Logistics & Supply Chain Management

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Lecture 50 : Transportation Problem Programming

hello dear friends welcome back to NPTEL online course on logistics and supply chain management so in the last session we started discussion on transportation problem programming and we have seen that there are basically two phases we need to find out first the initial basic feasible solution and then we will go for the optimality right so we discussed about the three methods how we can get the initial basic feasible solution and in detail we discussed about the north west corner method so here we will discuss about the second method which is least cost method and we will try to allocate as many units as possible in that cell where the minimum cost is there, right? And then we will strike either the capacity of that factory fully in that particular row or we will try to strike off the demand from that particular market, right? Whosoever is the minimum will strike off that completely, right? Like we did in the last session while allocating using northwest corner method, right? So, this is just a brief introduction about that and you can just go through how we are doing that algorithm, I will just go through the first step, obviously we will check whether supply is equal to demand means balanced problem, if it is not we will go for balancing, so that we will discuss towards the end of this session. like same question again I am repeating we have three factories we have three markets and demand is also the equal demand right so that means 170 is the demand 170 is the supply so in that way it is balanced we have seen in the last session as well now the algorithm says we need to find out the minimum cost cell and we will allocate the maximum units as many we can do and those units are restricted by either the supply or the demand whosoever is the minimum value either supply or demand will pick will simply assign those many units right so now minimum cost cell if I will see is this one 1 rupee per unit cost so maximum unit what how many I can allocate 40 is supply 60 is demand, so I can allocate maximum 40, so in that way if I allocate 40, so 20 will be left here and the supply from Jaipur is fully exhausted. So, what if there is tie between two cells, so then you find out in those two cells where you can allocate maximum, let us say if one is here also. So, then you see where you can allocate the maximum, but in this case, also, I think you can allocate a maximum of 40 only. So, let us say if 1 is somewhere, if I will say somewhere here. So, in that case how many you can allocate maximum? 60 is the supply, 60 is the demand, maximum you can allocate 60.

So, you will not allocate in this cell in that case, you go for Udaipur factory first. So, minimum cost, but if it is tie, you can break the tie in this way. Now, this is fully exhausted. Now, next minimum cell is this one.

How many I can allocate here maximum? demand is 40 supply is 70 I can allocate 40 in that way this Pune market demand is totally met, and this is also exhausted by 40 units, so rest supply is 30 now next minimum cost is out of those cells which are not strike off so the next is now 3 here 3 like we got the tie now So, how many maximum I can allocate here? In this case only 20, but in this case how many I can allocate? 60 So, you make allocation 60 here because maximum. So, if I will allocate 60, this Udaipur supply is totally gone and here we are left with 10 more demand. So, obviously then there is no option 10 will allocated here and rest of the 20 will be allocated here. This will be your total allocation if we are going for minimum cost cell. If I will ask you to calculate the cost, obviously from Jaipur to Delhi per unit cost is 1 rupee, total units we are transporting 40.

From Udaipur to Kanpur per unit cost is 3, total we are transporting 60. Then from Mumbai to Kanpur per unit cost is 6, we are transporting 10 units. From Mumbai to Pune per unit cost is 2 rupees, we are transporting 40. From Mumbai to Delhi per unit cost is 8 rupees, we are transporting 20. So, if you can calculate what is the total cost, that will be total cost.

So, in the further slides, step wise I have given you same steps which I have done. So, you can just use that and you can see this is the total allocation whatever we have done, same allocation. So now the transportation cost again is 480. Alternate solution, if we have tie in selecting minimum value, see like we were having tie, I think in this solution they have, I allocated 60 all the units in this cell only, they allocated 40 and 20, now there is tie. So, tie means what is the meaning? That means I can transport either fully 60 units from Udaipur to Kanpur or I can transport may be from Udaipur to Delhi 20 units.

Now, it depends upon again, then you can pick which option you want to pick because whatever option you will pick the cost will be same right so that means instead of one optimal solution now you are having two optimal solution two optimal solution means you have more than one options and all the options are giving you minimum cost so in that way you are at win-win position that still you can pick out of those different options right So, this is the meaning of how we can break the tie. Next is your Vogel's approximation method. So, if I will read all the steps may be little confusing. So, I will just go through explaining the numerical and that is the best way how you can go. This is also known as penalty method.

