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Optimal Allocation Policy for Fleet Management

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ABSTRACT

The transportation problem is one of the biggest problem that face the fleet management, whereas the main objectives for the fleet management is reducing the operations cost besides improving the fleet efficiency. Therefore, this paper presents an application for a transportation technique on a company to distribute its products over a wide country by using its fleet. All the necessary data are collected from the company, analyzed and reformulated to become a suitable form to apply a transportation model to solve it. The results show that using this technique can be considered as powerful tool to improve the operation management for any fleet.

KEYWORDS: *Transportation, Optimization, Minimum Distance, Optimal Distribution*

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1. INTRODUCTION

The transportation model was considered the oldest model where presented in 1941 by Hitchcock, and developed by Koopman and Dantzing to formulate and solve it as linear programming problem. In this section, we present a brief survey about the transportation problem technique. In the beginning, the researchers can be classified into two groups; the first group concerned with the techniques the used to soving the transportation problem and suggest the new algorithms and the second gourp concerned with the applications of the transportation problem in our life. **Ravi et.al [1]** presented a new approach to find the optimal solution for transportation problem. This a approach can be found the feasible and optimal solution with or without degeneracy condition by a minimum number of iterations. **Amaravathy et. al [2]** also presented a new method namely MDMA (Maximum Divide Minimum Allotment) to find the feasible solution and may be optimal solution or the transportation problem without disturbance of degeneracy condition. **Juman and Nawarathne [3]** introduced a new approach to find the efficient the Initial basic feasible solution to reach faster to the optimal solution for transportation problem, and used the numerical example to illustrate a proposed approach. **Ramesh et.al [4]** proposed a new algorithm to find the initial allocation of the basic cells without converting the problem to a classical from, the paper presented a numerical example to illustrate the proposed algorithm technique. **Sharmin and Babul [5]** developed an algorithm and its computer program to solving a transportation Problem. They formulated the transportation problem as linear problem so the problem became more difficult but by using their computer program, the solution can be obtained in a shorter time. **Ellaimony et. al [6]** introduced an algorithm for solving a bi-criteria multistage transportation problem without any restrictions in the intermediate stage. The proposed model is depended on a dynamic programming. This paper introduced a numerical example to illustrate the proposed algorithm technique. . **Khalil [7, 8]** applied the transportation model to solving the non-productive kilometers on a transportation company by redistributing the buses between their garages and bus stations to minimize the total non-productive kilometers in order to saving the fuel consumption of these buses. **Nabendu et. al. [9]** found the optimal distribution for the rice company from different suppliers of Silchar to different distributers in Mizoram and made analysis on the basic feasible solution by various methods. **Azizi et. al. [10]** solved a transportation problem for Bio-Pharma Company by formulated it as linear programming model to minimize the total cost. The new shipment plan enables the company to reduce 12% of its cost. In this paper, we applied the transportation mathematical model for a large company that works in SODA Water distributions on a wide country to minimize the total operating fleet cost by minimizing the travelled kilometers.

2. THE MATHEMATICAL MODEL OF THE TRANSPORTATION PROBLEM

The transportation problem can be defined as the following: when there are many sources produce a product and want distribute this production on many distributors through roads network and the cost or the distance of the transportation from any source to other destinations is known. Then the objective function can be represented as minimum cost/distance and formulate the required constraints that represent the transportation problem. Figure 1 represent the general transportation problem network that help to formulate the mathematical model for transportation model.

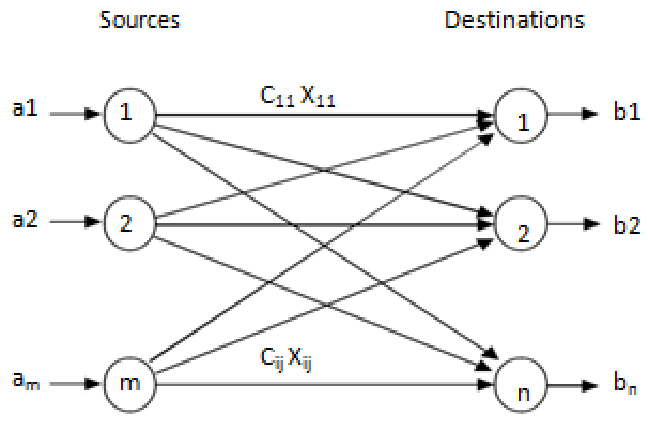

Figure 1 General transportation problem network

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

Subject to:

