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# Optimization of Vegetable Planting and Allocation

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**Abstract:** In this paper, we aiming at question about vegetable planting. First we use the method of line segment superposition to calculate the minimum distance between 8 vegetable planting bases and 35 sales points' and every route must through traffic junction. After we get the shortest distance, we change the conditions and establish the relationship between the planting base supply and the demand of each point of sale. According to the above relationship to write lingo program, and get optimal allocation scheme from direct allocation. Then we change the procedure and get the optimal allocation schemes between expanding the planting area and ensuring the vegetable species two circumstance.

**Keywords:** Vegetable Planting, Transportation Scheme, Optimization Problem, Lingo Software

## 1. Introduction

The data we use is from Jilin Province mathematical modeling contest. Contest provides JG City, vegetable growing base day vegetable supply, "Vegetable sales point daily demand for vegetables" and "daily shortage of compensation standards" and other information.

The 8 vegetable planting bases, through 15 major traffic junctions, the daily delivery of vegetables to the urban area of 35 vegetable sales point. If the vegetable sales point of demand cannot be met, the city government will give a certain shortage of compensation. At the same time, the city government will give the corresponding freight subsidies, based on the number of vegetables grown in the supply of vegetables and the distance, in order to improve the enthusiasm of vegetable cultivation, freight subsidy standard for 0.04 Yuan (ton/km).

## 2. Solution of the Shortest Distance Based on the Superposition of Line Segments

To design a transport plan, we must first solve the problem of distance, from planting to the point of sale need to go through 15 traffic junctions, so we need to calculate the shortest distance of each route according to different road conditions.

Suppose our vegetable transport only considers the following three transport pathways:

Base - point of sale, can be directly get through the information we have;

Base - traffic junction - point of sale, calculate two segment distance;

Base - traffic junction - point of sale - point of sale, calculate three segment distances.

We consider the last two cases and prepare two procedures were calculated the shortest distance, through the above two procedures, we selected a different path of the minimum distance, the shortest distance as follows:

***Table 1.** The shortest distance between each planting base and point of sale.*

| | a | b | c | d | e | f | g | h |
|---|---|---|---|---|---|---|---|---|
| 1 | 29 | | | | | 21 | 7 | 30 |
| 2 | 27 | | | 23 | 16 | 19 | 14 | 23 |
| 3 | | | | | | | 14 | 23 |
| 4 | 13 | 18 | | | | | | 29 |
| 5 | 17 | 18 | | | | 29 | | 30 |
| 6 | 22 | | | | | 14 | 15 | 23 |
| 7 | 30 | 26 | | | | 22 | 27 | 31 |
| 8 | 34 | | | | | 6 | 25 | 35 |
| 9 | 54 | | | | | 25 | 45 | 55 |
| 10 | | | | | | | | |
| 11 | 23 | 12 | | | | 23 | 28 | 36 |
| 12 | 27 | 16 | | | | 27 | | 43 |
| 13 | 31 | 13 | | | | 31 | | 38 |
| 14 | 12 | 9 | | | | | | |
| 15 | 46 | 5 | 23 | | | 46 | | |
| 16 | 19 | 8 | 15 | 29 | | 12 | | |
| 17 | 27 | 16 | 16 | 30 | | 13 | | |

| | a | b | c | d | e | f | g | h |
|---|---|---|---|---|---|---|---|---|
| 18 | 26 | 15 | 21 | 35 | | 16 | | |
| 19 | | | 21 | 35 | | 8 | | |
| 20 | | | 17 | 31 | 30 | 14 | | |
| 21 | | | 15 | 17 | 10 | 12 | | |
| 22 | | | 15 | 16 | 9 | 12 | | |
| 23 | 32 | 21 | 24 | 18 | 11 | 21 | | |
| 24 | 45 | 34 | 17 | 19 | 12 | 14 | | |
| 25 | 23 | 12 | 15 | 29 | 18 | 12 | | |
| 26 | 26 | 14 | 14 | 28 | | 11 | | |
| 27 | | 15 | 11 | 31 | | 14 | | |
| 28 | | 21 | 12 | 30 | | 13 | | |
| 29 | | | 21 | 20 | 19 | 18 | | |
| 30 | 20 | | 26 | 17 | 10 | 12 | 13 | 21 |
| 31 | 27 | | 21 | 15 | 8 | 18 | 20 | 28 |
| 32 | | | 22 | 16 | 9 | 19 | | |
| 33 | | | | 19 | 3 | | | |
| 34 | | | | 19 | 12 | | | |
| 35 | 28 | | | 10 | 18 | 20 | 21 | 29 |

