



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

SUPPLY CHAIN ANALYTICS

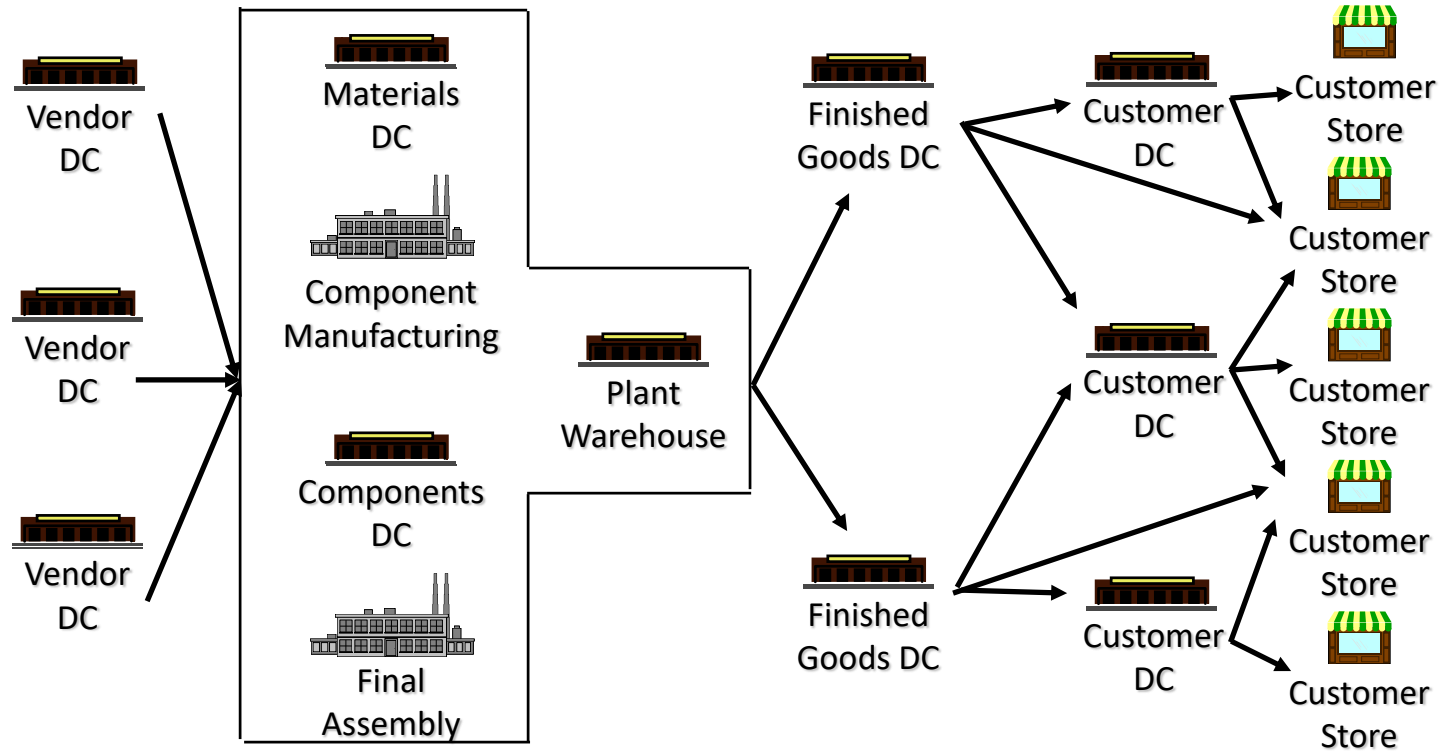
Location Decisions in Supply Chain

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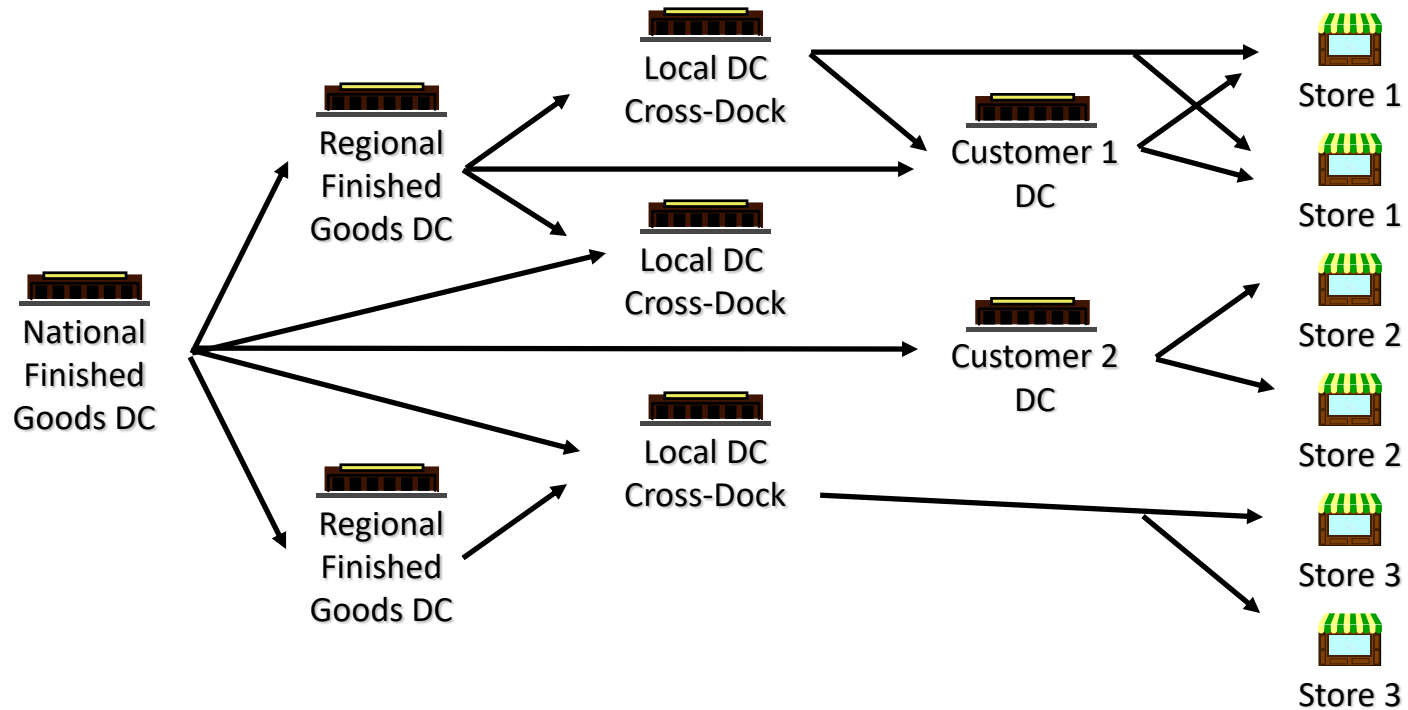
Department of Management Studies



Conventional Network



Tailored Network: Multi-Echelon Finished Goods Network



Gravity Methods for Location

- Ton Mile-Center Solution

- x, y : Warehouse Coordinates
- x_n, y_n : Coordinates of delivery location n
- d_n : Distance to delivery location n
- F_n : Annual tonnage to delivery location n

$$\text{Min} \quad \sum d_n D_n F_n$$

$$d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}$$

$$x = \frac{\sum_{n=1}^k D_n x_n F_n / d_n}{\sum_{n=1}^k D_n F_n / d_n}$$

$$y = \frac{\sum_{n=1}^k D_n y_n F_n / d_n}{\sum_{n=1}^k D_n F_n / d_n}$$



Network Optimization Models

- Allocating demand to production facilities
- Locating facilities and allocating capacity

Key Costs:

- Fixed facility cost
- Transportation cost
- Production cost
- Inventory cost
- Coordination cost

