Department of Industrial Engineering
University of Stellenbosch

Simulasie 442 : Simulation 442
2025

MEMORANDUM

Tutoriaal 9 *Tutorial 9*	Punt: 112 *Mark:*	Ingeedatum: **03-10-2025** (10:00) B3003 *Due date:*

Instruksies:	Formatteer alle syfers sinvol. Ontwikkel die modelle individueel. U mag in groepe van **twee** of minder werk om die vrae te beantwoord. Handig slegs een dokument in. Gebruik Tecnomatix en Excel vir u berekenings.
Instructions:	*Format all numbers sensibly.* *Develop the models individually.* *You may work in groups of* ***two*** *or less when answering the questions.* *Submit one document only.* *Use Tecnomatix and Excel for your calculations.*

Question 1: The inventory model [20]

State the:	Inventory Model	
Essence of the problem	Inventory problem with a lead time, reorder level r and reorder quantity Q. Performance measures are service level and inventory cost. The latter is made up of holding cost and reorder cost. We assume acquisition cost is salvaged when the item is sold, and ignore any losses due to interest.	[2]
Objective of the simulation	Multi-objective optimization (MOO) problem. Maximize service level while minimizing total cost.	[1]
Input variables	•Customer inter-arrival times (exponential distribution, mean=3) •Demand with Weibull(1.1,8) •Order lead time - delay in hours between order and delivery in intervals (1:04,1:00,1:16)	[3]
Decision variables	•Reorder level (r) •Reorder quantity (Q)	[2]
Output parameters	•The service level •The inventory cost	[2]
Assumptions made	•Infinite inventory holding area. •The supplier is reliable (as in the order delay is triangular (1:04,1:00,1:16) distributed but the supplier always delivers the required number of units Q)	[2]
Validation considerations	•If the inventory drops too low the customers leave without making a purchase. •See Question 2.2	[2]
/////		
Shannon's world view:		
Entity	Customers	[1]
Attributes	Customer demand	[1]
Resources	Server	[1]
Conditions	FIFO, customer is not satisfied with an alternate number of cokes, must have at least the number needed.	[1]
Events	Customer arrives, customer purchases inventory unit, supplier arrives with reorder quantity Q.	[1]
System State	Average queue length for customers, number of customers served up to time T, number of customer arrivals up to time T, server utilization.	[1]

Question 2: The inventory model [50]

Build the inventory model in Tecnomatix and answer the following questions:

1. Formulate the multi-objective simulation optimisation problem, like (6.13) on p. 96 of the eBook.

[5]

2. Give numerical values for r and Q with graphical evidence of how you verified/validated your model.

[8]

3. Using the `ExperimentManager`, determine the near-optimal (r, Q) combination which will ensure lowest possible inventory cost and highest possible service level.

[10]

4. Plot some scenario outcomes as coordinates (f_1, f_2), where f_1 = Average inventory cost, and f_2 = service level.

[5]

5. How is the service level calculated?

[2]

6. Use the GA Wizard of TPS and find good values for r and Q so that the service level is maximised. State your parameter values.

[10]

7. Use the DBMOSA Wizard provided in the model file `rQwithDBMOSA.spp` and find good values for r and Q so that the inventory cost is minimised and the service level is maximised. State your parameter values.

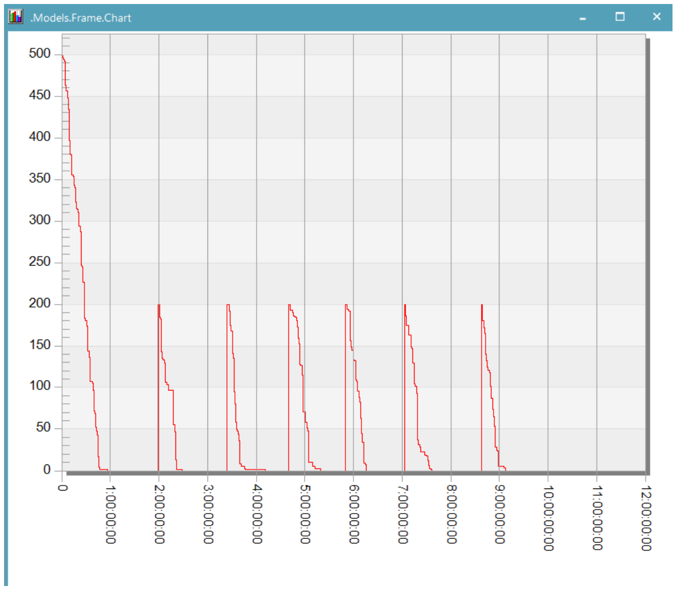
[10]

1.

