# Operation Research Project

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## Transportation of EGGS:

A case study using multi-objective Transportation Problem (MOTP)

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Table 1 :- Distance Matrix($d_{ij}$)

| origin | $D_1$ | $D_2$ | $D_3$ | Supply |
|---|---|---|---|---|
| $S_1$ | 551 | 314 | 280 | 8 |
| $S_2$ | 521 | 267 | 341 | 5 |
| $S_3$ | 396 | 142 | 193 | 3 |
| Demand | 5 | 3 | 2 | |

The Matrix is not balanced Problem. To make it balanced add a Column and we Considered as a dummy variable that is Called $D_4$

Table :- 2

| origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply |
|---|---|---|---|---|---|
| $S_1$ | 551 | 314 | 280 | 0 | 8 |
| $S_2$ | 521 | 267 | 341 | 0 | 5 |
| $S_3$ | 396 | 142 | 193 | 0 | 3 |
| Demand | 5 | 3 | 2 | 6 | 16 |

Solve it with one of the transportation method that is Called approximation

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| Origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 551 | 314 | $\boxed{2}$ 280 | $\boxed{6}$ ~~0~~ | ~~82~~ 0 | 280 | 34 | 34 | 271 | - |
| $S_2$ | $\boxed{2}$ 521 | $\boxed{3}$ 267 | 341 | ~~0~~ | ~~52~~ 0 | 267 | 74 | 74 | 780 | 521 |
| $S_3$ | $\boxed{3}$ 396 | 142 | 193 | ~~0~~ | ~~3~~ 0 | 42 | 51 | - | - | - |
| Supply | ~~52~~0 | ~~3~~0 | ~~2~~0 | ~~6~~0 | 16 | | | | | |
| | 125 | 125 | 87 | 0 | | | | | | |
| | 125 | 125 | 87 | – | | | | | | |
| Penalty | 30 | 47 | 61 | – | | | | | | |
| | 30 | – | 61 | – | | | | | | |
| | 521 | – | | – | | | | | | |
| | – | – | | – | | | | | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 551 | 314 | $\boxed{2}$ 280 | $\boxed{6}$ 0 |
| $S_2$ | $\boxed{2}$ 521 | $\boxed{3}$ 267 | 341 | 0 |
| $S_3$ | $\boxed{3}$ 396 | 142 | 193 | 0 |
| | | | | |

The optimal Solution select the allocated cells ~~&~~ numbers that is

$S_1D_3 = x_{13} = 2$ , $S_1D_4 - x_{14} = 6$

$S_2D_1 - x_{21} = 2$ , $S_2D_2 = x_{22} = 3$

$S_3D_1 - x_{31} = 3$

| Origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 551 | 314 | [2] 280 | [6] 0 | 8 2 0 | 280 | 34 | 34 | 271 | - |
| $S_2$ | [2] 521 | [3] 267 | 341 | 0 | 5 2 0 | 267 | 74 | 74 | 120 | 52 |
| $S_3$ | [3] 396 | 142 | 193 | 0 | 3 0 | 42 | 51 | - | - | - |
| Supply | 5 2 0 | 3 0 | 2 0 | 6 0 | 16 | | | | | |
| | 125 | 125 | 87 | 0 | | | | | | |
| | 125 | 125 | 87 | - | | | | | | |
| Penalty | 30 | 47 | 61 | - | | | | | | |
| | 30 | - | 61 | - | | | | | | |
| | 521 | - | | - | | | | | | |
| | - | - | | - | | | | | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 551 | 314 | [2] 280 | [6] 0 |
| $S_2$ | [2] 521 | [3] 267 | 341 | 0 |
| $S_3$ | [3] 396 | 142 | 193 | 0 |
| | | | | |

The optimal Solution select the allocated cells ~~&~~ numbers that is

$S_1D_3 = x_{13} = 2$ , $S_1D_4 = x_{14} = 6$

$S_2D_1 = x_{21} = 2$ , $S_2D_2 = x_{22} = 3$

$S_3D_1 = x_{31} = 3$

Minimum distance = ?

