Optimization of Transport Costs as a Tool for Profit Maximization: A Study Based on Lion Brewery Ceylon PLC.

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INTRODUCTION

Emerging rise of incidences corresponding to increasing volumes in freight transport should be answered by innovative solutions. The invention of contemporary solutions in transport and logistics sector is significantly important with the growth in the volume of freight transportation in Sri Lanka. Most transport problems are related to the çost incurred through congestion, shortage of labour and the fuel price hike. Considering all global and local difficulties in transportation each vehicle fleet of individual organizations should be improved to its optimum level to eliminate problems. Implementation of mitigation measures for negative impacts of natural and social habits is another challenge that lies on the logisticians in Sri Lanka.

Lion Brewery Ceylon Plc. is one of the leading companies in the beer market in Sri Lankan with a total investment of USD 30,000,000. In the Sri Lankan beer market, Tiger, Baron Strong, ABC Stout, 3 Coins Lager, Heineken and Grand Blond are the leading competitive brands. The acquisition of McCallum Breweries and Three Coins Company for LKR.1.42 billion by Cargills (Ceylon) PLC group and formation of 100% owned subsidiary Millers Brewery Ltd. can be a significant threat to the Lion Company. However, the management of Lion Company is anticipating an increase in beer demand in the near future that will surpass the present beer production and distribution capacity.

The main objective of the research was to optimize transport costs by minimizing the number of truck movements, maximizing the quantity volume per kilo-meter and minimizing the mileage of each vehicle in the fleet. Other objectives of the research were to provide a platform for developing transport scheduling software which can be utilized by companies engaged in transporting the similar kind of goods, to increase the customer satisfaction by elimination stockouts, to minimize human errors, and to reduce company carbon footprint by eliminating unnecessary truck movements.

LITERATURE REVIEW

Bartling, U. & Muhlenbein, H. (1997) have described a large scale vehicle scheduling and routing issue which is greatly significant to parcel distribution companies. They have developed a Breeder Genetic linear algorithm with the capability to deal with up to 10,000 transportation requests to be serviced by an inhomogeneous fleet of vehicles within a 24 hour time interval. A transportation request is defined as the task to move a loaded container from one depot to another. Since the depots do not send out the same amount of containers as they receive, the number of empty containers available at the depots has to be balanced. The optimization task, thus, is twofold: determine suitable balance trips and find a low cost schedule for the fleet of vehicles.

As per Lee, Y.H, et al, (2006) one of the most significant factors in implementing supply chain management is to efficiently control the physical flow of the supply chain. Due to its importance, many companies are trying to imitate those efficient methods to increase customer satisfaction and reduce costs. Cross-docking is considered a good method to reduce inventory and improve responsiveness to different customer demands. It is also necessary, when considering cross-docking from an operational viewpoint, to find the optimal vehicle routing schedule. Thus, an integrated model considering both cross-docking and vehicle routing scheduling was treated in their study. Linear programming algorithm based on a Tabu search algorithm was proposed.

