three3 Littlefield Report

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Part 1. Introduction

In the Littlefield Technologies simulation project, we were asked to run two rounds to manage the capacity of the factory to cope with the predicted complex demand patterns. For both rounds, the manufacturing processes are the same, and we can buy and sell machines at any station and change the priority scheduling rules at the tester. Furthermore, we had more operations access in the second round that we can change the reorder point (ROP) and order quantity (EOQ), and we can choose the pricing contract from three options and make changes at any time. We mainly focused on the changes in revenue, inventory, lead time, daily demand, queued jobs, jobs accepted, orders completed, utilization, costs, and compared the changes in the cash balance of other groups. The following paragraphs include our detailed decision analysis, interpretations, and the impacts on the production. Also, we created a spreadsheet to collaborate the analysis for the operations management. Here is the link to the spreadsheet: *https://drive.google.com/open?id=1R76ExRHxysVc4mMdoqTN1Civaf6la53D.*

Part 2. Plan and Action

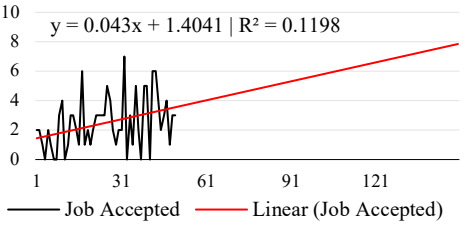
1. Flow Rate and Capacity Analysis

1) First-Round Simulation

In the first-round simulation, we made eight decisions for the machine based on the flow rate and the capacity analyses. The first decision was that we gave the priority of the jobs through the testers to step 4. We thought that the most important thing in this simulation is the lead time for accomplishing one job, as the revenue will go down linearly after the quoted time. Therefore, by giving priority to step 4, we can make sure that when the demand is much higher than our expectation, at least part of the jobs can be finished on time.

The other seven decisions are all about the number of three kinds of machines. At the beginning of the 51st day, we analyzed the demand for the past 50 days and generated a prediction line for the demand till day 150 in Excel because, accordingly, the demand will increase linearly in the first 5 months. Therefore, we will be able to use this predicted demand to calculate how many machines we are going to need.

Graph 1. Job Accepted



Another information we need is the capacity of each kind of machines. For this, we used the formula,

$$\textbf{Capacity} = \frac{\sum Jobs\ completed\ in\ the\ first\ 50\ days}{\sum Machine's\ utilization\ in\ the\ first\ 50\ days} \qquad (equation\ 1)$$

Accordingly, the capacity of machine 1, 2, and 3 are *4.47 jobs/day, 12.49 jobs/day, and 11.51 jobs/day*. With both the demand and the capacity of the machines on hands, we figured out that on the 50th day, machine 1 still works well, but it will soon run over its capacity in just a few days. Therefore, we all agreed on purchasing another machine 1 on the 52nd day. The following decisions are also made based on the analysis of current demand and machine capacity, that we purchased the third machine 1 on the 91st day, and the second machine 3 and machine 2 on the 171st and 185th day separately.

The demand remained between day 150 and day 180, and it decreased linearly after that. Therefore, to avoid holding useless machines after the demand decreased, we calculated the decrease rate and decided to sell one machine 3, one machine 2, and one machine 1 on the 202nd, 204th, and 213th day separately.

2) Second-Round Simulation

In the second-round simulation, we do much less on the machines than the first round because the demand remained the same in the long run from the first to the last day of the simulation. We only changed the variables at the beginning of the simulation. Same as what we did in the first round, we gave the priority of using machine 2 to the jobs in step 4 because of the same reason.

We also calculated the capacity of the three machines this time. By using the same method, we learned that the capacity of machine 1, 2, and 3 are *4.30 jobs/day, 12.52 jobs/day, and 12.98 jobs/day.* As we already have three machine 1 in this round, the total capacity of stage 1 is *12.90 jobs/day*. Theoretically, the capacities of the three machines have covered the average demand around 12.5. However, because of randomly-high demand and the buffer resulted by the two stockouts during the first fifty days, the three machines are often over utilized. Therefore, we purchased one of each kind of machine once the 51st day started to avoid further buffers. Also, as the average demand remained the same during the whole simulation period, we don't have to sell any machines at the end of the simulation.

2. Inventory and Contract Analysis

1) Inventory Analysis

We are not given access to edit the economic order quantity and the reorder point in the first round, so we only did the inventory analysis in the second simulation and made changes three times. The first change of both EOQ and ROP was made at the end of the 50th day when the factory was about to reorder the inventory. We changed the order quantity to *23160 kits/order* and the reorder point to *3480 kits*. The formulas we used are,

$$\boldsymbol{Economic\ Order\ Quantity} = \sqrt{\frac{2 * Fixed\ cost\ per\ order * Annual\ demand}{Unit\ holding\ cost\ per\ year}} \qquad (equation\ 2)$$

$$\boldsymbol{Reorder\ Point} = Lead\ Time * Average\ Daily\ Demand + Safety\ Inventory \qquad (equation\ 3)$$

According to the given information, the fixed cost is $1000 per order, and the annual demand is 365 times the average daily demand for the first 50 days, which is about 12.18 jobs. Therefore, we modified our optimal order size to 23160 kits/order. We also know that each order would take 4 days to arrive, so we set the reorder point to 3480 kits under the service level of 90%.

