Research paper analysis, Optimization

PROPOSAL OF AN OPTIMIZATION MODEL FOR DRY PORT APPLICATION FOR CONTAINER TRANSPORTATION FROM KOCAELI PORTS

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INTRODUCTION

Problem Statement:

- A seaport that might have difficulties to meet the future demands due to the capacity constraints collaborates with a dry port to welcome the surplus amount and not to lose the customers.
- It is assumed that the seaport has the overall authority to either stack the boxes (containers) in its terminal or to send them to dry port to provide room for the coming surplus amount.
- However, the issue of how many to stack in the terminal and how many to send to the dry port will be revealed by solving an LP problem.

Assumptions

- A 30 days period is considered at or after 2023.
- Only import boxes are being handled in the seaport.
- Transporting the boxes out of the seaport is carried out through trucks.
- Average Dwell Time (D_T) in the seaport is 6 days. Each arriving box leaves the port after 6 days.
- The railway connection between the seaport and the dry port enables 12 train shuttles to be executed in a day. Each shuttle must contain 25 cars, and each 60 feet length railway car must carry 2 boxes, one 20 feet, and the other 40 feet.

Assumptions

- Each box, either 20 or 40 feet, weighs between 18 and 26 tons.
- The aggregate cost of a truck carrying any type of box is 0.8 /km.
- Seaport earns 50 /box as Terminal Handling Cost (THC), 12 /day for each 20 feet box and 20 /day for each 40 feet box as warehouse fees.
- Dry port earns 3 /day for warehousing any type of box.
- Seaport authority manages a team in dry port to load/unload boxes to/from cars/land by operating reach stackers. Each operation by a reach stacker will cost 4 .

Parameters

Parameters:

- A: Number of containers arriving at seaport each day,
- $T_{v,d}$: Number of containers of size v going out of terminal by trucks in day d,
- Cap: Stacking capacity of the seaport in TEU,
- F: Container stock at the beginning of first day in TEU,
- Box_v: Container (box) size of type v (Box_v1: 1 TEU, Box_v2: 2 TEU),
- I_v: Income through a container with size v stacked at sea
- I_r: Income through 1 railway car carrying 2 boxes(60 feet)

Sets and Decision Variables

Sets:

$D = \{1...\|D\|\}$ set of Days - indexed by d
$V = \{1...\|V\|\}$ set of container size - indexed by v.

Decision Variables:

- Y_d: Total number TEUs being stocked at sea terminal's yard, d $\in D$
- $S_{v,d}$: Number of stacked containers size in that day, v $\in V, d \in D$
- J_d: Number of railway journey to dry port, d $\in D$
- $R_{v,d}$: Number of railway cars including containers' size in that day, v $\in V, d \in D$

Objective Function

$$z_{max} = \sum_{v} \sum_{d} (I_v * S_{v,d} + \sum_{d} (I_r * 25 * I_d)$$

- The objective function maximizes the total income of seaport. I_v includes THC and warehouse fees in seaport.
- I_r indicates the income through 2 boxes after subtracting the expenses of transportation on railway, warehouse fee and reach stacker operations.

Constraints

$$S_{v,d} + R_{v,d} = A \qquad \forall v, d \tag{1}$$

$$Y_d \leq Cap \qquad \forall d \tag{2}$$

$$Y_1 = F + \sum_v Box_v * (S_{v,1} - T_{v,1}) \tag{3}$$

$$Y_d = Y_{d-1} + \sum_v Box_v * (S_{v,d} - T_{v,d}) \qquad \forall d \in (2...6) \tag{4}$$

$$Y_d = Y_{d-1} + \sum_v Box_v * (S_{v,d} - S_{v,d-6}) \qquad \forall d \in (7...10) \tag{5}$$

$$\sum_v Box_v * T_{v,d} = S_{v,d-6} \qquad \forall d \in (2...6) \tag{6}$$

$$J_d \leq 12 \qquad \forall d \tag{7}$$

$$R_{v,d} = 25 * J_d \qquad \forall v, d \tag{8}$$

$$Y_d, S_{v,d}, J_d, R_{v,d} \qquad \in \mathbb{Z}^+ \tag{9}$$

Constraints

- Constraint (1) indicates that the amount of freight arriving at the port will be equal to the sum of the TEU-denominated amounts that are stacked in the terminal and sent to the dry port within that day.
- Constraint (2) ensures that the amount of boxes waiting in the terminal cannot be more than the capacity.
- Constraint sets (3), (4) and (5) explains that the difference between the amount stacked at the terminal's yard and the amount withdrawn through the trucks will be added to the previous day's amount to find the final waiting value at the yard.

Constraints

- The amount withdrawn in the first six days will be equal to the amount stacked six days ago as indicated in constraint (6)
- Constraint sets (7) and (8) ensures that the number of freight journeys on the railway cannot be more than 12 times in a day; each shuttle must involve 25 cars and each car must be carrying 2 boxes.
- Constraint (9) shows that all decision variables will be natural and positive numbers.