When saying penalty means what if we will not allocate into this cell. if we are allocating in some other cell what is the penalty if we will allocate into some other cell may be the opportunity cost we need to calculate right so again the first step is we need to find out whether the problem is balanced or not supply is equal to demand or not same problem again we are going for now Here the step is we will for all the rows and for all the columns, we will subtract the minimum value, minimum cost from the next minimum cost. In one row, we will find out all the values, what is the minimum cost? and next minimum we will find out the difference that is row difference here we are writing row difference and same we will do for all the columns here we are writing column difference right like for first row minimum value is 1 next minimum value is 4 difference between 1 and 4 3 here minimum value is 2 next minimum value is 6 difference is 4 this is how we will find out the row difference and column difference what if We have two identical minimum values, which means one is repeated twice. Since this is the minimum value, the row difference will be zero. Now, once it is done for all the rows and columns, we will find the highest penalty.

In this case, the highest penalty is 4. Row difference or column, whichever it is—whether it's the row value or the column value—whichever is highest, you will pick that. If there is a tie, you will break the tie by finding the minimum cost, and you will choose the maximum value.

Even then, the first point to break the tie is to determine where the minimum cost cell is. If the minimum cost cell is the same for two rows, you will break the tie again by finding out where you can allocate the maximum. If the maximum is also tied, for example, if both cells have a maximum of 10, then you can arbitrarily choose either of the cells to make the allocation. Thus, I have outlined three steps on how to break the tie.

But here, there is no tie; we can see that 4 is the largest row difference. We need to allocate the demand that we must fulfill in this specific row. Now, what is the minimum cost in this row? The minimum cost is $2.

I have told you to check the supply and demand. Whoever has the minimum value, that is the number of units you can allocate.

Since 40 is the minimum value, after utilizing these 40 units, the Pune facility will be completely depleted, the market will be gone, and you will be left with 30 units. The next matrix will not include this column, and you will repeat the first step again. You will find the row difference and the column difference, but don’t skip this step. Just imagine that the difference will be the same. No, it won’t be, because now one column is deleted, and many cells in the row are deleted as well.

This means your row difference or column difference may change. After completing that second step, we are left with a 3-by-2 matrix. A 2 by 3 matrix will now be used to find the row difference and column difference. The maximum value is identified, and the minimum cost value is 1. We will try to allocate a maximum of 40.

The Jaipur facility is no longer available, leaving us with a demand of 20 for Delhi. This is now a 2 by 2 matrix, and we will again find the row where the maximum penalty is 5. The sentence is indeed grammatically correct as it is. No changes are needed. So, we will continue this same process until we have allocated all the supplies to all the markets.

This is your Vogel's approximation method, so once it is completed, you can see how you made the allocation. Similarly, you will find the total cost; in this case, the cost is 480. Incidentally, all three algorithms yielded 480, but usually, Vogel's approximation method is more efficient than the minimum cost method. The correct form of the sentence is: "The northwest corner method." The sentence is indeed grammatically correct as it stands; no corrections are necessary.

So, this is how we have discussed all three methods you can use to find the initial basic feasible solution. The original sentence is grammatically correct, but if you want a slightly refined version, you could say: "So, this is how we have discussed all three methods that you can use to find the initial basic feasible solution." Now, the next topic is the optimal basic solution and how we can utilize it. This is a modified distribution method; its short term is the MODI method, which we use to determine the optimal solution for the next stage. First, we found the initial basic feasible solution; now we will determine that the MODI method is based on the opportunity cost method.

So, let's say that if you state that factory 3 will supply market 3 and market 4, what is the opportunity cost if we say that factory 3 will supply only market 5? Let us say the total cost of supplying these two markets may be 100 rupees, but here it is 90 rupees.

We will continue to iterate on the solution until we find the minimum transportation costs. I will go through this. One of the cells with the most significant potential for improvement has been identified. We will update the allocation if we made any allocations earlier using the initial basic feasible solution or possibly the MODI method. The MODI method may not yield a solution in one iteration; sometimes, you may need to run more than five iterations to arrive at a solution.

For example, in the earlier allocations, you may have made allocations in x1, x3, and possibly x5. Now you are... By deleting it, you are making it x 23.

5, right? So, you are reallocating because it results in lower costs. The original sentence is indeed grammatically correct; no changes are necessary. We will find the initial basic feasible solution using any of the available methods. The original sentence is indeed grammatically correct.