Minimum Cost = ?

$x_{13} = 2 = 280$ , $x_{14} = 6 = 0$ (dummy)

$x_{21} = 2 = 521$ , $x_{22} = 3 = 2,67$

$x_{31} = 3 = 396$

So

Minimum distance = 280 + 521 + 2.67 + 396

$\boxed{= 1464}$

Minimum Transportation Cost =

~~2×521~~ 2×280 + 6×0 + 2×521 + 267×3 + 396×3

= 560 + 0 + 1042 + 801 + 1188

= 3591

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Table 3- Time Matrix (tij) Speed 30km/h

| Destination/ origin | $D_1$ | $D_2$ | $D_3$ | Supply in Lacs |
|---|---|---|---|---|
| $S_1$ | 18.36 | 10.46 | 9.33 | 8 |
| $S_2$ | 17.5 | 8.9 | 11.36 | 5 |
| $S_3$ | 13.25 | 4.73 | 6.43 | 3 |
| Demand in lacs | 5 | 3 | 2 | |

The Proposed Matrix is not balanced Problem to Make it a balanced Problem we Considered a dummy variable that is Called $D_4$

| Destation/origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply in Lacs |
|---|---|---|---|---|---|
| $S_1$ | 18.36 | 10.46 | 9.33 | 0 | 8 |
| $S_2$ | 17.5 | 8.9 | 11.36 | 0 | 5 |
| $S_3$ | 13.25 | 4.73 | 6.43 | 0 | 3 |
| Demand in lacs | 5 | 3 | 2 | 6 | |

Now Solve it with the transportation Method of vogel approximation.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | supply | Penalty | | | |
|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 2.36 | 10.46 | [2] 9.33 | [6] 0 | 820 | 9.33 | 1.13 | 1.13 | 9.03 |
| $S_2$ | [3] 17.5 | [3] 8.9 | 11.36 | 0 | 820 | 8.9 | 2.46 | 2.46 | 6.14 |
| $S_3$ | [3] 13.25 | 4.73 | 6.43 | 0 | 20 | 4.73 | 1.7 | - | - |
| Demand in Lacks | 250 | 30 | 20 | 80 | | | | | |
| | 4.25 | 4.17 | 2.9 | 0 | | | | | |
| | 4.25 | 4.17 | 2.9 | — | | | | | |
| Penalty | 0.86 | 1.56 | 2.03 | — | | | | | |
| | 0.86 | — | 2.03 | — | | | | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 18.36 | 10.46 | [2] 9.33 | [6] 0 |
| $S_2$ | [2] 17.5 | [3] 8.9 | 11.36 | 0 |
| $S_3$ | [3] 13.25 | 4.73 | 6.43 | 0 |

Optimum solution of travelling time (Speed 30km/h) is

$x_{13}=2$ $x_{14}=0$ $x_{21}=2$ $x_{22}=3$ $x_{31}=3$

Therefore Minimum travelling time (Speed 30km/h)

$x_{13}=2=9.33$ $x_{14}=0=6$ $x_{21}=2=17.5$

$x_{22}=3=8.9$ $x_{31}=3=13.25$

$9.33+17.5+8.9+13.25$

$\boxed{=48.98\text{ hrs}}$

Table 4 Time Matrix (tij) speed 35km/h

| | $D_1$ | $D_2$ | $D_3$ | Supply |
|---|---|---|---|---|
| $S_1$ | 15.74 | 8.97 | 8 | 8 |
| $S_2$ | 14.89 | 7.63 | 9.74 | 5 |
| $S_3$ | 11.31 | 4.06 | 5.51 | 3 |
| Demand | 5 | 3 | 2 | |