Where, a, b,..., g express the eight planting bases, 1, 2,..., 35, express the point of sale. The delivery path with no value. n the table is not consistent with our hypothesis, so the shortest distance will set to zero, it means there is no path exist (distance calculate more than three segment), and the corresponding freight amount will set to zero.

# 3. Transport Scheme Design

The second part has calculated the shortest distance of each transport path, in order to not only can we transport vegetables to point of sales, but also to make the government's shortage of compensation and freight subsidies to the minimum, we consider the following two aspects.

The total cost is the sum of the cost of the freight and the shortage, that is $Z = P + Q$. First consider the freight subsidies $P$ ( $P = \text{distance} \bullet \text{freight amount} \bullet \text{freight subsidy standard}$ ), and freight and distance is proportional to. Secondly considering the shortage of compensation $Q$ ( $Q = (\text{requirement} - \text{supply}) \bullet \text{shortage compensation standard}$ ).

Finally, according to the requirement of each point of sale, supply of each point of sale and the shortest distance between bases and point of sales, we can get the constrained condition and establish the objective function $Z = P + Q$, use LINGO programming to find the minimum optimal solution.

## 3.1. Model of Freight Subsidy

Freight subsidies can be expressed by the following formula:

$$P = 0.04 \times \left( \sum_{i=1}^{35} S_{ai} \bullet D_{ai} + \sum_{i=1}^{35} S_{bi} \bullet D_{bi} + \cdots\cdots + \sum_{i=1}^{35} S_{gi} \bullet D_{gi} + \sum_{i=1}^{35} S_{hi} \bullet D_{hi} \right) \tag{1}$$

$D_{ji}$ express the distance between planting base $j$ and the point of sale $i$, $S_{ji}$ express the freight amount from planting base $j$ to the point of sale $i$, where $i, j = 1, 2, \cdots\cdots, 35$.

## 3.2. Model of Shortage Compensation Standard

The relationship between the actual receive amount and the demand is as follows:

$$\begin{aligned} &S_{a1} + S_{b1} + S_{c1} + S_{d1} + S_{e1} + S_{f1} + S_{g1} + S_{h1} \le 6.5 \\ &S_{a2} + S_{b2} + S_{c2} + S_{d2} + S_{e2} + S_{f2} + S_{g2} + S_{h2} \le 10.2 \\ &\qquad \vdots \\ &S_{a35} + S_{b35} + S_{c35} + S_{d35} + S_{e35} + S_{f35} + S_{g35} + S_{h35} \le 10.7 \end{aligned} \tag{2}$$

The relationship between the total supply and the actual supply of the base:

$$\begin{aligned} &\sum_{i=1}^{35} S_{ai} \le 6.5 \\ &\sum_{i=1}^{35} S_{bi} \le 10.2 \\ &\quad \cdots\cdots \\ &\sum_{i=1}^{35} S_{hi} \le 10.7 \end{aligned} \tag{3}$$

Shortage compensation standard can be expressed by the following formula:

$$\begin{aligned} Q = {} & 710 \times [6.5 - (S_{a1} + S_{b1} + S_{c1} + S_{d1} + S_{e1} + S_{f1} + S_{g1} + S_{h1})] \\ & + 700 \times [10.2 - (S_{a2} + S_{b2} + S_{c2} + S_{d2} + S_{e2} + S_{f2} + S_{g2} + S_{h2})] \\ & \qquad \vdots \\ & + 500 \times [10.7 - (S_{a35} + S_{b35} + S_{c35} + S_{d35} + S_{e35} + S_{f35} + S_{g35} + S_{h35})] \end{aligned} \tag{4}$$

## 3.3. The Optimal Solution of the Total Cost

Using lingo13.0 software programming to solve the total cost, part of the running results are as follows (due to the program and the results are relatively long, so only with the final results):

Global optimal solution found.

| | | |
|---|---|---|
| Objective value: | 39077.34 | |
| Total solver iterations: | 66 | |
| Model Class: | LP | |
| Variable | Value | Reduced Cost |
| P | 145.3400 | 0.000000 |
| Q | 38932.00 | 0.000000 |

So, when $P = 145.34$, $Q = 38932.00$, Total cost to achieve the minimum $Z_{\min} = 39077.34$.

