IE 630: Simulation Modelling and Analysis

Report: Assignment

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Topic Assigned Topic 2 with Addendum Option C

Key Pointers Given

- ❏ (M, L) inventory system where (M-I) items ordered whenever inventory level I < L
- ❏ M is maximum inventory level | L is reorder point
- ❏ Backordering allowed at a cost of $4 per item short per month
- ❏ Initial inventory level = 50 units
- ❏ Holding cost = $1 per unit per month
- ❏ Cost of an order of Q units = $(60 + 5Q) | Cost of each item = $5 | Ordering cost = $60
- ❏ Lead time of orders given by uniform distribution on [0.25, 1.25] months
- ❏ Time between demands ~ Exponential (mean = 1/15)
- ❏ Size of demand as per distribution given.
- ❏ Selling price of items as per table given, based on time in shelf (in months)
- ❏ Any item on the shelf for > 2 months discarded and cannot be sold.

Required

- ❏ Estimate long run mean monthly cost and profit with 90% confidence interval
- ❏ Estimate total number of replications needed to estimate mean monthly cost within $5. Run the model the required number of replications and construct the CI.
- ❏ For the addendum, keep Factor2 at Level 1, and Factory 5 at Level 1. Compare the performances of systems across the design points of F1, F3 and F4 (total 8 combinations). Also, find the minimum mean monthly profit combination of M and L such that Fill Rate is >= 99%.

Assumptions

In our model, we have assumed the following:

- The backorders are sold at a price of $10, with a backorder cost keeping account of the number of months the said order remained unsatisfied. The backordering cost is computed as $ (4*Number of months order is unsatisfied).
- Fill rate is defined as the number of demands that were fulfilled with the existing inventory, divided by the total number of demands observed times 100.
- Warmup period is taken as 12 months in all the runs, i.e. we start storing the revenue, cost and fill rate calculations after the initial 12 months.
- While finding the best (M, L) pair for minimum cost and fill rate > 99%, we take the search space for M to be [50, 150] and that of L to be [30, 140]. (We observed that taking any parameter outside this search space only increased the cost to a great extent)

Question (a)

We have a warm up period of 12 months, followed by a 100- month simulation period. The results obtained are based on the values obtained after the warmup period.

The results obtained are as follows:

- Long-run mean Monthly Cost : **245.052448**
- 90% CI for mean Monthly Cost : **[231.481328, 258.62356]**
- Long-run mean Monthly Profit: **-10.424129**
- 90% CI for mean Monthly Profit : **[-15.7241, -5.1241]**

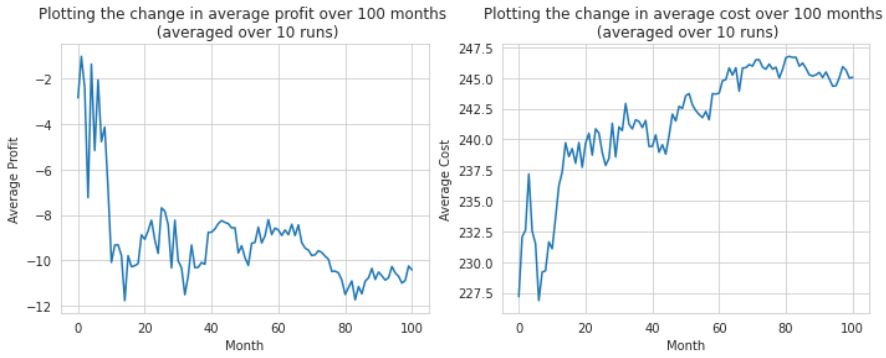


Fig 1: Plotting the change in cost and profit over the simulation period

Comments: We observe a negative average profit of the firm in the long run, and a large average cost.

Question (b)

We are now required to obtain the total number of replications that would estimate the mean monthly cost within $5.