The Proposed Matrix is not balanced Problem to make it a balanced Problem we Considered a dummy variable that is Called $D_4$

| Destination | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply |
|---|---|---|---|---|---|
| $S_1$ | 15.74 | 8.97 | 8 | 0 | 8 |
| $S_2$ | 14.89 | 7.63 | 9.74 | 0 | 5 |
| $S_3$ | 11.31 | 4.06 | 5.51 | 0 | 3 |
| Demand | 5 | 3 | 2 | 6 | |

Now Solve it with the transportation Method of Vogel Approximation

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| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 15.74 | 8.97 | $\boxed{2}$ 8 | $\boxed{6}$ 0 | ~~8~~ ~~2~~ 0 | 8 | 0.97 | 0.97 | 7.74 | - | - |
| $S_2$ | $\boxed{2}$ 14.89 | $\boxed{3}$ 7.63 | 9.74 | 0 | ~~8~~ ~~2~~ 0 | 7.63 | 2.11 | 2.11 | 5.15 | - | - |
| $S_3$ | $\boxed{3}$ 11.31 | 4.06 | 5.51 | 0 | ~~8~~ 0 | 4.06 | 1.45 | - | - | - | - |
| Demand | ~~8~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | | | | | | | |
| Penalty | 3.58 | 3.57 | 2.49 | 0 | | | | | | | |
| | 3.58 | 3.57 | 2.49 | – | | | | | | | |
| | 0.85 | 1.34 | 1.74 | – | | | | | | | |
| | 0.85 | – | 1.74 | – | | | | | | | |
| | – | – | – | – | | | | | | | |
| | – | – | – | – | | | | | | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 15.74 | 8.97 | $\boxed{2}$ 8 | $\boxed{6}$ 0 |
| $S_2$ | $\boxed{2}$ 14.89 | $\boxed{3}$ 7.63 | 9.74 | 0 |
| $S_3$ | $\boxed{3}$ 11.31 | 4.06 | 5.51 | 0 |
| | | | | 0 |

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Date:

Optimum Solution of travelling time (Speed 35km/h is

$x_{13} = 2$ $x_{14} = 0$ $x_{21} = 2$
$x_{22} = 3$ $x_{31} = 3$

Therefore Minimum travelling time (Speed 30 km/h)

$x_{13} = 2 = 8$ $x_{14} = 0 = 6$ (dummy)
$x_{21} = 2 = 14.89$ $x_{22} = 7.63 = 3$
$x_{31} = 3 = 11.31$

$= 8 + 14.89 + 7.63 + 11.31 = 41.83$ hours

$\boxed{= 41.83 \text{ hours}}$

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Table: 5 Time Metrix ($t_{ij}$) Speed 40 km/h

| origin/destination | $D_1$ | $D_2$ | $D_3$ | supply |
|---|---|---|---|---|
| $S_1$ | 13.78 | 7.85 | 7 | 8 |
| $S_2$ | 13.03 | 6.68 | 8.53 | 5 |
| $S_3$ | 9.9 | 3.55 | 4.83 | 3 |
| Demand | 5 | 3 | 2 | |

Make it balanced by adding column that is considered as dummy variable called $D_4$

| origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | supply |
|---|---|---|---|---|---|
| $S_1$ | 13.78 | 7.85 | 7 | 0 | 8 |
| $S_2$ | 13.03 | 6.68 | 8.53 | 0 | 5 |
| $S_3$ | 9.9 | 3.55 | 4.83 | 0 | 3 |
| Demand | 5 | 3 | 2 | 6 | 16 |

Solve it with one of the transportation method called vogel Approximation.