No changes are necessary. Whether these are at independent locations or not. Correction: Whether these are at independent locations or not is unclear. Allocations are either at independent locations or not. Now, there is the point we discussed initially regarding some definitions. In the last session, I talked about the degeneracy of feasible solutions, and I mentioned that these should have non-negative allocations at independent positions.

I will quickly go back and illustrate this. Let's say this is the example: allocations are here, here, here, here, and here. All of these are non-negative. Yes, these are non-negative values. The original sentence is grammatically correct.

The sentence is already grammatically correct. The sentence "You are in an independent position." is indeed grammatically correct. No corrections are needed. The sentence is already grammatically correct.

However, if you want to rephrase it for clarity, you could say: "That means, how do you define an independent position?" The sentence is indeed grammatically correct as it is. No changes are needed. You can take a turn from another occupied cell, and there should not be any closed loops. You see, if I start from anywhere, I can take a turn here, I can take a turn there, I can take a turn here, yet I am still unable to make a closed loop. The original sentence is already grammatically correct.

Let us say the allocations are as follows: one is allocated here, another is allocated there, another is allocated here, another is allocated there, one is here, and one is here. If I start from the allocated cell and take a term from here, I cannot take a term from anywhere else, right? So, there is no closed loop if I go there. Then take a turn here, and then another turn here, which creates a closed loop. This is not an independent position. The meaning of an independent position is as follows: if I start from an occupied cell, I can only make a 90-degree turn at that occupied cell, right? Therefore, there should not be any closed loop.

If a closed loop is present, then it is not an independent position. This is how we can test whether the allocations are made at independent positions. And we will check if these are independent. If they are, we can optimize the solution by implementing the MODI method. We will find the set of values u_i and v_j.

Although discussing these steps may be a little difficult to understand, I will try to communicate that we will attempt to find the opportunity cost. If the opportunity cost is lowering your... The total allocation cost will be for the optimal solution, and then we will check whether the optimal solution has been reached.

There are three conditions to consider, but for now, let's not focus on them. I will start solving the question with the numerical values, and we will understand it better this way. So, until now, we have confirmed that you need to ensure, as we were doing before, that while applying the initial basic feasible solution, we verify whether your problem is balanced. Similarly, while processing for the optimal solution, we need to check whether there are known negative allocations and if they are in independent positions.

Right now, this is the allocation, so we will... Find out what u_i and v_j mean for all columns. You are assigning these variables $v_1, v_2, v_3, v_4,$ and v_5. How many columns are there? You will assign that many values. Similarly, for all rows, you are referring to $u_1, u_2,$ and u_3. These represent the cell costs that are occupied, as you can see at the end.

This number indicates that it is occupied; "occupied" means that we have completed the allocation. So, we are not considering other cells; we are only considering the occupied ones. (The original sentence is already grammatically correct.) We will calculate these Vj's and Ui for all occupied cells, and then we will evaluate all unoccupied cells.

The original sentence is indeed grammatically correct. However, if you want a slightly different phrasing, you could say, "Therefore, we will develop all of the equations." So, here you can see that this cell is made up of U2 plus V1. The sentence is already grammatically correct. However, if you're looking for a slight rephrasing for clarity, you could say, "Thus, V1 plus U2 equals 3." This consists of B1 plus U3, which equals 6; U3 plus V2, which equals 2; V3 plus U1, which equals 1; and V3 plus U2, which equals 3; all of these are occupied cells.

From the six occupied cells and five empty cells, we derived these five equations. Now, we forgot to check whether we have m plus n minus 1 allocations. What is m? The order of the matrix has 3 columns and 3 rows. Subtracting 1 gives us 5, and since we have 5 allocations, this means that the condition is fulfilled. The second condition is that these should be in an independent position.

Can I draw any closed loop? No, I cannot do that. Here as well, I cannot do that; there is no closed loop. This means that these allocations are in an independent position. Only when they are in an independent position can you start calculating these equations; before that, you cannot do so, correct? The sentence is already grammatically correct. However, if you're looking for a slight variation, you could say, "We have five equations available." To solve these equations, you can set any one of these variables to zero.

(The original sentence is already grammatically correct.) Let us set v_1 equal to zero. (The original sentence is already grammatically correct.) If I set v1 equal to 0, that will give me u2 equal to 3 from here. Sorry, u2. The sentence is indeed grammatically correct as it stands: "From here, I can calculate that.

