue, Red
C) Blue, Green, Red
D) Green, Red, Blue



Exponential smoothing

Dealing with trends

Year	Demand A_t	Forecast F_t	
2017	63.3	63.3	Use $F_t = A_1$
2018	62.5	63.3	$F_2 = \alpha A_t + (1 - \alpha) F_1$
2019	67.7	63.06	
2020	66	64.45	
2021	67.2	64.92	
2022	68.4	65.6	
2023		66.44	
α=0.3			

- Add extra term:
  $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$ …*compare* $F_{t+1} = \alpha A_t + (1 - \alpha)F_t$

- Where:
  $B_t = \beta(F_t - F_{t-1}) + (1 - \beta)B_{t-1}$

Exponential smoothing

Dealing with trends

- In 2017, trend 0, and forecast F_{2017} = actual A_{2017}
- Forecast for 2018, $F_{2018} = \alpha A_{2017} + (1 - \alpha)(F_{2017} + 0) = 63.3$

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5		63.3
2019	67.7		
2020	66		
2021	67.2		
2022	68.4		
2023			
α= 0.3	**β= 0.5**		

Forecast $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$
Where $B_t = \beta(F_t - F_{t-1}) + (1 - \beta)B_{t-1}$

Exponential smoothing

Dealing with trends

- In 2018, trend $B_{2018} = \beta(63.3 - 63.3) + (1 - \beta) \times 0 = 0$
- Forecast for 2019, $F_{2019} = \alpha A_{2018} + (1 - \alpha)(F_{2018} + 0) = 63.06$

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5	0	63.3
2019	67.7		63.06
2020	66		
2021	67.2		
2022	68.4		
2023			
α= 0.3	**β= 0.5**		

Forecast $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$
Where $B_t = \beta(F_t - F_{t-1}) + (1 - \beta)B_{t-1}$

Exponential smoothing

Dealing with trends

- In 2019, trend $B_{2019} = \beta(63.06 – 63.3) + (1 – \beta) \times 0 = -0.12$
- Forecast for 2020, $F_{2020} = \alpha A_{2019} + (1 - \alpha)(F_{2019} – 0.12) = 64.368$

Forecast $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$
Where $B_t = \beta(F_t - F_{t-1}) + (1 – \beta)B_{t-1}$

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5	0	63.3
2019	67.7	- 0.12	63.06
2020	66		64.368
2021	67.2		
2022	68.4		
2023			
α= 0.3	**β= 0.5**		

Exponential smoothing

Dealing with trends

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5	0	63.3
2019	67.7	- 0.12	63.06
2020	66	0.594	64.368
2021	67.2	0.7497	65.273
2022	68.4	0.962	66.376
2023		1.090	67.631
α= 0.3	**β= 0.5**		

Question

Suppose in 2023 the actual demand turns out to be 70.0. What is the forecast for 2024?

A) 66.8
B) 68.2
C) 69.1
D) 70.4

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5	0	63.3
2019	67.7	- 0.12	63.06
2020	66	0.594	64.368
2021	67.2	0.7497	65.273
2022	68.4	0.962	66.376
2023		1.090	67.631
α= 0.3	**β= 0.5**		

Forecast $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$
Where $B_t = \beta(F_t - F_{t-1}) + (1 – \beta)B_{t-1}$

This is just the first equation: 0.3 x 70 + 0.7 x (67.6 + 1.1) = 69.1

Question

Given a forecast for 2024 of 69.1, when you get to 2024 what will be the trend term used in the forecast for 2025?

A) 0.8
B) 1.3
C) 1.8
D) 2.2

Year	Demand A_t	**Trend** B_t	Forecast F_t
2017	63.3	0	63.3
2018	62.5	0	63.3
2019	67.7	- 0.12	63.06
2020	66	0.594	64.368
2021	67.2	0.7497	65.273
2022	68.4	0.962	66.376
2023		1.090	67.631
α= 0.3	**β= 0.5**		

Forecast $F_{t+1} = \alpha A_t + (1 - \alpha)(F_t + B_t)$
Where $B_t = \beta(F_t - F_{t-1}) + (1 - \beta)B_{t-1}$

0.5 x (69.1 – 67.6)+ 0.5 x 1.1
= 1.3

Measuring error: famous forecasts

There is no perfect forecast.