- For the particular run that is being reported, the required number of replications came out to be **33**
- The 90% CI for mean Monthly Cost obtained by running the model for 33 replications is **[228.716, 238.144]**
- The long-run mean Monthly Cost for 33 replications is obtained as **233.4305**
- Estimate of the Average monthly profit: **-12.3203**
- 90% Confidence interval for average monthly profit: **[-14.448, -10.192]**

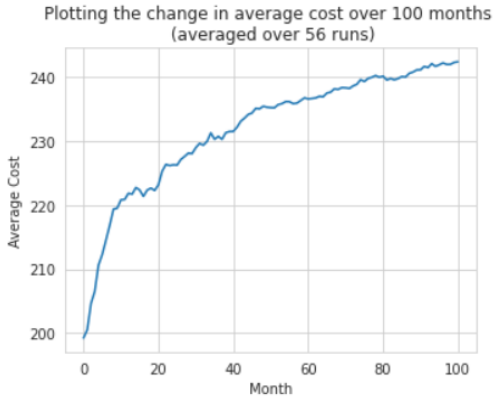


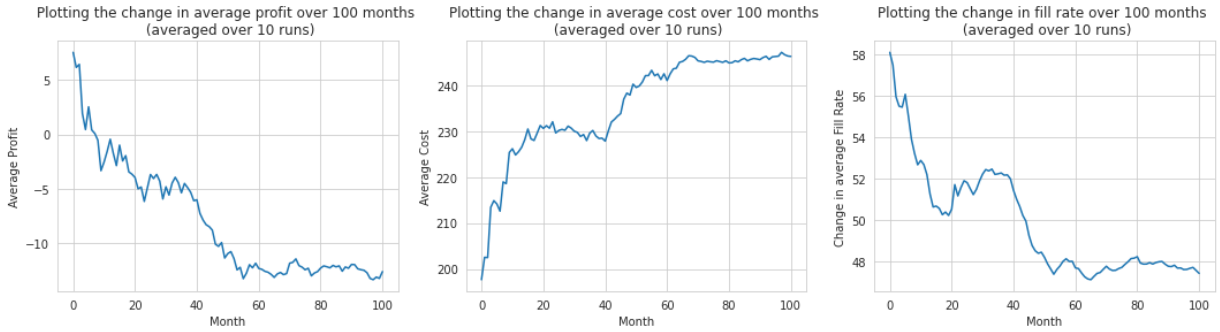
Fig 2 : Plotting the change in cost over the 100 months for 56 replications

Question (c)

Here, we look at comparing alternatives over different choices of M (50 and 100), L (30 and 40) and inventory policies (monthly review and continuous review). We assume that all the excess demand will be backordered.

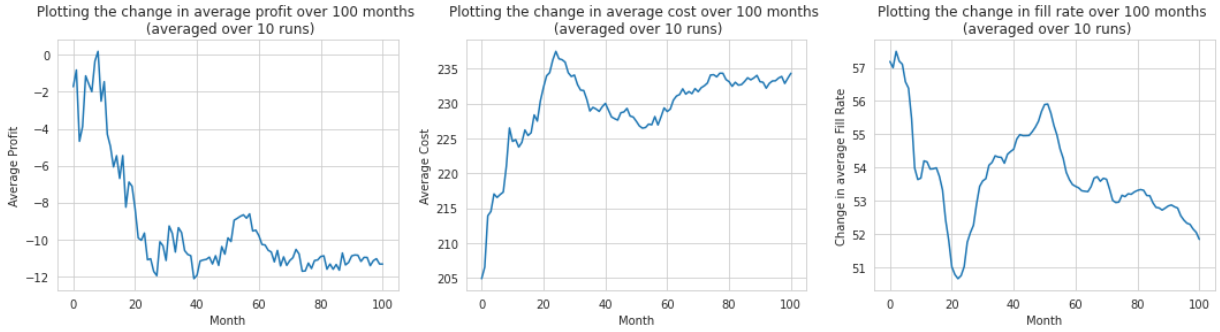
We summarize our findings from each of them below:

Case 1: Monthly review, M = 50, L = 30



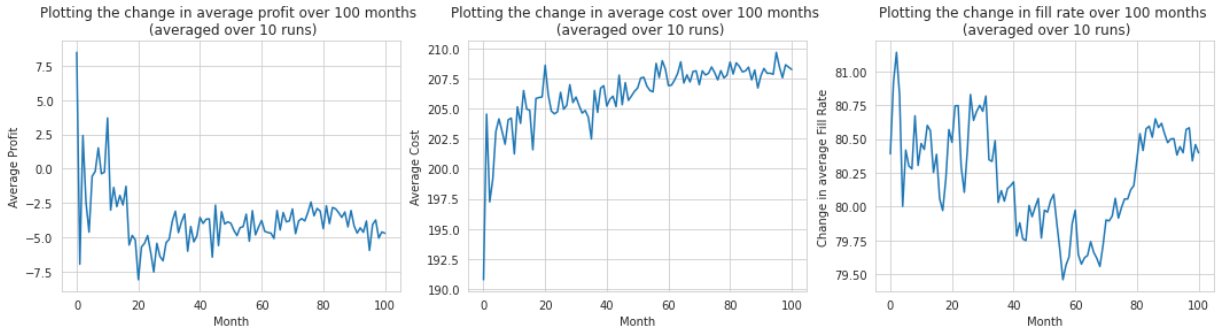
- Estimate of the Average monthly profit: **-12.602**
- Estimate of the Average monthly cost: **246.301**
- 90% Confidence interval for average monthly profit: **[-17.323, -7.88]**
- 90% Confidence interval for average monthly cost: **[236.546, 256.056]**
- Average Fill Rate at the end of 100 months: **47.445%**

Case 2: Monthly review, M = 50, L = 40



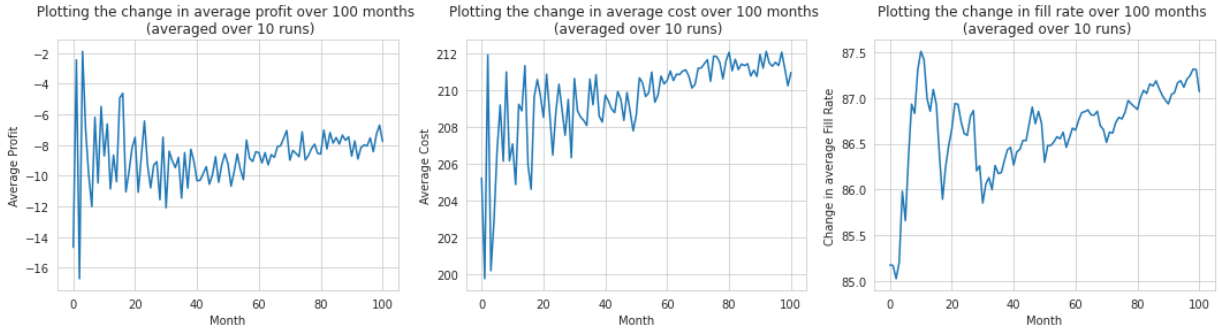
- Estimate of the Average monthly profit: **-11.3424**
- Estimate of the Average monthly cost: **234.32917**
- 90% Confidence interval for average monthly profit: **[-14.9813, -7.7035]**
- 90% Confidence interval for average monthly cost: **[224.889, 243.7692]**
- Average Fill Rate at the end of 100 months: **51.8393 %**

Case 3: Monthly review, M = 100, L = 30



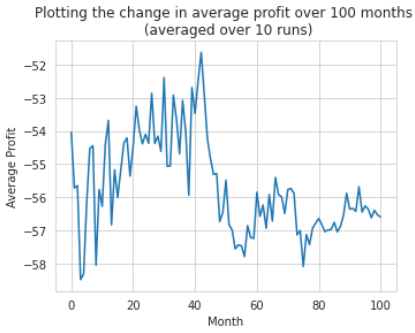
- Estimate of the Average monthly profit: **-4.704**
- Estimate of the Average monthly cost: **208.239**
- 90% Confidence interval for average monthly profit: **[-7.2303, -2.1779]**
- 90% Confidence interval for average monthly cost: **[204.7623, 211.7167]**
- Average Fill Rate at the end of 100 months: **80.3982** %

