SCperf: An inventory management package for R

Marlene Marchena
marchenamarlene@gmail.com

Department of Electrical Engineering
Pontifical Catholic University of Rio de Janeiro - Brazil.

Outline

- Inventory
- The basic Economic Order Quantity (EOQ) model
  - EOQ assumptions
  - Derivation of the model
- Inventory models
- What is `SCperf`?
- `EOQ()` example
- Bullwhip Effect (BE)
  - Measuring the BE
  - Measuring the BE for a generalized demand process
  - `SCperf()`
- Why did we develop SCperf?

Inventory

- What is inventory?

  Stock of items kept to meet future demand

Inventory

- What is inventory?

  Stock of items kept to meet future demand

- Why to hold inventory?

  To protect himself against irregular supply and demand

Inventory

- What is inventory?

  Stock of items kept to meet future demand

- Why to hold inventory?

  To protect himself against irregular supply and demand

- Inventory Control Decisions

  Objective: To minimize total inventory cost

  Decisions:

  - How much to order?
  - When to order?

EOQ assumptions

1. Instantaneous production,
2. immediate delivery,
3. deterministic demand,
4. constant demand,
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

EOQ model

Notation:

D: demand per time unit,

h: holding cost per unit and time unit,

c: unit cost for producing or purchasing each unit.

A: ordering or setup cost,

Q: batch quantity,

T: cycle time$= Q/D$

EOQ model

Notation:

D: demand per time unit,

h: holding cost per unit and time unit,

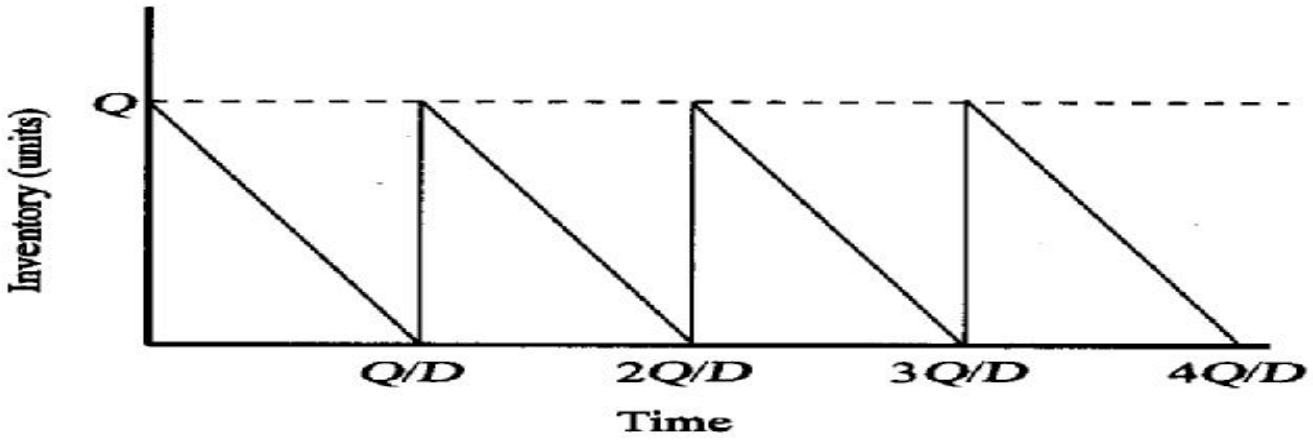
c: unit cost for producing or purchasing each unit.

A: ordering or setup cost,

Q: batch quantity,

T: cycle time$= Q/D$

$$\text{Total cost per cycle } = A + cQ + \frac{hQ^2}{2D}$$



EOQ model

Notation:

D: demand per time unit,

h: holding cost per unit and time unit,

c: unit cost for producing or purchasing each unit.

