Spare Parts' Inventory Management Forecasting, Optimization, and Simulation

By: Hadi Mosadegh

Department of Industrial Engineering
Amirkabir University of Technology (Tehran Polytechnic)

An Overview

- ❖ Problem definition
- ❖ Forecasting models
- ❖ Optimization models
- ❖ Simulation models
- ❖ Implementation

Problem Definition

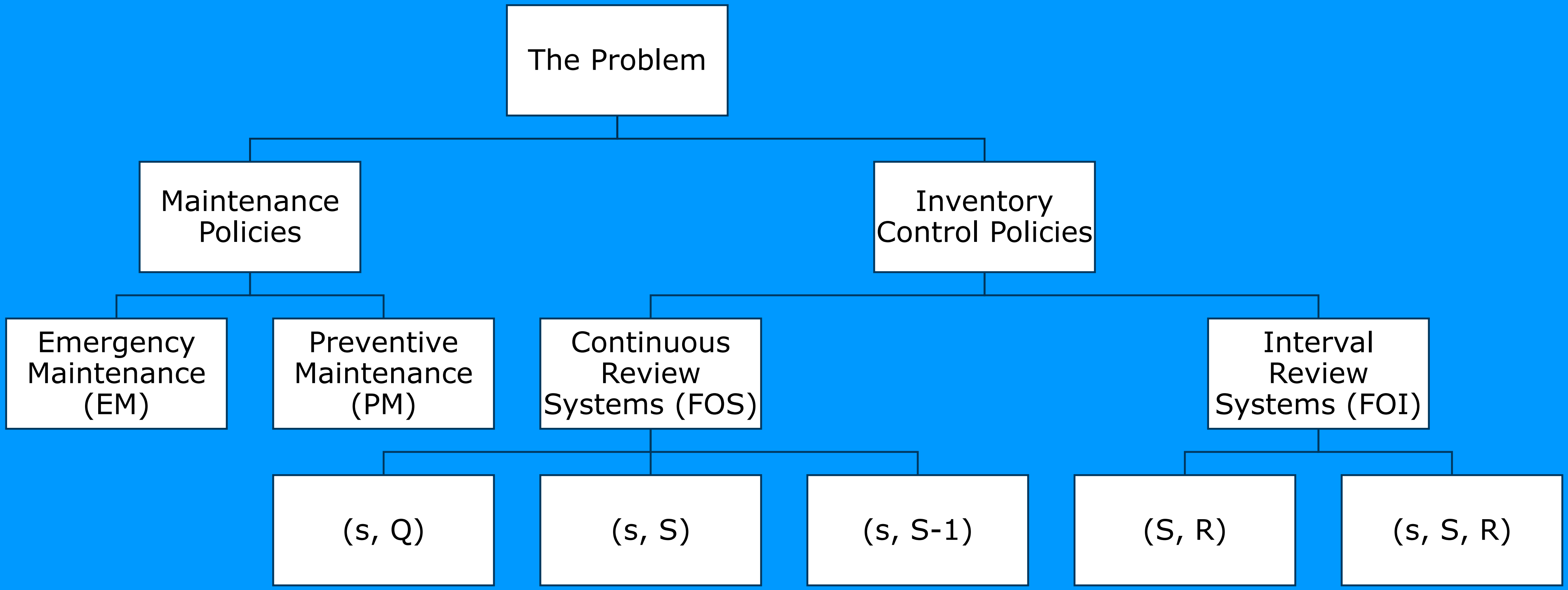
- Maintaining the right amount of each spare part not only controls maintenance costs, but also speeds up the execution and maintenance schedule.

- The problem is to determine an optimal inventory control policy to decide on the time and amount of spare parts order.

- The purpose of this project is to provide a practical model to solve this problem in a car manufacturing company.

- In order to provide a suitable model, maintenance and inventory management issues should be considered.

Maintenance and Inventory Control

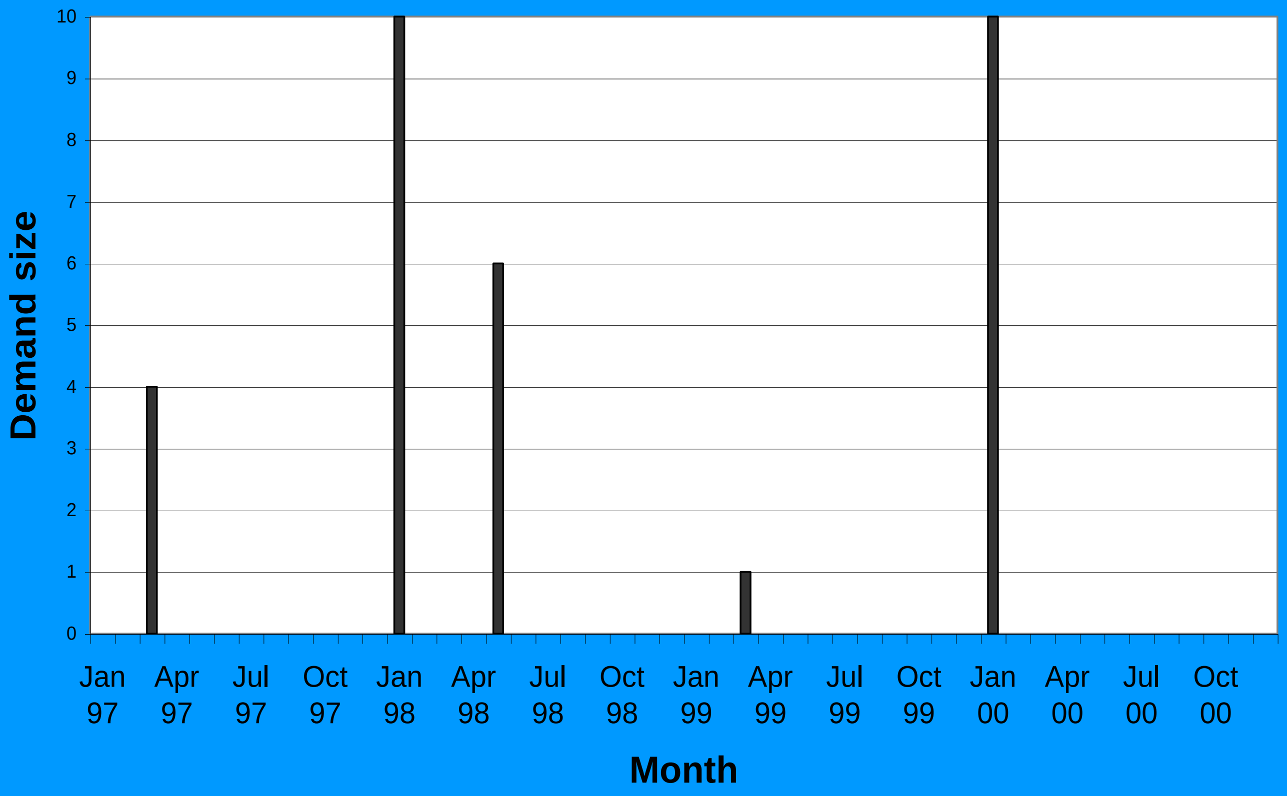


Forecasting of Spare Part’s Demand

	Demand Pattern	Recommended Forecasting Method
High Volume Consumption	Stationary Constant Failure Rate	• Moving Average • Weighted Moving Average • Exponential Smoothing • Linear Regression
Low Volume Consumption	Non-Intermittent	• Moving Average • Exponential Smoothing
	Intermittent	• Moving Average • Croston • Bootstrap