" If I set v1 = 0 here as well, u3 will also be 6. Because I received a U3, I will place the V2 value here, which is 6. The original sentence is correct as it is: "2 minus 6 minus 4 equals -8." So, from here, you can see we got v3 somewhere; no, we got u1.

Let's leave it at v3. We did not get v3; we got u3. Yes, we got u3. u3 is 6. So, from u, 3 is 6, and from v, 3 will be negative 3. Now, we have version 3 of this equation, and we can also solve for u1, which will be 4: 1 minus (-3) equals 4. By setting any of these variables equal to 0, you can solve the other equations to find the solutions.

Now we have the values of v_1, v_2, v_3, u_1, u_2, and u_3. (The original sentence is already grammatically correct.) You can write these values as if they were the equations I had already solved, and this is how you found all those values. The sentence is already grammatically correct. However, if you prefer a slight variation, you could say, "So, what is the next step?" Now, for the variables we found, we will determine the opportunity cell cost for any cell; this value will be Cij minus Ui plus Vj. Here is the corrected version of the sentence: "We initially received the cost per unit and will find it out for all unoccupied cells only, so we will not consider the occupied cells.

If we do that, you will see that the initial cost is 4 for the first cell, while for this cell, it is 5. You can check." (Note: The original sentence was already grammatically correct.

No changes were necessary.) Now, this is u1, u1, and v1. So, the u1 value is -5, and the v1 value is 6. So, we will calculate the opportunity cost as I mentioned: Cij minus Ui plus Vj. So, for this cost, 4 minus (minus 5 plus 6) equals 3. Similarly, we will determine the costs and opportunity costs associated with this cell.

Similarly, we will identify the opportunity costs of this cell. So, all the unoccupied cells are available. (The sentence is already grammatically correct.) The original sentence is already grammatically correct: "Why did we not calculate these cells?" Your revisions are accurate. Here's a slightly different option as well: "These cannot be used because they are already occupied.

" This maintains the original meaning while providing a complete sentence. We are determining whether any new cells are available for allocation, and if we allocate them, the total cost can be further reduced. Now, there is a condition: if all the opportunity costs we are calculating for the maximum books are represented by dij, whatever dij represents, I am stating that this is the opportunity cost. If these opportunity costs are all positive, it means this is the optimal solution, and you need to stop iterating because this is the final solution. If any of the Dij values are negative, it means that this is not optimal. A negative value, such as -2, indicates that if I allocate resources to this cell, the transportation cost will be further reduced, as -2 represents the opportunity cost.

So, if I am getting all positive values, at least one zero means that it is the optimal solution. However, if I allocate resources to a cell with a zero opportunity cost, that represents another alternative I can pursue, but the total cost will remain the same. So, all three conditions are clear, correct? So, in this question, all D_{ij} values are positive. So, this is the optimal solution; there is no need to seek additional ones.

You can check the condition of everything I told you about. Any negative values we encounter will require us to perform an iteration. I will choose one numerical example to determine if we can obtain a negative value. So, we will quickly address the numerical aspect first. This unbalanced problem relates to the transportation problem we discussed earlier. We mentioned that the first step is to ensure the problem is balanced, meaning the total number of supplies should equal the total number of demands.

However, in this case, our supply is 170 units, and our demand is 95 units, which cannot work for optimization. To make this problem balanced, we will add one more dummy market. In the dummy market, we will maintain the demand regardless of the difference; for example, if the difference is 22, we will keep the demand at a 22-unit difference. If you ask me about the cost, it will be assigned as 0, 0, 0. This is just to represent a dummy market so that we can proceed with the linear programming problem to solve this issue.

Otherwise, when we allocate resources to this particular dummy market, it becomes meaningless because the excess supply is always too high. We are unable to consume that, but we do need to include it somewhere in our calculations; that is why we are adding the dummy market. You can see here that we have added one dummy market; we now have 22, which is the additional one. This is not just about adding a dummy market; sometimes we need to add a supply source, which may be S5. If S4 supplies are already available, we will fulfill any extra demand using that supply.

The cost will be zero in all the cells, and you may ask me when we will make the cost zero. If you use the least-cost method, you will obviously allocate to these cells first. Therefore, the maximum you can allocate is 22. We need to allocate this amount anyway because it represents the extra demand that we need to meet.

