Empty Container Management at Regional Level

# Objective

The proposed model has the following objectives:

At each **[expansion]** period of [**finite] planning horizon**, locate new inland depots *(from candidate depots)* and/or expand capacity of existing inland depots **[strategic decision]** in the region that minimizes the total expected system cost in repositioning empty containers. The formulation satisfies the customer demand-and-supply requirement with budget constraints under each probable scenario in the planning horizon.

# Model Assumption

1. No movement between depots

# Optimization Model

Following is the tables for Indices, Decision variables, Input variables, Parameters, Cost function and Constraints.

Table : Indices in the model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Indices | Description |  |
| Time | |  | Time periods in the planning horizon, T |  |
| Consignee / Importer | |  | Set of Consignees |  |
| Shipper / Exporter | |  | Set of Shippers |  |
| Port-terminal | |  | Set of Port terminal |  |
| Ocean-carrier | |  | Set of Ocean-carrier |  |
| Depot Owner | |  | Set of Inland-depot owners |  |
| Depot | |  | Depot  Owned by inland-depot owner  Serves ocean-carrier |  |
|  | Existing Depot |  | Set of existing inland-depots |  |
|  | Potential Depot |  | Set of potential inland-depots |  |
| Expansion design | |  | Set of Capacity modules for each depot and for each time-period | where |

Table : Decision variables in the model

|  |  |  |
| --- | --- | --- |
| Decision Variables |  | Description |
|  | Binary | Inland-depot (owned by depot owner , serves ocean-carrier )  that has been opened by  time-period  under scenario |
|  | **Binary** | **Expansion design**  **is selected for inland-depot (owned by depot owner , serves ocean-carrier )**  **time-period**  **under scenario** |

Table : Parameters used in the model

|  |  |  |
| --- | --- | --- |
| Parameters |  | Description |
| Location |  | Geographic location of   1. Port-terminal 2. Importers 3. Exporters 4. Existing Depots 5. Potential Depots |
| Supply |  | Supply of ocean-carrier empty containers  from consigneein  time-period  under scenario |
| Supply |  | Supply of ocean-carrier empty containers  from port-terminalin  time-period  under scenario |
| Demand |  | Demand of ocean-carrier empty containers  by shipperin  time-period a  under scenario |
| Demand |  | Demand of ocean-carrier empty containers  by port-terminalin  time-period  under scenario |
| Storage |  | Storage capacity of  depot (Owned by depot owner , serves ocean-carrier ) |
| Inventory |  | Initial inventory of ocean-carrier’s empty containers  at depot (Owned by depot owner , serves ocean-carrier )  time-period =1  under scenario = 1 |
| Inventory |  | Inventory of ocean-carrier’s empty containers  at depot (Owned by depot owner , serves ocean-carrier )  time-period  under scenario |
| Cost |  | Fixed-cost of opening  Depot  in the time-period |
| Cost |  | Fixed-cost of opening  Depot  in the stage 1 |
| **Cost** |  | **Capacity expansion cost for**  **Depot**  **in the time-period** |
| Distance |  | Distances between nodes |
| Cost |  | Cost of trucking a container (TEU) per mile in time-period |
| Cost |  | Trucking cost between nodes |
| Budget |  | Budget constraint for expansion period, t |
| Street turn |  | Fraction of EC at importer (consignee)  That is transported directly to a exporter (shipper) |

*At each* ***[expansion]*** *period of [****finite] planning horizon****, locate new inland depots (from candidate depots) and/or expand capacity of existing inland depots* ***[strategic decision]*** *in the region that minimizes the total expected system cost in repositioning empty containers. The formulation satisfies the customer demand-and-supply requirement with budget constraints under each probable scenario in the planning horizon.*

## Cost Function:



Constraints:

|  |  |  |
| --- | --- | --- |
| **Supply-Demand** |  |  |
| Supply from Importer to depot |  |  |
| Supply from port to depot |  |  |
| Demand of Exporter from depot |  |  |
| Demand of port from depot |  |  |
|  |  |  |
| **Inventory** |  |  |
| Beginning inventory for every ocean-carrier at every depot in *t, s* |  |  |
|  |  |  |
| **Capacity** |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| Once depot opened remain open in all time-period |  |  |
| Existing depot remains open for all time-period |  |  |
|  |  |  |
| **Budget Constraints** |  |  |
| For each time-period and each scenario, fixed cost of opening new facility + expansion of existing facility less than equal to budget |  |  |
| At most one expansion module selected |  |  |
|  |  |  |
|  |  |  |
| **Non-negativity constraints** |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| **Integrality Constraints** |  |  |
|  | are integers |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Experiments:

Depot owner, Depot and ocean-carrier business interaction

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Depot Owner | I | | | | II | II | III |
| Depot | 1 | 2 | | 3 | 4 | 5 | 6 |
| Ocean-carrier | A | | B | | C | | D |

Time-period and Scenario:

|  |  |  |  |
| --- | --- | --- | --- |
| Time-period | S1 | S2 | S3 |
| 0 |  |  |  |
| 5 |  |  |  |
| 10 |  |  |  |
| 15 |  |  |  |
| 20 |  |  |  |

Experiments:

Supply == Demand

Tried aggregator 3 times.

MIP Presolve eliminated 13 rows and 15 columns.

Aggregator did 9 substitutions.

All rows and columns eliminated.

Presolve time = 0.00 sec. (0.04 ticks)

Root node processing (before b&c):

Real time = 0.00 sec. (0.05 ticks)

Parallel b&c, 8 threads:

Real time = 0.00 sec. (0.00 ticks)

Sync time (average) = 0.00 sec.

Wait time (average) = 0.00 sec.

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Total (root+branch&cut) = 0.00 sec. (0.05 ticks)

Solution value = 8860.0

Solution Status = 101 : MIP\_optimal

Solution type: 3

Binary variable:

time\_0\_carr\_0\_owner\_0\_DEPOT\_E\_0 1.0

time\_0\_carr\_0\_owner\_0\_DEPOT\_N\_0 1.0

time\_1\_carr\_0\_owner\_0\_DEPOT\_E\_0 1.0

time\_1\_carr\_0\_owner\_0\_DEPOT\_N\_0 1.0