



rijksuniversiteit  
 groningen

| 1

# Rijksuniversiteit Groningen

400 years of passion and performance



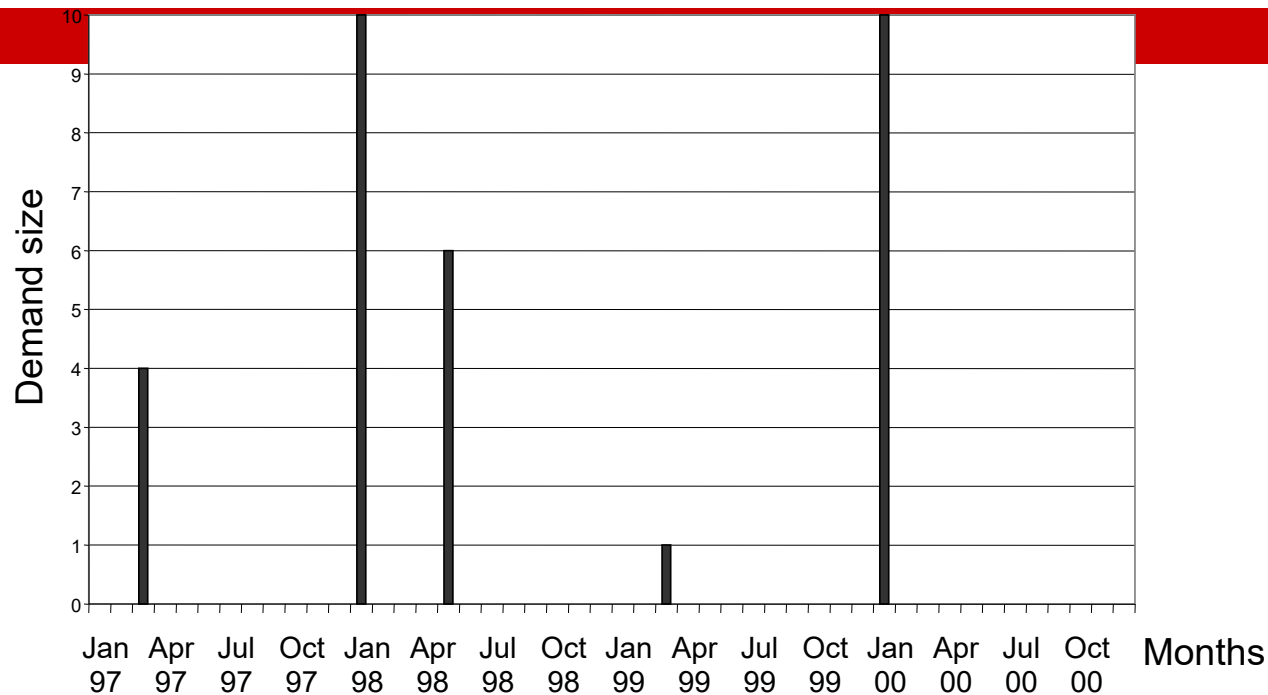


# Theory behind spare parts forecasting

9 Sept 2026 | SLF Back to College



- › Maintaining stocks of many different spare parts, most of which are very slow moving
- › Maximize service levels whilst minimizing costs



Any Stock Keeping Unit (SKU) within the range of products at any level of a given supply chain