The second change was made on the 71st day that we increased the reorder point to 4140 kits and increased the order quantity to 23400 kits. The main reason forced us to modify the reorder point is that we can't suffer any stockout under contract 1 because of its extremely low quoted lead time. Once we stock out of inventory, we will earn nothing. Therefore, we calculated the average daily demand based on the 70-days data and increased the service level to 99%. Under the new circumstance, the reorder point is 4140 kits.

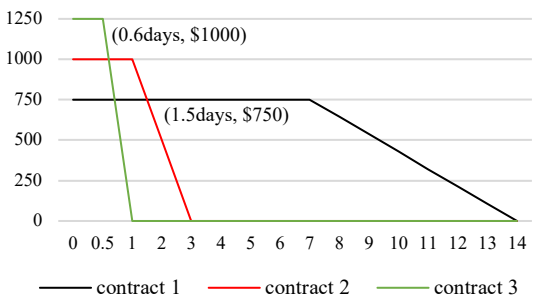
The third change was made when the simulation was about to end that we decrease our order quantity to 20100 kits. We made this decision to avoid the useless purchase of the inventory and to maximize our cash interest. As the last 50 days was about to run automatically, we set the new order quantity to cover the demand for the rest of the days while remaining an inventory above the reorder point at last in to avoid unnecessary order.

2) Contract Analysis

Another supplement to the first simulation is that we have three contract options with different revenue and quote time. One major distinction is that the contracts with higher revenue have shorter quoted lead time and shorter maximum lead time as well. In other words, lead time is a significant influencer for us to choose the contract. To select the most appropriate, we made a plot to visualize the relationship between the contract lead time and the revenue.

Accordingly, for each contract, the revenue will decrease linearly between the quoted lead time and the maximum lead time. Therefore, we found two important nodes to make the change of the contract, which is located in *Graph 2*. Namely, when the average daily lead time dropped under 1.5 days, we can switch from contract 1 to contract 2 to earn $250 more on each contract. Moreover, when the lead time dropped under 0.6 days, we can consider about having contract 3 to earn even more. Therefore, based on this analysis, we signed contract 2 on the 55th day after the inventory was refilled, and we signed contract 3 on the 64th day when the average daily lead time stabled around 0.5 days.

Graph 2. Revenue on Lead Time



Part 4. Lessons Learned

We learned a lot from the first round - unthoughtful analysis and timid actions took our performance down from top 3 to 8th. It was too late when we realized our capacity could not afford the high demand 10 days before the demand would decline. It taught us a lesson without which we could not make the first place in the second round.

The first round began with a vague analysis of machine capacity and difficulty of demand forecasting. We could not estimate a constant capacity of stage 3 and chose to wait for a better forecast of demand. As a result, we did not have a strategic plan and always followed the peer's actions to buy machines in stage 2 and stage 3. It worked when demand was low; however, revenue collapsed during Day 180 to 190, when our capacity could not handle the extremely high demand of 24, the lead time hugely increased that ate up all of the revenue. Even if we bought a machine 3 followed a machine 2, we had to wait for the buffer piled up for days to be delivered, which made us miss the period with high demand. Another mistake was that we forgot to check the system's capacity and the change of the bottom neck. When the "emergency" happened, we focused on the comparison between buying a machine in stage 3 and doing nothing in the declining demand and forgot to solve the new bottom neck, stage 2, after purchasing a new machine on stage 3.

In the second round, we analyzed average demand, EOQ, ROP, and when we should change the contract to earn more revenue per order. To maximize revenue, we bought machines right after the simulation began to enhance the system capacity and changed the contract when the lead time decreases to 0.6 days, the break-even point of contract 3 over contract 2. What lifted us from third place to the very first was one of our team members suggested to adjust the EOQ around Day 200 so that we could save some interests by leaving as few as inventories as possible. It perfectly works and makes our team become the best.

Part 5. Conclusion

Following the analysis and predictions, we finally got the top score for the first place. Therefore, we made some advice on long term operations management. 1) Pay more attention to set the reorder point and order quantity, especially the reorder point should not be set too low. 2) Well balancing the holding cost with the financial purchasing cost. 3) Adjusting the contracts in time when the lead time is small. 4) Comparing with other competitors instantaneously so that we can always make better strategies to operate.