STUDENT CASE COMPETITION

\IISE - Logistics & Supply Chain Division

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INTRODUCTION

This report discusses a possible solution for a Supply Chain Logistics problem faced by an Indian logistics company called Coastal and Automotive Logistics Corporation (CALC). This problem is described by authors Saurabh Chandra and Amit Kumar Vatsa in their research paper, 'Coastal Shipping for Automobile Distribution', which has been published by INFORMS. [1]

Our job is to work as analysts as part of the research team for CALC, and determine how profitable it would be for the company when incorporating the recently adopted coastal shipment method into their current logistics system, especially when compared to using transportation only by road, which was the already existing, conventional logistics method.

ANALYSIS

Coastal shipping method basically involves the transportation of vehicles from the manufacturing plants to the nearest seaport by trucks, from where the vehicles would be loaded into ships and these ships would then carry these vehicles to the destination port. And from the destination port, the vehicles are unloaded from the ships, then again loaded into trucks, and finally distributed to the customers. The government has been strongly investing in and encouraging the development of coastal transportation mainly because it provides an environmentally much more friendly mode of transportation, and also possesses the potential to reduce highway congestion in the country.

There are 3 vehicle manufacturing plants - AM1, AM2, AM3; 261 customers; 2 ports - one at Chennai and the other at Pipavav; and 2 ro-ro ships. The research is conducted on data gathered over a duration of 3 months. Other data such as the relative customer locations, demand at each customer location for each manufacturing plant for each month, plant and ship capacities, the various costs, etc. has been extensively provided to us in a separate Excel file called CALC.xlsx which can be found attached to this report.

PROCEDURE

We use a MIP to determine the optimal number of vehicles to be transported via coastal route to the customer locations. The objective of the model is to minimize the overall cost of transportation.

Cost = cost for trucking from factory to customer location + cost of transportation via coastal route

The cost of transportation via shipping is further divided into the cost of trucking from factory to port and port to customer and the summation of the fixed and variable costs for shipping.

The optimization model for this problem was written on AMPL and solved using CPLEX with a time limit of 3600 seconds to get the optimal solution. We solve for each month individually and add fractional cost of operation of the ship in each month since total operation cost for ship is given as a 3-month contract.

All demand not fulfilled by the coastal shipping method is covered by direct trucking from factory to the customer location.

The input data includes set of ports, factories, customer locations and their respective demands for 3 months. It also includes distances between each of these locations.

Constraints are set to cover entire demand, capacity of ships and travel time of ships. We keep a track of number of trucks sent from each location as we need to use ceiling function for each destination of the truck since the trucks have a capacity of 8 units per truck. We have not taken capacity of the factory into consideration as demand is way below capacity levels.

The solution generated from this model given the number of units of vehicles to be sent in each time period from manufacturer to customer via either direct trucking or shipping via coastal route.

RESULTS

Based on our model, we suggest the following customer locations switch to Coastal Shipping instead of traditional trucking from the Manufacturer to the dealership:

Table 1 a - shows locations with high demand for AM2 and AM3 units which are located closer to the Chennai Port

Table 1 b - shows locations with high demand for AM1 units that are closer from the Pipalav port

Ajmer	Ganga Nagar	Malout
Alwar	Gorakhpur	Mandsaur
Ambala	Gurdaspur	Moga
Amritsar	Gurgaon	Nagaur
Barmer	Hansi	Pali
Bathinda	Hanumangarh	Patiala
Bharthla	Hisar	Rajsamand
Bhilwara	Hoshiarpur	Ratlam
Bhiwani	Jaipur	Rewari
Bikaner	Jalandhar	Rohtak
Chandigarh	Jhunjhunu	Sangrur
Chittorgarh	Jodhpur	Sikar
Dahod	Kaithal	Sirsa
Dehradun	Kapurthala	Solkhian
Didwin Tikker	Karnal	Sonipat
Faridabad	Kota	Sumerpur
Faridkot	Kurukshetra	Udaipur
Ferozepur	Ludhiana	Ujjain

Table 1 a

Alappuzha
Chittoor
Ernakulam
Idukki
Kolar
Kollam
Kottayam
Nanapalli
Nellore
Palakkad
Pathanamthitta
Prakasam
Thiruvananthapuram
Thrissur

Table 1 b

Based on the current transportation method, the auto manufacturers combined spend an average of 69 million USD on shipping every month, by switching the above locations to the coastal shipping method and sending the remaining demand to be covered at these locations via road, the auto manufacturers would spend an average of 65 million USD a month. This would translate to a yearly saving of 48 million USD in transportation costs.

	Month 1	Month 2	Month 3	Average
Current mode	68656460.2	68990170.5	69508042.5	69051557.7
Suggested mode	64738400.0	65043300.0	65636300.0	65139333.3
Savings	3918060.2	3946870.5	3871742.5	3912224.4

Both ships would be needed for these numbers to be accomplished and the ships would have to run at full capacity all year round.