- May account for up to 60% of the total stock value in any industrial setting

⇒ Small improvements imply substantial cost savings

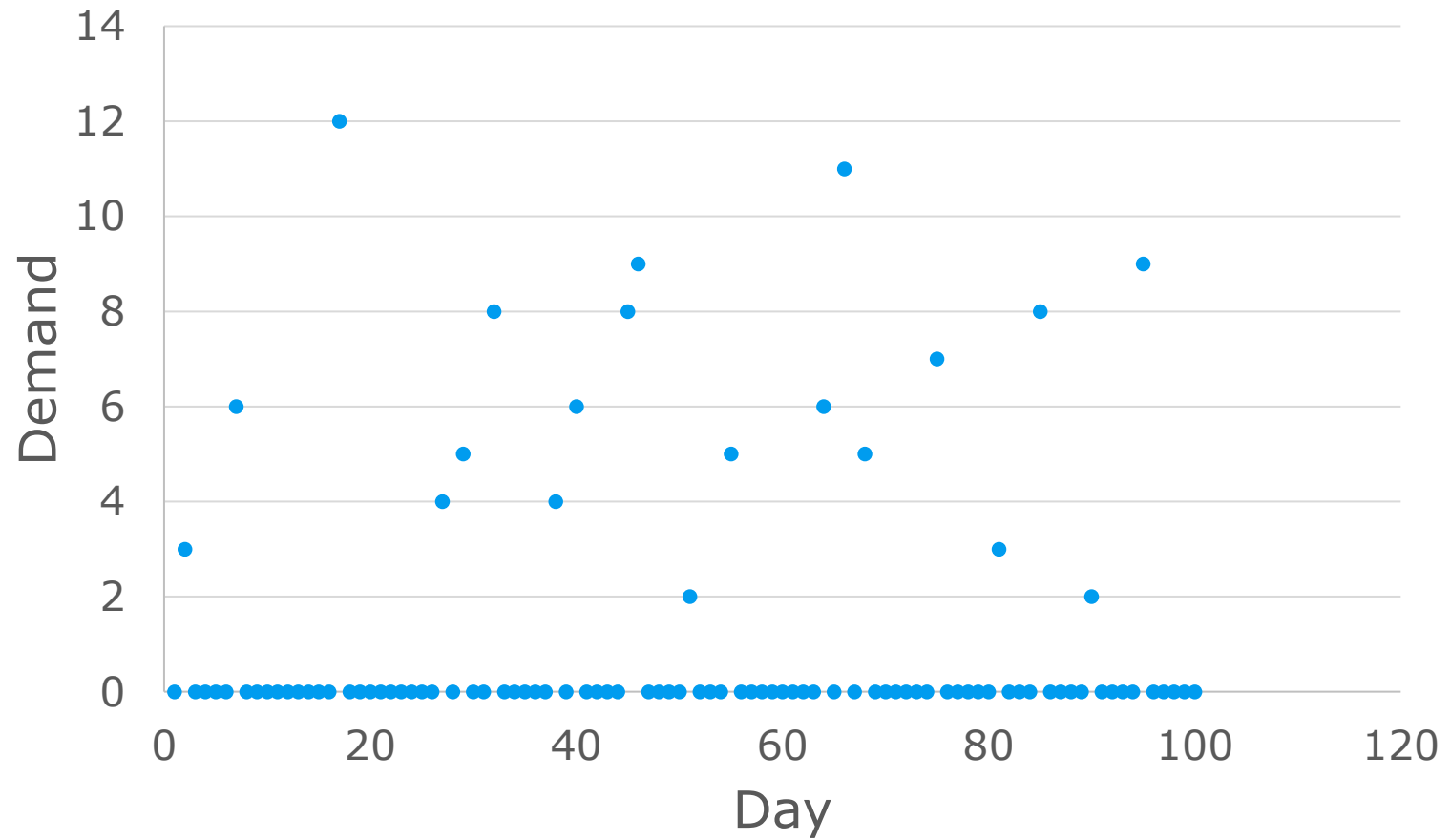


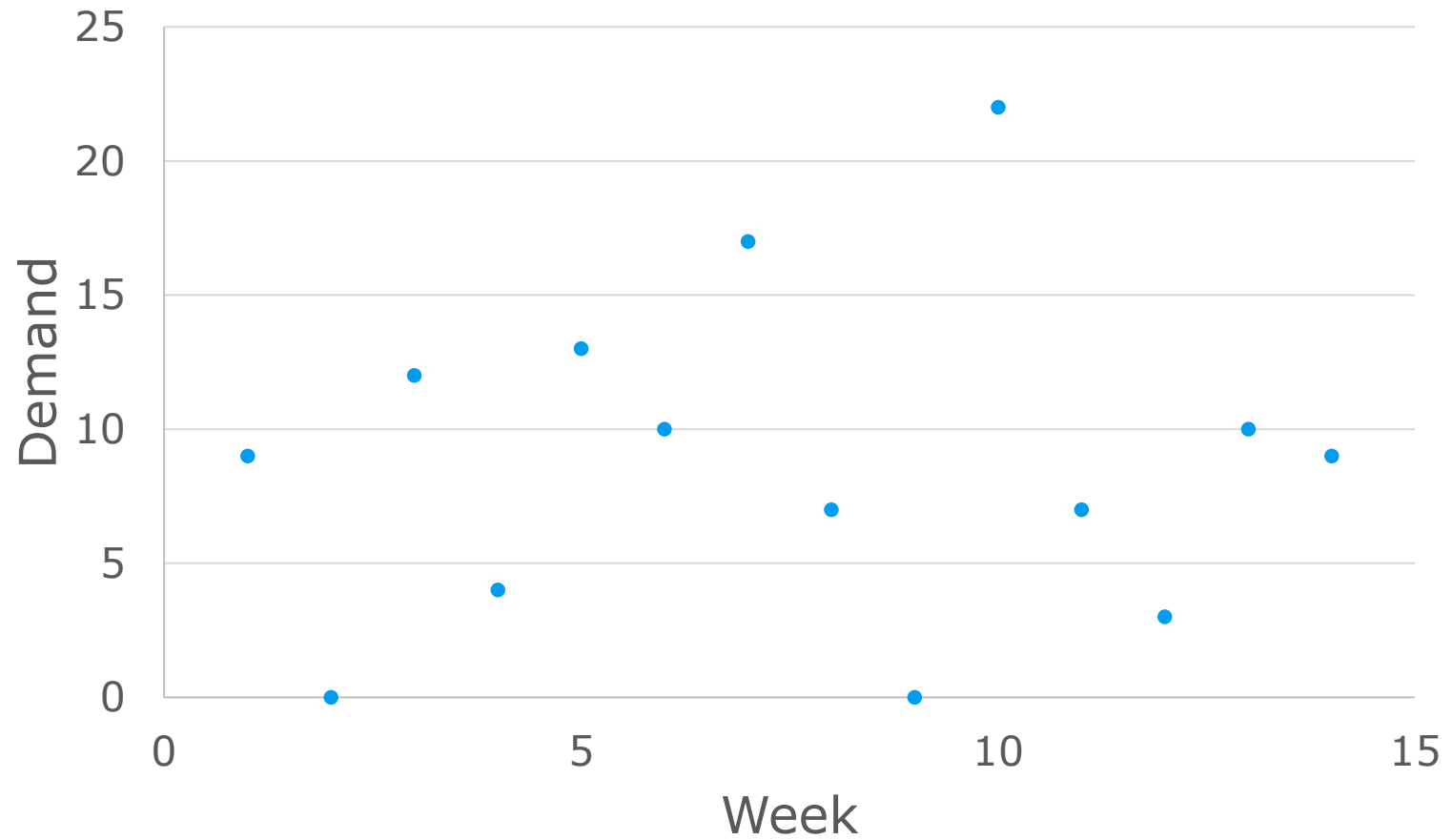
- › Forecasting intermittent demand
  - General (all demand) methods
  - Specific (intermittent demand) methods
  - Accuracy
  
- › Inventory control
  - Fast moving demand
  - Intermittent demand
  
- › Conclusion



How to reduce cost in Spare Parts Management?

- › Data quality
- › Apply Forecasting & Inventory methods for slow movers
- › Service level differentiation









- › A shorter period is always better.
- › The more zero's we see, the more likely we see customer demand.
- › The smallest lead time should cover at least one and ideally multiple periods.



