Chapter – VI

Modelling for Inventory and Transportation of Some Goods
Modelling for Inventory and Transportation of Some Goods

6.1 Introduction

In this chapter we are intended to model and analyze the data collected from Food Corporation of India, Silchar of some of the essential goods being supplied by them to the local markets as well as the neighboring states of Manipur and Mizoram by using inventory control technique. Also we develop a transportation schedule for transporting the most essential commodity rice from different suppliers of Silchar to the different destinations of the neighboring state Mizoram. The transportation schedule for other two commodities could not be considered due to no availability of the concerned data.

6.2 Problem 1: Inventory model

This model is based on the data collected (see tables 3.26-3.38) from the Food Corporation of India, Silchar division for some of the essential goods like rice, wheat and sugar. Since orders are not placed by the Silchar division of ‘Food Corporation of India’, rather these are placed by Head Office and the divisional office carries out the order of the Head Office by processing them, so we can term it as order processing cost. In view of this region being flood prone and communication system not being
well adequate, our first inventory related problem is to find the EOQ of the essential goods for which data pertaining to different years are given in tables 3.26-3.38.

6.1.1 Determination of EOQ

The EOQ can be determined by using the formula

\[ EOQ = \sqrt{\frac{2AS}{C}} \]

where

- \( A \) = Annual usage in units.
- \( S \) = Order Processing Cost.
- \( C \) = Annual carrying cost per unit.

Annual usage for this region are obtained from the data contained in the tables 3.28 & 3.29. Order processing cost will be taken as 10% of Staff Salary of Divisional Office, which is listed in table 3.34 and 10% of miscellaneous expenditure, which is given in table 3.33. Carrying cost is taken from 3.36.

**Determination of EOQ of the items (Rice, Wheat & Sugar) for the year 2004 – 2005**

For Rice

- \( A = 2115262 \)
- \( C = 110 \)
- \( S = 1858485 \)

Then

\[ EOQ = \sqrt{\frac{2 \times 2115262 \times 110}{1858485}} \]

\[ = 266616.5 \text{ quintals} \]
For Wheat \( A = 498791 \), \( C = 110 \), \( S = 1858485 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 129444.5 \text{ quintals} \]

For Sugar \( A = 45720 \), \( C = 110 \), \( S = 1858485 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 39194.7 \text{ quintals} \]

Determination of EOQ of the items (Rice, Wheat & Sugar) for the year 2005 – 2006

For Rice \( A = 2421675 \), \( C = 120 \), \( S = 1757875 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 266583.3 \text{ quintals} \]

For Wheat \( A = 356693 \), \( C = 120 \), \( S = 1757875 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 101922.3 \text{ quintals} \]

For Sugar \( A = 45492 \), \( C = 120 \), \( S = 1757875 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 36398.2 \text{ quintals} \]

Determination of EOQ of the items (Rice, Wheat & Sugar) for the year 2006 – 2007

For Rice \( A = 2597411 \), \( C = 125 \), \( S = 1657985 \)
Then \( EOQ = \sqrt{\frac{2AS}{C}} \)
\[ = 261712.7 \text{ quintals} \]
For Wheat $A = 271950$, $C = 125$, $S = 1657985$

Then $EOQ = \sqrt{\frac{2AS}{C}}$

$= 84677.64$ quintals

For Sugar $A = 67607$, $C = 125$, $S = 1657985$

Then $EOQ = \sqrt{\frac{2AS}{C}}$

$= 42229.9$ quintals


6.3 Problem 2

In this problem we make a transportation schedule for rice, as being the essential commodity for the state of Mizoram, the data for which are obtained from the different suppliers of rice, who used to supply rice to the different markets of Mizoram. The data are tabulated in Tables 3.39 to 3.42. Combining the data of the tables 3.40, 3.41 and 3.42 we get the following transportation model to determine an optimal schedule so as to minimize the transportation cost for rice to different markets of Mizoram.
Here $\Sigma a_i = 34450, \Sigma b_j = 23000$