| | D1 | D2 | D3 | D4 | Supply | Penalty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 13.78 | 7.85 | $\boxed{2}$ 7 | $\boxed{6}$ 0 | ~~8~~ ~~2~~ 0 | 7 | 0.85 | 0.85 | 6.78 | - |
| $S_2$ | $\boxed{2}$ 13.03 | $\boxed{3}$ 6.68 | 8.53 | 0 | ~~8~~ ~~2~~ 0 | 6.68 | 1.85 | 1.85 | 4.5 | 13.03 |
| $S_3$ | $\boxed{3}$ 9.9 | 3.55 | 4.83 | 0 | ~~3~~ 0 | 3.55 | 1.28 | - | - | - |
| Demand | ~~8~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | 16 | | | | | |
| | 3.13 | 3.13 | 2.17 | 0 | | | | | | |
| | 3.13 | 3.13 | 2.17 | – | | | | | | |
| | 0.75 | 1.17 | 1.53 | – | | | | | | |
| | 0.75 | – | 1.53 | – | | | | | | |
| | 13.03 | – | | – | | | | | | |

| | D1 | D2 | D3 | D4 |
|---|---|---|---|---|
| $S_1$ | 13.78 | 7.85 | $\boxed{2}$ 7 | $\boxed{6}$ 0 |
| $S_2$ | $\boxed{2}$ 13.03 | $\boxed{3}$ 6.68 | 8.53 | 0 |
| $S_3$ | $\boxed{3}$ 9.9 | 3.55 | 4.83 | 0 |

The optimal solution for time Matrix (4 column)

$S_1D_3 = x_{13} = 2$, $S_1D_4 = x_{14} = 6$, $S_2D_1 = x_{21} = 2$,

$S_2D_2 = x_{22} = 3$, $S_3D_1 = x_{31} = 3$

Therefore Minimum travelling time (Speed 4 column)

$x_{13} = 2 = 7$ $\quad x_{14} = 6 = 0$ (dummy)

$x_{21} = 2 = 13.03$ $\quad x_{22} = 3 = 6.68$ $\quad x_{31} = 3 = 9.9$

$= 7 + 13.03 + 6.68 + 9.9$

$\boxed{= 36.61 \text{ hrs}}$

Table 6: Time Matrix($t_{ij}$) Speed 45km/h

| Destination/Origin | $D_1$ | $D_2$ | $D_3$ | Demand in lacks |
|---|---|---|---|---|
| $S_1$ | 12.24 | 6.98 | 6.22 | 8 |
| $S_2$ | 11.58 | 5.93 | 7.58 | 5 |
| $S_3$ | 8.8 | 3.16 | 4.29 | 3 |
| Demand in lacks | 5 | 3 | 2 | |

The prepesed matrix is not balanced Problem to make it a balanced problem we considered a dummy variable that is called $D_4$

| Destination/origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Demands in lacks |
|---|---|---|---|---|---|
| $S_1$ | 12.24 | 6.98 | 6.22 | 0 | 8 |
| $S_2$ | 11.58 | 5.93 | 7.58 | 0 | 5 |
| $S_3$ | 8.8 | 3.16 | 4.29 | 0 | 3 |
| Demands in lacks | 5 | 3 | 2 | 6 | |

Use the vogel approximate method for this transportation problem.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty |
|---|---|---|---|---|---|---|
| $S_1$ | 12.24 | 6.98 | [2] 6.22 | [6] 0 | ~~8~~ ~~2~~ 0 | [illegible] \| [illegible] \| [illegible] \| [illegible] \| - |
| $S_2$ | [2] 11.58 | [3] 5.93 | 7.58 | 0 | ~~5~~ ~~2~~ 0 | [illegible] \| [illegible] \| [illegible] \| - \| - |
| $S_3$ | [3] 8.8 | 3.16 | 4.29 | 0 | ~~3~~ 0 | [illegible] \| [illegible] \| - \| - \| - |
| Demand | ~~5~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | | |
| Penalty | 2.78 | 2.77 | 1.93 | 0 | | |
| | 2.78 | 2.77 | 1.93 | - | | |
| | 0.66 | 1.05 | 1.36 | - | | |
| | 0.66 | - | 1.36 | - | | |
| | - | - | - | - | | |
| | - | - | - | - | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 12.24 | 6.98 | [2] 6.22 | [6] 0 |
| $S_2$ | [2] 11.58 | [3] 5.93 | 7.58 | 0 |
| $S_3$ | [3] 8.8 | 3.16 | 4.29 | 0 |

For optimum solution select the allocation numbers. From the table above.