$$\sum_{j=1}^{n} x_{ij} = a_i, \qquad i = 1,2,\ldots\ldots,m \qquad (2)$$

$$\sum_{i=1}^{m} x_{ij} = b_j, \qquad j = 1,2,\ldots\ldots,n \qquad (3)$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \qquad \text{(Balanced Condition)} \qquad (4)$$

$$x_{ij} \geq 0, \qquad i = 1,2,\ldots.m, \qquad j = 1,2,\ldots.,n$$

Where,

c_{ij} : is the costs of transporting a unit from source *i* to destination *j*,
x_{ij} : is the amount transported from source *i* to destination j,
a_j : is the availability at *i* source
b_j : is the requirement at *j* destination
m : is the total number of sources
n : is the total number of destinations

The previous equations represent the classical transportation problem model. The objective function can be represented by the equation (1). The first constraint (2) represents the minimum capacity of the factories (sources) from the production while the second constraint (3) represents the maximum capacity to the stores (destinations). The transportation problem becomes balance when the total availabilities of sources equal the total requirements of destinations (4).

3. STEPS OF SOLUTION THE TRANSPORTATION PROBLEM

The following procedure illustrates the steps for check of optimality as given below and there is the flow chart for this algorithm in Figure 2.

Step 1: Solve the transportation problem by any of the initial basic feasible solution methods.

- North West Corner Method
- Minimum Column Method
- Minimum Row Method
- Lest Cost Method
- Vogel's Approach

Step 2: Ensure the requirement of the optimization test which states that the number of occupied (filled) cells in the transportation network from step (1) equals. m+n-1.

Step 3: For the occupied cells only determine (u_i; i=1, 2, ..., m) for each row (i), and (v_j; j= 1, 2,…, n) for each columns (j) according to the equation ($u_i + v_j = c_{ij}$). Start by assuming one of the values of u_i or v_j = 0. Then calculate the other values of u_i and v_j. After calculating the values of the other u_i and v_j for all rows and columns, calculate ($\Delta_{ij} = c_{ij} - u_i - v_j$) for all non-occupied cells.

Step 4: Prepare a new matrix for the calculated values of (Δ_{ij}) as indicated in step (3):

A. If all Δ_{ij} non-occupied cells is greater than zero, the initial basic solution would be an optimal solution. Stop.
B. If one or more of Δ_{ij} at the non-occupied cells equal zero, and Δ_{ij} at all other non-occupied cells is greater than zero, this means that the current solution is optimal, but there is one more other optimal solution as well. We can stop here, or we can find the other optimal solution(s) as in step 5 below.
C. If there is one or more of Δ_{ij} less than zero, the solution is not optimal and from here determine the cell which includes the value of the largest negative number. This cell must be filled by as much products as we can to minimize the total transportation cost. Go to step 5 below.

Step 5: If the initial basic feasible solution is not optimal, start with the cell which includes the highest negative (Δ_{ij}) and draw a square or a rectangular closed path with 4 cells. Give this cell a (+) sign which means that this cell must receive products. The next cell in the closed path corner should include a (-) sign which means this cell must give products. This cell must have products (from the initial basic feasible solution). The next cell in the closed path corner should include a (+) sign, and the last one should include a (-) sign. Remember that the two cells with the (-) signs must have products to give.

Step 6: Now transfer as much products from the two (-) cells to the two (+) cells such that the transferred amounts should not exceed the amounts exists in any of the giver cells. By this distribution the total transportation cost should be reduced.

Step 7: After making the previous improvements as in step (6) go back to Step (3) to test the optimization and do the consecutive steps till we reach the optimal solution.