Intermittent Demand

دانشگاه صنعتی امیرکبیر
(پلی تکنیک تهران)



$$\hat{X}_n = \alpha\, x_n + (1-\alpha)\hat{X}_{n^*} \qquad 0<\alpha<1$$

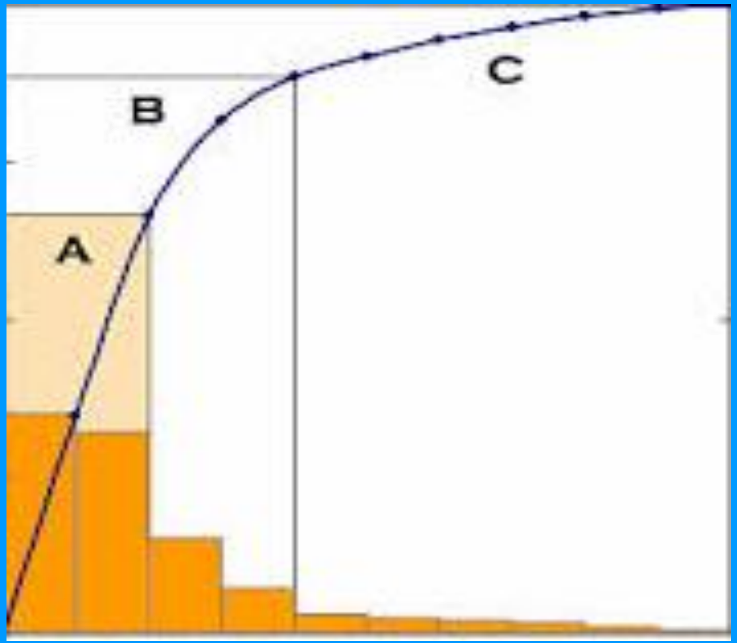
$$\hat{m}_n = \beta(n-n^*) + (1-\beta)\hat{m}_{n^*} \qquad 0<\beta<1$$

$$\hat{X}_{n,n+t} = \left(1-\frac{\beta}{2}\right)\frac{\hat{X}_n}{\hat{m}_n} \qquad t=1,2,3,\ldots$$

ABC Analysis of Spare Parts

- **Recommended inventory control policies based on ABC groups:**

Group	FOS	FOI
A	(S −1, S) or (s,Q)	(R, s, S)
B	(s,Q)	(R, S)
C	EOQ or (s, S)	(R, S) or EOQ



Two-Stage Modeling: (s, Q) Policy

$$\min \sum_{s} P_s \times TC_s$$

$$s.t.$$

$$I^{+}_{t-1,s} - I^{-}_{t-1,s} + Q_{t-L} = d_{t,s} + I^{+}_{t,s} - I^{-}_{t,s} \qquad \forall t,s$$

$$Q_t \le M x_t \qquad \forall t$$

$$TC_s = HC_s + SC_s + OC_s$$

$$HC_s = h \sum_{t} I^{+}_{t,s},\ SC_s = b \sum_{t} I^{-}_{t,s},\ OC_s = A \sum_{t} x_t$$

$$x_t \in \{0,1\} \qquad \forall t$$

$$I^{+}_{t,s},\ I^{-}_{t,s},\ Q_t \ge 0 \qquad \forall t,s$$

Two-Stage Modeling: (S-1, S) Policy

$$\min \sum_s P_s \times \left(h\sum_t I^+_{t,s} + b\sum_t I^-_{t,s} + A\sum_t x_{t,s} \right)$$

$s.t.$

$$I^+_{t-1,s} - I^-_{t-1,s} + Q_{t-L,s} = I^+_{t,s} - I^-_{t,s} + d_{t,s} \qquad \forall t,s$$

$$Q_{t,s} \le Mx_{t,s} \qquad \forall t,s$$

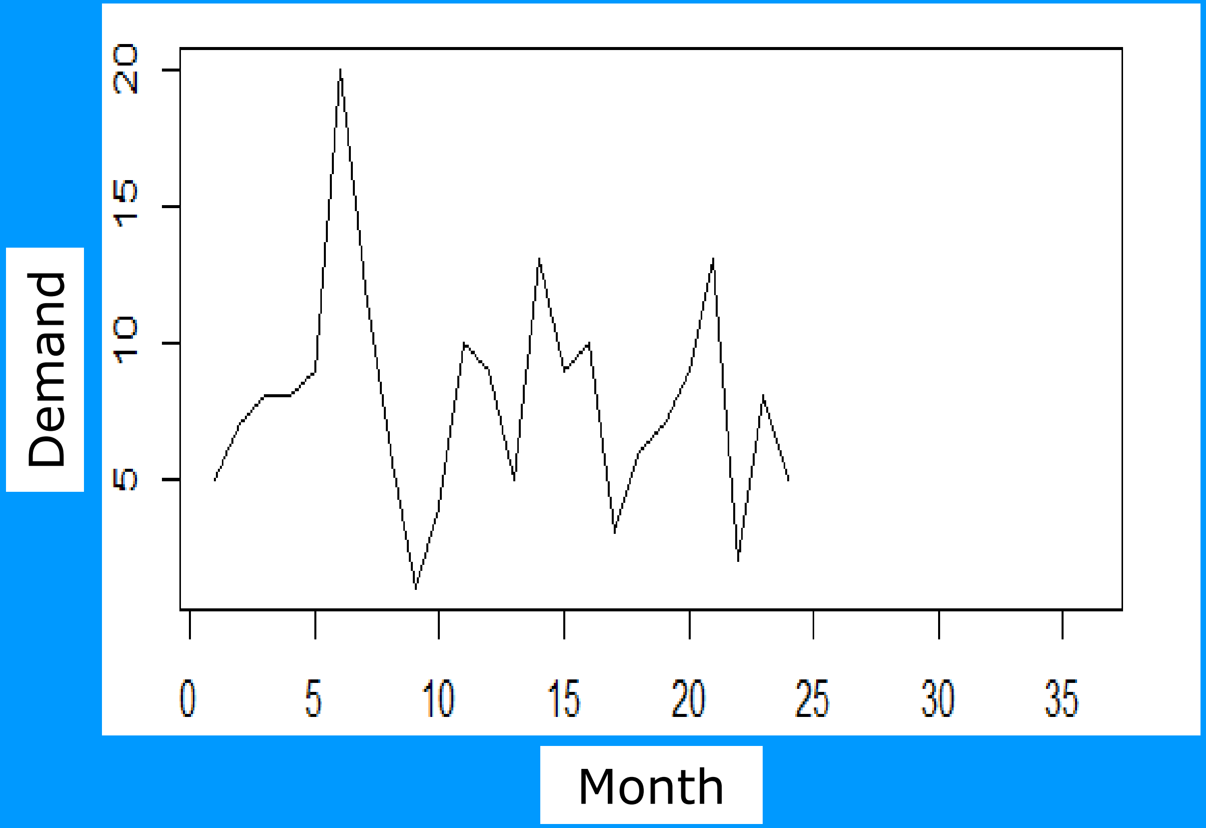
$$S \ge I^+_{t,s} - I^-_{t,s} \qquad \forall t,s$$