$S_1D_3 = x_{13} = 2$, $S_1D_4 = x_{14} = 0$

$S_2D_1 = x_{21} = 2$, $S_2D_2 = x_{22} = 3$

$S_3D_1 = x_{31} = 3$

Now minimum travelling time (speed 45 km/h)

For this select the $c_{ij}$ of allocation cell.

$= 6.22 + 11.58 + 5.93 + 8.8$

$= 32.53$ hrs

Table 7: Percent Breakages Matrix ($p_{ij}$) Speed 30 km/h

| Destination/origin | $D_1$ | $D_2$ | $D_3$ | Supply in lacks |
|---|---|---|---|---|
| $S_1$ | 5 | 2.85 | 2.54 | 8 |
| $S_2$ | 4.77 | 2.42 | 3.1 | 5 |
| $S_3$ | 3.61 | 1.29 | 1.75 | 3 |
| Demand in lacks | 5 | 3 | 2 | |

The proposed Model is not balanced problem to make it a balanced problem we considered a dummy variable that is called $D_4$

| Destination/origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply in lacks |
|---|---|---|---|---|---|
| $S_1$ | 5 | 2.85 | 2.54 | 0 | 8 |
| $S_2$ | 4.77 | 2.42 | 3.1 | 0 | 5 |
| $S_3$ | 3.61 | 1.29 | 1.75 | 0 | 3 |
| Demand in lacks | 5 | 3 | 2 | 6 | 16 |

Now we solve it with the transportation method of vogel approximate method:

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty | | | |
|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 5 | 2.85 | [2] 2.54 | [6] 0 | ~~8~~ ~~2~~ 0 | 2.54 | 0.31 | 0.31 | 2.46 |
| $S_2$ | [2] 4.77 | [3] 2.42 | 3.1 | 0 | ~~5~~ ~~2~~ 0 | 2.42 | 0.68 | 0.68 | 1.67 |
| $S_3$ | [3] 3.61 | 1.29 | 1.75 | 0 | ~~3~~ 0 | 1.29 | 0.46 | – | – |
| Demand | ~~5~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | | | | | |
| Penalty | 1.16 | 1.13 | 0.79 | 0 | | | | | |
| | 1.16 | 1.13 | 0.79 | – | | | | | |
| | 0.23 | 0.43 | 0.56 | – | | | | | |
| | 0.23 | – | 0.56 | – | | | | | |
| | 4.77 | – | – | – | | | | | |

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|
| $S_1$ | 5 | 2.85 | [2] 2.54 | [6] 0 |
| $S_2$ | [2] 4.77 | [3] 2.42 | 3.1 | 0 |
| $S_3$ | [3] 3.61 | 1.29 | 1.75 | 0 |

Optimum solution of percent breakage of eggs is given as.

$x_{13} = 2$ $x_{14} = 6$ $x_{21} = 2$ $x_{22} = 3$

$x_{31} = 3$

Minimum Breakges with speed 30Km/h

$x_{13} = 2 = 2.54$
$x_{14} = 6 = 0$
$x_{21} = 2 = 4.77$
$x_{22} = 3 = 2.42$
$x_{31} = 3 = 3.61$

$= (2.54 + 4.77 + 2.42 + 3.61)/4$

$=$ 3.34% Breakages.