# 4. Based on the Expansion of the Planting Area of the Scheme Design

In order to meet the needs of the residents of the vegetable supply, we consider the situation of expanding the scale of vegetable planting base. Before the implementation of the expansion of planting area, the total supply of original eight bases are 210 (tons / day), but the total demand of all vegetable ales are 360.1(tons / day), so the difference between the total demand and the supply is 90.1 (tons / day), and each vegetable planting base needs add 90.1 (tons / day).

So we get the new constraint conditions of after expanding area, add the constraint conditions to lingo programming of the third part and after some fine-tuning will be able to find the solution, the constraint conditions are as follows:

$$X_a + X_b + X_c + X_d + X_e + X_f + X_g + X_h = 90.1 \tag{5}$$

$X_y\,(y = a, b, \cdots, g, h)$ express the amount of new planting in base $y$

Change the relationship between the total supply and the actual supply of the base and as follows (other constraint conditions remain unchanged):

$$\begin{aligned} &\sum_{i=1}^{35} S_{ai} - X_a \le 6.5 \\ &\sum_{i=1}^{35} S_{bi} - X_b \le 10.2 \\ &\cdots\cdots \\ &\sum_{i=1}^{35} S_{hi} - X_h \le 10.7 \end{aligned} \tag{6}$$

The constraint conditions are incorporated into the lingo13.0 software, and the results are as follows:

| | | |
|---|---|---|
| Global optimal solution found. | | |
| Objective value: | 6083.196 | |
| Total solver iterations: | 5 | |
| Model Class: | LP | |
| Variable | Value | Reduced Cost |
| P | 161.1960 | 0.000000 |
| Q | 5922.000 | 0.000000 |

So we get the solution

$$P = 161.1960,\quad Q = 5922.000,\quad Z_{\min} = 6083.196$$

The value of $X_y\,(y = a, b, \cdots, g, h)$ as follows:

***Table 2.*** *The new vegetable amount of every planting base (ton / day).*

| Variable | Xa | Xb | Xc | Xd | Xe | Xf | Xg | Xh |
|---|---|---|---|---|---|---|---|---|
| Value | 0 | 40.1 | 0 | 0 | 18.5 | 27.8 | 3.7 | 0 |

***Table 3.*** *The supply amount of new planting base (ton / day).*

| Base | a | b | c | d | e | f | g | h |
|---|---|---|---|---|---|---|---|---|
| Supply | 40 | 85.1 | 30 | 38 | 47.5 | 62.8 | 28.7 | 28 |

## 5. Based on Given Vegetable Species of Scheme Design

In order to improve the quality of residents' life, vegetable planting base not only to ensure the total supply of vegetables, but also to meet the needs of the residents of vegetable species. Each vegetable planting base can plant 12 kinds of vegetables, and the demand for each type of vegetable to the point of sale is known. Then, we combine the relationship between the amount of planting base supply and the amount of sale demand, find out the supply source and quantity of each kind of vegetables.

### *5.1. Supply and Demand Allocation of Vegetables*

#### *5.1.1. The Relationship Between the Demand and Supply of All Kinds of Vegetables*

$$\begin{aligned} &R_{a1} + R_{b1} + R_{c1} + R_{d1} + R_{e1} + R_{f1} + R_{g1} + R_{h1} \ge 62.1 \\ &R_{a2} + R_{b2} + R_{c2} + R_{d2} + R_{e2} + R_{f2} + R_{g2} + R_{h2} \ge 42.5 \\ &\cdots\cdots \\ &R_{a12} + R_{b12} + R_{c12} + R_{d12} + R_{e12} + R_{f12} + R_{g12} + R_{h12} \ge 15.7 \end{aligned} \tag{7}$$

***Table 4.*** *The total amount of vegetables required.*

| Vegetable species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total amount of vegetables | 62.1 | 42.5 | 34.5 | 34.8 | 25.35 | 29.5 | 22.05 | 27.95 | 23.05 | 21.3 | 21.2 | 15.7 |