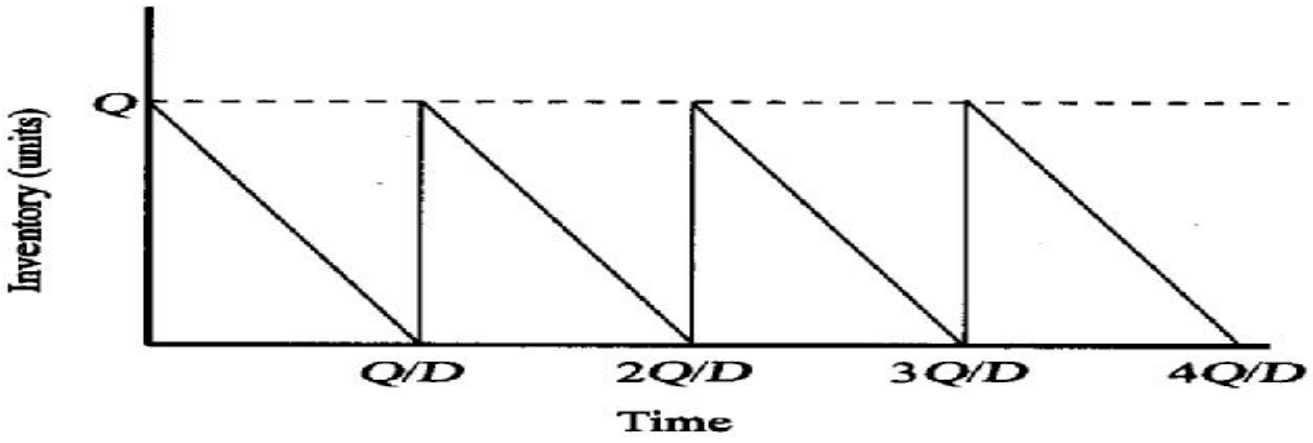
A: ordering or setup cost,

Q: batch quantity,

T: cycle time$= Q/D$

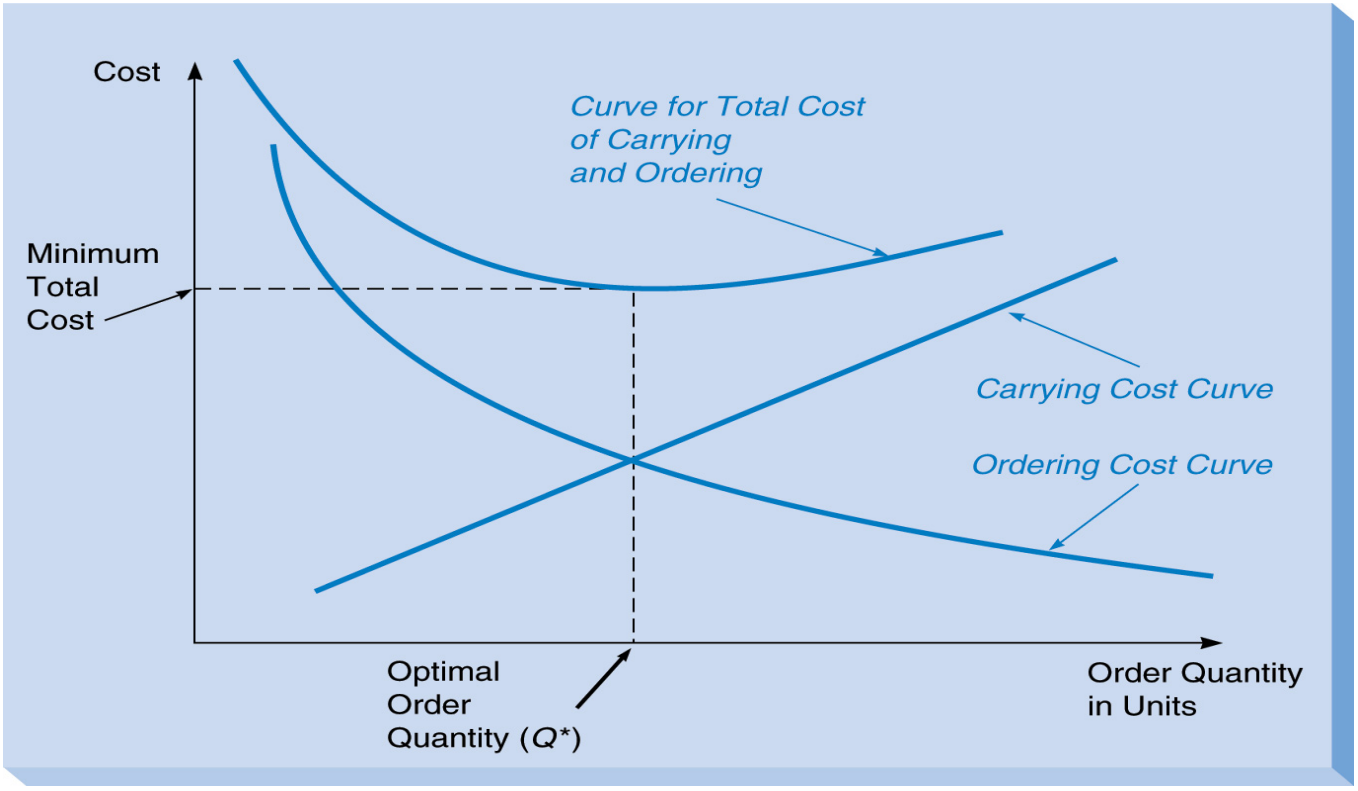
$$\text{Total cost per cycle } = A + cQ + \frac{hQ^2}{2D}$$