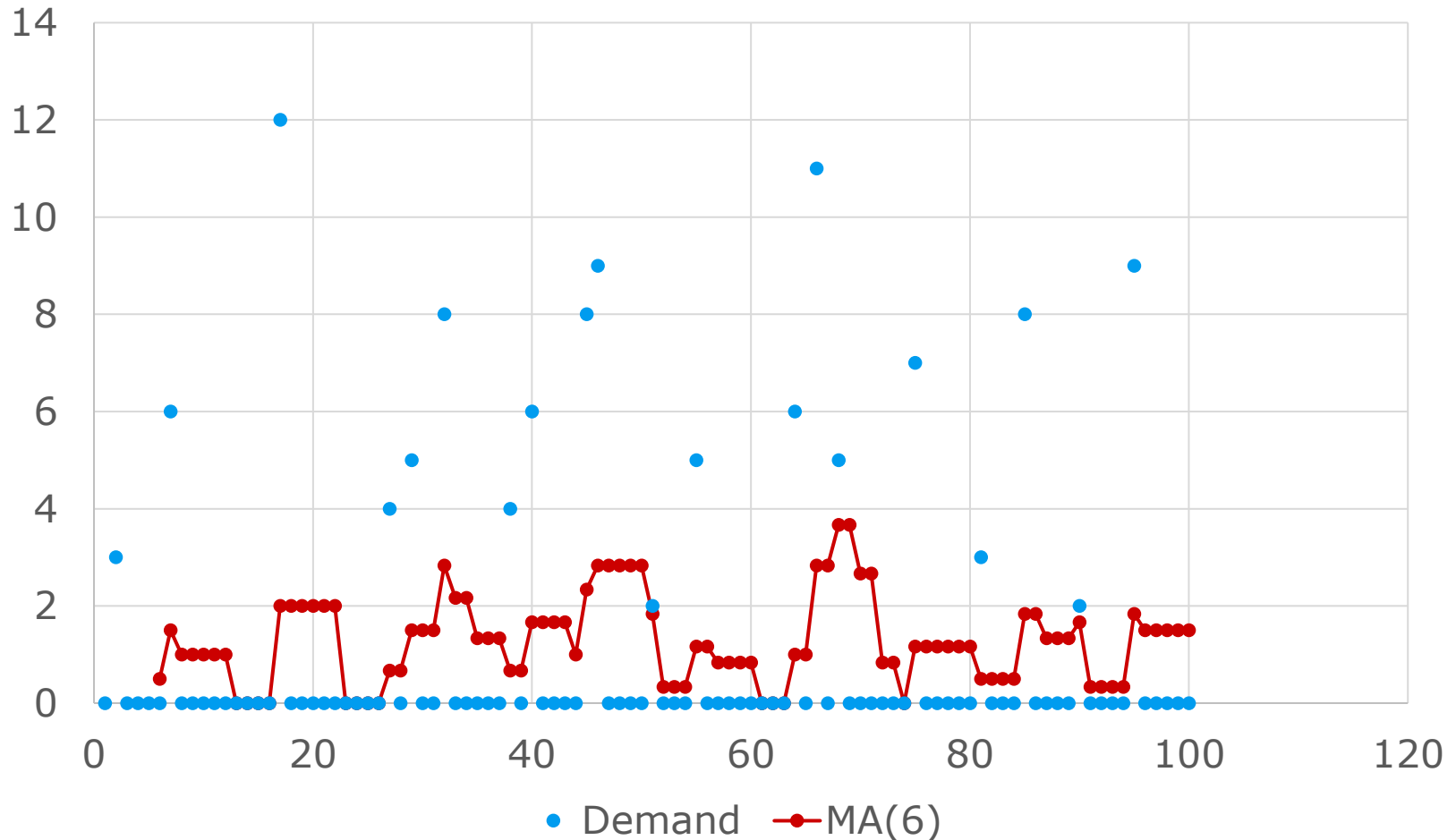
Traditional techniques directly forecast the demand per period :

- › Moving average: average over the last, say, 6 periods
- › Exponential smoothing: weighted average with more weight on recent observations