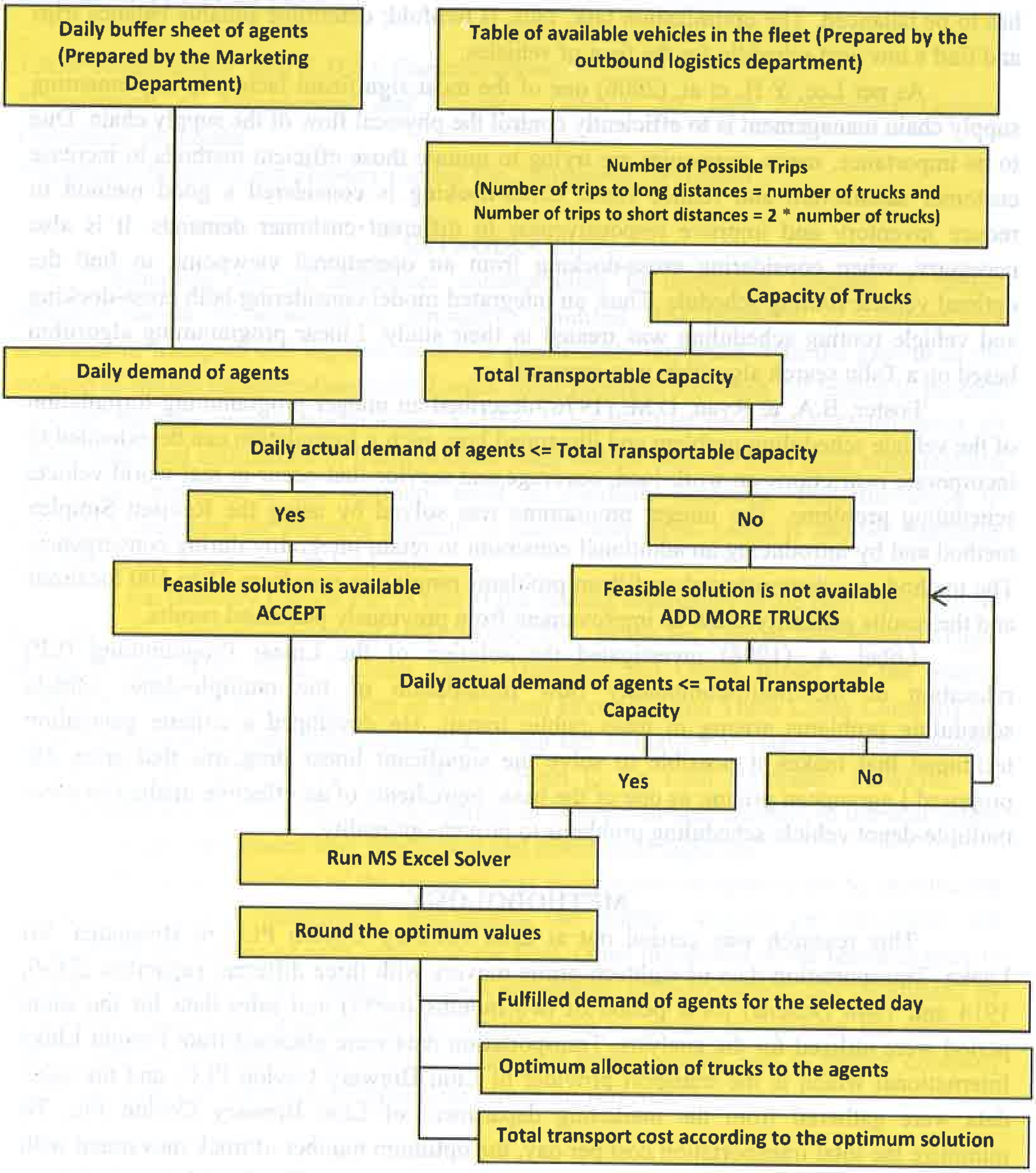
Foster, B.A, & Ryan, D.M. (1976) described an integer programming formulation of the vehicle scheduling problem and illustrated how such a formulation can be extended to incorporate restrictions on work load, coverage and service that occur in real world vehicle scheduling problems. The integer programme was solved by using the Revised Simplex method and by introducing an additional constraint to retain integrality during convergence. The method was demonstrated on fifteen problems ranging in size from 21 to 100 locations and the results generally show an improvement from previously published results.

Löbel, A. (1998) investigated the solution of the Linear Programming (LP) relaxation of the multi-commodity flow formulation of the multiple-depot vehicle scheduling problems arising in mass public transit. He developed a column generation technique that makes it possible to solve the significant linear programs that arise. He proposed Lagrangean pricing as one of the basic ingredients of an effective method to solve multiple-depot vehicle scheduling problems to proven optimality.

METHODOLOGY

This research was carried out at Lion Brewery Ceylon PLC in Biyagama, Sri Lanka. Transportation data of eighteen prime movers with three different capacities (2156, 1914 and 1848 Dozens) for a period of two months (n=55) and sales data for the same period were utilized for the analysis. Transportation data were obtained from Freight Links International which is the transport provider of Lion Brewery Ceylon PLC, and the sales data were gathered from the marketing department of Lion Brewery Ceylon Plc. To minimize the total transportation cost per day, the optimum number of truck movement with different capacities was selected for each agent by applying the Simplex Method in Linear Programming. After determining the optimum number of truck movements, a vehicle schedule was prepared by prioritizing the agents based on their available safety stocks. The hypothesis of the study was that the proposed method maximizes profit by increasing the efficiency of outbound logistics activities of the company. First phase of the proposed vehicle scheduling system is exhibited in Figure 1.