#### *5.1.2. Total Supply of All Vegetables Are Less Than the Total Amount*

$$\sum_{i=1}^{12} \left( R_{ai} + R_{bi} + R_{ci} + R_{di} + R_{ei} + R_{fi} + R_{gi} + R_{hi} \right) \le 360.1 \tag{8}$$

#### *5.1.3. The Sum of All Kinds of Vegetables Supplied by the Base Is Equal to the Amount of the Supply*

$$\begin{aligned} &R_{a1} + R_{a2} + R_{a3} + R_{a4} + R_{a5} + R_{a6} + R_{a7} + R_{a8} = 40 \\ &R_{b1} + R_{b2} + R_{b3} + R_{b4} + R_{b5} + R_{b6} + R_{b7} + R_{b8} = 85.1 \\ &\cdots\cdots \\ &R_{h1} + R_{h2} + R_{h3} + R_{h4} + R_{h5} + R_{h6} + R_{h7} + R_{h8} = 28 \end{aligned} \tag{9}$$

The above constraints are incorporated into the lingo13.0 software to solve $R_{yi}$, and the results are shown as follows:

***Table 5.*** *The number of vegetables grown in each base.*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | | | | | | | | | | 3.1 | 21.2 | 15.7 |
| b | | 15.8 | 34.5 | 34.8 | | | | | | | | |
| c | | | | | | | | | 11.8 | 18.2 | | |
| d | | | | | | | | 27.95 | 10.05 | | | |
| e | | 24.25 | | | | | 22.05 | | 1.2 | | | |
| f | 5.5 | 2.45 | | | 25.35 | 29.5 | | | | | | |
| g | 28.7 | | | | | | | | | | | |
| h | 28 | | | | | | | | | | | |

The $R_{yi}(y=a,b,\ldots,g,h\ ;\ i=1,2,\ldots,12)$ value of the blank is zero.

### *5.2. Transport Scheme Design*

Observing the supply of these 12 kinds of vegetables, we found that there is at least one source of supply for each. So we decided to according to the type of vegetables, will be the optimal solution to be divided into 12 decomposition (that is, the optimal solution of each vegetable), in order to obtain the 12 after the decomposition of the sum, so as to obtain the final minimum optimal solution.

Take vegetables 1 as an example, planting base $f,g,h$ can provide vegetables 1 to the various points of sale, set $Y_{fi},Y_{gi},Y_{hi}$ respectively express the vegetables amount provided by the planting base $f,g,h$ to the point of sales $i$, we can get the following constraints:

#### *5.2.1. The Relationship Between the Demand of Each Point of Sale and the Actual Supply of Vegetable 1*

$$Y_{gi}+Y_{fi}+Y_{hi}\le c_{i1},\ \ (i=1,2,\ldots,35)\ \ (c_{i1}\ \text{express the supply of sale } i) \tag{10}$$

#### *5.2.2. The Relationship Between the Actual Supply and the Total Supply of Each Base*

$$\begin{aligned} &Y_{f1}+Y_{f2}+Y_{f3}+\cdots\cdots+Y_{f34}+Y_{f35}\le 62.8\\ &Y_{g1}+Y_{g2}+Y_{g3}+\cdots\cdots+Y_{g34}+Y_{g35}\le 28.7\\ &Y_{h1}+Y_{h2}+Y_{h3}+\cdots\cdots+Y_{h34}+Y_{h35}\le 28 \end{aligned} \tag{11}$$

#### *5.2.3. Freight Subsidies Can Be Expressed by the Following Formula*

$$P=0.04\times\left(\sum_{i=1}^{35}Y_{fi}\bullet D_{fi}+\sum_{i=1}^{35}Y_{gi}\bullet D_{gi}+\sum_{i=1}^{35}Y_{hi}\bullet D_{hi}\right) \tag{12}$$

#### *5.2.4. Shortage Compensation Standard Can Be Expressed by the Following Formula*

$$\begin{aligned} Q=\ &710\times[1-(Y_{f1}+Y_{g1}+Y_{h1})]\\ &+700\times[1.5-(Y_{f2}+Y_{g2}+Y_{h2})]\\ &\cdots\cdots\\ &+500\times[2-(Y_{f35}+Y_{g35}+Y_{h35})] \end{aligned} \tag{13}$$