Other methods (Croston, TSB) consider intermittency and lumpiness

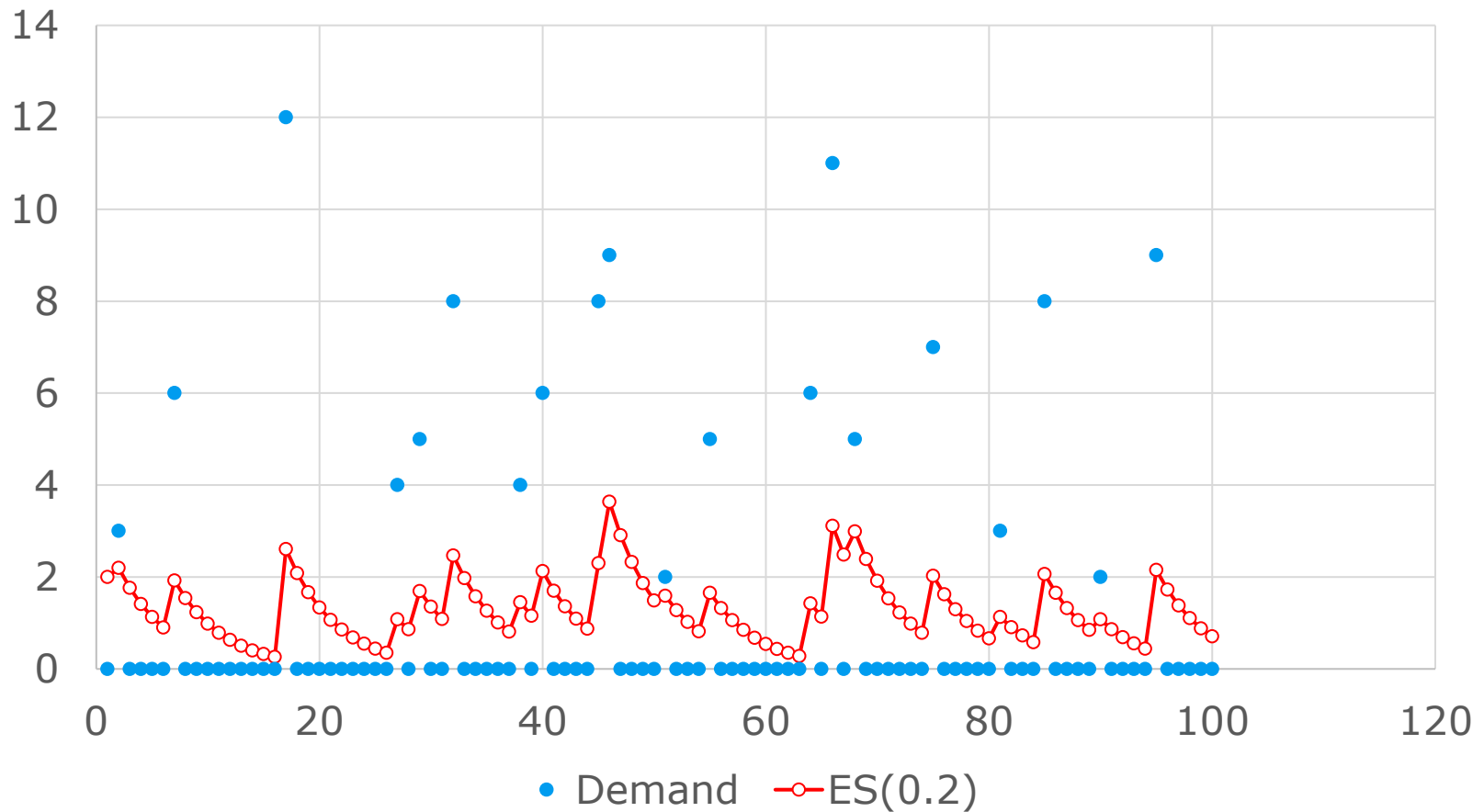


# Moving Average (6)





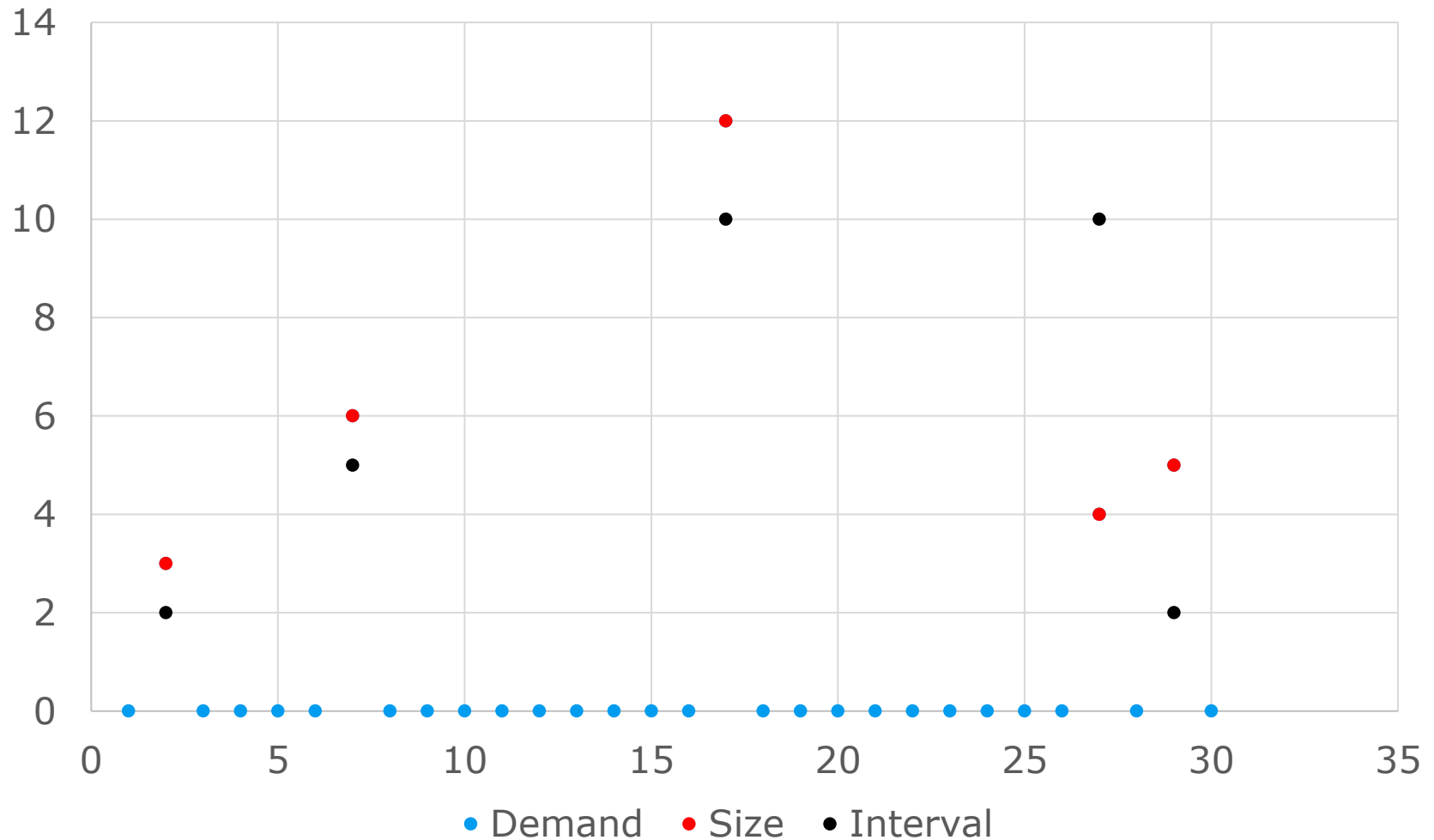
# Exp. Smoothing (0.2)





