OPTIMAL CAPACITY ALLOCATION IN TRUCK INDUSTRY IN TANZANIA: A case of National Transport Corporations (NTC)

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ABSTRACT

This paper tries to examine truck transportation service in Tanzania, particularly, in National Transport Corporation's subsidiary companies - Regional Transport Companies. It provides an analysis based on operations research approach on resource allocation, specifically, truck allocation, with an aim of trying to minimize running costs and hence improve profits.It is established that there had been higher running costs and hence decline of profits in some Regional Transport Companies due to misallocation of capacity. However, this problem had been compounded by some other factors as discussed in the paper. It is recommended that these Regional Transport Comapanies and other transport companies should follow some strategies to optimise capacity allocation so as to maximise profit.

INTRODUCTION

The majority of the developing countries are seeking to accelerate their economic growth through planned development based on priorities and allocation of resources in projects, which will ensure the highest benefits and fulfilment of the goals set out in the development plan.

A distinctive feature of resource allocation in the developing countries, has been the large amount of capital being invested in transportation [6]. The rapid increase of capital investment in transportation has been regarded as an indication of the size of the transportation problem existing in developing countries.

The challenge facing developing countries, therefore, is in making transportation contribute more than has been the case in previous years, and in assisting to bring about rapid economic development.Generally, the way a transport system develops and its subsequent improvement will depend on the physical environment of the country, its economic, social and political characteristics. These factors in one country may lead to the development of a successful transport system, while in another less so.

In view of the above, one of the immediate needs in Tanzania is to evaluate the resource allocation in truck industry, particularly, to the National Transport Corporation's (NTC's) regional subsidiary companies so as to minimize running costs[1] and hence maximize profit.

Importance of the Transport Sector in Tanzania

The transport sector's importance to the national economy is reflected by the relatively large size of the country and the concentration of population and economic activity in its peripheral regions.

Other factors which highlight the sector's importance are the high foreign exchange intensity of transport operations and the country's geographic location in relation to the land-locked countries of central and southern Africa.

Transport's contribution to the Growth Domestic Product (GDP) has been fairly constant, at 6-10%, over the past ten years [10]. Thus in view of promoting the transport sector, the government has formulated various policies.

While the social objectives of the transport policy remain intact, public ownership or control of the transport fleet is no longer seen as an end in itself but as an option which must stand on its own merits against the other options, i.e. private ownership and public-private joint ventures.

Performance of the Transport Sector in Tanzania

In Tanzania, several studies have been done to analyse the performance of the transport sector. One such a study was done by Mrema [7] when examining the operational performance of public and private operators. With the aid of operational indices mainly load factors of National Road Haulege Company (UMITA) and the occupancy ration of UDA and KAMATA, he concluded that the private sector is more efficient than the public sector.

Another study on the performance of the transport sector in Tanzania was done by Mwase [8]. The study also confirmed the findings of Mrema [7] and Bagachwa [1]. Basing his arguments on the study done by the World Bank in 1977, he concluded that the public companies are inefficient compared to private companies and that performance targets set for RETCOs are unrealistic.

Beenhakker and Bruzelius [2] analysed the relationship between the marketing and transportation of maize and cotton with the aim of examining how marketing operations could be improved. Basing their arguments on the cost of marketing maize by the National Milling Corporation and cotton by the Tanzania Cotton Authority, they concluded that the public transport sector in Tanzania is highly inefficient (despite preferential treatment accorded to them by the government in procuring factor inputs) that is why the cost of marketing these two agricultural commodities is very high.

Haule [4] evaluated the performance of Regional Transport Companies (RETCOs) with the aim of in pinpointing sources of and factors which has led to poor performance in public trucking firms. Haule [4] established that labour productivity in RETCOs exhibited a decline trend because of low capacity utilization, low vehicle availability and utilization. Also, Haule [4] found out that the financial performance is less satisfactory since in most cases the level of performance declined and that standard target set were not achieved.

In view of the above, we have also undertaken a study on transport sector, particularly, on optimal capacity allocation in Truck industry in Tanzania with reference to RETCOs. While most of the above studies on performance use an economic approach, our study is based on operations research approach with an emphasis on the determination of optimal capacity allocation so as to minimize running costs and hence increase profit.