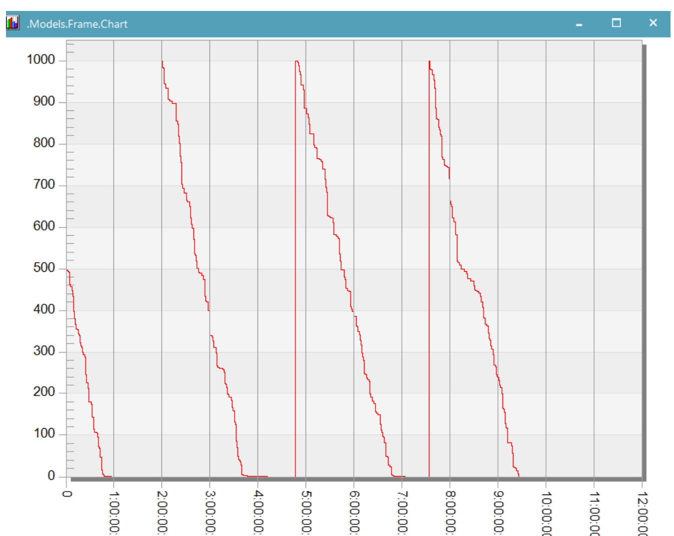
Min	$\mathbb{E}\{\text{Cost}(r, Q, \xi)\}$ (Expected value of cost as a function of r, Q and the stochastic elements ξ) ✓✓
Max	$\mathbb{E}\{\text{Service level}(r, Q, \xi)\}$ (Expected value of service level as a function of r, Q and the stochastic elements ξ) ✓merk
s.t.	$S_F = \{(1, 500); (1, 500)\}$ Both r and Q are limited to the integers in {1,500}. ✓

2. Show inventory-against-time graphs for these, explain the trends. We started the inventory at 500 units each time.

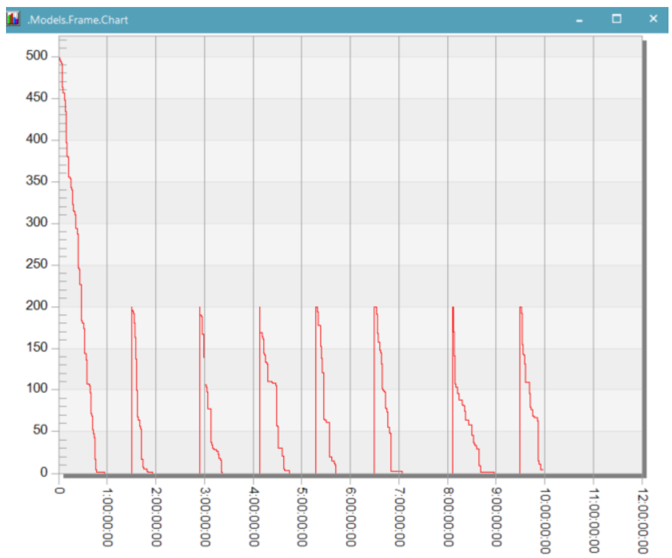
   (a) Run model for low r and low Q ($r = 200$, $Q = 200$). ✓It must yield low SL (38%) and low cost (R1 115). ✓
   Prof explains: The reorder happens too late, and too little is replenished. The cost is mainly due to the many reorders, but little inventory is carried, and many customers are not served.



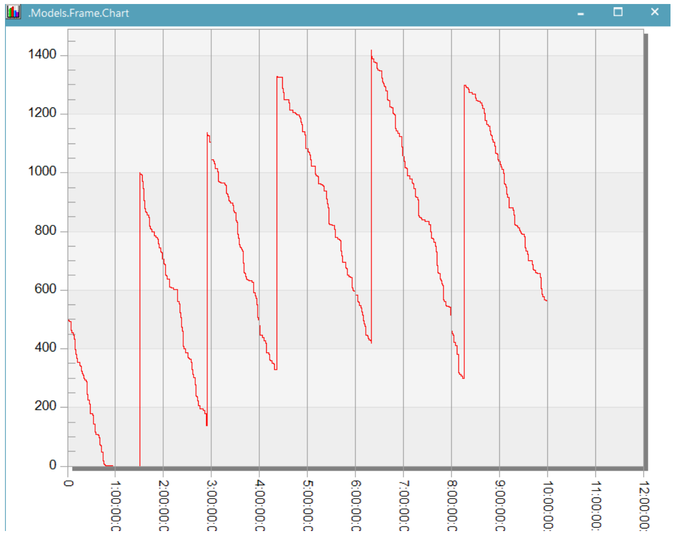
(b) Run model for low r and high Q ($r = 200$, $Q = 1\,000$). ✓It must yield fair SL (65%) and relatively medium cost (R3 500). ✓
Prof explains: The reorder happens too late, but a large replenishment occurs each time. For a long time we can supply the customers, but then run out of stock due to the late reorders. The SL is thus fair, we have fewer reorders, but we carry a significant number of stock items, contributing to the total inventory cost.



