

MATH/OR 441

Prof. Huang

Junzhou Lin

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MPL Project — Pharmaceutical Clinical Trial Distribution

Part. I
Executive Summary for the Manager

1. According to our optimization, **the total cost** of the whole distribution plan of this ten weeks that starting with empty inventory will be \$3004.
2. **The cost spends on shipping** for the plan of this ten weeks will be \$2850.
3. **The cost spends on Holding** for the plan of this ten weeks will be \$154, which represents all clinics will accumulatively hold for 1540 trials overall.
4. **Size of the truck** is already optimal, switch to a smaller truck would cause a huge increase in cost, switch to a bigger truck only would cause a little decrease in cost. so no need to consider a change to a new type of truck.
5. Only one week needs all 3 trucks, so **sell one of the truck** would be a good choice, however, in order to compensate that. First, we can rent a truck for **\$250 additional cost**. Second, we can have a volunteer in the company to deliver only 20 trials to the 1st Clinic every 10 weeks, the total cost can be reduced by \$6-\$10 without renting fee.
6. Inventory size for the 1st Clinic can be **shrink to 160 trials capacity** and keeping the lowest possible total cost of the whole plan.
7. Inventory size for the 2nd Clinic need to be **untouched**, neither shrinking nor extending.
8. If Inventory size for the 3rd Clinic can expand to **190 trials capacity** (more than 190 would be a waste), the company will reduce \$154 per 10 weeks, this advantage can start to pay off within 7 years
9. Even though the shipping cost is a big portion of the total cost, but we **don't suggest the company to focus on reducing the cost per round** too much unless the company can reduce the shipping cost per round in a huge scale.
10. To dealing with the +/- 10% variation, we suggest to **always ship 110%** of the needed demand (satisfy the demand is always the priority), then take feedback from the clinics, knowing how much trials have left, and plan to ship the amount that adds up to the last week leftover gives the 110% needed demand for the new week.

Part. II

Project Description

According to the project plan, we want to first discuss the sensitivity of the plan from all aspect:

1. Change the constraint of the number of trucks:

if we sell one of the truck (let's set number of truck equal to 2), there will be no feasible solution, because on the first week both trucks need to go to the 2nd and the 3rd Clinic, while on the second week two truck is needed by the 1st Clinic and one truck is needed by the 3rd Clinic which would be impossible to solve unless the 1st Clinic already starts with at least 20 trials of inventory level.

If we buy one more truck, there will be no change to the cost, because from number of total truck been used, only one week utilized all three trucks, having four trucks would be a waste. With this being said, truck constrain has no sensitivity.

2. Change the constraint of Size of trucks: The size of trucks determines how many trials it can contain for each run, but definitely the bigger the tuck is which is more expensive. We want to see the shift in cost when truck size change and whether it's worth to buy a bigger truck or switch to a smaller one.

We found once the size of truck shrink by 1 unit (if 199 for all 3 trucks), the total cost will immediately increase by \$407, with 150 trials size, the total cost will increase by \$1051. There is no feasible solution if the truck only has the size of 100.

Moreover, if the truck size increase by 100, or double its size, the profit of doing so would only be few hundred (about \$1 per \$1 trial size increase) through whole 10 weeks, it seems very unwise to change the size of the truck, 200 is the optimal size.

3. Change the constraint of Inventory limit: From our software report, we can see the weekly activities of Inventory level for each clinic.

For the 1st Clinic, we don't see it reach nearly to the 225 cap. So we only need to find the lower bound of Inventory level for 1st Clinic, by testing the maximum inventory level that the 1st Clinic can reach, 160 would be the optimal lower bound that won't affect the cost outcome with lowest possible cost.

For the 2nd Clinic, 150 is already the lowest optimal inventory level, so has no sensitivity.

For 3rd Clinic, as we decrease the inventory level, the cost increase, as we increase the inventory level, the cost decrease until when it reaches 190(reduce total cost by \$154), after that, inventory level has no effect on the cost.

So we can conclude that 1st, 2nd, 3rd inventories level need to be 225, 150 and 190 for the lowest possible cost.

4. Change the variable of the Cost of shipping per round: For all clinics, the lower the shipping cost per round, the lower the total cost, so we are just going to find the

ratio between them; “how the change in the shipping cost per round could impact the total cost?”.

For the 1st Clinic, when we shift the shipping cost per round, the total cost is either being reduced or increased by \$4 per \$1 change in the shipping cost, once the shipping cost per round is below \$30, the ratio will increase to \$5 per \$1 change in the shipping cost per round.