$$\text{Total cost per unit time } = \frac{A + cQ + hQ^2/2D}{Q/D} = \frac{DA}{Q} + cD + \frac{hQ}{2}h$$



We have that $\frac{\partial TC}{\partial Q} = \frac{D}{Q}A + \frac{Q}{2}h$,

then $Q_{opt} = \sqrt{\frac{2DA}{h}}$ and $T_{opt} = \frac{Q_{opt}}{D}$



Reorder Point: order when the inventory position is equal to zero.

Modification of the basic model

1. Instantaneous production,
2. immediate delivery,
3. deterministic demand,
4. constant demand,
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery,
3. deterministic demand,
4. constant demand,
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand,
4. constant demand,
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand, $\Leftarrow$ Stochastic demand
4. constant demand,
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand, $\Leftarrow$ Stochastic demand
4. constant demand, $\Leftarrow$ Time-varying demand
5. known fixed setup costs,
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand, $\Leftarrow$ Stochastic demand
4. constant demand, $\Leftarrow$ Time-varying demand
5. known fixed setup costs, $\Leftarrow$ Constraint approach
6. no shortages are allowed,
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand, $\Leftarrow$ Stochastic demand
4. constant demand, $\Leftarrow$ Time-varying demand
5. known fixed setup costs, $\Leftarrow$ Constraint approach
6. no shortages are allowed, $\Leftarrow$ Shortages are allowed
7. single product.

Modification of the basic model

1. Instantaneous production, $\Leftarrow$ Finite production rate
2. immediate delivery, $\Leftarrow$ Lags can be added
3. deterministic demand, $\Leftarrow$ Stochastic demand
4. constant demand, $\Leftarrow$ Time-varying demand
5. known fixed setup costs, $\Leftarrow$ Constraint approach
6. no shortages are allowed, $\Leftarrow$ Shortages are allowed
7. single product. $\Leftarrow$ Multiple products

What is SCperf?

An R package for inventory control.

What is SCperf?

An R package for inventory control.

➢ Inventory models

What is SCperf?

An R package for inventory control.

➢ Inventory models

- ❑ Economic Lot Size Models with Constant Demands

  Economic Order Quantity, `EOQ()`

  Economic Production Quantity, `EPQ()`

What is SCperf?

An R package for inventory control.

➢ Inventory models

- ❑ Economic Lot Size Models with Constant Demands

  Economic Order Quantity, `EOQ()`

  Economic Production Quantity, `EPQ()`

- ❑ Economic Lot Size Models with Varying Demands,

  Wagner-Whitin algorithm, `WW()`

What is SCperf?

An R package for inventory control.