$$x_{t,s} \in \{0,1\} \qquad \forall t,s$$

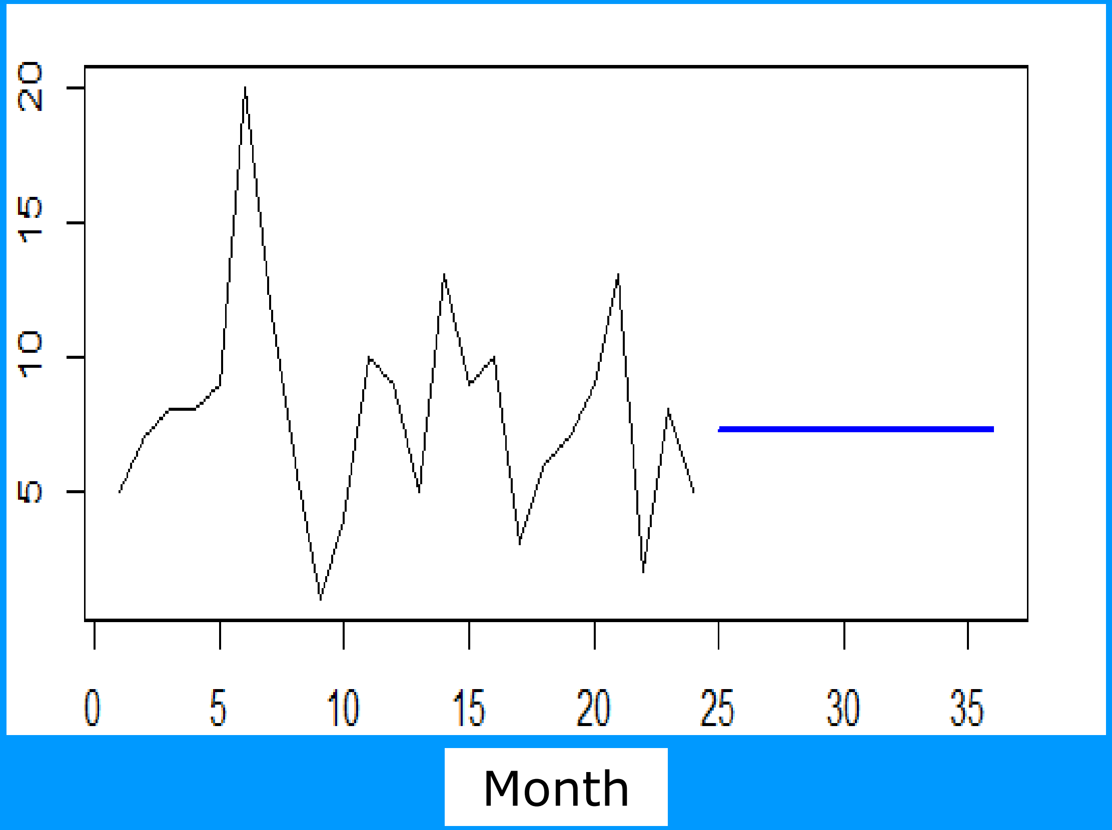
$$Q_{t,s} \ge 0 \qquad \forall t,s$$

$$S \ge 0$$

An Example of forecasting



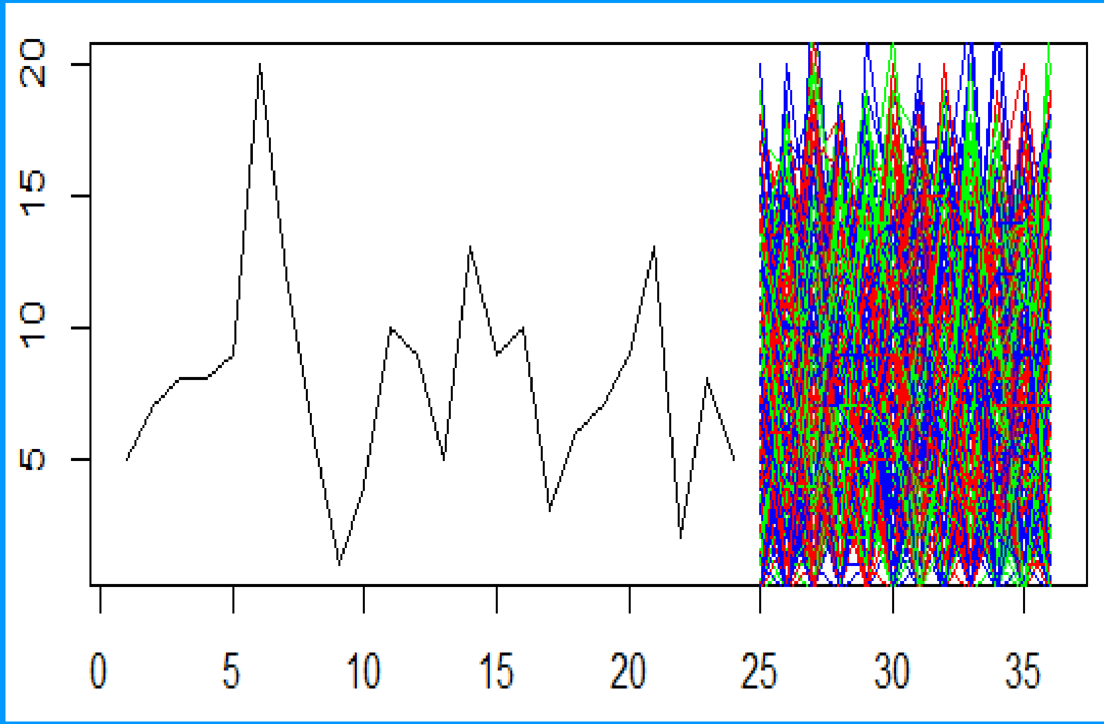
(a) A 12-month historical data



(b) Forecast of the next 12 month

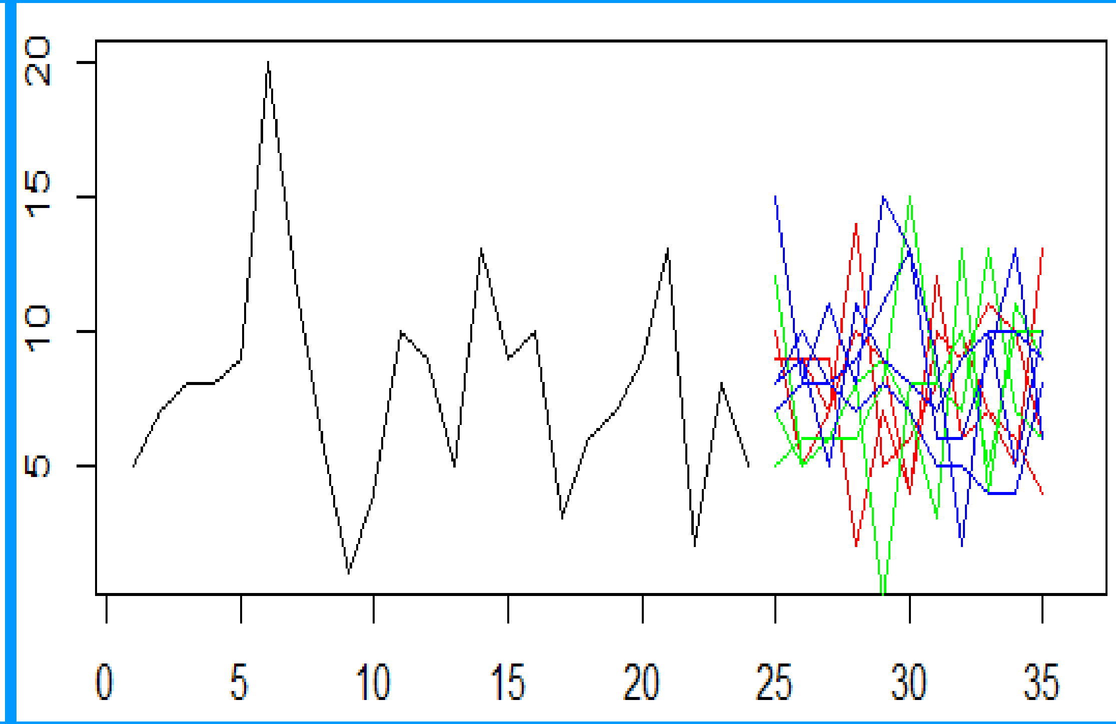
An Example of simulation

Demand



Month