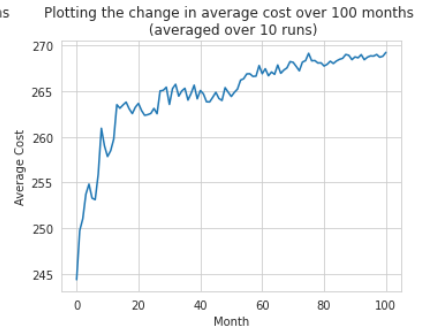
Case 4: Monthly review, M =100, L = 40

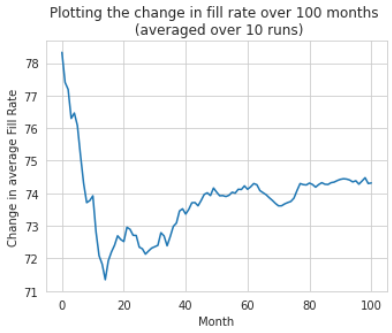


- Estimate of the Average monthly profit: **-7.7575**
- Estimate of the Average monthly cost: **210.9831**
- 90% Confidence interval for average monthly profit: **[-9.739, -5.775]**
- 90% Confidence interval for average monthly cost: **[207.135, 214.831]**
- Average Fill Rate at the end of 100 months: **87.069** %

Case 5: Continuous review, M = 50, L = 30

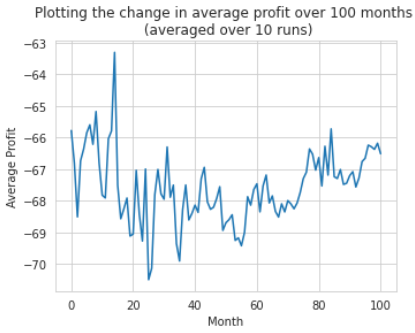


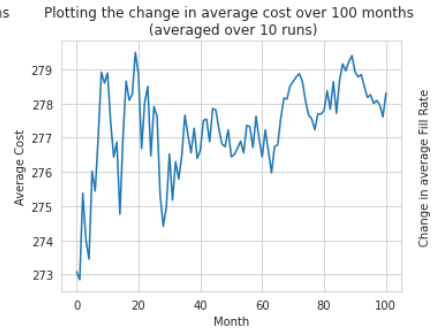


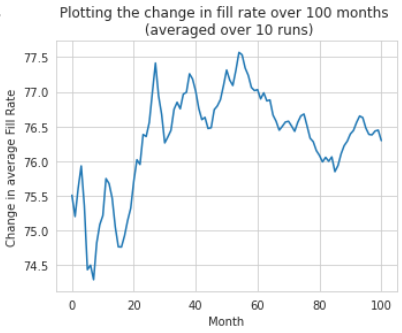


- Estimate of the Average monthly profit: **-56.594**
- Estimate of the Average monthly cost: **269.223**
- 90% Confidence interval for average monthly profit: **[-61.787, -51.402]**
- 90% Confidence interval for average monthly cost: **[265.576, 272.869]**
- Average Fill Rate at the end of 100 months: **74.316 %**

