Operation Research – Formulation

Sets:

DC : Set of distribution centers
SM : Set of supermarkets
SC : Set of scenarios
L : Set of labour types

Data:

$cost_{dc\,sm}$:Cost to supply supermarket sm ∈ SM from distribution center dc ∈ DC
$dcCapacity_{dc.}$:Capacity of distribution center dc ∈ DC
$smDemand_{sc\,sm}$:Demand of each supermarket sm ∈ SM in each sc ∈ SC
$costLabour_l$:Cost of labour l ∈ L
$workLabour_l$:Work of labour l ∈ L
$weekScenario_{sc}$:Number of weeks under scenario sc ∈ SC

Variables:

- ***Binary Variables***
  - $X_{dc\,sm.}$:Contribution from distribution center *dc* ∈ DC for the supermarket *sm*
  - $dcOperational_{dc}$:Operational state of dc ∈ DC
- ***Integer Variables***
  - $labourNeed_{dc\,l\,sc}$:Labour needed by distribution center *dc* ∈ DC of type l in L during scenarios SCs

Objective:

$$\min \sum_{sc \in SC} \sum_{dc \in DC} \sum_{sm \in SM} X_{dc\,sm} * cost_{dc\,sm} * smDemand_{sc\,sm} * dcOperational_{dc} * weekscenario_{sc} + \sum_{sc \in SC} \sum_{dc \in DC} \sum_{sm \in SM} labourNeed_{dc\,l\,sc} * costLabour_l * weekScenario_{sc}$$

Constraints:

- ***Supply Chain Constrains***
  - It should be just one distribution centre per supermarket.

$$\sum_{dc \in \mathrm{DC}} X_{dc\,sm} == 1 \ \forall\ sm \ \in SM$$

- ***Distribution Centre Capacity Constrain***
  - The total quantity sent out from each distribution center for all supermarkets in each scenario is less than distribution center capacity.

$$\sum_{sm \in SM} X_{dc\,sm} * \ \mathrm{smDemand}_{sc\,sm} * \mathrm{dcOperational}_{\,dc} \leq \ \mathrm{dcCapacity}_{dc} \quad \forall \ sc \in SC \ \forall \ dc \in \ DC$$

- ***Distribution Centre Operational Constrains***
    - Total number of working distribution centers from old distribution centers(DC0, DC1, DC2) is greater than or equal to 2, because we are trying find if it will be more profitable to find another distribution centre at a new location.

$$\sum_{dc \in (\mathrm{DC0,DC1,DC2})} \mathrm{dcOperational}_{dc} \geq 2$$

    - Total number of working distribution centers from new location of distribution centre (DC3, DC4, DC5, DC6) is less than or equal to 2. As we are trying to find two or less most profitable distribution centers. Hence, total distribution centre should be less than or equal to 4.

$$\sum_{dc \in \mathrm{DC}} \mathrm{dcOperational}_{dc} \leq 4$$

- ***Labour Constrains***
    - For each distribution center, the workload of the total labour should be more than the load handled in the distribution center for all scenarios.

$$\sum_{l \in L} \mathrm{labourNeed}_{dc\ l\ dc} \mathrm{workLabour}_{l} \geq \sum_{sm \in SM} X_{dc\ sm} * smDemand_{sc\ sm} \quad \forall\, sc \in SC \quad \forall\, dc \in DC$$

    - The casual labour in the base scenario should be zero. As the cost of casual labour is very high, we will not use this constrain in the model.

$$labourNeed_{dc\ l\ sc} == 0 \quad \forall\ sc \in 0\ \forall\, dc \in DC\ \ \forall\, l \in casual$$

    - The full time and part time labour for scenario in SC1, SC2, SC3, SC4, SC5, SC6 is equal to the full time and part time labour for scenario in SC0

$$labourNeed_{dc\ l\ sc} == labourNeed_{dc\ l\ 0} \quad \forall\, dc \in DC\ \ \forall\, l \in [fulltime, part\ time]$$