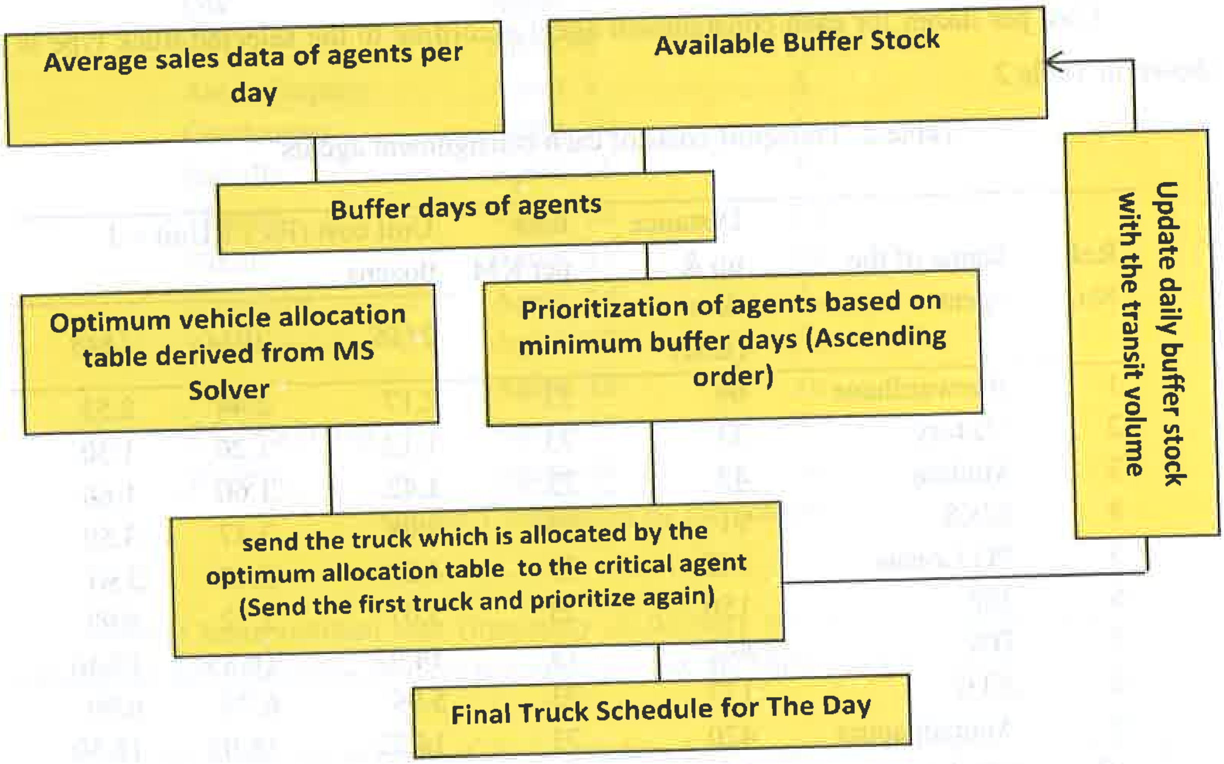
Figure 1: First phase of the proposed vehicle scheduling system



Source: Constructed by the authors

After allocating the optimum number of trips with the minimum transport cost for each consignment agents by using MS Excel Solver, the truck schedule and the departure time for each truck should be arranged according to the priority of the agents. The management of the company calculates the buffer-days by using average redistribution data and the existing buffer level of each agent. The term buffer-days refers to the number of days that a consignment agent can survive in the market without creating a stockout situation. Agents have been prioritized by ascending order based on their buffer days in order to avoid stockout situation in a particular market area. The process of prioritizing the consignment agent is exhibited in Figure 2.

Figure 2: Second phase of the proposed vehicle scheduling system (Prioritization of agents based on minimum buffer days)



Source: Constructed by the authors

Only a single trip can be made to an agent in a day except the short distance agents (below 50km from the brewery). A short distance agent can be visited twice a day. The company does not send half or less truck loads of prime movers to the agents. According to the agreement, eighteen trucks are in operation. However, during the festival seasons the company adds two more trucks to the fleet. Available prime movers with different capacities are shown in the Table 1.

Table 1: Vehicle types and their capacities

Vehicle type	Capacity (Dozens)
Type 'a' (5 trucks)	2156
Type 'b' (2 trucks)	1914
Type 'c' (11 trucks)	1848

Source: Constructed by the authors

Quantity of freight and the capacity of vehicles can be measured in terms of dozens (1 dozen = 12 * 625 ml = 7500 ml = 7.5 L). Cost per dozen varies as per the capacity of the selected prime mover and the travel distance between the Lion Brewery and the particular consignment agent. Cost per dozen can be calculated as follows:

$$\text{Cost Per Dozen} = \frac{\text{Distance between Lion Brewery and particular consignment agent} \times \text{Rate per Kilometer}}{\text{Capacity of the selected prime mover (Dozens)}}$$

Cost per dozen for each consignment agent according to the selected truck type is shown in Table 2

