# FIT3158 Note - W6 Degeneracy in Transportation Problem (MODI)

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▼ More exercises

Transportation Problem | Set 7 ( Degeneracy in Transportation Problem ) - GeeksforGeeks

▼ Degeneracy: Transportation Problem (universalteacherpublications.com)

Table 1

| Factory | Dealer 1 | 2 | 3 | 4 | Supply |
| --- | --- | --- | --- | --- | --- |
| A | 2 (900) | 2 (100) | 2 | 4 | 1000 |
| B | 4 | 6 (700) | 4 | 3 | 700 |
| C | 3 | $\boxed{2}$ | 1 (500) | 0 (400) | 900 |
| Requirement | 900 | 800 | 500 | 400 | |

Lowest value and cannot form the loop

▼ [Degeneracy in Transportation Problem (With Examples) | Operations Research (engineeringenotes.com)]

**Table 2 :**

| Source \ Destination | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | Supply |
| --- | --- | --- | --- | --- | --- | --- |
| $S_1$ | 5 | 8 | (5) 6 | 6 | (3) 3 | 8 |
| $S_2$ | (4) 4 | 7 | 7 | (1) 6 | (Δ) 5 | 5 |
| $S_3$ | 8 | (4) 4 | 6 | 6 | (5) 4 | 9 |
| $S_{excess}$ | 0 | 0 | 0 | (3) 0 | 0 | 3 |
| Demand | 4 | 4 | 5 | 4 | 8 | 25 |

This solution includes occupied cells but in a rule there will be m + n – 1 = 5 + – 4 = 8 occupied cell.

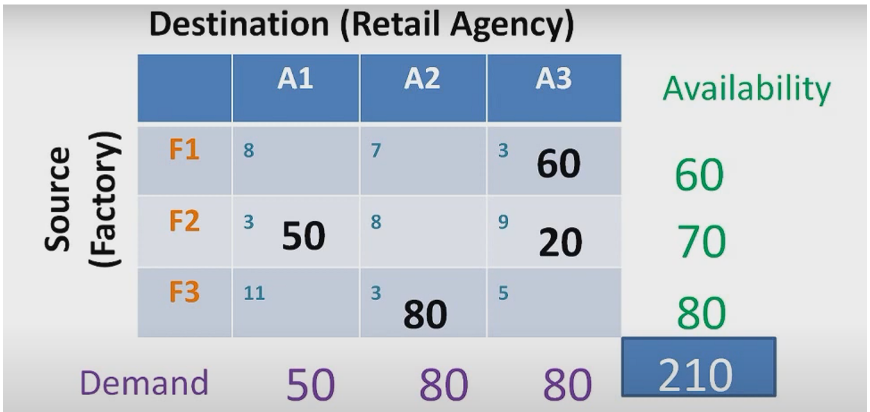
lowest cost and cannot form loop

[DEGENERACY IN TRANSPORTATION PROBLEMS in Quantitative Techniques for management Tutorial 27]
(This example is weird!)

## Example from  ([Here]) YouTube illustrates how to solve degeneracy in transportation problem.

▼ Its explanation in pdf is here:

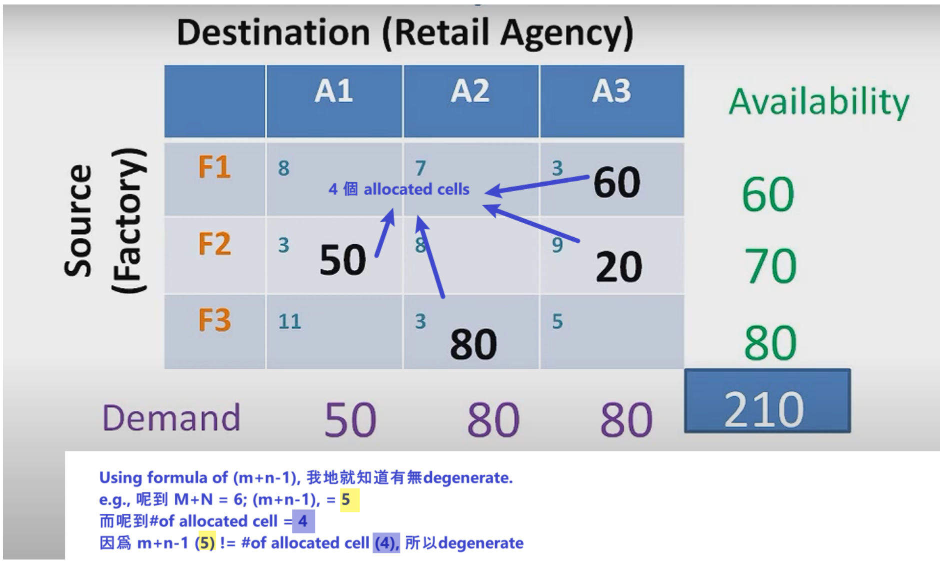
https://s3-us-west-2.amazonaws.com/secure.notion-static.com/95414ef1-70b0-4509-a4f6-5d1e89095345/TP-Degeneracy-LeastCost-MODI.pdf




Suppose we used least cost / vogel to get this feasible solution. Now our task is to find the optimal one using MODI method.