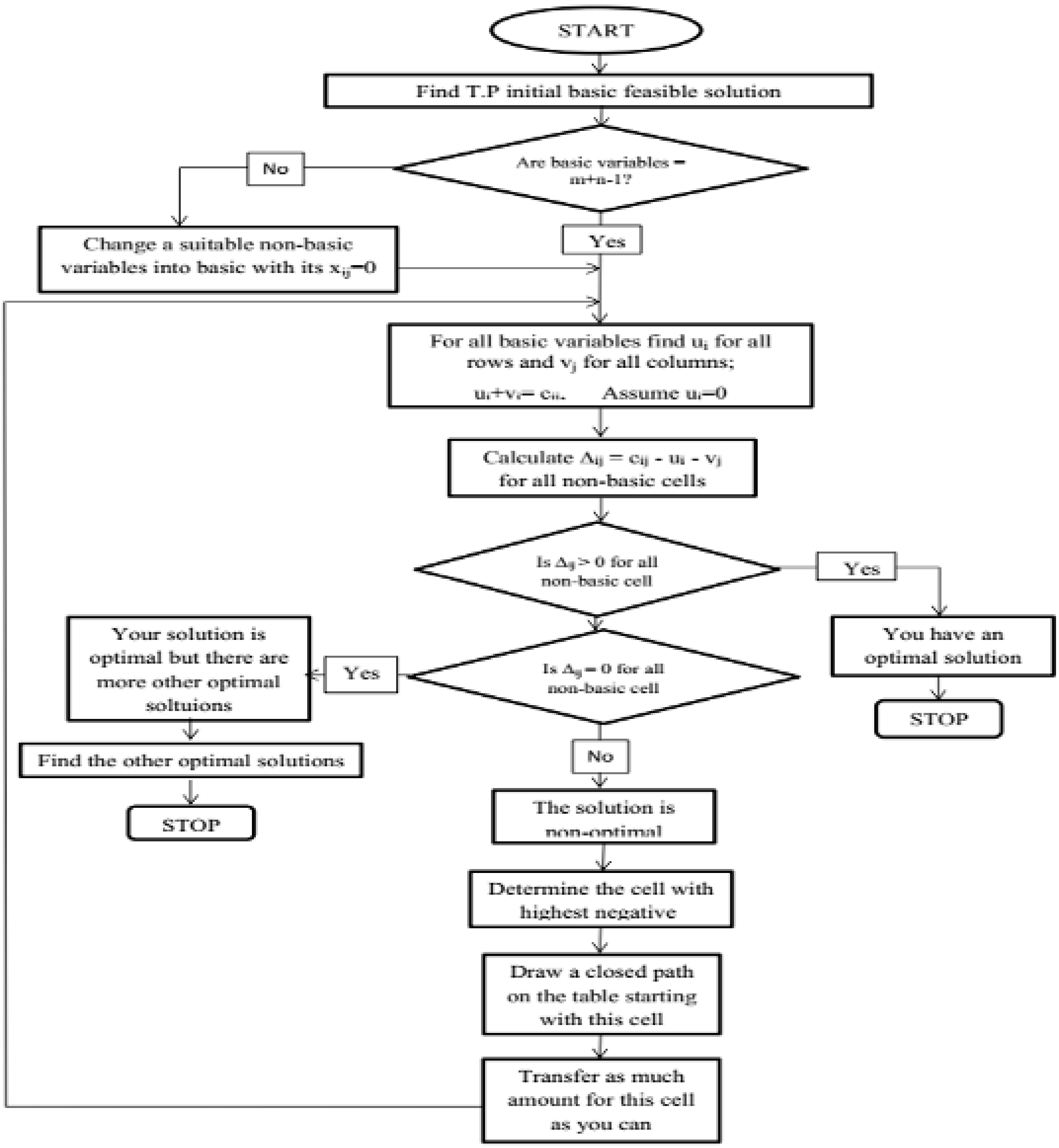

Figure 2: Flow chart of finding an optimal solution [7]

4. CASE STUDY

4.1. COLLECTED DATA

The company works in SODA Water field has 8 factories and 25 stores, these factories and stores are spreaded in a country. The production plan of each factory are stated in Table 1 and is represented it by Pie chart in Fig (3), while the capacities of each store are stated in Table 2 and is represented by Pie chart in Fig (4). In addition, Table 3 represents the distance between sources and destinations.

Table 1: Factories production Plan

No.	Factory	Production by Pallet
1	CBI	10,226
2	Qalub	3,677
3	October	7,194
4	ABI	11,590
5	Tanta	10,636
6	Crush	3,430
7	Elsadat	6,100
8	Assiut	19,093