Since $\Sigma a_i \neq \Sigma b_j$, we introduce a dummy destination $V*$ with requirement of 11450 units and zero (0) transportation costs, as shown in the next table in the form of balanced transportation problem.
<table>
<thead>
<tr>
<th></th>
<th>X*</th>
<th>Y*</th>
<th>Z*</th>
<th>U*</th>
<th>V*</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>60</td>
<td>120</td>
<td>75</td>
<td>180</td>
<td>0</td>
<td>8000</td>
</tr>
<tr>
<td>B*</td>
<td>58</td>
<td>100</td>
<td>60</td>
<td>165</td>
<td>0</td>
<td>9200</td>
</tr>
<tr>
<td>C*</td>
<td>62</td>
<td>110</td>
<td>65</td>
<td>170</td>
<td>0</td>
<td>6250</td>
</tr>
<tr>
<td>D*</td>
<td>65</td>
<td>115</td>
<td>80</td>
<td>175</td>
<td>0</td>
<td>4900</td>
</tr>
<tr>
<td>E*</td>
<td>70</td>
<td>135</td>
<td>85</td>
<td>195</td>
<td>0</td>
<td>6100</td>
</tr>
<tr>
<td>Demand</td>
<td>5000</td>
<td>2000</td>
<td>10000</td>
<td>6000</td>
<td>11450</td>
<td>(2) (10) (5) (5) (0)</td>
</tr>
</tbody>
</table>
Now we solve it for its initial basic feasible solution by using Vogels approximation method which leads to the following final table as:

<table>
<thead>
<tr>
<th></th>
<th>X*</th>
<th>Y*</th>
<th>Z*</th>
<th>U*</th>
<th>V*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>5000</td>
<td>3000</td>
<td>75</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B*</td>
<td>2000</td>
<td>1200</td>
<td>6000</td>
<td>60</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C*</td>
<td>5800</td>
<td>450</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>110</td>
<td>65</td>
<td>170</td>
<td>0</td>
</tr>
<tr>
<td>D*</td>
<td>4900</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>115</td>
<td>80</td>
<td>175</td>
<td>0</td>
</tr>
<tr>
<td>E*</td>
<td>6100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>135</td>
<td>85</td>
<td>195</td>
<td>0</td>
</tr>
</tbody>
</table>

Here number of occupied cell is (5+5-1=9) which is exactly same as \(m+n-1\). Therefore we get the initial feasible solution as

\[ x_{11} = 5000, \quad x_{13} = 3000, \quad x_{22} = 2000, \]
\[ x_{23} = 1200, \quad x_{24} = 6000, \quad x_{33} = 5800, \]
\[ x_{35} = 450, \quad x_{45} = 4900, \quad x_{55} = 6100. \]

Now we check by MODI method whether the obtained solution is optimal or not. Here we determine a set of \(u_i\) and \(v_j\) starting with \(u_i=0\) and using the relation \(c_{ij} = u_i + v_j\) for occupied basic cells as shown below.
Now we calculate net evaluations for unoccupied cells by using the relation \(d_{ij} = z_{ij} - c_{ij}\)

\[
\begin{align*}
    d_{12} &= z_{12} - c_{12} = u_1 + v_2 - 120 = 0 + 115 - 120 = -5 \\
    d_{14} &= z_{14} - c_{14} = u_1 + v_4 - 180 = 0 + 180 - 180 = 0 \\
    d_{15} &= z_{15} - c_{15} = u_1 + v_5 - 0 = 0 + 10 - 0 = 10 \\
    d_{21} &= z_{21} - c_{21} = u_2 + v_1 - 58 = -15 + 60 - 58 = -13 \\
    d_{25} &= z_{25} - c_{25} = u_2 + v_5 - 0 = -15 + 10 - 0 = -5 \\
    d_{31} &= z_{31} - c_{31} = u_3 + v_1 - 62 = -10 + 60 - 62 = -12 \\
    d_{32} &= z_{32} - c_{32} = u_3 + v_2 - 110 = -10 + 115 - 110 = -5 \\
    d_{34} &= z_{34} - c_{34} = u_3 + v_4 - 170 = -10 + 180 - 170 = 0 \\
    d_{41} &= z_{41} - c_{41} = u_4 + v_1 - 65 = -10 + 60 - 65 = -15 \\
    d_{42} &= z_{42} - c_{42} = u_4 + v_2 - 115 = -10 + 115 - 115 = -10 \\
    d_{43} &= z_{43} - c_{43} = u_4 + v_3 - 80 = -10 + 75 - 80 = -15 \\
    d_{44} &= z_{44} - c_{44} = u_4 + v_4 - 175 = -10 + 180 - 175 = -5 \\
    d_{51} &= z_{51} - c_{51} = u_5 + v_1 - 70 = -10 + 60 - 70 = -20
\end{align*}
\]
\[ \begin{align*}
    d_{52} &= z_{52} - c_{52} \cdot d_{52} = u_5 + v_2 - 135 \cdot d_{52} = 10 + 115 - 135 = -30 \\
    d_{53} &= z_{53} - c_{53} \cdot d_{53} = u_5 + v_3 - 85 \cdot d_{53} = 10 + 75 - 85 = -20 \\
    d_{54} &= z_{54} - c_{54} \cdot d_{54} = u_5 + v_4 - 195 \cdot d_{54} = 10 + 180 - 195 = -25,
\end{align*} \]