➢ Inventory models

- ❑ Economic Lot Size Models with Constant Demands

  Economic Order Quantity, `EOQ()`

  Economic Production Quantity, `EPQ()`

- ❑ Economic Lot Size Models with Varying Demands,

  Wagner-Whitin algorithm, `WW()`

- ❑ Stochastics Inventory Models

  Newsvendor model, `Newsvendor()`

What is SCperf?

An R package for inventory control.

- Inventory models
  - Economic Lot Size Models with Constant Demands
    - Economic Order Quantity, `EOQ()`
    - Economic Production Quantity, `EPQ()`
  - Economic Lot Size Models with Varying Demands,
    - Wagner-Whitin algorithm, `WW()`
  - Stochastics Inventory Models
    - Newsvendor model, `Newsvendor()`
- Safety Stocks, `SS()`

What is SCperf?

An R package for inventory control.

- Inventory models
  - Economic Lot Size Models with Constant Demands
    - Economic Order Quantity, `EOQ()`
    - Economic Production Quantity, `EPQ()`
  - Economic Lot Size Models with Varying Demands,
    - Wagner-Whitin algorithm, `WW()`
  - Stochastics Inventory Models
    - Newsvendor model, `Newsvendor()`
- Safety Stocks, `SS()`
- Inventory and Supply Chain Management (SCM)
  - The bullwhip effect, `bullwhip()` and `SCperf()`

EOQ() function

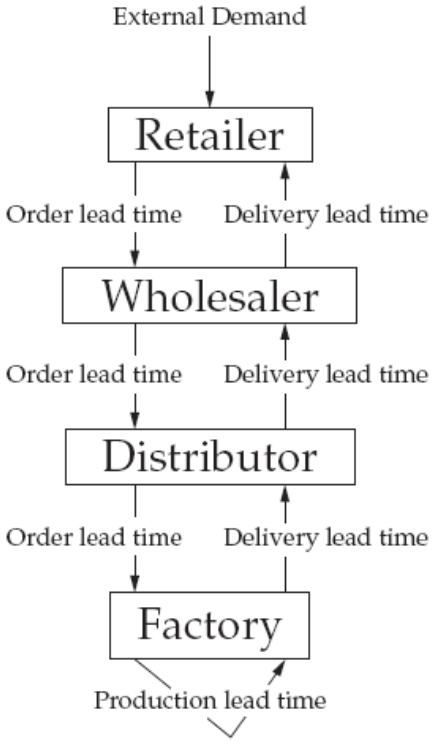
Implements the basic (and with planned shortages) EOQ model

Example:
> EOQ(8000,12000,0.3)

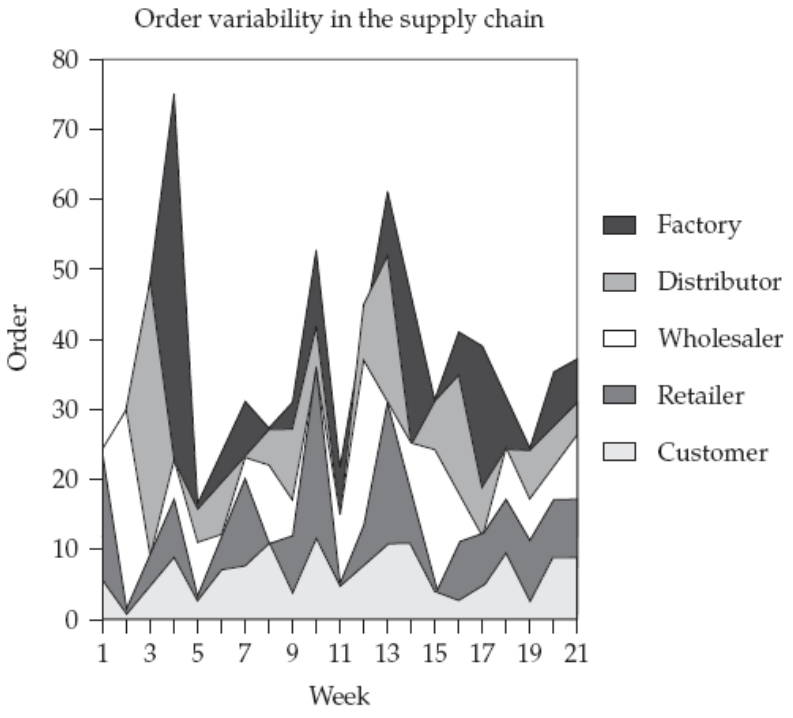
Q	T	TVC
25298.22	3.16	7589.47

The Bullwhip Effect (BE)

Definition: The BE is the increase of the demand variability as one moves up the supply chain.