We incorporated the above constraints conditions into programming, the minimum optimal value of the total cost of vegetables 1 was solved, and the results are as follows:

| | | |
|---|---|---|
| Global optimal solution found. | | |
| Objective value: | 4441.614 | |
| Model Class: | LP | |
| Variable | Value | Reduced Cost |
| P | 39.61400 | 0.000000 |
| Q | 4402.000 | 0.000000 |

That, is $P=39.614,\ \ Q=4402,\ \ Z_{1\min}=4441.614$.

In the same way, we can obtain the minimum optimal value of the total cost of the remaining 12 kinds of vegetables.

***Table 6.*** *The minimum optimal value of the total cost of the 12 kinds of vegetables.*

| 3 | 1 | 2 | 3 | 4 | 5 | 6 | Solution |
|---|---|---|---|---|---|---|---|
| **p** | **39.614** | **21.044** | **10.886** | **11.27** | **14.822** | **17.396** | |
| q | 4402 | 1295.25 | 10725 | 10286 | 0 | 0 | P |
| Total | 4441.614 | 1316.294 | 10735.89 | 10297.27 | 14.822 | 17.396 | 186.542 |
| Vegetables | 7 | 8 | 9 | 10 | 11 | 12 | Q |
| p | 5.284 | 14.986 | 8.014 | 15.972 | 15.526 | 11.728 | 38810 |
| q | 0 | 0 | 4391 | 1266.25 | 3782.25 | 2662.25 | Z |
| Total | 5.284 | 14.986 | 4399.014 | 1282.222 | 3797.776 | 2673.978 | 38996.54 |

# 6. Evaluation and Promotion

### *6.1. Model Advantages*

*6.1.1* Be able to take into account the planting base, traffic junction, point of sale of three aspects of the analysis and calculation, and get the shortest distance;

*6.1.2* Reasonable assumptions help us to better solve the problem, and make a lot of problems are better to start;

*6.1.3* Through the lingo model to solve the linear programming problem, relatively simple and easy to operate, and the initial value is convenient to change, the model is more flexible.

### *6.2. Model Disadvantages*

*6.2.1* The shortest distance calculation method has some limitations, may leak to calculate the distance between the two points, Or there is a very individual point is not the shortest distance, can seek a more appropriate way to calculate distance;

*6.2.2* The model in the transport of the consideration is unilateral, some stiff, If we want to apply it in practice, the transport subsidies constraints need to become more flexible;

# References

[1] Jiang Qiyuan, mathematical model, Beijing, higher education press, 2003

[2] Diao Zaiyun, operational research, Beijing, higher education press, 2007.

[3] Su Xiaohong, C language programming, Beijing, higher education press, 2013.

[4] LIU Xiao-ke. Discussion on Vegetable Planting Problem Model in Vegetable Basket Project [J]. Journal of Science &, 2016, (3): 184-184. DOI: 10.3969/j.issn.1674-6813(z).2016.03.148.

[5] Shao Xian. Financial Model Innovation of Agricultural Supply Chain - Taking Mawangdui Vegetable Wholesale Market as an Example [J]. Agricultural Economy, 2013, 34 (8): 62-68.

[6] ZOU Gui-fang, ZHANG Pei-ai. Improved Floyd Algorithm for Shortest Path Problem in Network Optimization [J]. Science Technology and Engineering, 2011, 11 (28): 6875-6878, 6892. DOI: 10.3969/j.issn.1671-1815.2011.28.020.

[7] Yijie Han. An O (n~3(log log n/log n)~(5/4)) Time Algorithm for All Pairs Shortest Path [J]. Algorithmica, 2008, 51 (4): 428-434.

[8] The Floyd-Warshall algorithm on graphs with negative cycles [J]. Information processing letters, 2010, 110 (8/9): 279-.

[9] DENG Ao. Study on Traffic Congestion and Accident Avoidance System Based on Genetic Algorithm and Ant Colony Algorithm [J]; Jiangsu University.

[10] WANG Li. Application of Graph Theory in Algorithm Design [D]. Xidian University, 2010. DOI: 10.7666 / d.y1706742.