then the initial iteration is given as

**Initial Iteration:**

<table>
<thead>
<tr>
<th></th>
<th>X*</th>
<th>Y*</th>
<th>Z*</th>
<th>U*</th>
<th>V*</th>
<th>u_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>5000</td>
<td>(-5)</td>
<td>3000 - θ</td>
<td>(0)</td>
<td>+ θ</td>
<td>(10)</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>20</td>
<td>75</td>
<td>180</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>B*</td>
<td>(-13)</td>
<td>2000</td>
<td>1200</td>
<td>6000</td>
<td>(-5)</td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>100</td>
<td>60</td>
<td>165</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>C*</td>
<td>(-12)</td>
<td>(-5)</td>
<td>5800 + θ</td>
<td>(0)</td>
<td>450 - θ</td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>110</td>
<td>65</td>
<td>170</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>D*</td>
<td>(-15)</td>
<td>(-10)</td>
<td>(-15)</td>
<td>(-5)</td>
<td>4900</td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>115</td>
<td>80</td>
<td>175</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>E*</td>
<td>(-20)</td>
<td>(-30)</td>
<td>(-20)</td>
<td>(-25)</td>
<td>6100</td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>135</td>
<td>85</td>
<td>195</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>v_i</td>
<td>60</td>
<td>115</td>
<td>75</td>
<td>180</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Since $d_{15}$ is most positive, therefore cell (1,5) enters the basis. We allocate an unknown quantity $\theta$ to this cell and identify a closed loop involving basic cells around this entering cell.

Now $\theta = \min\{450, 3000\} = 450$, so we drop cell (3, 5).

The next table found is:

<table>
<thead>
<tr>
<th></th>
<th>X*</th>
<th>Y*</th>
<th>Z*</th>
<th>U*</th>
<th>V*</th>
<th>$u_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>5000</td>
<td>60</td>
<td>20</td>
<td>75</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td>B*</td>
<td>2000</td>
<td>58</td>
<td>100</td>
<td>60</td>
<td>165</td>
<td>0</td>
</tr>
<tr>
<td>C*</td>
<td>62</td>
<td>110</td>
<td>65</td>
<td>170</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D*</td>
<td>65</td>
<td>115</td>
<td>80</td>
<td>175</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>E*</td>
<td>70</td>
<td>135</td>
<td>85</td>
<td>195</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>$v_i$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Now continuing the above process for iterative initial basic feasible solution we calculate \( u_i \) and \( v_j \) by the relation \( u_i + v_j = c_{ij} \)

\[
\begin{align*}
c_{11} &= u_1 + v_1 \cdot 60 = 0 + v_1 \cdot v_1 = 60 \\
c_{13} &= u_1 + v_3 \cdot 75 = 0 + v_3 \cdot v_3 = 75 \\
c_{22} &= u_2 + v_2 \cdot 100 = u_2 + v_2 \cdot v_2 = 75 \\
c_{23} &= u_2 + v_3 \cdot 60 = u_2 + 75 \cdot u_2 = -15 \\
c_{24} &= u_2 + v_4 \cdot 165 = -15 + v_4 \cdot v_4 = 180 \\
c_{33} &= u_3 + v_3 \cdot 65 = u_3 + 75 \cdot u_3 = -10 \\
c_{35} &= u_3 + v_5 \cdot 0 = -10 + v_5 \cdot v_5 = 10 \\
c_{45} &= u_4 + v_5 \cdot 0 = u_4 + 10 \cdot u_4 = -10 \\
c_{55} &= u_5 + v_5 \cdot 0 = u_5 + 10 \cdot u_5 = -10
\end{align*}
\]