The supply chain.



The increase in variability in the supply chain.

Quantifying the BE

A common index used to measure the BE is:

$$M = \frac{Var(q_t)}{Var(d_t)}$$

Quantifying the BE

A common index used to measure the BE is:

$$M = \frac{Var(q_t)}{Var(d_t)}$$

- $M = 1$, there is no variance amplification.

Quantifying the BE

A common index used to measure the BE is:

$$M = \frac{Var(q_t)}{Var(d_t)}$$

- $M = 1$, there is no variance amplification.
- $M > 1$, the BE is present.

Quantifying the BE

A common index used to measure the BE is:

$$M = \frac{Var(q_t)}{Var(d_t)}$$

- $M = 1$, there is no variance amplification.
- $M > 1$, the BE is present.
- $M < 1$, smoothing scenario.

Quantifying the BE

A common index used to measure the BE is:

$$M = \frac{Var(q_t)}{Var(d_t)}$$

- $M = 1$, there is no variance amplification.
- $M > 1$, the BE is present.
- $M < 1$, smoothing scenario.

Zhang 2004:

$$M = 1 + \frac{2\sum_{i=0}^{L}\sum_{j=i+1}^{L}\psi_i\psi_j}{\sum_{j=0}^{\infty}\psi_j^2}$$

The model

Inventory model

- Two stage supply chain
- Single item with no fixed cost
- OUT replenishment policy
- MMSE as forecast method

Define:

d_t: demand
L: lead time
$y_t = \hat{D}_t^L + z\hat{\sigma}_t^L$
z: $\Phi^{-1}(\alpha)$
$SSLT = z\hat{\sigma}_t^L$

q_t: order quantity
α: the desired SL
$\hat{D}_t^L = \sum_{\tau=1}^{L} \hat{d}_{t+\tau}$
$\hat{\sigma}_t^L = \sqrt{Var(D_t^L - \hat{D}_t^L)}$
$SS = z\sigma_d\sqrt{L}$

$$q_t = y_t - (y_{t-1} - d_t) = (\hat{D}_t^L - \hat{D}_{t-1}^L) + z(\hat{\sigma}_t^L - \hat{\sigma}_{t-1}^L) + d_t$$

SCperf()

Computes the BE and other SC performance variables.

Usage: `SCperf`(ar, ma, *L*, *SL*)

Arguments:

- *ar*: a vector of *AR* parameters,
- *ma*: a vector of *MA* parameters,
- *L*: is the LT plus the review period which is equal to one,
- *SL*: service level, 0.95 by default.

Example:

> `SCperf`(0.95, 0.1, 2, 0.99)

bullwhip	VarD	VarLT	SS	SSLT	z
1.5029	12.3077	5.2025	11.5419	5.3062	2.3264

Why did we develop `SCperf`?

- Educational purposes:
  to offer to useRs, teachers, researchers and managers a free, open-source, package for inventory control

Why did we develop `SCperf`?

- Educational purposes:
  to offer to useRs, teachers, researchers and managers a free, open-source, package for inventory control

- Managerial purposes:
  might be used as an alternative (or complement) to other SCM commercial packages.

Why did we develop `SCperf`?

- Educational purposes:
  to offer to useRs, teachers, researchers and managers a free, open-source, package for inventory control

- Managerial purposes:
  might be used as an alternative (or complement) to other SCM commercial packages.

- The long-term goal of `SCperf` is to implement the last research in inventory control theory as well as all the state-of-the-art capabilities that are currently available in commercial packages.

Thank you for your attention!

Marlene S. Marchena
marchenamarlene@gmail.com