THEORETICAL FRAMEWORK

Various literature reveal different meanings attached to the concept of capacity. But it is generally agreed that the concept refers only to plant and machinery and not to any other factor of production. The reason is that it is usually regarded as the strategic factor of production since unlike the others it will have to be provided well in advance [3].

From technical point of view, and for practical purpose, capacity is referred as the rate of output that can be produced in a unit of time by a firm operating within normal conditions. This is what is called the practical engineering capacity or the technical or the practical capacity. It is this definition which will be used in the study despite the likely difficulties of determining the so called normal working conditions and consequently the implied capacity level. In our study we will refer to truck tonnage as capacity.

OBJECTIVES

Many transport organisations operating in Tanzania encounter similar problems [9]. Over the past decade, Tanzania's policies on transport sector put much emphasis on the socio-economic importance of transport services while the necessity of making these service more profitable in order to ensure that they can be sustained in the long run was not fully appreciated. Hence most of the transport parastatals operated at a loss (or a modest profit which was never sufficient to allow for fleet replacement). As a result, by the mid- 1980s the parastatals services had declined considerably because of ageing fleets, lack of spareparts as well as weak management.

The purpose of this paper, therefore, was to study the practical and theoretical relations of capacity allocation in the truck industry so that timely attempts should be made to increase its degree of penetration to the transport sector.The specific objective of this paper was to evaluate capacity allocation to RETCOs by using mathematical models (the details of which are given under section of materials and methods).The significance of the study lies in the fact that improved capacity allocation of the transport sector, at the firm level, could raise profit margin.

MATERIALS AND METHODS

The research focused mainly on the external restraints (i.e. social, political, technological and economic influences) as well as internal restraints (resource and technical capabilities) of Trucking Industry of National Transport Corporation (NTC). The study considered only five of the nine RETCOs. The other four RETCOs were not included in our study due to the fact that some of them had incomplete data and others were just being established.

The choice of RETCOs was for the reason that, apart from the availability of data, the government through its public transport sector policy had given them high importance in terms of financial, material and political will.Information regarding the business of RETCOs were obtained at NTC offices in Dar es Salaam. Some of the information regarding specific issues such as running costs per ton-km which were the focus of this study were not readily available. For such information computed results were used.

The data collected included: make and model of trucks in the industry, tonnage, number of trucks (fleet size) per truck-model, costs (Variable, fixed and total costs), average annual km operated by each truck, and average annual revenue.

The methodology to determine an optimal capacity allocation of a regional transportation centre (RETCO) was theoretically related to the general "Transportation problem" described in the sense of operations research. It was based on determining the optimal capacity allocation with the goal of minimizing total running cost of transport for each RETCO.

Transport model 1

The Transportation Model has been adopted from Wagner [11].
Let x_{ij} be the capacity of truck-model ($plant_i$) allocated to RETCO ($warehouse_j$), and c be the associated average running cost per unit capacity. A mathematical specification of the model is Minimize

$$\sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} \tag{1}$$

Subject to

$$\sum_{j=1}^{n} X_{ij} \leq S_i, \qquad \text{for } i = 1, 2 \ldots m \tag{2}$$

(S_i, supply - restriction capacity available for truck-model_i.)
(D_j, Demand restriction-Capacity required by $RETCO_j$)

$$\sum_{i=1}^{m} X_{ij} \geq D_j, \qquad \text{for } j = 1,2,\ldots, n \tag{3}$$

$$X_{ij} \geq 0 \tag{4}$$

The other relevant model used in our study was the Markov Chain Model.The Markov Chain Model with the aid of transportation model was used to determine the optimal theoretical expected capacity to be maintained by each RETCO during steady state. The optimal expected capacity and the actual capacity of RETCOs were then compared to determine whether there existed excess capacity.

Markov Chain Model :

Let π be the collection of steady state probabilities($\pi_1,\pi_2,\ldots,\pi_n$), and **P** be the transition matrix.The steady state probabilities for each RETCO was determined from the relationship:

$$\pi = \pi P \quad (5)$$

The theoretical aspect of all the above models used are not included under this section because such literature is readily available elsewhere.