Now we calculate net evaluation for unoccupied cells by using the relation

\[
d_{ij} = z_{ij} - c_{ij}
\]

\[
\begin{align*}
d_{12} &= z_{12} - c_{12} \cdot d_{12} = u_1 + v_2 - 120 \cdot d_{12} = 0 + 115 - 120 = -5 \\
d_{14} &= z_{14} - c_{14} \cdot d_{14} = u_1 + v_4 - 180 \cdot d_{14} = 0 + 180 - 180 = 0 \\
d_{21} &= z_{21} - c_{21} \cdot d_{21} = u_2 + v_1 - 58 \cdot d_{21} = -15 + 60 - 58 = -13 \\
d_{25} &= z_{25} - c_{25} \cdot d_{25} = u_2 + v_5 - 0 \cdot d_{25} = -15 + 10 - 0 = -5 \\
d_{31} &= z_{31} - c_{31} \cdot d_{31} = u_3 + v_1 - 62 \cdot d_{31} = -10 + 60 - 62 = -12 \\
d_{32} &= z_{32} - c_{32} \cdot d_{32} = u_3 + v_2 - 110 \cdot d_{32} = -10 + 115 - 110 = -5 \\
d_{34} &= z_{34} - c_{34} \cdot d_{34} = u_3 + v_4 - 170 \cdot d_{34} = -10 + 180 - 170 = 0 \\
d_{35} &= z_{35} - c_{35} \cdot d_{35} = u_3 + v_5 - 0 \cdot d_{35} = -10 + 10 - 0 = 0 \\
d_{41} &= z_{41} - c_{41} \cdot d_{41} = u_4 + v_1 - 65 \cdot d_{41} = -10 + 60 - 65 = -15 \\
d_{42} &= z_{42} - c_{42} \cdot d_{42} = u_4 + v_2 - 115 \cdot d_{42} = -10 + 115 - 115 = -10
\end{align*}
\]
\[ d_{43} = z_{43} - c_{43} \cdot d_{43} = u_4 + v_3 - 80 \cdot d_{43} = -10 + 75 - 80 = -15 \]
\[ d_{44} = z_{44} - c_{44} \cdot d_{44} = u_4 + v_4 - 175 \cdot d_{44} = -10 + 180 - 175 = -5 \]
\[ d_{51} = z_{51} - c_{51} \cdot d_{51} = u_5 + v_1 - 70 \cdot d_{51} = -10 + 60 - 70 = -20 \]
\[ d_{52} = z_{52} - c_{52} \cdot d_{52} = u_5 + v_2 - 135 \cdot d_{52} = -10 + 115 - 135 = -30 \]
\[ d_{53} = z_{53} - c_{53} \cdot d_{53} = u_5 + v_3 - 85 \cdot d_{53} = -10 + 75 - 85 = -20 \]
\[ d_{54} = z_{54} - c_{54} \cdot d_{54} = u_5 + v_4 - 195 \cdot d_{54} = -10 + 180 - 195 = -25. \]

This after one iteration gives the final table obtained as:

<table>
<thead>
<tr>
<th>X*</th>
<th>Y*</th>
<th>Z*</th>
<th>U*</th>
<th>V*</th>
<th>u_1</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>5000</td>
<td>(-5)</td>
<td>2550</td>
<td>(0)</td>
<td>450</td>
</tr>
<tr>
<td>60</td>
<td>20</td>
<td>75</td>
<td>180</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B*</td>
<td>(-13)</td>
<td>2000</td>
<td>1200</td>
<td>6000</td>
<td>(-5)</td>
</tr>
<tr>
<td>58</td>
<td>100</td>
<td>60</td>
<td>165</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>C*</td>
<td>(-12)</td>
<td>(-5)</td>
<td>6250</td>
<td>(0)</td>
<td>(0)</td>
</tr>
<tr>
<td>62</td>
<td>110</td>
<td>65</td>
<td>170</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D*</td>
<td>(-15)</td>
<td>(-10)</td>
<td>(-15)</td>
<td>(-5)</td>
<td>4900</td>
</tr>
<tr>
<td>65</td>
<td>115</td>
<td>80</td>
<td>175</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>E*</td>
<td>(-20)</td>
<td>(-30)</td>
<td>(-20)</td>
<td>(-25)</td>
<td>6100</td>
</tr>
<tr>
<td>70</td>
<td>135</td>
<td>85</td>
<td>195</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>vi</td>
<td>60</td>
<td>115</td>
<td>75</td>
<td>180</td>
<td>10</td>
</tr>
</tbody>
</table>

Here all \( d_i \leq 0 \), an optimal solution has reached, which is given below:

\[ x_{11} = 5000, \quad x_{13} = 2550, \quad x_{15} = 450. \]
Thus the optimal transportation cost is $Z = \text{Rs. } 2159500.00$

If this above optimal schedule is adopted by the suppliers of rice to Mizoram it would not only involve minimization of the transportation cost but it would also minimize the consumption of fuel in transporting the goods by different carriers on the other hand.