Which plants to establish? How to configure the network?



Demand Allocation Model

- Which market is served by which plant?
- Which supply sources are used by a plant?

x_{ij} = Quantity shipped from plant site i to customer j

$$\text{Min} \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij}$$

s.t.

$$\sum_{i=1}^n x_{ij} = D_j, j = 1, \dots, m$$

$$\sum_{j=1}^m x_{ij} \leq K_i, i = 1, \dots, n$$

$$x_{ij} \geq 0$$



Plant Location with Multiple Sourcing

- $y_i = 1$ if plant is located at site i , 0 otherwise
- x_{ij} = Quantity shipped from plant site i to customer j

$$\text{Min} \sum_{i=1}^n f_i y_i + \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij}$$

s.t.

$$\sum_{i=1}^n x_{ij} = D_j, j = 1, \dots, m$$

$$\sum_{j=1}^m x_{ij} \leq K_i y_i, i = 1, \dots, n$$

$$\sum_{i=1}^n y_i \leq k; y_i \in \{0,1\}$$



Plant Location with Single Sourcing

- $y_i = 1$ if plant is located at site i , 0 otherwise
- $x_{ij} = 1$ if market j is supplied by factory i , 0 otherwise

$$\text{Min} \sum_{i=1}^n f_i y_i + \sum_{i=1}^n \sum_{j=1}^m D_j c_{ij} x_{ij}$$

s.t.