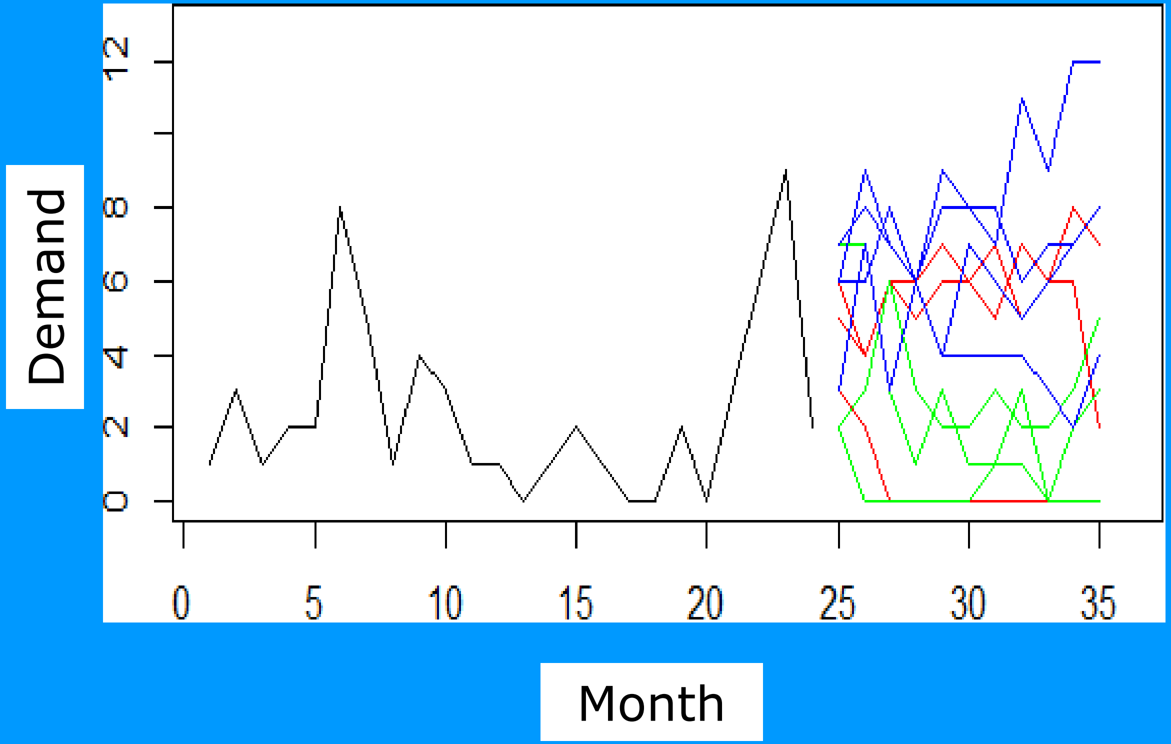
(a) Simulating 1000 scenarios



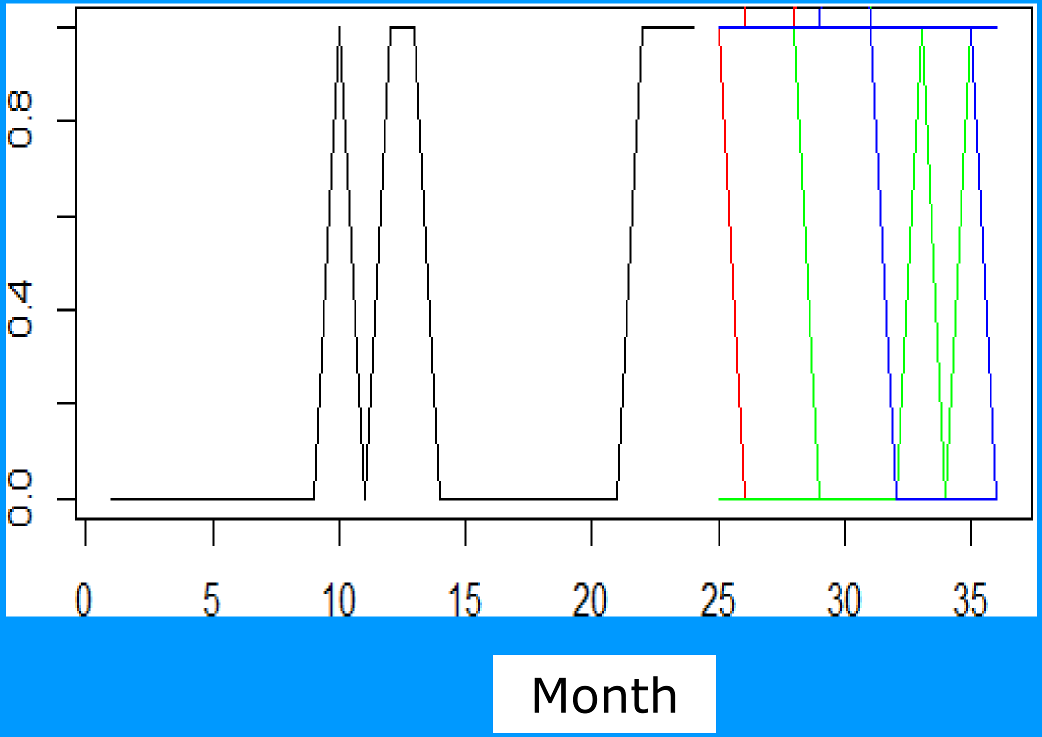
Month

(b) Reducing to 10 scenarios

Non-Intermittent and Intermittent Demands

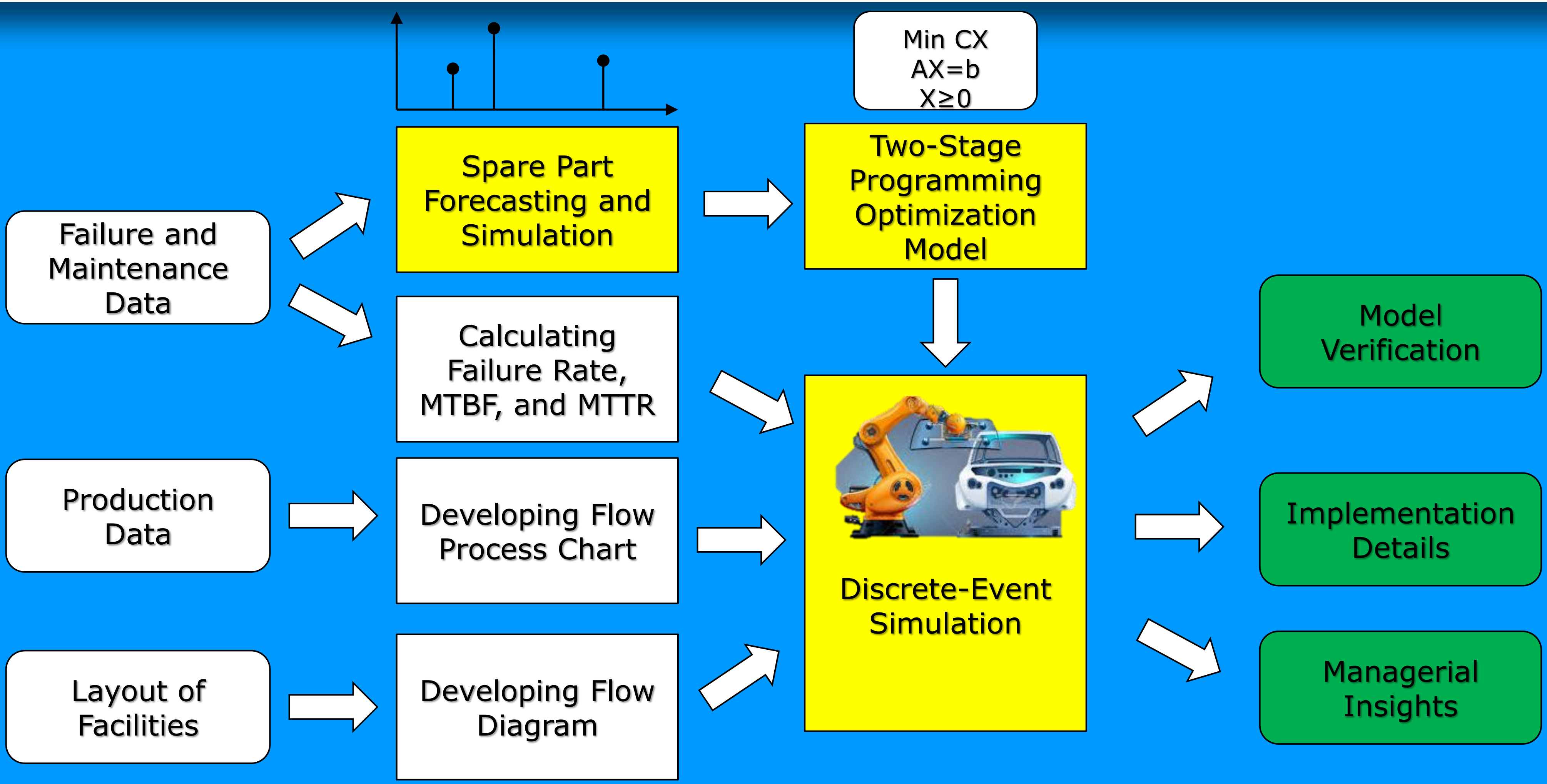


(a) Non-intermittent and stationary pattern

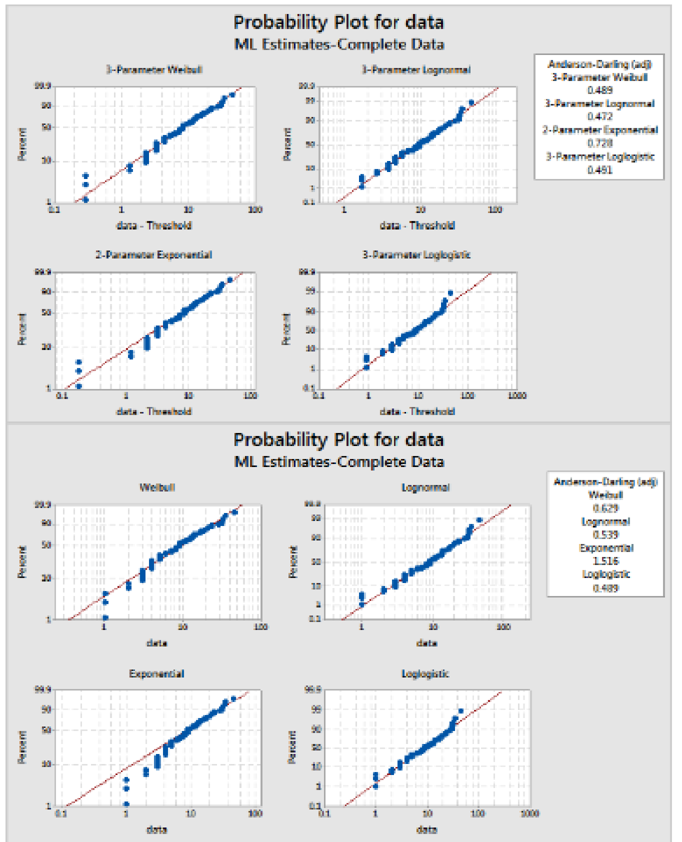


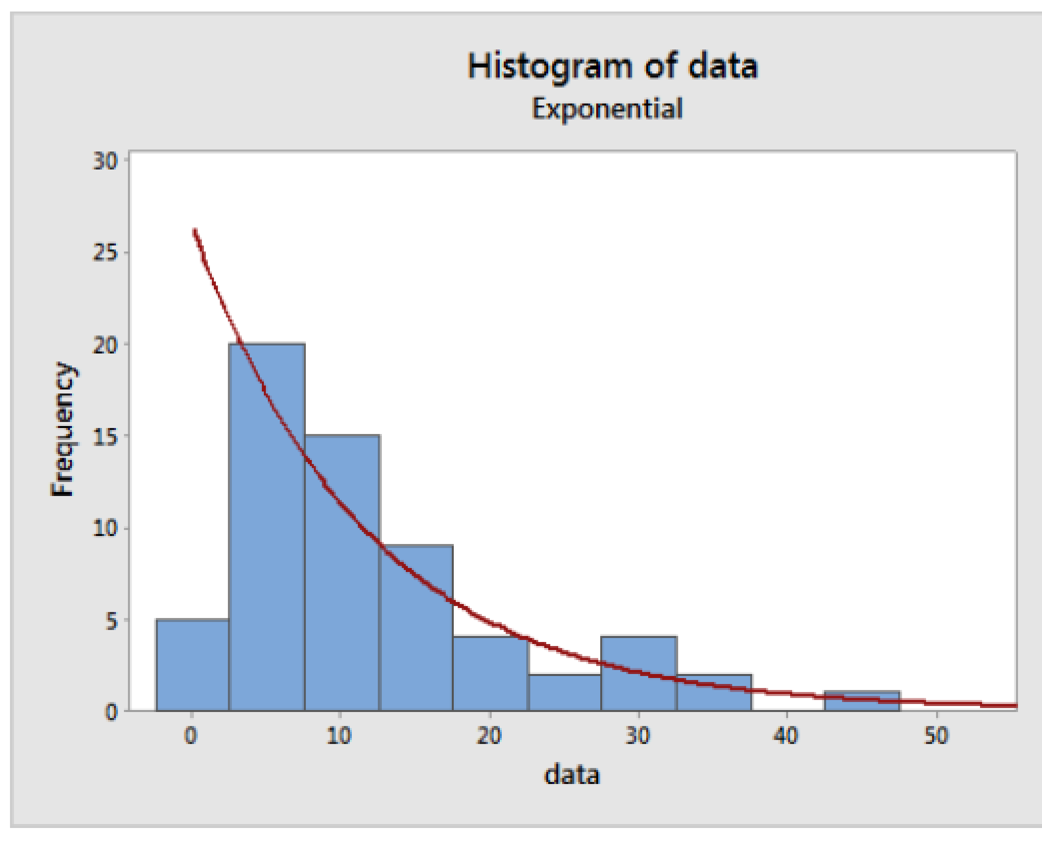
(b) Intermittent and lumpy pattern