(c) Run model for high r and low Q ($r = 800$, $Q = 200$). ✓The SL is low (42%) and the cost is low (R1 220). ✓
Prof explains: The start inventory is at 500, so the model immediately reorders because $r = 800$, but Q is set at 200, so each time we run out of stock we only fill up to 200. The reorder then occurs again, but it does not help our service because we order so few units. The SL is low (42%0, and the cost low (R1 220). The cost is mainly due to the many reorders whille carry cost is low.

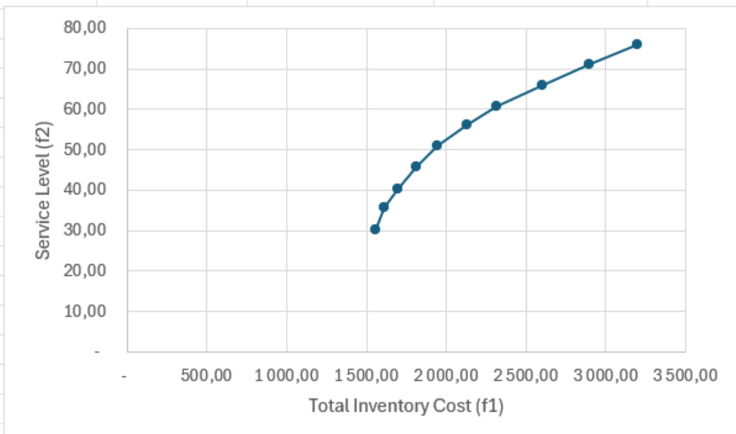


(d) Run model for high r and high Q ($r = 1\,000$, $Q = 1\,000$). ✓The Sl is high (94%) and the cost is high (R8 460).✓
Prof explains: Here we have a wonderful SL but unnecessary inventory cost. We push the inventory level beyond 1 000 units, then reorder each time we go below that level – it contributes to the total cost. It also causes the inventory level to keep on rising, and we carry lots of inventory, adding more cost.



3. There is no single combination. This problem is bi-objective, there are many “good” solutions. The business case will determine which is the best solution. eg: M**aximizing Customer Satisfaction** = Achieve the highest possible service level to ensure customer satisfaction and loyalty. BUT This might involve maintaining higher safety stock levels, which could increase holding costs but reduce the risk of stockouts. VS **Minimizing Inventory Costs** = Reduce holding and reorder costs to the lowest possible level. BUT This could involve optimizing reorder quantities and levels to minimize excess inventory, even if it means a slightly lower service level.

Experiment	ReorderPoint	ReorderQuantity	TotalInventoryCost	ServiceLevel
Exp 01	50	50	1 560,49	30,26
Exp 02	100	100	1 614,75	35,53
Exp 03	150	150	1 699,91	40,38
Exp 04	200	200	1 811,37	45,62
Exp 05	250	250	1 943,61	50,95
Exp 06	300	300	2 127,66	56,13
Exp 07	350	350	2 315,26	60,84
Exp 08	400	400	2 601,06	66,03
Exp 09	450	450	2 892,68	71,09
Exp 10	500	500	3 195,97	75,87



4.

5. $S_L = \frac{\#\text{Customers serviced}}{\text{Total customers arrived}}$

6. Marks for the parameters in the GA Wizard; is the answer reasonable?

7. Marks for the parameters in the DBMOSA Wizard; are the answers reasonable?

Question 3: The Sawmill model [20]

State the:	Inventory Model	
Essence of the problem	The Sawmill model aims to balance efficiency. If the bin size is too small, incoming logs are diverted and lost or if the conveyor is too slow, the throughput drops. The goal is to maximise the processed volume while minimising the costs.	[2]
Objective of the simulation	Multi-objective optimization (MOO) problem. Maximize average volume processes while minimizing total cost.	[1]
Input variables	•Day length • Log length • Log radius • Log arrrival rate • Processing times of machines • Buffer size	[3]
Decision variables	• Speed of 10 m conveyor • Speed of 8 m conveyor • Bin size •Peel rate	[2]
Output parameters	• Average volume of wood processed per shift • Cost of resources • Number of logs lost	[2]
Assumptions made	• Handling times are negligible. • A partial load may be accepted, *i.e.* if 12 logs arrive, but there are seven spaces in the bin open, they are filled and the remaining five logs are discarded. • Sufficient personnel are present and do not affect operations. • Equipment are ideal and do not fail or stop for maintenance during the day. • The setup time at the peeler is does not vary much and is taken as fixed with a value of 12s.	[2]
Validation considerations	• The bin capacity may not be exceeded. • The conveyor capacities may not be exceeded. • The volume of material must balance, *i.e.* the volume processed at the end of the day must equal the volume received.	[2]
/////		
Shannon's world view:		
Entity	Logs	[1]
Attributes	Length and radius	[1]
Resources	Bin (Space in), Conveyors, cutting machine, peeling machine	[1]
Conditions	Given there is space in the bin, FIFO for conveyors and machines, except when logs are shorter than 2m.	[1]
Events	Cutting logs to desired sizes	[1]
System State	Machines utilization, throughput at time T	[1]