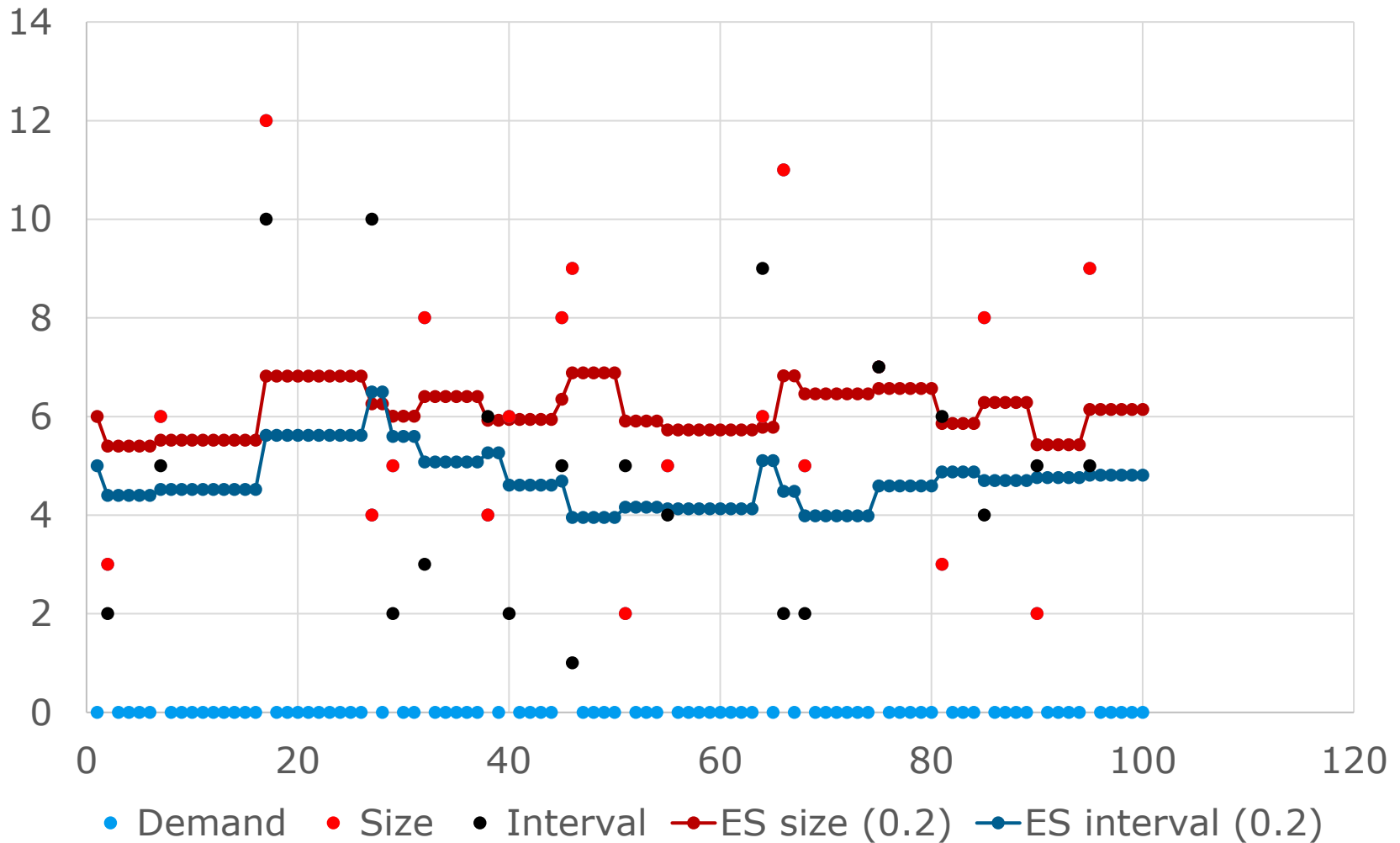
- › If demand occurs
  1. Re-estimate mean demand size (S) using Exponential Smoothing
  2. Re-Estimate mean demand interval (I) using Exponential Smoothing
  3. Re-estimate mean demand :  $D = S / I$
- › Else if demand does not occur  
Do not re-estimate

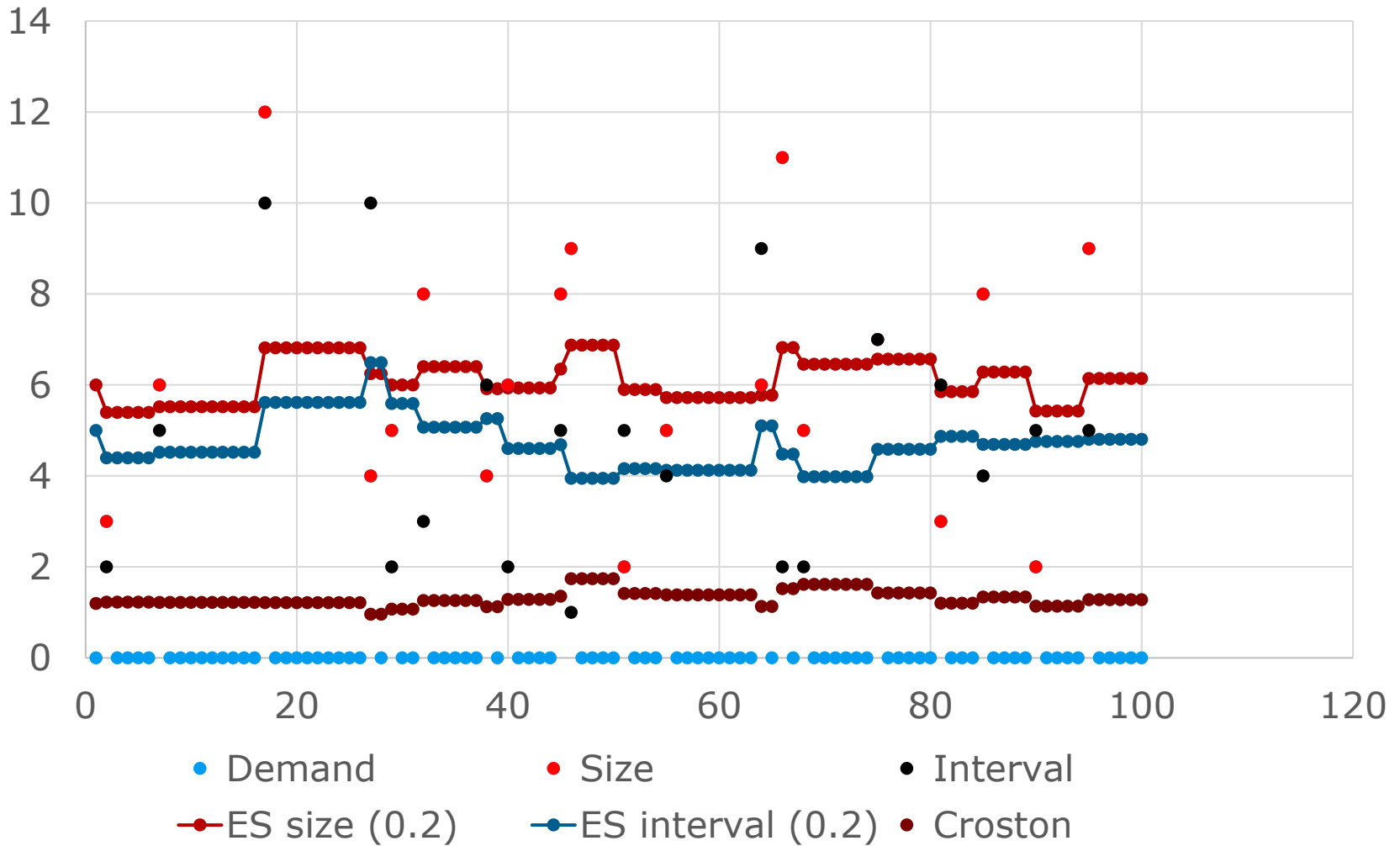
*Croston (1972)*





# Croston (0.2)







- › Small bias (not discussed here)
- › By not updating in periods with zero demand, forecasts become outdated
- › Not suitable for estimating the risk of obsolescence



- › If a demand occurs
  1. Re-estimate mean demand size (S) using Exponential Smoothing
  
- › In every period
  2. Re-Estimate demand probability (p) using Exponential Smoothing
  3. Re-estimate mean demand :  $D = S * p$

*Teunter, Syntetos, Babai (2011)*



› Besides the (point) forecast, the forecast error is crucial.