Table 2: Transport costs of each consignment agents

Ref. No.	Name of the agent	Distance up & down (KM)	Rate per KM	Unit cost (Rs.) 1 Unit = 1 dozens		
				2156	*1914*	*1848*
1	Abewardhane	64	73	2.17	2.44	2.53
2	Victory	33	73	1.12	1.26	1.30
3	Modern	42	73	1.42	1.60	1.66
4	SJKS	91	73	3.08	3.47	3.59
5	PG Gomas	142	73	4.80	5.42	5.61
6	JSP	150	73	5.07	5.72	5.93
7	DW	442	73	14.97	16.85	17.46
8	RTN	177	73	5.99	6.75	6.99
9	Anuradhapura	420	73	14.22	16.02	16.59
10	Geethanjan	141	73	4.77	5.38	5.57
11	Badulla	430	73	14.56	16.40	16.99
12	Maweli	350	73	11.85	13.35	13.83
13	Sakura	50	73	1.69	1.91	1.98
14	Hansagiri	264	73	8.94	10.07	10.43
15	South Asia	220	73	7.45	8.39	8.69
16	Pears	850	73	28.78	32.41	33.58
17	MM Marketing	504	73	17.06	19.22	19.91
18	Eastern	630	73	21.33	24.03	24.88

Source: Constructed by the authors

Frequency of sending prime movers to the consignment agents in order to fulfil the daily requirement of dozens of the consignment agents are shown in Table 3.

Table 3: Frequency of trips to consignment agents from the brewery per day

Name of the agent	Assigned name	Frequency of trips per day
Abewardhane	Agent 1	f_1
Victory	Agent 2	f_2
Modern	Agent 3	f_3
SJKS	Agent 4	f_4
PG Gomas	Agent 5	f_5
JSP	Agent 6	f_6
DW	Agent 7	f_7
RTN	Agent 8	f_8
Anuradhapura	Agent 9	f_9
Geethanjan	Agent 10	f_{10}
Badulla	Agent 11	f_{11}
Maweli	Agent 12	f_{12}
Sakura	Agent 13	f_{13}
Hansagiri	Agent 14	f_{14}
South Asia	Agent 15	f_{15}
Pears	Agent 16	f_{16}
RR Marketing	Agent 17	f_{17}
Eastern	Agent 18	f_{18}

Source: Constructed by the authors

Total transportation cost (frequency of delivery x capacity of the prime mover x unit cost) of different prime movers per agent per day are shown in Table 4.

Table 4: Transport costs of the agents based on frequencies made by each truck per day

Ref. No	Assigned name of the agent	Distance up & down (KM)	Transport cost (Rs.)		
			a (2156)	*b (1914)*	*c (1848)*
1	Agent 1	64	2.17 f_1a	2.44 f_1b	2.53 f_1c
2	Agent 2	33	1.12 f_2a	1.26 f_2b	1.30 f_2c
3	Agent 3	42	1.42 f_3a	1.60 f_3b	1.66 f_3c
4	Agent 4	91	3.08 f_4a	3.47 f_4b	3.59 f_4c
5	Agent 5	142	4.80 f_5a	5.42 f_5b	5.61 f_5c
6	Agent 6	150	5.07 f_6a	5.72 f_6b	5.93 f_6c
7	Agent 7	442	14.97 f_7a	16.85 f_7b	17.46 f_7c
8	Agent 8	177	5.99 f_8a	6.75 f_8b	6.99 f_8c
9	Agent 9	420	14.22 f_9a	16.02 f_9b	16.59 f_9c
10	Agent 10	141	4.77 $f_{10}a$	5.38 $f_{10}b$	5.57 $f_{10}c$
11	Agent 11	430	14.56 $f_{11}a$	16.40 $f_{11}b$	16.99 $f_{11}c$

12	Agent 12	350	11.85 $f_{12}a$	13.35 $f_{12}b$	13.83 $f_{12}c$
13	Agent 13	50	1.69 $f_{13}a$	1.91 $f_{13}b$	1.98 $f_{13}c$
14	Agent 14	264	8.94 $f_{14}a$	10.07 $f_{14}b$	10.43 $f_{14}c$
15	Agent 15	220	7.45 $f_{15}a$	8.39 $f_{15}b$	8.69 $f_{15}c$
16	Agent 16	850	28.78 $f_{16}a$	32.41 $f_{16}b$	33.58 $f_{16}c$
17	Agent 17	504	17.06 $f_{17}a$	19.22 $f_{17}b$	19.91 $f_{17}c$
18	Agent 18	630	21.33 $f_{18}a$	24.03 $f_{18}b$	24.88 $f_{18}c$