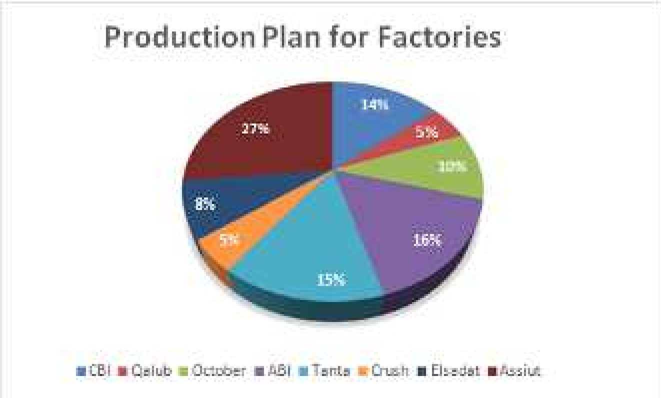

Figure 3: Pie chart for capacity used of each source for road transportation

Table 2: Stores Capacity

No.	Location	Qt. by Pallet
1	Cairo	**10,566**
2	Giza	**5,554**
3	Qalub	**4,977**
4	Alexandria	**8,353**
5	Matrouh	**870**
6	Kafr El Dawar	**2,367**
7	Tanta	**4,932**
8	Shebin El Koum - Menouf	**1,604**
9	Kafr El Sheikh- Beheira	**900**
10	El Sharkeya	**3,200**
11	Mansoura	**1,480**
12	Damietta	**1,950**
13	Branch BeniSuef	**2,700**
14	Branch Fayoum	**660**
15	Minya	**2,740**
16	Assiut	**2,229**
17	Sohag	**3,050**
18	Branch Qena	**1,655**
19	Aswan	**1,354**
20	Luxor	**845**
21	Suez	**2,560**
22	Ismailia	**2,350**
23	Port Said	**2,100**
24	Hurghada	**1,500**
25	Sharm El Sheikh	**1,450**
	Total	**71,946**