› Mean Squared Error (MSE)

| Demand | MA(3)    | Error | Squared Error |
|--------|----------|-------|---------------|
| 12     | Forecast |       |               |
| 15     |          |       |               |
| 6      |          |       |               |
| 8      | 11       | -3,0  | 9             |
| 12     | 9,7      | 2,3   | 5,4           |
| 23     | 8,7      | 14,3  | 205,4         |
| 9      | 14,3     | -5,3  | 28,4          |
| 14     | 14,7     | -0,7  | 0,4           |
| 9      | 15,3     | -6,3  | 40,1          |

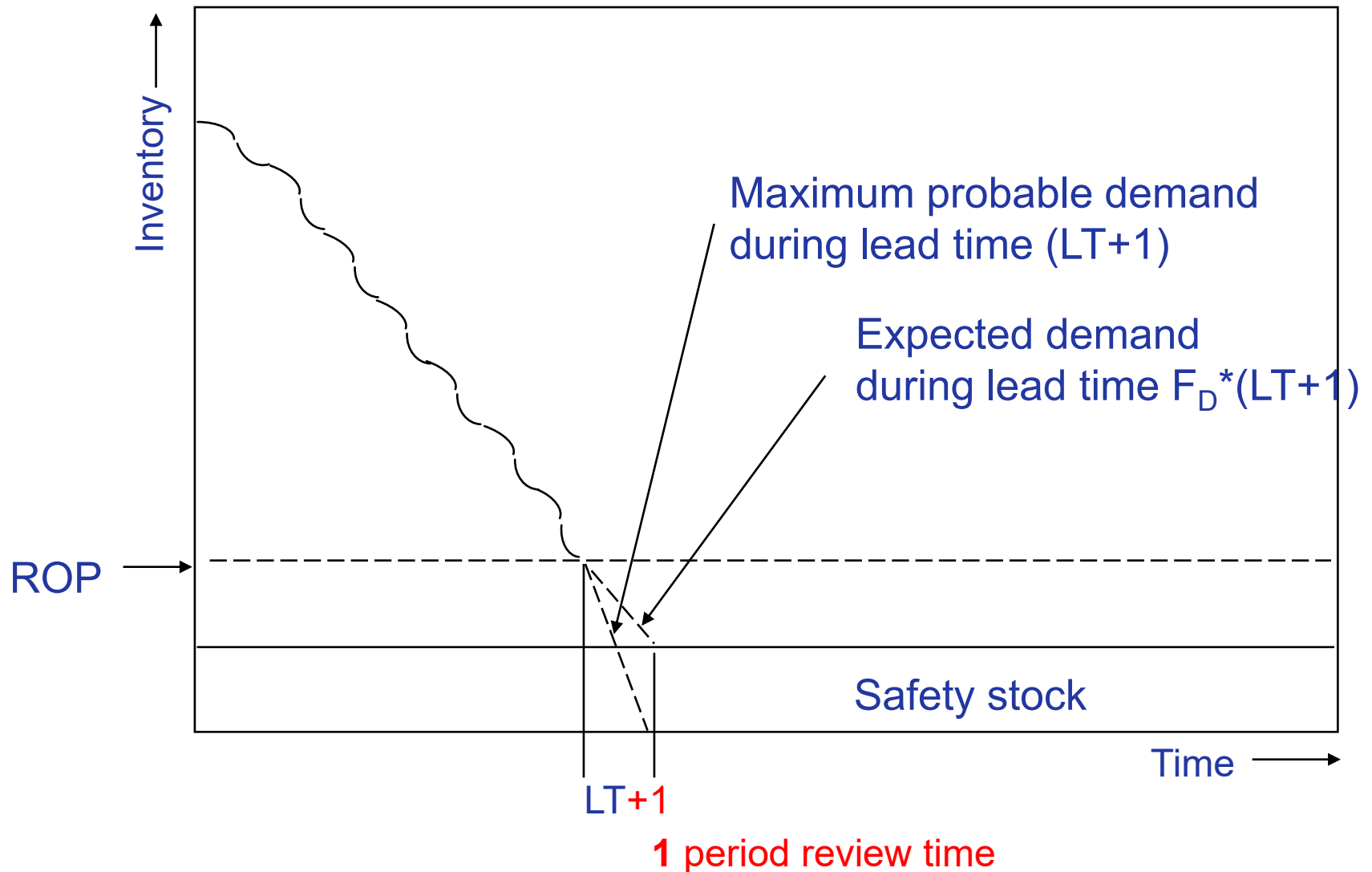
›  $MSE = (9 + 5.4 + \dots + 40.1) / 6$



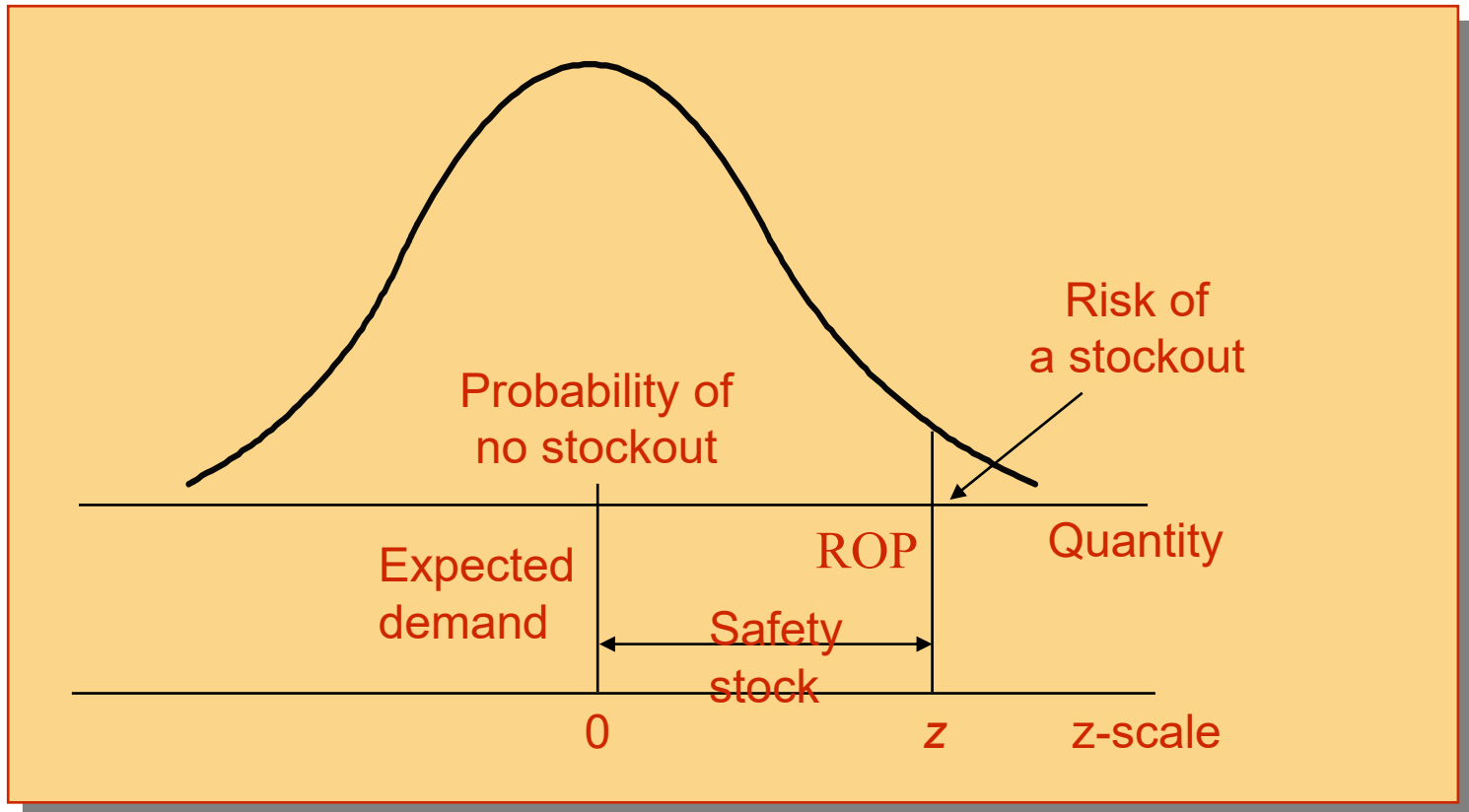
- › How to determine when to order?
- › How is it done for fast moving demand?
- › Why is it different for slow moving demand?

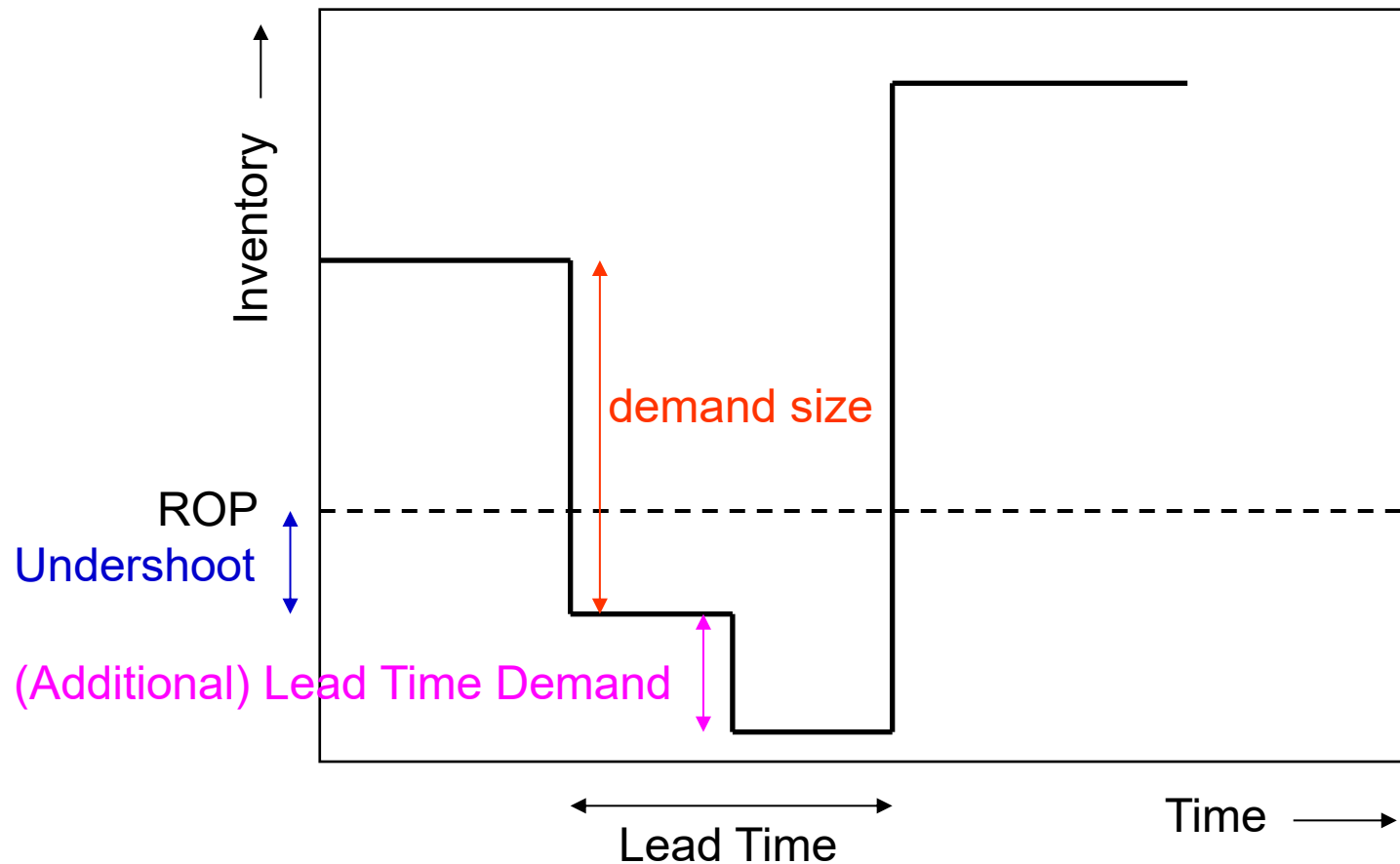


# Reorder Point – fast moving demand



- >  $ROP = (LT+1) \times F_D + z \sqrt{[(LT+1) \times MSE_D]}$
- > Where  $z$  is the safety factor