The Comprehensive Model

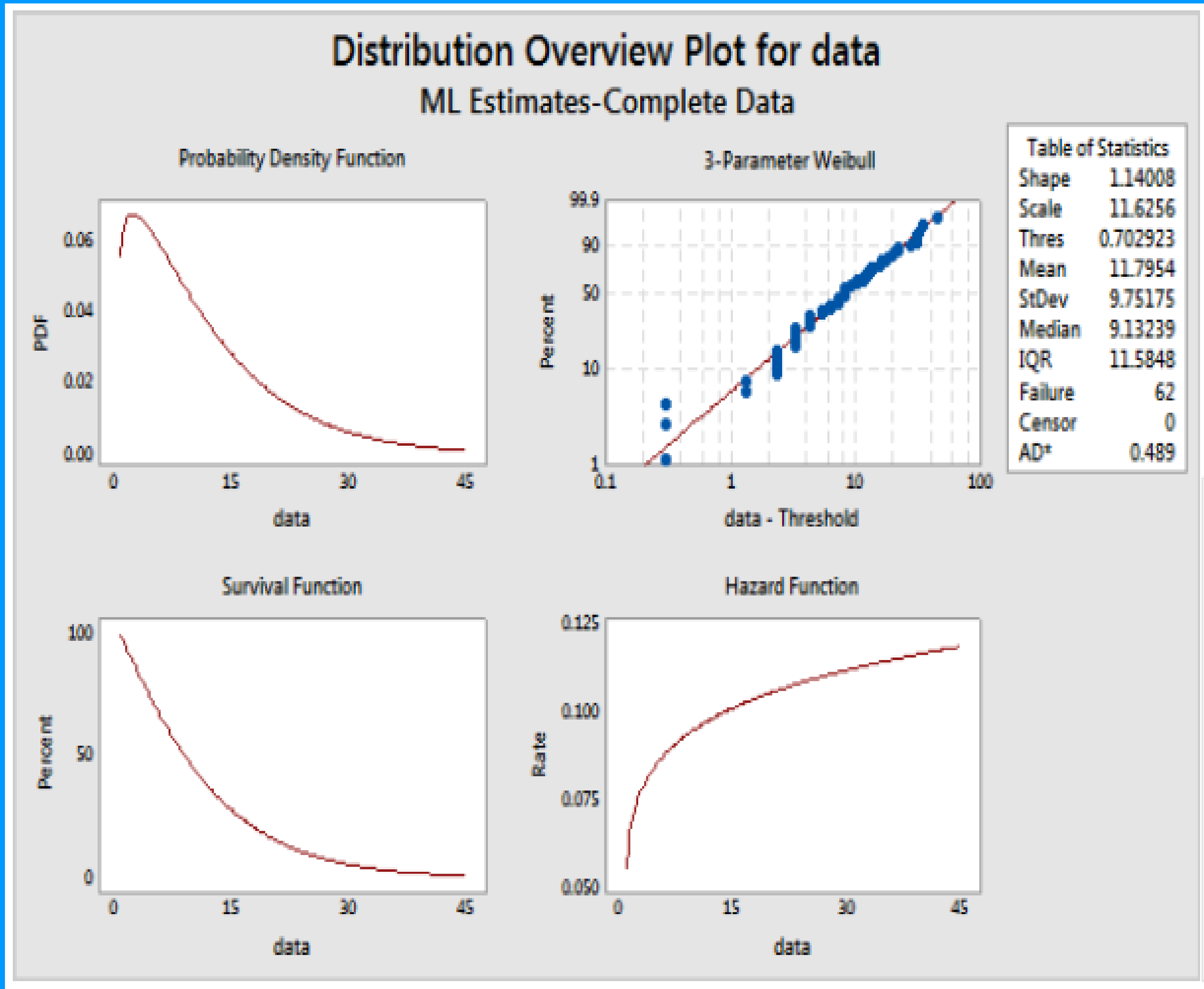


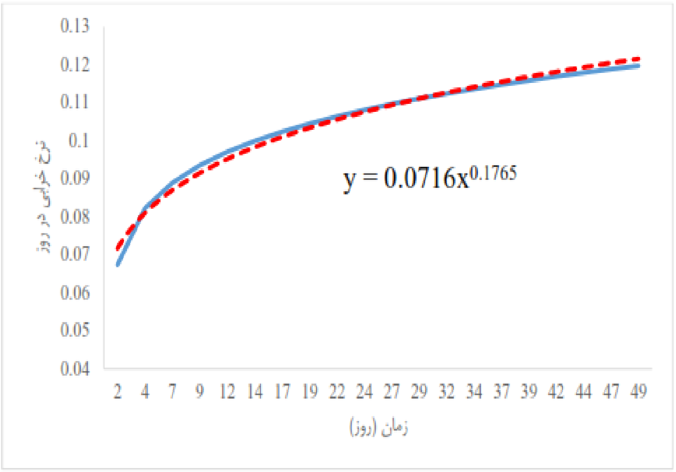
Failure Rate Estimation

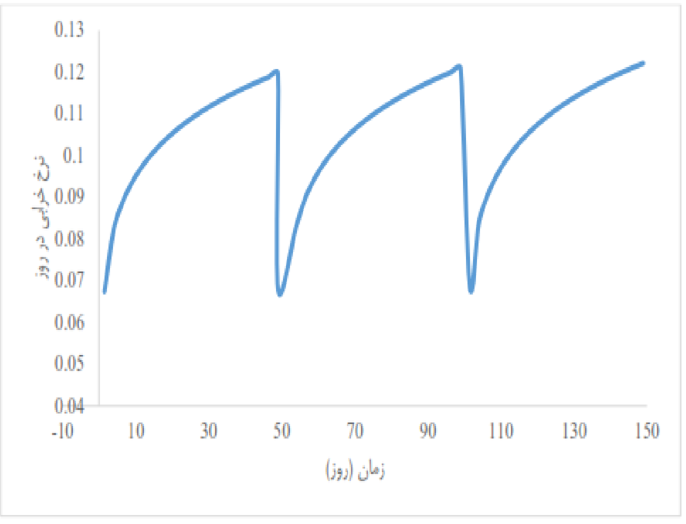




Failure Function Estimation of Robots

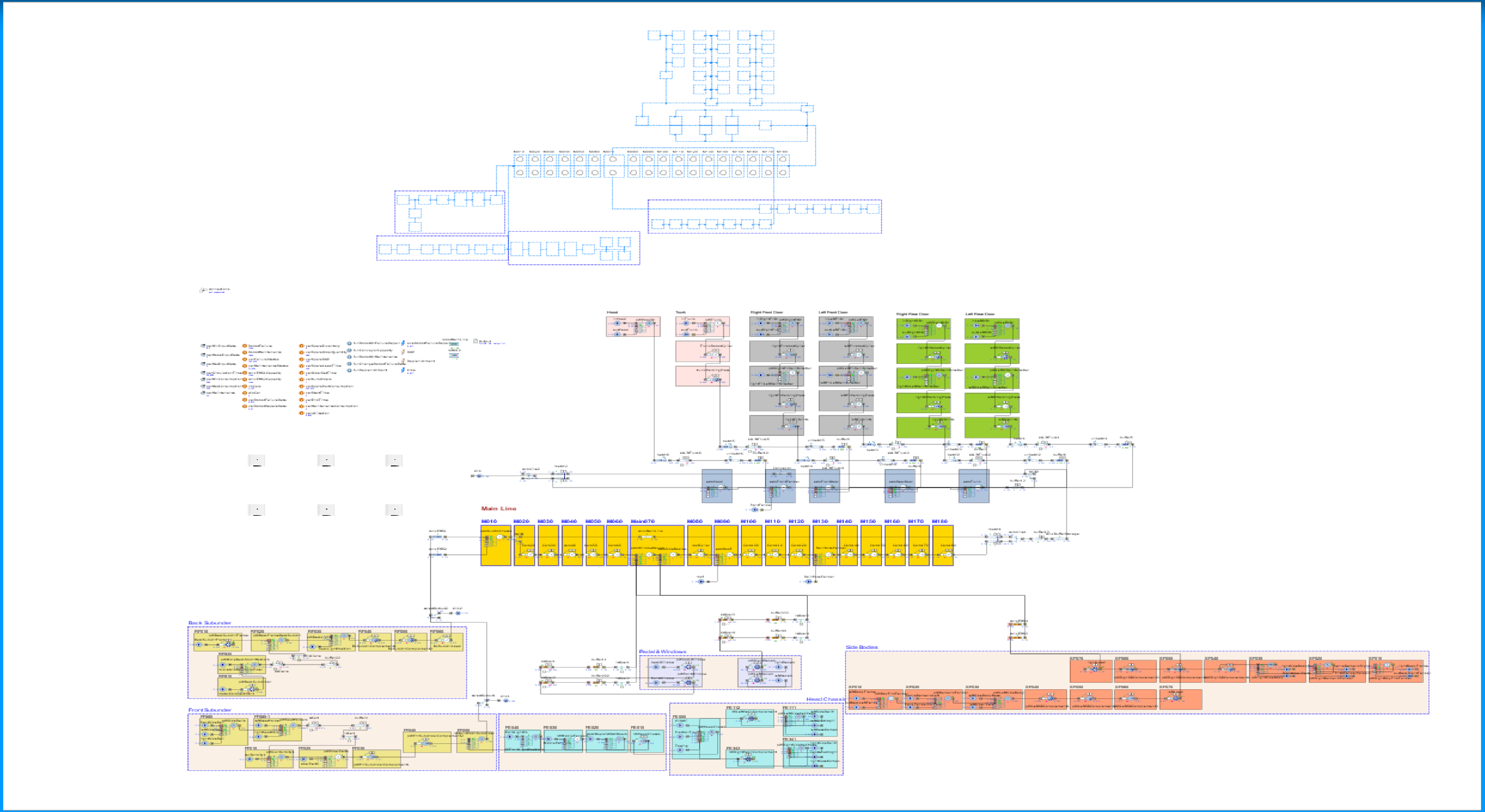




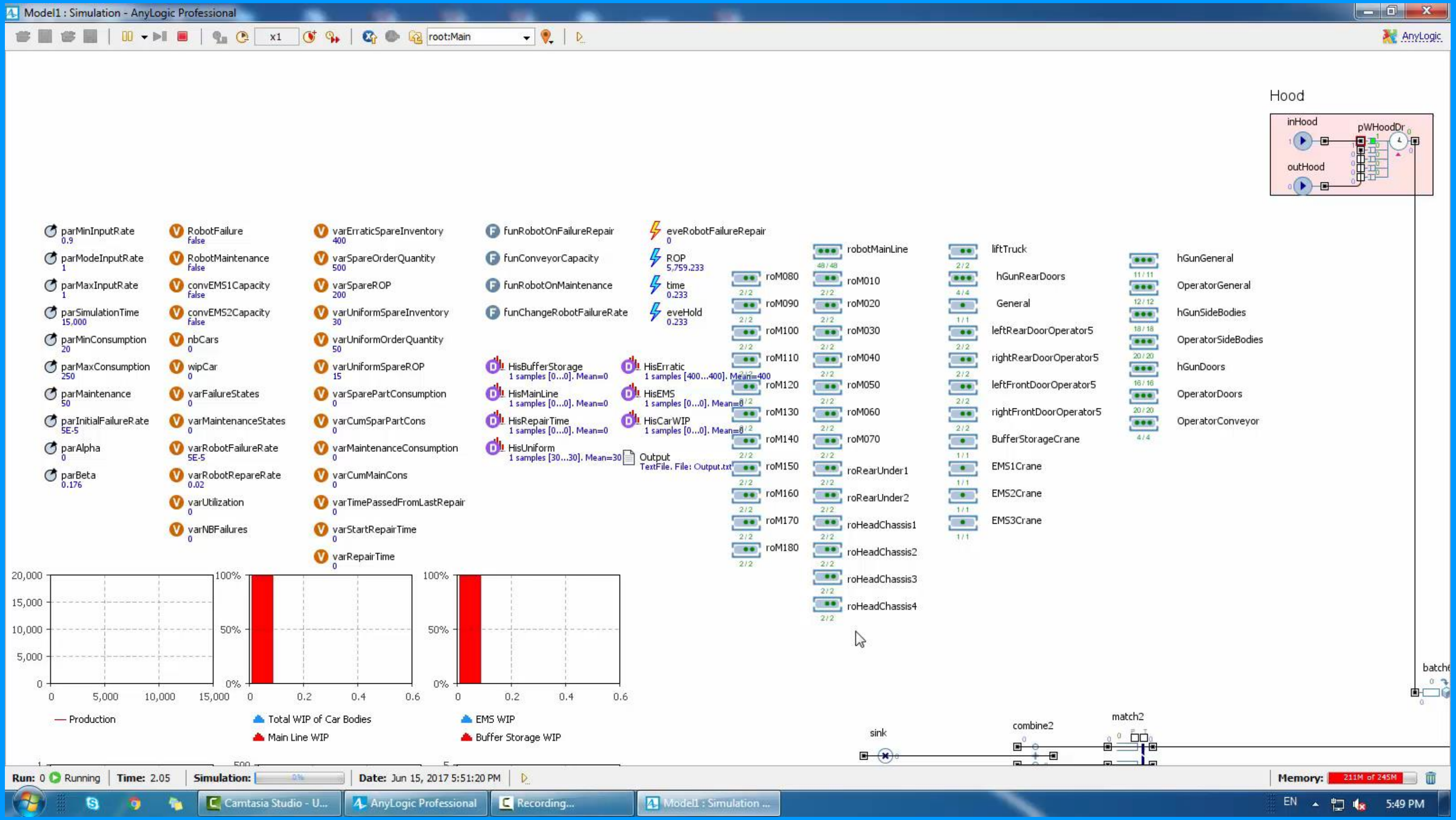


Discrete-Event Simulation in AnyLogic

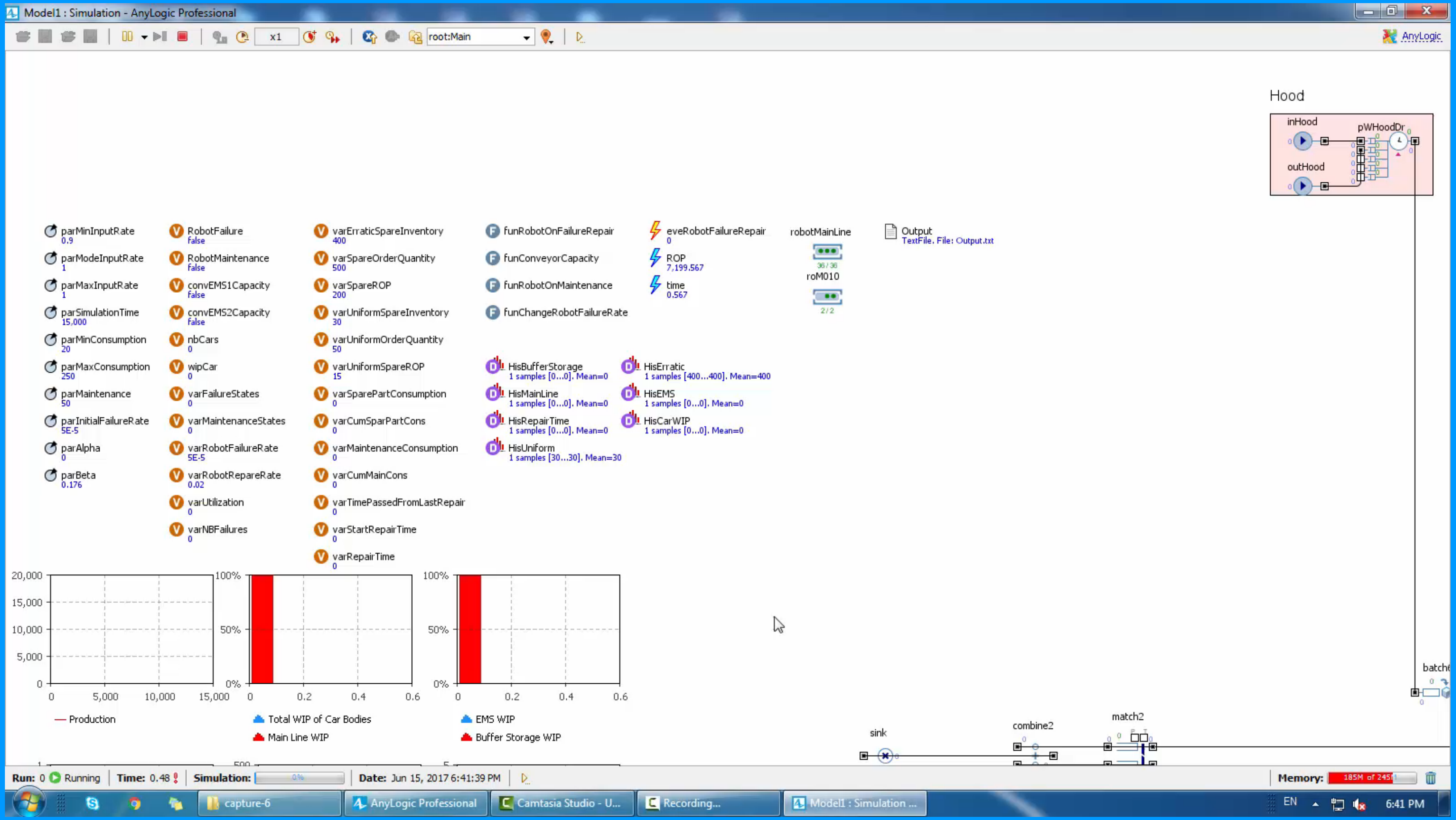