Estimates

Table-1: Container Handling Values (1000 TEU)

Year	Turkey Total		Kocaeli Ports Total		YILPORT	
	Value	Change	Value	Change	Value	Change
2007	4.582		132		68	
2008	5.091	11.1%	252	90.9%	135	98.5%
2009	4.404	-13.5%	280	11.1%	133	-1.4%
2010	5.743	30.4%	415	48.2%	184	38.3%
2011	6.523	13.6%	507	22.1%	230	25.0%
2012	7.192	10.3%	630	24.2%	230	0.0%
2013	7.899	9.8%	807	28.1%	305	32.6%
2014	8.351	5.7%	899	11.4%	354	16.0%
2015	8.146	-2.5%	988	9.9%	375	5.9%
2016	8.761	7.6%	1.143	15.6%	395	5.33%
2017	**10.010**	**14.3%**	**1.315**	**15.0%**	**499**	**26.3%**

Source: Statistics of "Ministry of Transportation, Maritime and Communication", and "YILPORT".

Table-2: Projections for Future Throughput Values of Turkey's Ports.

		Year	Turkey Total		Kocaeli Ports		YILPORT	
			Value (1000 TEU)	CAGR %	Value (1000 TEU)	CAGR %	Value (1000 TEU)	CAGR %
Recent Throughput Value		2018	10.843		1.597		**552**	
Projected Throughput Values in Scenarios	**Scenario-I (Pessimistic)**	2023	12.570	3,0	1.851	3,0	640	3,0
		2029	15.009	3,0	2,210	3,0	764	3,0
		2035	17.922	3,0	2.639	3,0	912	3,0
	Scenario-II (Average)	2023	14.510	6,0	2.137	6,0	739	6,0
		2029	20.583	6,0	3.032	6,0	1.048	6,0
		2035	29.198	6,0	4.301	6,0	1.487	6,0
	Scenario-III (Optimistic)	2023	15.567	7,5	3.212	15,0	1.110	15,0
		2029	24.025	7,5	5.690	10,0	1.966	10,0
		2035	34.080	6,0	8.072	6,0	2.790	6,0

Source: Prepared by the Authors.

Values

$$F = 12000 \tag{10}$$

$$S_{v,d-6} = 2000 \qquad \forall d \in 1, 2, ...6 \tag{11}$$

$$A = 3000 \tag{12}$$

$$Cap = 13800 \tag{13}$$

$$I_{v1} = THC + (12 * DT) \tag{14}$$

$$I_{v2} = THC + (20 * DT) \tag{15}$$

$$I_r = (I_{v1} + I_{v2}) - (92 + 2 + 3 * DT + 2 * (2 * 4)) \tag{16}$$

THC : Terminal handling cost = 50 €.

DT : Dwell Time = 6 days

Solution

D	Y_d	S_d	J_d	D	Y_d	S_d	J_d
1	1240	2400	8	16	13800	2100	12
2	12500	2100	12	17	13800	2100	12
3	13500	3000	0	18	13800	2100	12
4	13600	2100	12	19	13800	2100	12
5	13700	2100	12	20	13500	2100	12
6	13800	2100	12	21	13500	3000	0
7	13800	2400	8	22	13800	2400	8
8	13800	2100	12	23	13800	2100	12
9	13800	3000	0	24	13800	2100	12
10	13800	2100	12	25	13800	2100	12
11	13800	2100	12	26	13800	2100	12
12	13800	2100	12	27	13200	2400	8
13	13500	2100	12	28	13800	3000	0
14	13800	2400	8	29	13800	2100	12
15	13800	3000	0	30	13800	2100	12

Table: Final Result

Solution

- 21.000 TEUs (280*25*3) should be sent to KLC.
- 69.000 TEUs should be stacked in the terminal to **maximise the income** of YILPORT
- This solution will result in a total of **"7,752.000€"** income.
- Extra income from transportation for TCDD = **644.000€** (280*25*92€)
- Extra income from warehousing for KLC = **252.000€** (280*25*2€)
- Roadway of 14.000 containers will be diminished by aout 50km(distance between YILPORT and KLC). So carriers will save **560.000€** (280*25*2*0,8€*50km)

Solution

- If there were no possibility to make use of a dry port system, YILPORT would have to cancel the arrival of 10 vessels which means a loss for handling 30.000 TEUs.
- This time the total income of YILPORT would come down to **"5.840.000€"**
- If the circumstances assumed are encountered in the future , this optimisation model demonstrates that YILPORT may boost its income up by **32.7%**

Solution

This scenario also assumes that :

- An average of 200 containers per day will be directed to Ankara .
- For this job , carriers may use 100 railway cars to transfer containers to HLC with a cost of **12.600€**
- Then they are ransported to Ankara by truck with a total cost of **19.400€**
- Excluding expenses given to seaport ,the carriers will spend **32.000€** per day for goods to be transported to Ankara.

Code for this problem can be accessed here
Hyper link for paper in the subtitle session