Table 8:- Percent Breakage(pij) Matix Speed 35Km/h

| Destination/Origin | D1 | D2 | D3 | Supply in lacks |
|---|---|---|---|---|
| S1 | 5.5 | 3.13 | 2.8 | 8 |
| S2 | 5.2 | 2.66 | 3.4 | 5 |
| S3 | 3.95 | 1.42 | 1.93 | 3 |
| Demand in lacks | 5 | 3 | 2 | |

The proposed model is not balanced problem to make it a blanced we considered a dummy variable that is called D4

| Destination/Orign | D1 | D2 | D3 | D4 | Supply in lacks |
|---|---|---|---|---|---|
| S1 | 5.5 | 3.13 | 2.8 | 0 | 8 |
| S2 | 5.2 | 2.66 | 3.4 | 0 | 5 |
| S3 | 3.95 | 1.42 | 1.93 | 0 | 3 |
| Demand in lacks | 5 | 3 | 2 | 6 | 16 |

Now solve it with the transportation method of vogel approximation.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penalty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 5.5 | 3.13 | [2] 2.8 | [6] 0 | ~~8~~ ~~2~~ 0 | [illegible] | [illegible] | [illegible] | [illegible] | - |
| $S_2$ | [2] 5.2 | [3] 2.66 | 3.4 | 0 | ~~8~~ ~~2~~ 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| $S_3$ | [3] 3.95 | 1.42 | 1.93 | 0 | ~~3~~ 0 | [illegible] | [illegible] | / | / | / |
| Demand | ~~8~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | 16 | | | | | |
| Penalty | 1.25 | 1.24 | 0.87 | 0 | | | | | | |
| | 1.25 | 1.24 | 0.87 | - | | | | | | |
| | 0.3 | 0.47 | 0.6 | - | | | | | | |
| | 0.3 | - | 0.6 | - | | | | | | |
| | 0.3 | - | - | - | | | | | | |
| | - | - | - | - | | | | | | |

Opptimum Solution of percent breakage of Eggs is gives as

$x_{13} = 2$  $x_{14} = 6$  $x_{21} = 2, x_{22} = 3$

$x_{31} = 3$

Minimum Brekage with speed 35km/h

$x_{13} = 2.8 = 2$  $x_{14} = 6 = 0$

$x_{21} = 2 = 5.2$  $x_{22} = 3 = 2.66$

$x_{31} = 3 = 3.95$

$= (2.8 + 5.2 + 2.66 + 3.95)/4$

$= 3.65\%$ Breakages.

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Table 9: Percent Breakage Matrix ($P_{ij}$)
Speed 40 Km/h

| Destination/orign | $D_1$ | $D_2$ | $D_3$ | Supply in lacks |
|---|---|---|---|---|
| $S_1$ | 6 | 3.42 | 3.05 | 8 |
| $S_2$ | 5.67 | 2.91 | 3.71 | 5 |
| $S_3$ | 4.13 | 1.55 | 2.1 | 3 |
| Demand in lacks | 5 | 3 | 2 | |

The Proposed Model is not balanced problem to make it a balanced problem we considered a dummy variable.

| Destination/Orign | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply in lacks |
|---|---|---|---|---|---|
| $S_1$ | 6 | 3.42 | 3.05 | 0 | 8 |
| $S_2$ | 5.67 | 2.91 | 3.71 | 0 | 5 |
| $S_3$ | 4.13 | 1.55 | 2.1 | 0 | 3 |
| Demand in lacks | 5 | 3 | 2 | 6 | 16 |