Source: Constructed by the authors

Simplex Method in Linear Programming can be applied to determine the optimum truck movements. Based on the above information, the objective function can be derived as follows:

$$
\begin{aligned}
Total\ Cost\ Per\ Day\ 2.17f_1a+ 2.44f1b+ 2.53f1c+ 1.12f2a+ 1.26f2b+ 1.30f2c+\\
1.42f3a+ 1.60f3b+ 1.66f3c+ 3.08f4a+ 3.47f4b+ 3.59f4c+\\
4.80f5a+ 5.42f5b+ 5.61f5c++ 5.07f6a+ 5.72f6b+\\
5.93f6c+14.97f7a+ 16.85f7b+ 17.46f7c+ 5.99f8a+ 6.75f8b+\\
6.99f8c+ 4.22f9a+ 16.02f9b+ 16.59f9c+4.77f10a+ 5.38f10b+\\
5.57f10c+ 14.56f11a+ 16.40f11b+ 16.99f11c+ 11.85f12a+\\
13.35f12b+ 3.83f12c+1.69f13a+ 1.91f13b+ 1.98f13c+\\
8.94f14a+ 10.07f14b+ 10.43f14c+ 7.45f15a+ 8.39f15b+\\
8.69f15c+8.78f16a+ 32.41f16b+ 33.58f16c+ 17.06f17a+
\end{aligned}
$$

The above objective function should be minimized subject to constraints arising from the daily demand of the agents and number of possible movements available for each type of truck.

Constraints arise from the daily demand of agents:

$a^* f_{1a} + b^* f_{1b} + c^* f_{1c} \geq$ *Daily demand of Agent 1*
$a^* f_{2a} + b^* f_{2b} + c^* f_{2c} \geq$ *Daily demand of Agent 2*
$a^* f_{3a} + b^* f_{3b} + c^* f_{3c} \geq$ *Daily demand of Agent 3*
$a^* f_{4a} + b^* f_{4b} + c^* f_{4c} \geq$ *Daily demand of Agent 4*
$a^* f_{5a} + b^* f_{5b} + c^* f_{5c} \geq$ *Daily demand of Agent 5*
$a^* f_{6a} + b^* f_{6b} + c^* f_{6c} \geq$ *Daily demand of Agent 6*
$a^* f_{7a} + b^* f_{7b} + c^* f_{7c} \geq$ *Daily demand of Agent 7*
$a^* f_{8a} + b^* f_{8b} + c^* f_{8c} \geq$ *Daily demand of Agent 8*
$a^* f_{9a} + b^* f_{9b} + c^* f_{9c} \geq$ *Daily demand of Agent 9*
$a^* f_{10a} + b^* f_{10b} + c^* f_{10c} \geq$ *Daily demand of Agent 10*
$a^* f_{11a} + b^* f_{11b} + c^* f_{11c} \geq$ *Daily demand of Agent 11*
$a^* f_{12a} + b^* f_{12b} + c^* f_{12c} \geq$ *Daily demand of Agent 12*

$a^* f_{13a} + b^* f_{13b} + c^* f_{13c} \geq$ *Daily demand of Agent 13*
$a^* f_{14a} + b^* f_{14b} + c^* f_{14c} \geq$ *Daily demand of Agent 14*
$a^* f_{15a} + b^* f_{15b} + c^* f_{15c} \geq$ *Daily demand of Agent 15*
$a^* f_{16a} + b^* f_{16b} + c^* f_{16c} \geq$ *Daily demand of Agent 16*
$a^* f_{17a} + b^* f_{17b} + c^* f_{17c} \geq$ *Daily demand of Agent 17*
$a^* f_{18a} + b^* f_{18b} + c^* f_{18c} \geq$ *Daily demand of Agent 18*

Constraints arise from number of possible trips for each type of vehicles:

$f_{1a}+f_{2a}+f_{3a}+f_{4a}+f_{5a}+f_{6a}+f_{7a}+f_{8a}+f_{9a}+f_{10a}+f_{11a}+f_{12a}+f_{13a}+f_{14a}+f_{15a}+f_{16a}+f_{17a}+f_{18a} \leq$ *Number of possible trips for "a" type vehicles*

$f_{1b}+f_{2b}+f_{3b}+f_{4b}+f_{5b}+f_{6b}+f_{7b}+f_{8b}+f_{9b}+f_{10b}+f_{11b}+f_{12b}+f_{13b}+f_{14b}+f_{15b}+f_{16b}+f_{17b}+f_{18b} \leq$ *Number of possible trips for "b" type vehicles*