## NOTE:

An order is triggered by a positive demand SIZE

Undershoot is at most the demand Size



# 'Easy fix' (retain Normality assumption)

- > So, for slow moving:
- >  $ROP = F_S + LT \times F_D + z\sqrt{[MSE_S + LT \times MSE_D]}$
- > Recall that for fast moving we had:
- >  $ROP = (LT+1) \times F_D + z\sqrt{[(LT+1) \times MSE_D]}$
- > Without the adjustment, your service level will always be below target!



- › The adjustment requires a forecast of the demand size
- › Hence, this is not possible if traditional forecasting techniques are used
- › Croston and TSB do provide all relevant information.



# Fill rate targets

- › Do NOT use the same SL target for all SKUs. This will double your safety stock cost at the assortment level, or worse.
- › We have developed a simple (in e.g. Excel) method for setting optimal target fill rates.
- › These increase with higher expected demand, better predictability (lower  $V[LTD]$ ), and lower holding cost.



- › We (I, Aris Syntetos, Zied Babai) are writing a short book (100 pages) for practitioners with all the basics on forecasting, order level calculations and service level differentiation.
- › We distinguish between slow and fast movers.
- › Should be finished by the end of the year.



# Conclusion

- › Don't loose your data! Keep the period small.
- › Do not use traditional forecasting techniques for intermittent demand. Special, simple forecasting techniques (Croston, TSB) are available.
- › Adjust order level calculations for slow movers to prevent poor service.
- › Vary service level targets across SKUs.



| SKU | Demand<br>forecast<br>$F_D$ | LT Demand<br>uncertainty<br>$\sqrt{MSE_{LT}}$ | Holding<br>cost $h$ | $\frac{h \times \sqrt{MSE_{LT}}}{\text{criticality}}$ |
|-----|-----------------------------|-----------------------------------------------|---------------------|-------------------------------------------------------|
| 1   | 20                          | 8                                             | 22                  | 176                                                   |
| 2   | 80                          | 20                                            | 7                   | 140                                                   |
| 3   | 250                         | 50                                            | 1                   | 50                                                    |
| SUM | 350                         |                                               |                     | 366                                                   |

›  $MSE_{LT} = MSE_S + LT \times MSE_D$

› Target fill rate: 95%

› Minimum SKU fill rate: 70%



## Example – Missed demands

| SKU $i$ | Demand<br>forecast<br>$F_D$ |  |  |  |
|---------|-----------------------------|--|--|--|
| 1       | 20                          |  |  |  |
| 2       | 80                          |  |  |  |
| 3       | 250                         |  |  |  |
| SUM     | 350                         |  |  |  |

- › Target fill rate: 95%
- › Allowed missed demands:  $5\% \times 350 = 17.5$



## Example: SKU 1

| SKU $i$ | Demand<br>forecast<br>$F_D$ | LT Demand<br>uncertainty<br>$MSE_{LT}$ | Holding<br>cost $h$ | $\frac{h \times MSE_{LT}}{\text{criticality}}$ |
|---------|-----------------------------|----------------------------------------|---------------------|------------------------------------------------|
| 1       | 20                          |                                        |                     | 176                                            |
| 2       |                             |                                        |                     |                                                |
| 3       |                             |                                        |                     |                                                |
| SUM     |                             |                                        |                     | 366                                            |

- › Missed demands:  $(176/366) \times 17.5 = 8.8$
- › Fill rate of  $1 - 8.8/20 = 0.58$  or 58%
- › Increased to minimum of 70%
- › So,  $30\% \times 20 = 6$  missed demands
- ›  $17.5 - 6 = 11.5$  missed demands left for SKUs 2 and 3



## Example: SKU 2

| SKU $i$ | Demand<br>forecast<br>$F_D$ | LT Demand<br>uncertainty<br>$MSE_{LT}$ | Holding<br>cost $h$ | $\frac{h \times MSE_{LT}}{\text{criticality}}$ |
|---------|-----------------------------|----------------------------------------|---------------------|------------------------------------------------|
| 2       | 80                          |                                        |                     | 140                                            |
| 3       |                             |                                        |                     |                                                |
| SUM     |                             |                                        |                     | 190                                            |

- › Missed demands:  $(140/190) \times 11.5 = 8.47$
- › Fill rate of  $1 - 8.47/80 = 0.894$  or 89.4%
- ›  $11.5 - 8.47 = 3.03$  missed demands left for 3



## Example: SKU 3

| SKU $i$ | Demand<br>forecast<br>$F_D$ | LT Demand<br>uncertainty<br>$MSE_{LT}$ | Holding<br>cost $h$ | $\frac{h \times MSE_{LT}}{\text{criticality}}$ |
|---------|-----------------------------|----------------------------------------|---------------------|------------------------------------------------|
| 3       | 250                         |                                        |                     | 50                                             |
| SUM     |                             |                                        |                     | 50                                             |

- › Missed demands:  $(50/50) \times 3.03 = 3.03$
- › Fill rate of  $1 - 3.03/250 = 0.988$  or 98.8%



# SAVINGS

| SKU     | Fill rate | Safety stock cost | Total cost | Fill rate | Safety stock cost | Total cost |
|---------|-----------|-------------------|------------|-----------|-------------------|------------|
| 1       | 95%       | 196.7             | 406.7      | 70%       | 10.2              | 220.2      |
| 2       | 95%       | 132.9             | 369.6      | 89.4%     | 71.6              | 308.2      |
| 3       | 95%       | 29.5              | 187.6      | 98.8%     | 68.8              | 226.9      |
| SUM     |           | 359.2             | 963.9      |           | 150.6             | 755.4      |
| SAVINGS |           |                   |            |           | 58%               | 22%        |