Question 4: The Sawmill model [22]

Run the experiments as given by the *ExperimentManager*. There should be 72 Experiments. *Please change the model run-time to 8 hours.*

1. Find the best combination for the peel rate, bin size, and the two conveyor speeds to maximise throughput.

   [8]

2. Find a good combination of the peel rate, bin size, and the two conveyor speeds to maximise throughput while simultaneously minimising the cost. (For this question you may need to use the Excel workbook `FilterParetoFront_Extended.xlsm`).

   [10]

3. Given that the sawmill sells the veneers for $R50/\mathrm{m}^3$, determine the best combination of peel rate, bin size, and the two conveyor speeds by reformulating the problem as a single-objective optimisation problem.

   [4]

Question 4.1

From the CI chart, we can clearly see that Experiments with a bin size of 1 do not yield a good throughput; therefore, these experiments can be discarded. ✓✓

Exp 68 and 72 result in the highest throughput of 71.53. These are statistically significantly different from Exp 14, 18, 22, 50, 54, and 58, since $p < \alpha$, where $\alpha = 5\%$. ✓✓

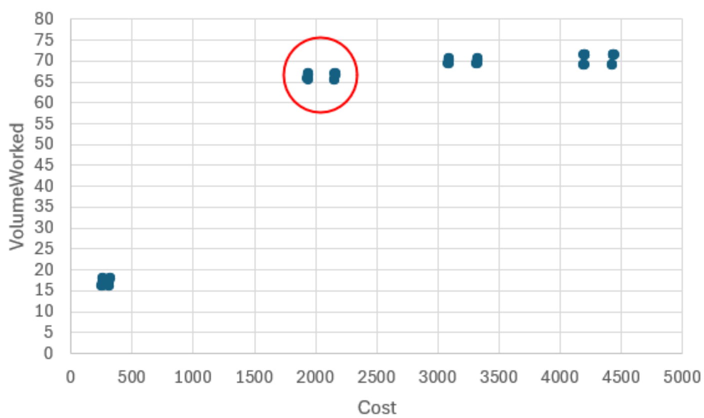
From the remaining experiments, Exp 46 yields the lowest cost at $R1937.03$. Therefore, configuration 46 will perform similarly to Exp 68 and 72, but at a lower cost. ✓✓

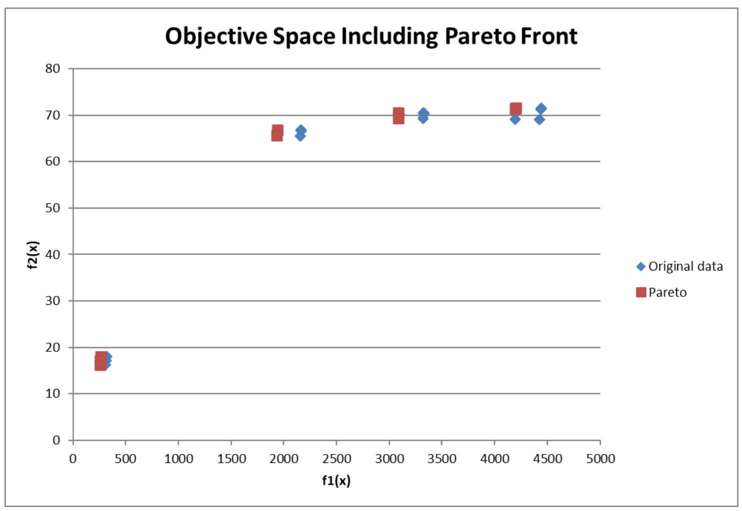
The recommended combination (Exp 46) is therefore: Peel rate = 1, Conv10 speed = 0.4, Conv8 speed = 1.2, Bin size = 12. ✓✓

Question 4.2

When plotting the Cost($f1(x)$ to the VolumeWorked ($f2(x)$, we can see that a good combination will fall within the cluster circled in red. When extracting the Pareto front, we can see that a good combination would yield $\pm R2000$ and $\pm 65m^3$. ✓✓

Experiments 58, 54, 46, 42, 70, 50, 66, 38, 62, 22, 18, and 14 would be a good combination. ✓✓





Question 4.3

To formulate this into a single objective, we need to calculate and use the profit as the objective.
The profit uses the following formula: Profit = (50 × VolumeWorked) - Cost.✓✓
By doing this we will find that Exp 46 gives the highest profit of $R1\,407.22$. ✓✓

Total: Cross-check: 112