“Computers in the future may weigh no more than 1.5 tons” Popular Mechanics, 1949

“I think there is a world market for maybe 5 computers”
Chairman of IBM, 1943

“There is no chance the iPhone is going to get any significant market share” Steve Ballmer, 2007

“640K [RAM] ought to be enough for anybody” Bill Gates, 1981

Measuring error

Which looks like the better method of forecasting
in this specific case?
i.e. Mean or 3PMA

Month	Demand	Mean (to date)	3PMA
1	98		
2	201	98.00	
3	33	149.50	
4	45	110.67	110.67
5	56	94.25	93.00
6	67	86.60	44.67
7	67	83.33	56.00
8	79	81.00	63.33
9	112	80.75	71.00
10	101	84.22	86.00

Measuring error

Mean forecast error

- **Sum $_{t = 1 \text{ to } N}(F_t – A_t) / n$**
- Sign indicates direction of bias
- Average of the differences between the forecasted and actual values.
- Tells us if the forecast was high or low

Period	Demand	Forecast	Error	Mean
1	63.3			
2	62.5			
3	67.7			
4	66	64.5	-1.5	
5	67.2	65.4	-1.8	
6	69.9	67	-2.9	
7	65.6	67.7	2.1	
8	71.1	67.6	-3.5	
9	68.8	68.9	0	-1.3
		68.5		

Measuring error

Mean absolute deviation (MAD) ie *scatter* rather than bias

- **Sum** $_{t=1 \text{ to } N}$ $|F_t - A_t| / n$

- Forecast is "good" if MAD is as small as possible
- MAD focuses on the magnitude of the error.

Period	Demand	Forecast	Error	| Error |	Mean
1	63.3				
2	62.5				
3	67.7				
4	66	64.5	-1.5	1.5	
5	67.2	65.4	-1.8	1.8	
6	69.9	67	-2.9	2.9	
7	65.6	67.7	2.1	2.1	
8	71.1	67.6	-3.5	3.5	
9	68.8	68.9	0	0	1.97
		68.5			

Measuring error

Mean absolute percent error (MAPE) gives a better perspective

- **Sum $_{t = 1 \text{ to } N}$ ($|F_t – A_t| / A_t$) * 100 / n**

- Measures the percentage difference between the forecasted and demand values

Period	Demand	Forecast	Error	| Error |	100* |Error| /Demand	Mean
1	63.3					
2	62.5					
3	67.7					
4	66	64.5	-1.5	1.5	2.27	
5	67.2	65.4	-1.8	1.8	2.68	
6	69.9	67	-2.9	2.9	4.15	
7	65.6	67.7	2.1	2.1	3.2	
8	71.1	67.6	-3.5	3.5	4.92	
9	68.8	68.9	0.1	0.1	0.15	2.895
		68.5				

Question

Intel made the following forecasts for one of its SKUs and saw the related demand *(Manary and Williams 2008)*.

What was the Mean Deviation for Months 11 and 12?

A) 245
B) - 892
C) 101
D) -347

Period	Forecast	Actual Demand
1	1000	681
2	1000	713
3	1000	857
4	1000	718
5	500	609
6	700	777
7	800	485
8	500	550
9	1200	992
10	1500	438
11	1349	2000
12	406	1539

= [(1349-2000)+(406-1539)]/2
= - 892

Question

Intel made the following forecasts for one of its SKUs and saw the related demand *(Manary and Williams 2008).*

What was the Mean Absolute Deviation for Months 11 and 12?

A) -245

B) 892

C) -101

D) 347

Period	Forecast	Actual Demand
1	1000	681
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8	500	550
9	1200	992
10	1500	438
11	1349	2000
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Measuring error

But all these measures are in hindsight
And numerical forecasting is only part of a larger process

- Consider also market intelligence eg from distributors, agents
- Consider knowledge about competitor behaviour
- Consider models of consumer perceptions
- Consider the knowledge of specific environmental conditions
- Consider the knowledge of one’s own actions eg sales promotions

Seminar task

Based on the Quik-Serv Garage case on Moodle

Please tackle the case before the seminar