Case 6: Continuous review, M = 50, L = 40

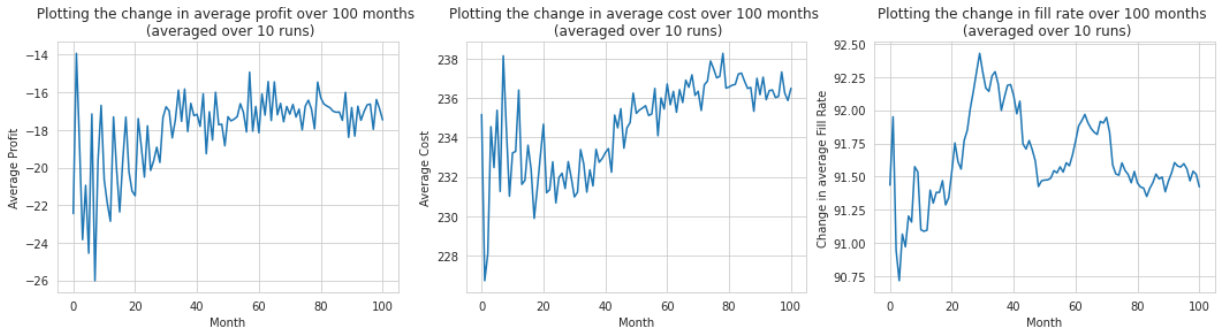






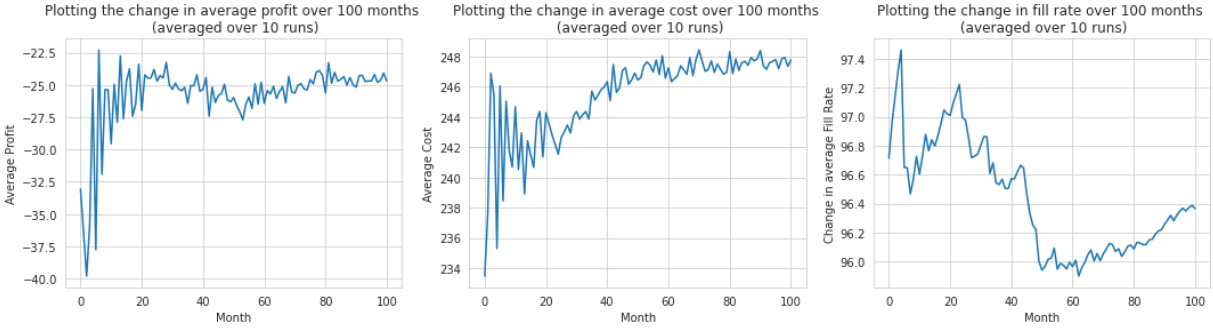
- Estimate of the Average monthly profit: **-66.511**
- Estimate of the Average monthly cost: **278.299**
- 90% Confidence interval for average monthly profit: **[-69.716, -63.306]**
- 90% Confidence interval for average monthly cost: **[274.427, 282.170]**
- Average Fill Rate at the end of 100 months: **76.296 %**

Case 7: Continuous review, M = 100, L = 30



- Estimate of the Average monthly profit: **-17.465**
- Estimate of the Average monthly cost: **236.509**
- 90% Confidence interval for average monthly profit: **[-21.296, -13.634]**
- 90% Confidence interval for average monthly cost: **[233.075, 239.944]**
- Average Fill Rate at the end of 100 months: **91.423 %**

Case 8: Continuous review, M = 100, L = 40



- Estimate of the Average monthly profit: **-24.689**
- Estimate of the Average monthly cost: **247.755**
- 90% Confidence interval for average monthly profit: **[-28.226, -21.152]**
- 90% Confidence interval for average monthly cost: **[244.432, 251.079]**
- Average Fill Rate at the end of 100 months: **96.365** %

Minimum mean monthly cost combination of M and L such that Fill Rate is >= 99%

From the simulation run that we are reporting, the best set of parameters (M, L) came out to be (88, 43), with the fill rate coming out to be >= 99% and the average monthly cost coming out to be 253.365

Comments

- ❏ We see from the above obtained results that when the maximum inventory level (M) is larger, the fill rate is significantly higher for both the levels of reorder point L, and for both the inventory review policies (i.e. monthly and continuous).

- ❏ With an increase in L from 30 to 40, the number of orders placed would be more frequent, thereby increasing the fixed cost as well as holding costs for large number of ordered units. Thus, we see a slight increase in the total cost with increase in L in the continuous case. However, in the discrete case for M = 50, this pattern does not hold. This is probably due to the fact that backordering plays a major effect in the L = 30.

- ❏ The decrease in cost is prominent for M = 50, and less significant for M = 100.

Conclusion

- ❏ Looking at the profit values, it is advisable to not operate the store given the current parameters.
- ❏ We observed from a larger period of simulation that a steady state is achieved after a few more months, which is not prominent in the current simulation horizon.

Thank you