$f_{1c}+f_{2c}+f_{3c}+f_{4c}+f_{5c}+f_{6c}+f_{7c}+f_{8c}+f_{9c}+f_{10c}+f_{11c}+f_{12c}+f_{13c}+f_{14c}+f_{15c}+f_{16c}+f_{17c}+f_{18c} \leq$ *Number of possible trips for "c" type vehicles*

And non-negativity constraint:

$f_{1a}, f_{2a}, f_{3a}, f_{4a}, f_{5a}, f_{6a}, f_{7a}, f_{8a}, f_{9a}, f_{10a}, f_{11a}, f_{12a}, f_{13a}, f_{14a}, f_{15a}, f_{16a}, f_{17a}, f_{18a}, f_{1b}, f_{2b}, f_{3b}+f_{4b}, f_{5b}, f_{6b}, f_{7b}, f_{8b}, f_{9b}, f_{10b}, f_{11b}, f_{12b}, f_{13b}, f_{14b}, f_{15b}, f_{16b}, f_{17b}, f_{18b}, f_{1c}, f_{2c}, f_{3c}, f_{4c}, f_{5c}, f_{6c}, f_{7c}, f_{8c}, f_{9c}, f_{10c}, f_{11c}, f_{12c}, f_{13c}, f_{14c}, f_{15c}, f_{16c}, f_{17c}+f_{18c} \geq 0$

After identifying the objective function and the constraints, data were fed to the Microsoft Excel Solver to find the optimal solutions in the vehicle scheduling system.

DATA ANALYSIS

Lion Brewery Ceylon Plc, established in 1881, enjoys over 85% present of the Sri Lankan beer market share of the main brands: Lion Lager, Lion Stout and Strong Beer (Lion Brewery Ceylon Plc., 2011). The company also brews internationally reputed beer brands called "Carlsberg" and markets "Corona Extra" which have been originated in Mexico. Lion products are emerging as an international presence exporting its products to 12 countries including the USA, the UK, Japan and France. The local products are distributed all over the Island by using capacity wise different prime movers and through 18 consignment agents scattered around the Island. The agents have been categorized into three groups according to the daily buffer level they maintain. Agents who maintain and have the ability to keep their daily buffer level over 16,000 dozens are referred to as large scale agents, The agents who maintain and have the capacity of keeping daily buffer level between 12,000 dozens to 16,000 dozens daily are referred to as medium scale agents. The agents who maintain and have the ability of keeping daily buffer level below 12,000 dozens are referred to as small scale agents. However, with the increase in the demand for Lion products over the last two years, gradually the small scale agents have grown into medium scale agents.

The Tables 5 and 6 depict the cost incurred by the manual system and proposed optimal allocation system. Furthermore, the tables show the percentage of the daily requirements and fulfilment.

Table 5: Outcomes of the existing manual vehicle scheduling system and proposed vehicle scheduling system for the month of May 2011

	Existing manual vehicle scheduling system			Proposed vehicle scheduling system	
Date	Minimum daily requirement (dozens)	Achieved amount (dozens)	Demand fulfilment	Achieved amount (dozens)	Demand fulfilment
1-May	79099	15774	20%	81202	103%
2-May	28620	15400	54%	21076	74%
3-May	35740	30932	87%	35002	98%
4-May	31315	25872	83%	31306	100%
5-May	31121	29018	93%	33770	109%
6-May	31677	25630	81%	28908	91%
7-May	34239	27170	79%	33154	97%
8-May	76128	15466	20%	79354	104%
9-May	25871	17864	69%	23474	91%
10-May	31171	32714	105%	24838	80%
11-May	34207	33022	97%	30932	90%
12-May	32136	31240	97%	33154	103%
13-May	31774	33330	105%	29150	92%
14-May	38375	26180	68%	38698	101%
15-May	49226	8074	16%	51942	106%
19-May	29960	39248	131%	25146	84%
20-May	29684	17556	59%	27302	92%
21-May	39034	23474	60%	36850	94%
22-May	79028	25564	32%	77440	98%
23-May	40126	11836	29%	36476	91%
24-May	41558	25630	62%	40480	97%
25-May	51718	29326	57%	51876	100%
26-May	46071	23848	52%	48488	105%
27-May	42000	33154	79%	44792	107%
28-May	58146	5852	10%	55264	95%
30-May	42191	29084	69%	40480	96%
31-May	41488	27478	66%	40788	98%

Source: Constructed by the authors based on the output of the model and transport data of Freight Links International (2012)

Table 6: Outcomes of the existing manual vehicle scheduling system and proposed vehicle scheduling system for the month of June 2011