The smaller ship would have to run at 800 units every trip and would run from base port to destination and back 33 times a year while the bigger ship would also be running at full capacity of 3518 units every voyage and 41 times in the year.

Shipments from Chennai to Pipavav would contain units of AM1 and would be distributed to the locations in table 1b. Shipments from Pipavav to Chennai would contain a combination of AM2 and AM3 units to customer locations mentioned in table 1a.

CONCLUSION

- Incorporating the coastal shipment method in the logistics system network is more profitable than transporting the vehicles only by road.
- CALC could potentially save millions of dollars on transportation costs by making this switch in turn increasing the profit margin for the auto manufacturers.
- Despite this, and the attention and resources invested in coastal transportation by the Indian Government, sustaining this mode of logistic could face the following challenges: ○ Extremely high operating charges
    - Inconsistent and uncertain demand from customers (car dealers), which could make it difficult to offset the high operating charges already incurred.
    - Resistance to change to a new transportation system from an already well-established transportation system, especially when there has been a long-standing relationship between the car dealers, manufacturing plants, truck vendors, etc.
    - Multimodal activities increase complexities in the network and delay or issues in any stage would cause issues in the subsequent stage.

APPENDIX

Model:

```
reset;

set I; #set of auto manufacturers
set J; #set of customers
set P; #set of ports
param T; #number of trips

param D{J,I}; #demand of manufacturer i at customer location j
param dist_M_C{J,I}; #distance between manufacturer i and customer j
param dist_M_Chen{I}; #distance between manufacturer and port at Chennai
param dist_M_Pip{I}; #distance between manufacturer and port at Pipavav
param dist_Chen_C{J}; #distance between port at Chennai and customer j
param dist_Pip_C{J}; #distance between port at Pipavav and customer j

param cap_S1 = 800; #capacity of ship 1
param cap_S2 = 3518; #capacity of ship 2

var Trip_Chen_Pip_S1{1..T} >=0 binary;# 1 if ship1 travels from Chennai to Pipavav on trip t, 0
otherwise var Trip_Pip_Chen_S1{1..T} >=0 binary; #1 if ship1 travels from Pipavav to Chennai on trip t,
0 otherwise var Trip_Chen_Pip_S2{1..T}>=0 binary; #1 if ship2 travels from Chennai to Pipavav on trip t,
0 otherwise var Trip_Pip_Chen_S2{1..T}>=0 binary; #1 if ship2 travels from Pipavav to Chennai on trip t,
0 otherwise

var N_M_Chen{1..T,I} >= 0 integer; #number of vehicles sent to Chennai port by manufacturer i on trip
t var N_M_Pip{1..T,I} >= 0 integer; #number of vehicles sent to Pipavav by manufacturer i on trip t

var N_Chen_C{1..T,I,J} >= 0 integer; #number of vehicles sent to customer j from Chennai port on trip
t var N_Pip_C{1..T,I,J} >= 0 integer; #number of vehicles sent to customer j from Pipavav port on trip
```

```
t

var N_M_Chen_Trucks{1..T,I} >= 0 integer; #no. of trucks sent from manufacturer i to port
Chennai var N_M_Pip_Trucks{1..T,I} >= 0 integer; #no. of trucks sent from manufacturer i to port
Pipavav

var N_Chen_C_Trucks{1..T,J} >= 0 integer; #no. of trucks sent from Chennai port to Customer j, on trip
t var N_Pip_C_Trucks{1..T,J} >= 0 integer; #no. of trucks sent from Pipavav port to Customer j, on trip
t

var N_D_T{I,J} >= 0 integer; #number of vehicles trucked directly from manufacturer i to customer j
var N_D_Trucks{I,J} >= 0 integer; #no. of trucks used to send vehicles directly from manufacturer i to
customer j