The original sentence is indeed grammatically correct. No corrections are needed. So, this is another problem: this is the per unit cost, the transportation cost, and the total supply. If you sum these up, I think they amount to 340. If you add this, as shown here, it confirms that 340 indicates this is a balanced problem. The first point is that the problem is well-balanced.

Now, we can proceed with the allocation, and the least-cost method will be applied. So, we have selected the least costly cells and allocated them as we discussed in your first example of how we can use the least cost method. Where is the lowest cost? If I repeat a few steps here, this is the lowest cost. The maximum we can allocate is 50 because the maximum demand from market B is only 50. Therefore, when allocating 50, it is completely used up, and we are left with a supply of 50. What is the next lowest cost? It is also 2 here, but this column is already exhausted, so we cannot make any further allocations.

Any further allotment in this cell indicates the maximum number we can allocate, which is 50. After allocating, we are left with a demand for 20 more, but this supply is completely exhausted. This is the least-cost method that we have already applied, so you can simply repeat all those steps to make the allocation. The total cost is 1,410. Now, to pursue an optimal solution, we first need to check whether we have made $m + n - 1$ allocations.

(Note: The original sentence is already grammatically correct.) So, here I have a total of 5 columns and 2 rows (3 minus 1). The sentence is already grammatically correct. However, if you want to make it slightly clearer, you could say, "Therefore, you can see seven of them." The sentence is already grammatically correct. However, if you want a slight variation, you could say: "Therefore, it is unclear whether we have completed allocations 1, 2, 3, 4, 5, 6, and 7.

" So, that means we can apply the MODI method to obtain the optimal solution. (This sentence is already grammatically correct.) Now, what is the MODI method? (The original sentence is already correct.) We need to assign $u_i + v_j$ so that $u_i, u_1, u_2, u_3, v_i, v_1, v_2, v_3, v_4,$ and v_5 can be calculated. How can we achieve this? We have seen that the cell is occupied, so for this cell, u1 plus v2 equals one. For this cell, U2 plus V3 equals 3, regardless of the cost, just as I explained in the previous example.

The original sentence is indeed correct; no grammatical changes are necessary. Here are seven equations you can create by setting any of the variables equal to 0, and then you can solve all the other equations. (The original sentence is grammatically correct and does not require any changes.) While stating that you can obtain u1 - 1, u2, 0, and 1, you can similarly find all the vj components. The sentence is already grammatically correct. We need to determine the opportunity cost of the unoccupied cell; d_{ij} is equal to c_{ij} minus u_i plus v_j.

The sentence is grammatically correct as it is. We will find out about all the unoccupied cells. (The original sentence is already grammatically correct.) The sentence is indeed grammatically correct. However, if you're looking for a slightly refined version, you might consider: "So, you can see that for all unoccupied cells, if you look closely, you will find those values. Therefore, let us focus on finding them here.

"   This keeps the original meaning intact while ensuring clarity. So, this is 4, right? Yes, I have written it down here. The sentence "So, this is four." is indeed grammatically correct; no corrections are needed.

The sentence is indeed grammatically correct as it stands. No corrections are needed. The sentence is already grammatically correct. However, if you are looking for an alternative way to express it, you could say, "Negative one." The sentence is already grammatically correct. However, if you want a slightly more formal version, you could say, "What is the value of V1?" Plus six.

The sentence is grammatically correct as it stands. If you'd like a rephrased version, you could say: "So, this is completely yours." So, the value is negative one. The sentence "Let us calculate one more time" is indeed grammatically correct.

No changes are needed. This Cij is 9 minus U1, which is minus 1, plus it is made up of V5 and 7. The sentence is grammatically correct as it is. So, the cost is three dollars. (The sentence is already correct.) So, I have written the opportunity costs for all the unoccupied cells here.

(Note: The original sentence is already grammatically correct.) The sentence is already grammatically correct. The sentence is already grammatically correct. that means positive then it is optimal solution. Any single value is either negative or greater than 1, which means it is not optimal. In this case, we are getting minus 1, a negative value, which means that this solution is not optimal, and we need to find the next best solution.

