A Simple and Effective Component Procurement Policy for Stochastic Assembly Systems

A paper by Jeremie Gallien and Laurence M. Wein

Presentation by Theophane Weber

This summary presentation is based on: Gallien, Jérémie, and Lawrence Wein. "A Simple and Effective Component Procurement Policy for Stochastic Assembly Systems." ***Queueing Systems Theory and Applications*** **38 (2), 2001.**

Introduction

- Framework: Procurement policies for assembly systems
- Make to stock / assemble to order
- Uncapacited / capacited suppliers
- Single / Multi items
- Stochastic / Deterministic

Literature review

- Usually capacitated
- When uncapacitated, usually deterministic
- When stochastic, usually algorithmic / computationally intensive
- Glasserman and Wang develop a simple and effective stochastic, multi items system with capacitated suppliers

The problem

- Make to stock
- Uncapacitated suppliers
- Stochastic supply
- Single item, instantaneous assembly

=> Simple and efficient policy

Presentation

- **Model**
- Analysis
- Simulation
- Conclusion

Model

- Suppliers
- Cost and objective
- Policies
- Synchronization assumption

Suppliers

(See Figure 1, page 7, in the Gallien and Wein paper.)

Cost and objective

- Z = steady state RV of the net inventory
- Z^i = component I, cost h_i
- $Z^+ = \max(Z,0)$: finished goods, cost h
- $Z^- = \max(-Z,0)$: backorder, cost b

$$C = h \cdot E[Z^+] + \sum (h_i E \cdot [Z^i] + b \cdot E[Z^-])$$

Policies

Pre specified class:

- Component base stock policies

$$[s_1, s_2.., s_n]$$

- Finished goods base stock policies

$$[S, l_1, l_2,.., l_n]$$

Synchronization assumption

- Assembly performed with components belonging to the same set of replenishement orders
- Typically suboptimal as opposed to asynchronous FCFS behavior

Presentation

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Analysis

- Problem formulation
- Deterministic lead times
- Approximation for solving
- Gumbel distributions and generalization

Problem formulation

Assembly line Queue:

Q=number of replenishments

- Arrival of orders : Poisson(λ)
- Number of servers : infinite
- Service time: $Max(X_i+L_i)$

=> $Q=Poisson(\rho)$, $\rho= \lambda E[max(X_i+L_i)]$

Problem formulation

Steady state inventory and back-order

- Q=Poisson(ρ), ρ= λE[max(X_i+L_i)]
- Z + Q = S
- Z = Z^+ - Z^-

➔ E[Z+]= $e^{-\rho}\sum_{j=0}^{S}(S-j)\cdot\frac{p^j}{j!}$

➔ E[Z-]=E[Z+]-S+ ρ

Problem formulation

Component queue
(queueing network)

(See Figure 3, Equation 5, and Equation 6, all on page 10, of the Gallien and Wein paper.)

Deterministic Lead Times

- Separation of S and $(l_1, l_2.., l_n)$
- For $(l_1, l_2.., l_n)$, S* is the smallest integer such that $P(Q \le S^*) \ge \frac{b}{b+h}$
- Reduction to single variable $l_i = \frac{\rho}{\lambda} - X_i$
- Resolution: $l_i^* = \max_j (X_j) - X_i$
- Interpretation

Approximation

(See page 13, section 3.4, in the Gallien and Wein paper.)

Gumbel CMT1 Lead times

- Problem: How to find an analytical solution?
- $E[\max(X_i+L_i)]$?

- Distribution with CMT property:

The only uniparameter family is the Gumbel univariance family

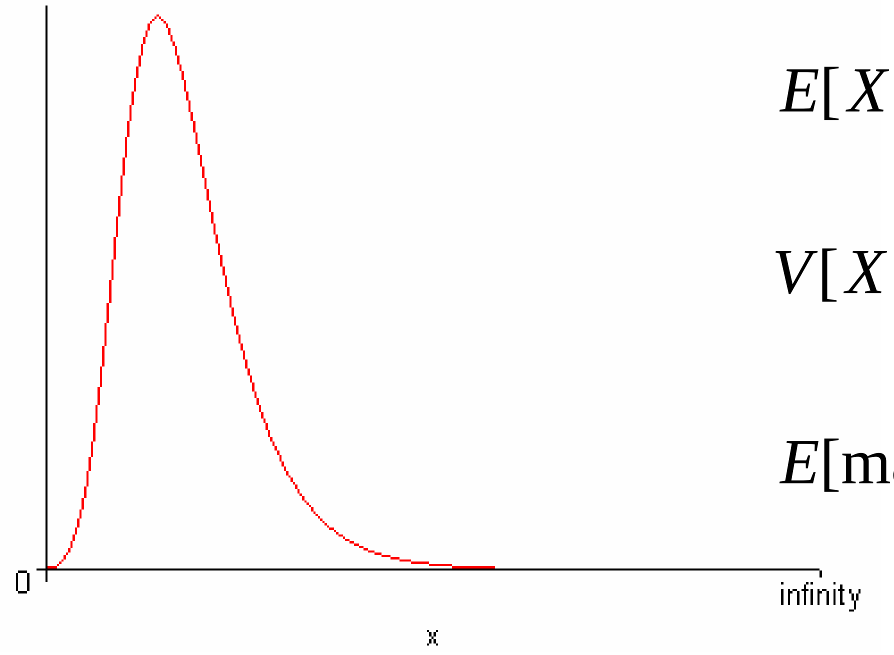
Gumbel CMT1

$$F_m(x,\alpha) = \exp(-\alpha \cdot e^{-m \cdot x})$$

$$E[X] = \frac{\gamma + \ln \alpha}{m}$$

$$V[X] = \frac{\pi^2}{6m^2}$$

$$E[\max(X_i + L_i)] = \frac{\gamma + \ln(\sum \alpha_i e^{m \cdot l_i})}{m}$$



Gumbel CMT1

Gumbel Distributions allow analytical results

$$l_i* = \max(E[X_j] - \frac{\sqrt{6}}{\pi} \cdot \sigma[X]\ln(h_j)) - E[X_i] - \frac{\sqrt{6}}{\pi} \cdot \sigma[X]\ln(h_i)$$

Gumbel CMT2

- Allow different variances
- Numerical results

Presentation

- Model
- Analysis
- **Simulation**
- Conclusion

Simulation

- Data from HP (Appolo 260 in Exeter)
- Five Policies:
  - Proposed
  - Numerical I
  - Numerical II
  - Deterministic
  - Independent

Simulation

(See Figures 4 – 7 in the Gallien and Wein paper.)

Conclusion

- Robust, efficient and simple policy
- Major drawback: Synchronization assumption
- Generalization: multi systems