For the 2nd Clinic and the 3rd Clinic, it is a little bit impactful than 1st Clinic, with \$5 shift for the total cost per \$1 change in the shipping cost. Once shipping cost per round is below \$35 for the 2nd Clinic, \$20 for the 3rd Clinic, the ratio will become \$6 per \$1 change.

According to our sensitivity analysis, our **recommendation** to the company are list below:

1. There are only one out of ten weeks we need to use all 3 trucks, additional upon that, it is almost feasible if the company sell one of the truck or let the truck to do other business. In order to make the plan feasible, the company only need to **rent a truck** on the second week for the 1st Clinic, that’s approximately \$250 (cost of shipping add up the additional fee) additional cost every 10 weeks. And a truck is usually worth for \$150,000, it will only zero the profit out after 125 years (6000 weeks). It’s definitely unwise to keep that one truck to be unused most of the time.

2. Depends on the first suggestion, once the company takes our plan for a long-term, we can consider having leftover trials from the last 10-week period to a new 10-week period. From our calculation, if the inventory level for 1st Clinic starts with 20 from the first week, we won’t need to rent a truck, we just **need someone from the company to drive a small car if they by any chance will pass through** 1st Clinic and deliver those 20 trials (not a big amount) and the total cost will lower down to \$2992 plus \$10-\$2(holding cost for 5-2 weeks), with even \$10-\$6 cheaper plan but only need 2 trucks, and no need for renting. So we suggest the company takes our first recommendation for the first 10 weeks, then take our second suggestion if the company willing to take our plan in a long run.

3. In the aspect of maximizing the space used for clinics’ inventory, we suggest to **shrink the 1st Clinic’s max inventory level** to 160, let the extra 65 trials space to put something else. No change need to make for the 2nd Clinic. And for the 3rd Clinic, we suggest to open up 90 units’ inventory which **extends the original inventory limit** to 190 units. The total cost will decrease by \$154, we assume open up such place require \$5,000, by our calculation, this loss will become profit within 7 years, if the company is having a contract with three clinics in a long run, definitely take this suggestion.

4. The size of trucks right now is already optimal, **no need to switch to bigger or smaller trucks**. It is not worth the extra cost to buy bigger trucks and not worth the extra shipping cost to switch to smaller trucks.

5. If the company have some ways to **corporate with oil companies** to reduce the gas fee or **negotiate with the government** to reduce toll fees by a big amount. We suggest the company to do so, because \$50 reduction of shipping cost per round for each clinic, that is \$700 less shipping cost, however, making a contract with oil companies and the government won't be free. The company should only corporate with them if share no more than \$3 per \$1 reduction in the shipping cost per round for the road to 1st Clinic and no more than \$4 per \$1 reduction for the road to the 2nd and 3rd Clinic (The company at least should get \$1 profit per \$1 reduction). Otherwise, no need to consider the shipping cost, this is a hardcore variable.

Part. III Counter uncertainty

However, when we do the optimization, it's always under an ideal condition, in the real world, things never can be such pleasant. The actual demand may have +10% or -10% variation. To deal with this, we need to think as "more is always better than less", **satisfy the demand is always the priority**. So the company should always ship 10% more trials than the clinic needs. However, to prevent waste, and the demand won't constantly be +10%, there has to be some trials left over, then the company need to take the feedback from the clinic and number of trials should be sent to the clinic for new week adds up with last week left over trials need to satisfy the 110% of new week demand. For instance, the demand for the 2nd Clinic (week 2) is 150, which the company need to make sure to send 165 trials. However, the 2nd Clinic may only use 5% more trials than its standard amount (158) which leftover 7 trials, then week 3 the 2nd Clinic need $30 \times 110\% = 33$ trials, so the 2nd Clinic only need 26 more trials to make sure there will always be sufficient trials.

At the last, if we assume every week are constantly having 110%-90% demand, we can calculate the maximum/minimum possible total cost:

If every other constraint is the same except the demand, the total cost would rise up \$525 to \$3529 or lower for \$69.3 to \$2934 under extreme cases. However, for maximum, only week 2 and week 6 need full 3 trucks, if we sell one of the truck and take \$500 per week to rent the two extra truck, our maximum cost is \$4029 per 10 weeks. For the minimum, two truck is sufficient enough, our minimum cost is \$2934 per 10 weeks. There is around \$1000 difference, with the truck sell for \$150,000, it takes more than 30 years to be considered as not worthy which is a very long term. This is definitely a wise move.