The sentence is already grammatically correct. What does it mean that this solution is not optimal? We are getting a negative value, which indicates that if we allocate to this cell right now, there will be no allocation in it. If we do allocate to this cell, the overall cost can be reduced. So, how many units can we allocate to this cell? That is what we need to decide. The next step is to start from this cell again; we will draw the closed loop and make turns only at the designated points. Where have you allocated the units already? The original sentence is indeed grammatically correct, so no changes are necessary.

Now, starting from where we began, we will assign a positive sign, and alternately, we will assign a negative sign. The sentence is already grammatically correct as it stands; no changes are needed. So, how do we draw this closed loop again? We will start from that negative opportunity cost cell. We will turn only at the occupied location, and then we will try to draw a closed loop to the right.

Now, we will allocate positive and negative alternative signs. We will assign positive to the first cell where we began tracking the path, then negative at the next turn, positive again, and finally negative once more. From these values, we will take the negative values where we have assigned negative signs. So, which one is the minimum? We will add that minimum value where we have assigned a positive sign and subtract that minimum value where we have assigned a negative sign.

That means we need to find the minimum value between 50 and 10, which is 10. Therefore, we will add 10. We will add 10 to this cell, subtract 10 here, and add 10 to another cell. This means the new allocation will leave this cell empty. We will allocate 10 here, increasing it from 50 to 60, and we are adding 10 to 20, which will make it 30. From 50, it will decrease to 40. Here is the corrected version of the sentence: In the next allocation, you can see how the closed-loop path is implemented.

By adding 10 here, 10 new allocations will be made. It will start at 0; then we will add 10, resulting in 20. After that, we will subtract 10, leaving us with 10. So, in total, there is no change in the number of units; this is something you need to keep in mind. The original sentence is indeed grammatically correct. However, if you're looking for a slight variation, you could say: "We are adding and subtracting the same number of units; this constitutes the new allocation.

" Earlier, we had 10 here; now they have been shifted here because it has further reduced the cost. Now, again, we need to check whether this is optimal; we have completed one iteration. Your sentence is mostly correct, but it can be improved for clarity and coherence. Here's a revised version: So, before proceeding with that, whether it is an m plus n minus 1 allocation—yes, 1, 2, 3, 4, 5, 6, 7—and since the order of the matrix is 8 minus 1, which equals 7. So, at any independent location where you start, can you track a closed path? You cannot do that.

Yes, you cannot do that here. Additionally, you cannot do that, so all of these are in independent positions. Now, once again, you need to find u_1, u_2, u_3, v_1, v_2, and v_3 up to v_5 by following the same procedure: take the cost of the occupied cells and then determine the opportunity cost for the unoccupied cells. Therefore, if you go for u_1, u_2, u_3, these values, and then.

.. For the unoccupied, if I calculate this, it is 6 minus u1 plus 4, which equals 10. The original sentence is grammatically correct; no changes are needed. So, you can see that this is how we have calculated all the opportunity costs and that all opportunity costs are greater than zero. That means that all of them are positive. (The original sentence is already correct.

) So, this is the optimal solution because changing the allocation from here will not decrease the cost. The sentence is already grammatically correct; no changes are needed. So, this is the complete numerical data that you can see, and the total cost is $1,400. Earlier, we were making progress; I think it was 2:10 PM.

So, this is how you can minimize the total transportation costs. This is the minimum possible cost with that setup. (The original sentence is already grammatically correct.) So, this is the complete algorithm for how we can apply the transportation method. (The sentence is already grammatically correct.) So, advantages quickly lead to a competitive edge; obviously, we will gain a competitive advantage by reducing costs and improving service levels.

When you reduce transportation costs, it means you are also reducing lead time. In some cases, reducing costs means minimizing distance, which, in turn, minimizes the per-unit delay during transportation. Overall, efficiency has improved, which will give you a competitive edge. Cost minimization will also provide you with an additional margin and help you reduce fuel expenses, vehicle maintenance, and labor costs.

Everything contributes to the improved service level you now enjoy. Reduce the lead time to improve service levels. By delivering services in a shorter time, you can also plan your inventory better, as you will know exactly when to expect the next delivery. This approach allows for resource optimization at minimal cost, thanks to the optimization algorithms we are using. We are utilizing the resources optimally, so resource optimization and time efficiency will be ensured. By reducing transportation distances and costs, we have developed a comprehensive transportation algorithm.

You can refer to the books from which I have taken numerical examples for further practice. That’s all for transportation management. Thank you very much.