دانشگاه صنعتی امیرکبیر
(پلی تکنیک تهران)



Discrete-Event Simulation in AnyLogic



Discrete-Event Simulation in AnyLogic



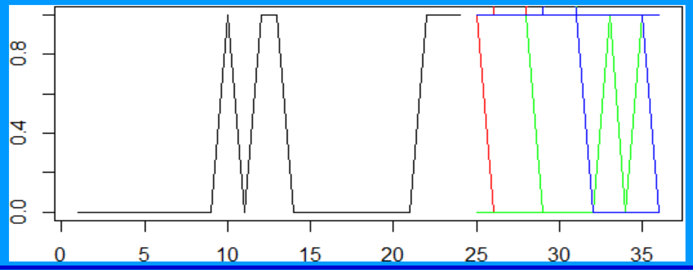
Implementation

Spare Part Card Index

Part Code	Description	Group
-	-	-

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total	Prob. %
Year ?	0	0	0	0	0	0	0	0	0	1	0	1	2	-
Year ?	1	0	0	0	0	0	0	0	0	1	1	1	4	-
Forecast	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2	Croston
Scenario 1	1	1	2	1	2	2	2	2	2	2	2	2	21	12%
Scenario 2	1	0	0	0	0	0	0	0	0	0	0	0	1	9%
Scenario 3	1	1	1	1	0	0	0	0	0	0	0	0	4	6%
Scenario 4	1	1	1	1	0	0	0	0	1	0	1	1	7	4%
Scenario 5	1	1	1	1	1	1	1	2	2	2	2	2	17	9%
Scenario 6	0	0	0	0	0	0	0	0	0	0	0	0	0	6%
Scenario 7	1	1	1	1	1	1	1	1	1	1	1	1	12	38%
Scenario 8	1	1	1	1	1	1	1	0	0	0	0	0	7	6%
Scenario 9	1	1	1	1	1	2	1	1	1	1	1	1	13	6%
Scenario 10	1	1	1	1	1	1	1	1	1	1	1	0	11	6%
Order Quan.	14												14	

Inventory, Lead time and order info				I_0	0
(s,Q)	✓	P	37,000	$\bar{I}$	
(S-1,S)		b	-	s	2
EOQ	✓	h	9,250	Q	14
(R, S)		A	500,000	S	
(R, s, S)		LT	3	R	



دانشگاه صنعتی امیرکبیر
(پلی تکنیک تهران)

Thank you for your attention.

Any questions?