$$\sum_{i=1}^n x_{ij} = 1, j = 1, \dots, m$$

$$\sum_{j=1}^m D_j x_{ij} \leq K_i y_i, i = 1, \dots, n$$

$$x_{ij}, y_i \in \{0,1\}$$



Locations of Supply Sources and Markets

Sources/ Markets	Transportation Cost (Rs/ Ton Km (F_n))	Quantity in Tons (D_n)	Coordinates	
			X_n	Y_n
Supply sources				
Pune	90	400	700	1,000
Gurgaon	95	200	200	500
Jamshedpur	85	600	300	800
Markets				
Ahmedabad	200	200	1,000	500
Cochin	200	100	1,000	2,000
Hyderabad	200	200	700	1,500
Chennai	200	300	800	1,800
Bengaluru	200	200	900	2,500



Input Data for Gravity Location Model

	A	B	C	D	E	F
1						
2		Sources/ Markets	Transport ation Cost (Rs/ Ton Km (F_n))	Quantity in Tons (D_n)	Coordinates	
3					X_n	Y_n
4	Supply sources	Pune	90	400	700	1000
5		Gurgaon	95	200	200	500
6		Jamshedpur	85	600	300	800
7	Markets	Ahemedabad	200	200	1000	500
8		Cochin	200	100	1000	2000
9		Hyderabad	200	200	700	1500
10		Chennai	200	300	800	1800
11		Bengaluru	200	200	900	2500
12						



Various formulae of model to be used in Excel Solver

Cell	Cell Formula	Equation	Copied to
G4	= SQRT((\$B\$15-E4)^2+ (\$B\$16-F4)^2)	(D)	G4:G11
B18	= SUMPRODUCT(G4:G11, D4:D11, C4:C11)	(E)	---



Spreadsheet Portion after Adding Formulae

	A	B	C	D	E	F	G
1							
2		Sources/ Markets	Transport ation Cost (Rs/ Ton Km (F_n))	Quantity in Tons (D_n)	Coordinates		
					X_n	Y_n	
3							d_n
4	Supply sources	Pune	90	400	700	1000	1220.656
5		Gurgaon	95	200	200	500	538.5165
6		Jamshedpur	85	600	300	800	854.4004
7	Markets	Ahemedabad	200	200	1000	500	1118.034
8		Cochin	200	100	1000	2000	2236.068
9		Hyderabad	200	200	700	1500	1655.295
10		Chennai	200	300	800	1800	1969.772
11		Bengaluru	200	200	900	2500	2657.066
12							
13	Facility Location						
14							
15	X=	0					
16	Y=	0					
17							
18	TC =	477873268.6					

Spreadsheet Portion after Invoking Solver Dialogue Box

B18		=SUMPRODUCT(G4:G11,D4:D11,C4:C11)									
	A	B	C	D	E	F	G	H	I	J	
1											
2		Sources/ Markets	Transport ation Cost (Rs/ Ton Km (F_n))	Quantity in Tons (D_n)	Coordinates X_n Y_n						
3							d_n				
4	Supply sources	Pune	90	400	700	1000	1220.656				
5		Gurgaon	95	200	200	500	538.5165				
6		Jamshedpur	85	600	300	800	854.4004				
7	Markets	Ahemedabad	200	200	1000	500	1118.034				
8		Cochin	200	100	1000	2000	2236.068				
9		Hyderabad	200	200	700	1500	1655.295				
10		Chennai	200	300	800	1800	1969.772				
11		Bengaluru	200	200	900	2500	2657.066				
12											
13	Facility Location										
14											
15	X=		0								
16	Y=		0								
17											
18	TC =		477873268.6								
19											
20											
21											
22											
23											
24											
25											

Solver Parameters

Set Target Cell:

Equal To: ☐ Max ☒ Min ☐ Value of:

By Changing Cells:

Subject to the Constraints:

Add

Change

Delete

Solve

Close

Options

Reset All

Help

Solver Parameters

Set Target Cell:

Equal To: ☐ Max ☒ Min ☐ Value of:

By Changing Cells:

Subject to the Constraints:

Add Change Delete

Solve Close Options Reset All Help

Optimised Location for Motorbike Manufacturer

	A	B	C	D	E	F	G
1							
2		Sources/ Markets	Transport ation Cost (Rs/ Ton Km (F_n))	Quantity in Tons (D_n)	Coordinates		
3					X_n	Y_n	
							$\sum d_n$
4	Supply sources	Pune	90	400	700	1000	500.0005
5		Gurgaon	95	200	200	500	1118.035
6		Jamshedpur	85	600	300	800	806.2263
7	Markets	Ahmedabad	200	200	1000	500	1044.031
8		Cochin	200	100	1000	2000	583.0946
9		Hyderabad	200	200	700	1500	0.000575
10		Chennai	200	300	800	1800	316.2272
11		Bengaluru	200	200	900	2500	1019.803
12							
13		Facility Location					
14							
15	X=	700.0001971					
16	Y=	1500.00054					
17							
18	TC =	193549144.3					



THANK YOU