	Existing manual vehicle scheduling system			Proposed vehicle scheduling system	
Date	Minimum daily requirement (dozens)	Achieved amount (dozens)	Demand fulfilment	Achieved amount (dozens)	Demand fulfilment
1-June	37247	33088	89%	36784	99%
2- June	37901	29700	78%	36784	97%
3- June	33450	30932	92%	31240	93%
4- June	30050	33396	111%	27544	92%
5- June	27306	27478	101%	21318	78%
6- June	30297	29326	97%	31856	105%
7- June	30873	26444	86%	25322	82%
8- June	28162	24948	89%	25630	91%
9- June	27025	26620	99%	25630	95%
10- June	31781	19096	60%	31548	99%
11- June	45143	19228	43%	40172	89%
13- June	41479	19404	47%	38324	92%
14- June	51902	26928	52%	47564	92%
16- June	41227	38016	92%	38632	94%
17- June	35897	25014	70%	34936	97%
18- June	45636	27544	60%	41954	92%
19- June	37945	22616	60%	36476	96%
20- June	45627	12320	27%	45716	100%
21- June	37886	32780	87%	38632	102%
22- June	36532	28468	78%	38632	106%
23- June	40252	33462	83%	38324	95%
24- June	49164	30250	62%	47630	97%
25- June	62049	13926	22%	65120	105%
26- June	57294	15466	27%	57420	100%
27- June	63595	9680	15%	65120	102%
28- June	47476	31174	66%	46332	98%
29- June	47422	28776	61%	44484	94%
30- June	54368	29326	54%	54032	99%

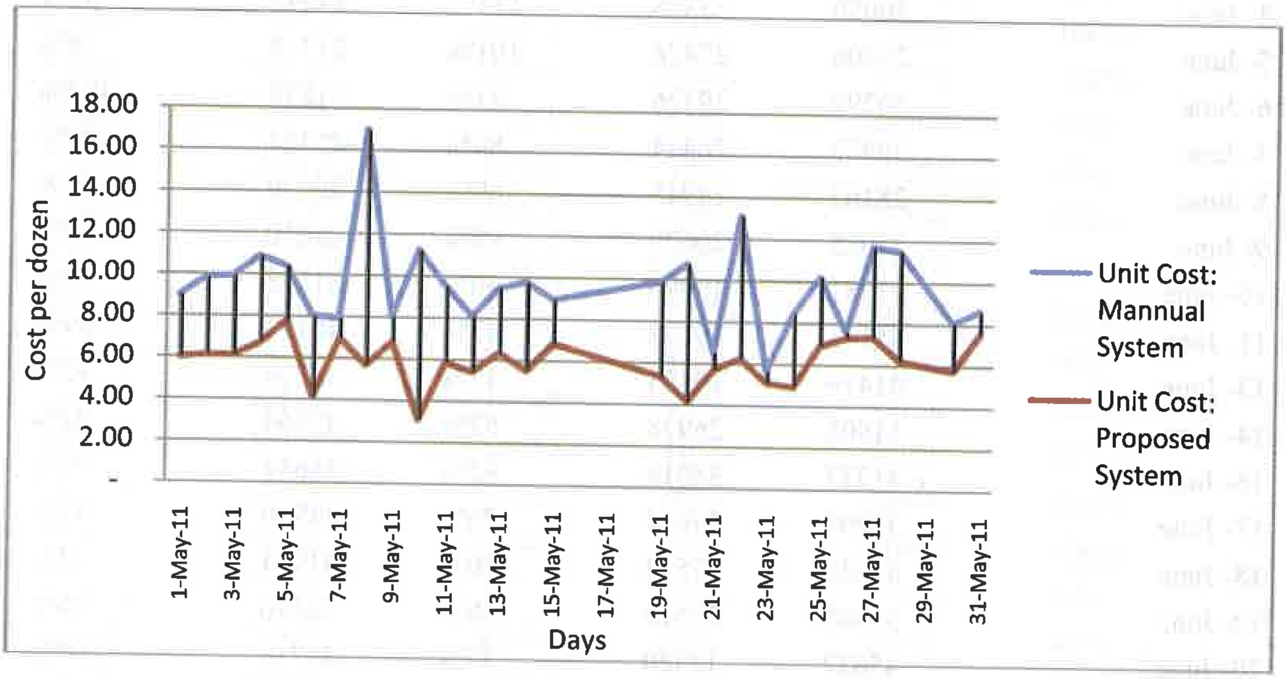
Source: Constructed by the authors based on the output of the model and transport data of Freight Links International (2012)