var S1 >=0 binary; #1 if ship 1 is being used, 0 otherwise
var S2 >=0 binary; #1 if ship 2 is being used, 0 otherwise


#objective function

minimize cost: (89455*S1) + (179592*S2)
+ sum{t in 1..T}((4.46*Trip_Chen_Pip_S1[t]*3218)+3467+(4.46*Trip_Pip_Chen_S1[t]*3218))
+ sum{t in
1..T}((3.41*Trip_Chen_Pip_S2[t]*6568)+15925+(3.41*Trip_Pip_Chen_S2[t]*6568)) + sum{i
in I, j in J}(N_D_Trucks[i,j]*(185.69+(dist_M_C[j,i]*1.46)))
 + sum{t in 1..T,i in I}((N_M_Chen[t,i]+N_M_Pip[t,i])*2) +
sum{t in 1..T, i in I}(N_M_Chen_Trucks[t,i]*(185.69+(dist_M_Chen[i]*1.46))) +
sum{t in 1..T,j in J}(N_Pip_C_Trucks[t,j]*(185.69+(dist_Pip_C[j]*1.46)))
+ sum{t in 1..T, i in I}(N_M_Pip_Trucks[t,i]*(185.69+(dist_M_Pip[i]*1.46)))
+ sum{t in 1..T,j in J}(N_Chen_C_Trucks[t,j]*(185.69+(dist_Chen_C[j]*1.46)));

#constraints

s.t. demand{i in I, j in J}: sum{t in 1..T}N_Chen_C[t,i,j] + sum{t in 1..T}N_Pip_C[t,i,j] + N_D_T[i,j]
= D[j,i]; #Demand Constraint

s.t. con1{t in 1..T, i in I}: N_M_Chen[t,i] = sum{j in J}N_Pip_C[t,i,j];#balances the total units flowing
from plant to customer via ship
s.t. {t in 1..T, i in I}: N_M_Pip[t,i] = sum{j in J}N_Chen_C[t,i,j]; #balances the total units flowing
from plant to customer via ship

s.t. con3{t in 1..T, i in I}: N_M_Chen_Trucks[t,i] >= (N_M_Chen[t,i]/8); #ceiling value of trucks from mfg
plant to Chennai
s.t. con4{t in 1..T, i in I}: N_M_Pip_Trucks[t,i] >= (N_M_Pip[t,i]/8);#ceiling value of trucks from mfg
plant to Pipavav

s.t. con5{t in 1..T, j in J}: 8*N_Chen_C_Trucks[t,j] >= sum{i in I}N_Chen_C[t,i,j]; #Ceiling value of
trucks from Chennai to customer
s.t. con6{t in 1..T, j in J}: 8*N_Pip_C_Trucks[t,j] >= sum{i in I}N_Pip_C[t,i,j]; #ceiling value of trucks
from Pipavav to cust

s.t. con7{i in I, j in J}: N_D_Trucks[i,j] >= (N_D_T[i,j]/8); #ceiling value of trucks directly from plant
to customer

s.t. cons3{t in 1..T, i in I}: N_M_Chen_Trucks[t,i] <= (N_M_Chen[t,i]/8) + 0.999; #Ceiling value of trucks
from plant to Chennai
s.t. cons4{t in 1..T, i in I}: N_M_Pip_Trucks[t,i] <= (N_M_Pip[t,i]/8) + 0.999;#ceiling value of trucks
from plant to Pipavav

s.t. cons5{t in 1..T, j in J}: (N_Chen_C_Trucks[t,j] - 0.999)*8 <= sum{i in I}N_Chen_C[t,i,j];#Ceiling
value of trucks from Chennai to customer
s.t. cons6{t in 1..T, j in J}: (N_Pip_C_Trucks[t,j] - 0.999)*8 <= sum{i in I}N_Pip_C[t,i,j];#ceiling value
of trucks from Pipavav to cust

s.t. cons7{i in I, j in J}: N_D_Trucks[i,j] <= (N_D_T[i,j]/8) + 0.999;#ceiling value of trucks directly
```

```
from plant to customer

s.t. capacity1{t in 1..T}: sum{i in I}N_M_Chen[t,i] <= Trip_Chen_Pip_S1[t]*(cap_S1)
+ Trip_Chen_Pip_S2[t]*(cap_S2);#ship capacity constraint
s.t. capacity2{t in 1..T}: sum{i in I}N_M_Pip[t,i] <= Trip_Pip_Chen_S1[t]*(cap_S1)
+ Trip_Pip_Chen_S2[t]*(cap_S2);#ship capacity constraint

s.t. trip_S1{t in 1..T}: sum{k in 1..t}(Trip_Chen_Pip_S1[k] - Trip_Pip_Chen_S1[k]) <= 1;#ship1 trip
sequence
s.t. trips_S1{t in 1..T}: sum{k in 1..t}(Trip_Pip_Chen_S1[k] - Trip_Chen_Pip_S1[k]) <= 1;#ship1 trip
sequence

s.t. trip_S2{t in 1..T}: sum{k in 1..t}(Trip_Chen_Pip_S2[k] - Trip_Pip_Chen_S2[k]) <= 1;#ship2 trip
sequence
s.t. trips_S2{t in 1..T}: sum{k in 1..t}(Trip_Pip_Chen_S2[k] - Trip_Chen_Pip_S2[k]) <= 1;#ship2 trip
sequence

s.t. S1usage: 100*S1 >= sum{t in 1..T}(Trip_Chen_Pip_S1[t] + Trip_Pip_Chen_S1[t]);#ship1 usage
s.t. S2usage: 100*S2 >= sum{t in 1..T}(Trip_Chen_Pip_S2[t] + Trip_Pip_Chen_S2[t]);#ship2 usage

s.t. nooftrips_S1: sum{t in 1..T}((Trip_Chen_Pip_S1[t]*5.46)+(5.46*Trip_Pip_Chen_S1[t])) <= 30;#no. of
trips in a month for ship1
s.t. nooftrips_S2: sum{t in 1..T}((Trip_Chen_Pip_S2[t]*4.41)+(4.41*Trip_Pip_Chen_S2[t])) <= 30;#no. of
trips in a month for ship2
```