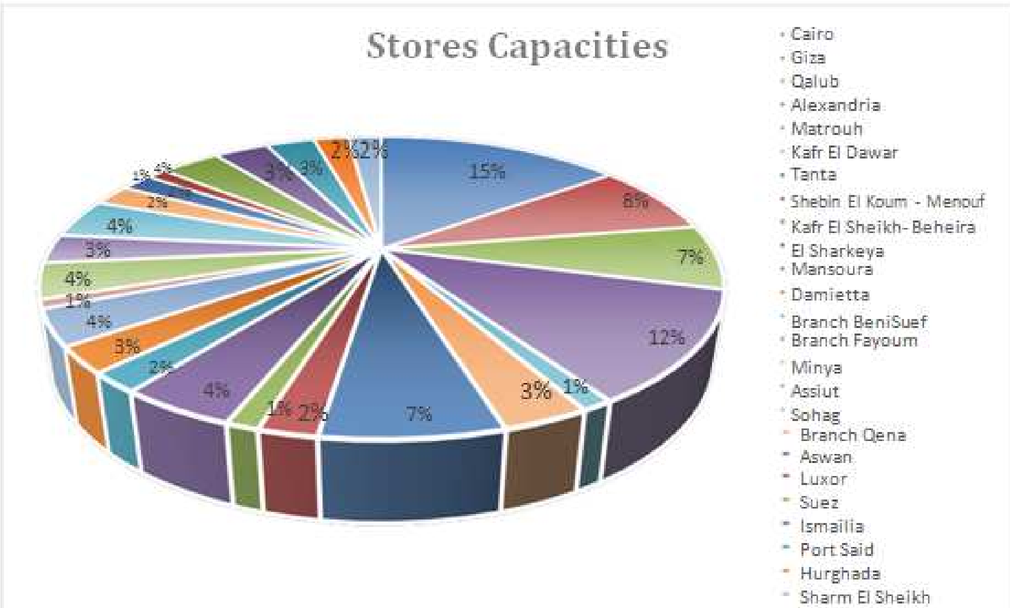

Figure 4: Pie chart for Stores capacity in each city

Table 3: The distance between the each factory and each store

Factory Store	CBI	Qalub	October	ABI	Tanta	Crush	Elsadat	Assiut
Cairo	56	56	83	288	138	184	155	560
Giza	64	68	74	310	158	231	118	536
Qalioub	62	33	67	260	116	177	185	584
Alexandria	281	239	253	71	188	237	368	816
Matrouh	503	460	454	292	466	512	604	1081
Kafr El Dawar	238	200	270	91	152	166	304	765
Tanta	143	125	156	178	66	118	285	678
Shebin El Koum	118	107	130	214	75	148	274	627
Kafr El Sheikh	173	140	171	211	92	148	319	667
El Sharkeya	126	118	153	345	109	91	259	632
Mansoura	183	173	213	266	113	54	319	661
Damietta	218	200	244	269	126	54	326	681
Branch BeniSuef	138	161	131	368	251	296	77	529
Branch Fayoum	113	130	90	318	201	243	90	541
Minya	227	236	218	466	363	391	102	461
Assiut	470	472	423	798	563	614	279	408
Sohag	630	662	600	958	763	816	445	388
Branch Qena	730	723	670	985	863	872	555	432
Aswan	945	932	932	1285	1070	1105	775	560
Luxor	800	803	740	1115	887	946	605	425
Suez	159	167	215	416	237	230	301	584
Ismailia	159	167	215	416	221	190	301	595
Port Said	246	358	300	346	250	100	389	672
Hurghada	466	522	605	723	590	620	779	490
Sharm El Sheikh	566	600	650	779	629	664	827	960

4.2. APPLIED THE MATHEMATICAL MODEL

$$Min \sum_{j=1}^{8} \sum_{i=1}^{25} c_{ij} x_{ij}$$

Subject to:

$$\sum_{j=1}^{25} x_{ij} = a_i, \qquad i = 1,2,.....,8$$

$$\sum_{i=1}^{8} x_{ij} = b_j, \qquad j = 1,2,.....,25$$

$$x_{ij} \geq 0, \qquad i = 1,2,....8, \quad j = 1,2,....,25$$

To solve the problem by using the mathematical model of the transportation model, it must be clarified that the transportation process is carried out using trucks that carry 12 pallets that is transported together at the same time. So the production plan must be divided according to the transport operations, meaning that the produced quantities must be divided into 12 Pallet so that it can be considered a single unit. By using LINGO software, the optimal distribution of the products is shown in Table 4, where the total required covered distance to distribute all goods is 1152478 km. compared with the current distribution policy, which required covered distance 1204522 km. That means that the new distribution policy will reduce the required covered distance by 52000 Km/month, i.e 624000 Km/year approximately. From the collected data the average fuel consumption 42 liter/100 Km and the fuel price is 6.75 EGP, plus according to the maintenance contract the maintenance cost is 4.25 EGP/Km including spare parts. that means the new policy will save about 6864000 EGP/year.

Table 4: Optimal distribution policy for the goods

LINGO/WIN32 19.0.32 (3 Dec 2020), LINDO API 13.0.4099.242	
Licensee info: Eval Use Only	
License expires: 11 AUG 2021	
Global optimal solution found.	
Objective value:	1152478.
Infeasibilities:	0.000000
Total solver iterations:	46
Elapsed runtime seconds:	0.11
Model Class:	LP
Total variables:	200
Nonlinear variables:	0
Integer variables:	0

Total constraints:		34
Nonlinear constraints:		0
Total nonzeros:		594
Nonlinear nonzeros:		0
Variable	Value	Reduced Cost
X11	852.0000	0.000000
X23	39.00000	0.000000
X210	267.0000	0.000000
X31	29.00000	0.000000
X32	135.0000	0.000000
X33	376.0000	0.000000
X38	60.00000	0.000000
X44	696.0000	0.000000
X45	73.00000	0.000000
X46	197.0000	0.000000
X57	411.0000	0.000000
X58	74.00000	0.000000
X59	75.00000	0.000000
X611	123.0000	0.000000
X612	163.0000	0.000000
X72	229.0000	0.000000
X713	225.0000	0.000000
X714	55.00000	0.000000
X82	99.00000	0.000000
X815	228.0000	0.000000
X816	186.0000	0.000000
X817	254.0000	0.000000
X818	138.0000	0.000000
X820	70.00000	0.000000
X822	196.0000	0.000000
X823	175.0000	0.000000
X824	125.0000	0.000000
X825	121.0000	0.000000
X519	113.0000	0.000000
X521	213.0000	0.000000

5. CONCLUSION

Transportation models have been applied to one of the companies that owns 8 factories, and these factories distribute their products to 25 warehouses distributed across the country based on the monthly needs plan. These products are distributed through a known transportation network. The used transportation model is powerful tool to save a lot of kms. Where, the policy that was proposed in this paper, it will save about 624000 Km/year, and by knowledge of the average fuel consumption per km and the price of a liter of fuel, and the maintenance cost including the spare parts we can save about 6864000 EGP/year.

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