In order to compare the cost of the proposed system with the manual system, unit cost of transportation (per dozen/ per day) can be calculated as follows:

$$\text{Unit cost of transportation (per day)} = \frac{\text{Total transport cost of the day}}{\text{Total volume of transport}}$$

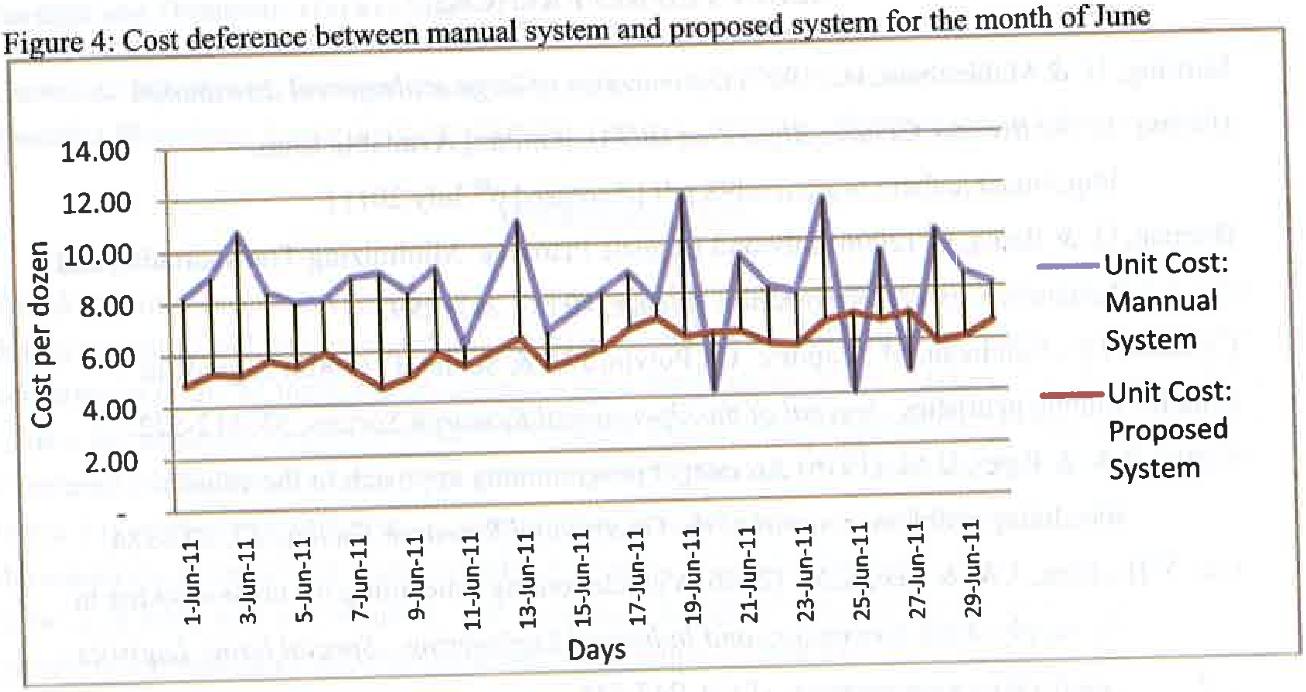
Figures 3 and 4 show the daily per unit cost of manual system and proposed system for the months of May and June.

Figure 3: Cost deference between manual system and proposed system for the month of May



Source: Constructed by the authors based on output of the proposed model and the sales database of Freight Links International (2012)

Figure 4: Cost deference between manual system and proposed system for the month of June



Source: Constructed by the authors based on output of the proposed model and the sales database of Freight Links International (2012)

Figures 3 and 4 demonstrate that the daily cost per unit of manual system is higher than the proposed system for both months.

CONCLUSION

Outcomes of the study facilitate the consignment agents in arranging their daily redistribution plan by identifying the volume of the freight and the Estimated Time of Arrival (ETA) of the trucks to their premises. This study assists the company to reduce its carbon footprint by eliminating unnecessary truck movements. Human errors are also reduced by using this systematic way of scheduling vehicles. Application of the proposed model for prime movers scheduling system in Lion Brewery Ceylon PLC increases the efficiency of outbound logistics thereby maximising the profit of the company. This paper therefore brings a solution to the vehicle scheduling problem and overcomes the bottlenecks in transportation at Lion Brewery Ceylon PLC subject to the uncontrolled variables of production failures, vehicle breakdowns, bad road and weather conditions, issues of drivers and helpers and physical shape of the product. The proposed system can be generalized by developing a software application which can be handled by staff members at different levels in the company. In order to automate the proposed scheduling system, sales data of the agents and the service providers should link with the main database of the company.

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