Now solve it with the transportation method of vogel approximation

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 6 | 3.42 | $\boxed{2}$ 3.05 | $\boxed{6}$ 0 | ~~8~~ ~~2~~ 6 | 3.05 | 0.37 | 0.37 | 0.95 | – |
| $S_2$ | $\boxed{2}$ 5.67 | $\boxed{3}$ 2.91 | 3.71 | 0 | ~~5~~ ~~2~~ 0 | 2.91 | 0.8 | 0.8 | 1.46 | 5.67 |
| $S_3$ | $\boxed{3}$ 4.13 | 1.55 | 2.1 | 0 | ~~3~~ 0 | 1.55 | 0.55 | – | – | – |
| Demand in lacks | ~~5~~ ~~2~~ 0 | ~~3~~ 0 | ~~2~~ 0 | ~~6~~ 0 | 16 | | | | | |
| | 1.54 | 1.36 | 0.95 | 0 | | | | | | |
| | 1.54 | 1.36 | 0.95 | – | | | | | | |
| | 0.33 | 0.5 | 0.66 | – | | | | | | |
| | 0.33 | – | 0.66 | – | | | | | | |
| | 5.67 | – | 0.66 | – | | | | | | |
| | | – | – | – | | | | | | |

Optimum Solution of Percent brekage of eggs is given as

$x_{13} = 2$ $x_{14} = 6$ $x_{21} = 2$ $x_{22} = 3$

$x_{31} = 3$

Minimum Breakage with speed 40 km/h

$x_{13} = 2 = 3.05$ $x_{14} = 6 = 0$

$x_{21} = 2 = 5.67$ $x_{22} = 3 = 2.91$

$x_{31} = 3 = 4.13$

$= (3.05 + 5.67 + 2.91 + 4.13)/4$

$= 3.94\%$ Breakages

Table 10: Percent Breakage Matrix ($p_{ij}$)
Speed 45 Km/h

| Destination/Origin | $D_1$ | $D_2$ | $D_3$ | Supply in lack |
|---|---|---|---|---|
| $S_1$ | 6.5 | 3.71 | 3.3 | 8 |
| $S_2$ | 6.15 | 3.15 | 4.02 | 5 |
| $S_3$ | 4.67 | 1.68 | 2.28 | 3 |
| Demand in lack | 5 | 3 | 2 | |

The proposed Model is not balansed problem to make it a balanced we considered a dummy variable that is called $D_4$

| Destination/origin | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply in lack |
|---|---|---|---|---|---|
| $S_1$ | 6.5 | 3.7 | 3.3 | 0 | 8 |
| $S_2$ | 6.15 | 3.15 | 4.02 | 0 | 5 |
| $S_3$ | 4.67 | 1.68 | 2.28 | 0 | 3 |
| Demand in lack | 5 | 3 | 2 | 6 | 16 |

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| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply | Penarlty | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 6.5 | 3.7 | [2] 3.3 | [6] 0 | ~~82~~0 | 3.3 | 0.4 | 0.4 | 3.2 | – |
| $S_2$ | [2] 6.15 | [3] 3.15 | 4.02 | 0 | ~~52~~0 | 3.15 | 0.83 | 0.83 | 2.13 | – |
| $S_3$ | [3] 4.62 | 1.68 | 2.28 | 0 | ~~3~~0 | 1.68 | 0.6 | – | – | – |
| Demand | ~~52~~0 | ~~3~~0 | ~~2~~0 | ~~16~~0 | 16 | | | | | |
| Penarlty | 1.48 | 1.47 | 1.02 | 0 | | | | | | |
| | 1.48 | 1.47 | 1.02 | – | | | | | | |
| | 0.35 | 0.55 | 0.72 | – | | | | | | |
| | 0.35 | – | 0.72 | – | | | | | | |
| | – | – | – | – | | | | | | |

Optimum Solution of percent of eggs is given as

$x_{13} = 2 \quad x_{23} = 2 \quad x_{22} = 3 \quad x_{31} = 3$

$x_{14} = 0$

Minimum Breakages with speed 45km/h

$x_{13} = 2 = 3.3 \quad x_{21} = 2 = 6.15$

$x_{14} = 0.6$ (Dummy Value)

$x_{22} = 3 = 3.15 \quad x_{31} = 4.67$

$= (3.3 + 6.15 + 3.15 + 4.67)/4$

$= 4.32\%$ Breakage

The End