## When will we know the solution has degeneracy?

### Step 1 of MODI: Check if there is a degeneracy.



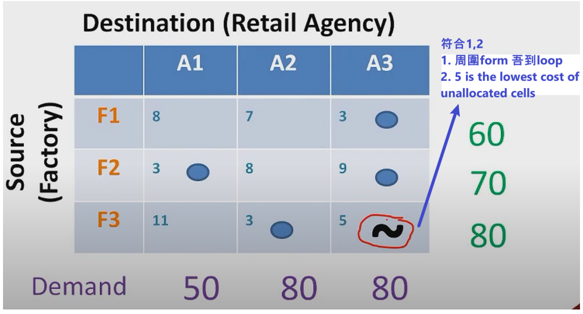

Now, we know there is a degeneracy. We want to find independent cells on which it can solve the problem.

## What is independent cell?

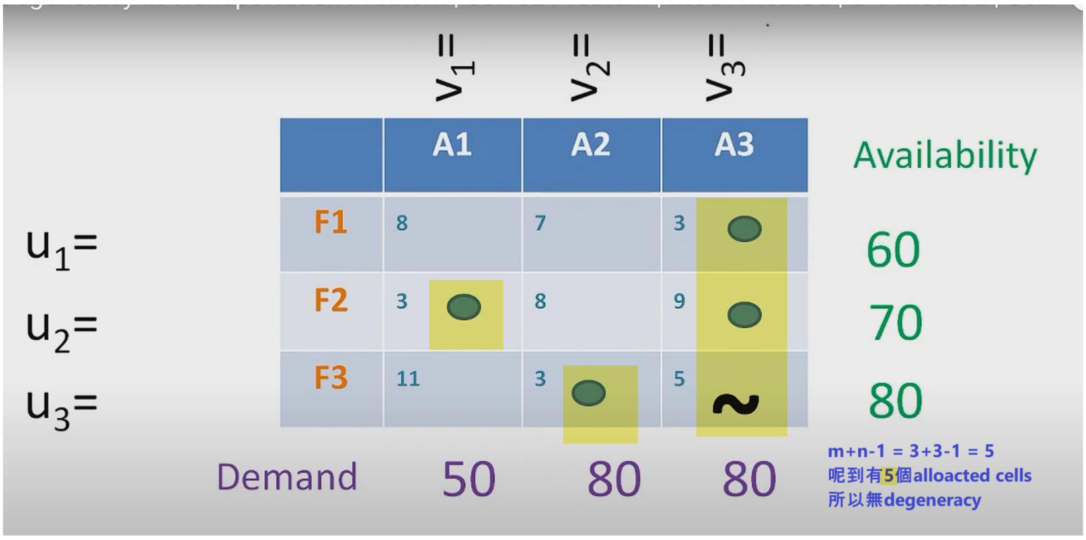
### Step 2 of MODI: Given there is a degeneracy, find independent cells on to solve the problem.

2 conditions:

1. Unallocated cells that cannot form a closed loop
2. Has the lowest value (e.g., cost)

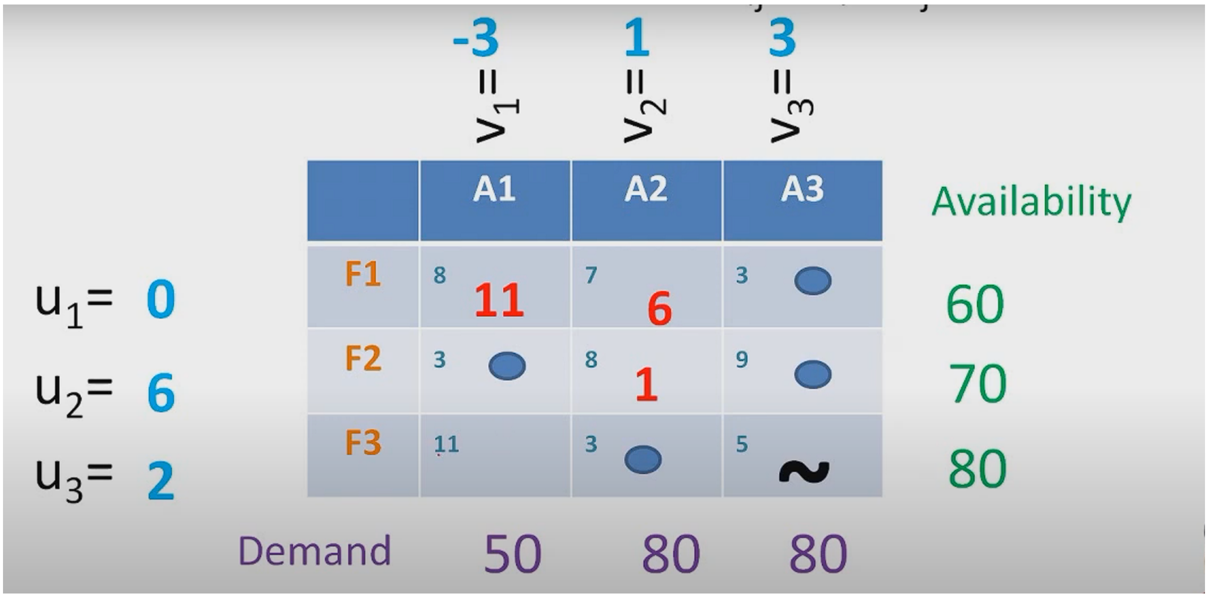




**Step 3 of MODI: After confirming the independent cell, the degenerate issues is solved.**




**Step 4 we continue doing the MODI, until the optimality is reached.**

Here is the solution:



Queuing, Probability and Simulation

Service and waiting times for a single server queue, Poisson arrivals, Exponential service:

$\lambda$ = the average number of arrivals per time period (arrival rate)

$\frac{1}{\lambda}$ = the average time between arrivals

$\mu$ = the average number of services per time period (service rate)

$\frac{1}{\mu}$ = the average time taken for each service

$P_0 = 1 - \frac{\lambda}{\mu}$ the probability that no units are in the system

$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$ the average number of units in the waiting line

$L = L_q + \frac{\lambda}{\mu}$ the average number of units in the system

$W_q = \frac{L_q}{\lambda}$ the average time a unit spends in the waiting line

$W = W_q + \frac{1}{\mu}$ the average time a unit spends in the system

$P_w = \frac{\lambda}{\mu}$ the probability that an arriving unit has to wait for service

$P_n = \left(\frac{\lambda}{\mu}\right)^n P_0$ the probability of $n$ units in the system

Probability distributions:

The Poisson distribution

$f(x) = \frac{\theta^x e^{-\theta}}{x!}$ for a distribution having mean $\theta$, $(e = 2.71828\ldots)$

The exponential distribution

$f(x) = \frac{1}{\theta} e^{-x/\theta}$ for a distribution having mean $\theta$, $(e = 2.71828\ldots)$

$P(x \le x_0) = 1 - e^{-x_0/\theta}$

$P(x \ge x_0) = e^{-x_0/\theta}$ for a given value of $x_0$

Linear congruential generation of uniform random variables

Let $X_0$ be an integer chosen at random (the random seed) then uniformly distributed integers are generated as $X_{n+1} = AX_n \bmod B$ where $A$ and $B$ are large co prime integers. Random numbers between 0 and 1 are calculated as $r_n = \frac{X_n - 1}{B - 2}$.

Generation of Exponentially distributed random variables

Exponential variates with mean $b$ are generated from uniform [0,1] random numbers, $r_n$, by the transformation $t_n = -b \log_e(r_n)$.

Service and waiting times for an M/M/S queue:

$$P_0 = 1 \Big/ \left[ \sum_{n=0}^{S-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^S}{S!} \left( \frac{1}{1 - \lambda/S\mu} \right) \right] \qquad L = L_q + \frac{\lambda}{\mu}$$

$$P_n = \begin{cases} \frac{(\lambda/\mu)^n}{n!} P_0 & \text{if } 0 \le n \le S \\ \frac{(\lambda/\mu)^n}{S! S^{n-S}} P_0 & \text{if } n \ge S \end{cases} \qquad W_q = \frac{L_q}{\lambda} \qquad W = W_q + \frac{1}{\mu}$$

$$L_q = \frac{(\lambda/\mu)^S (\lambda/S\mu)}{S!(1 - \lambda/S\mu)^2} P_0 \qquad \rho = \frac{\lambda}{S\mu}$$

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$W = W_q + \frac{1}{\mu}$ the average time a unit spends in the system

$P_w = \frac{\lambda}{\mu}$ the probability that an arriving unit has to wait for service / Service utilisation

$P_n = \left(\frac{\lambda}{\mu}\right)^n P_0$ the probability of $n$ units in the system