RESULTS

Table 1 and Table 2 show the available capacity (supply) each truck-model, the capacity required (demand) by each RETCO, and the running costs and total costs (per ton-km) per

Table 1. NTC'S Capacity allocation versus running cost (figures in brackets indicate number of trucks)

	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	TOTAL
TATA	13.45 35 (5)	32.20 35 (5)	32.00 42 (6)	24.35 35 (5)	18.80 28 (4)	175
ISUZU FTR	11.70 40 (5)	20.00 8 (1)	8.40 56 (7)	8.30 80 10	9.80 80 (10)	264
ISUZU CVR	11.10 100 (10)	10.40 150 (15)	16.40 110 (11)	12.40 110 (11)	14.40 110 (11)	580
NISSAN	7.60 100 (10)	6.00 -	7.70 50 (5)	6.00 -	4.00 100 (10)	250
MBISHI	9.60 195 (13)	4.90 210 (14)	9.30 165 (11)	7.30 165 (11)	7.90 255 (17)	990
TOTAL	470.	403	423	390	573	2259

truck for each truck - model at each respective RETCO. The costs are indicated on the right corner top box. These tables reveal that there are different running costs and total costs for each truck-model at different location. Some costs are high or low compared with others. From the findings, it was noted that, highest losses were registered where there were corresponding highest running costs or total costs. We also note that the RETCOs are centred at different geographical locations with some of them having more truck -capacity than others for the same truck-model i.e truck -capacity is not allocated equally.

Table 2: NTC's Capacity allocation Vs Total cost

	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	TOTAL
TATA	26.20 35	39.50 35	38.10 42	29.50 35	30.45 28	175
ISUZU FTR	25.60 40	27.20 8	17.10 56	14.30 80	20.10 80	264
ISUZU CVR	16.40 100	11.90 150	17.40 110	18.50 110	21.40 110	580
NISSAN	13.30 100	9.60 -	13.45 50	9.60 -	7.55 100	250
MBISHI	14.30 195	6.40 210	14.30 165	14.00 165	16.40 255	990
TOTAL	470	403	423	390	573	2259

The transportation model was used to find the optimal capacity allocation by using running costs in order to determine the minimum cost. We avoided using total cost because of the element of fixed costs involved which would give misleading results. From the transportation Table 3, the optimal allocation and total minimum running cost per ton-km (shs. 19,151.45) was obtained as shown in Table 4 the summary of which is presented in Table 5 below.

Table 3. RETCO'S Transport table Vs. running cost

TRUCK MODELS	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	SUPPLY
TATA	13.45	32.20	32.00	24.35	18.80	175
ISUZU FTR	11.70	20.00	8.40	8.30	9.80	264
ISUZU CVR	11.10	10.40	16.40	12.40	14.40	580
NISSAN	7.60	6.00	7.70	6.00	4.00	250
M/BISHI	9.60	4.90	9.30	7.30	7.90	990
DEMAND	470	403	423	390	573	2259

Table 4. RETCO'S Optimum capacity allocation Vs runing cost

TRUCK MODELS	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	SUPPLY
TATA	13.45 175					175
ISUZU FRT			8.40 264			264
ISUZU CVR	11.10 295			12.40 285		580
NISSAN					4.00 250	250
M/BISHI		4.90 403	9.30 159	7.30 105	7.90 323	990
DEMAND	470	403	423	390	573	2259

The total minimum cost per ton-km is 19,151.45

Table 5. Summary of optimal minimum running cost per ton-km

	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	
TATA	2353.75					
ISUZU FTR						
ISUZU CVR	3274.50			3534.00		
NISSAN					1000.00	
M/BISHI		1974.70	1478.70	766.50	2551.70	
TOTAL	5628.25	1974.90	3696.30	4300.50	3551.70	19151.45

From the above results, comparing the total running costs between the NTC's allocation plan and those determined due to optimal allocation, there is a difference of Shs. 4,347.45 per ton-km. This higher (extra) running costs is a result of misallocation of capacity.hc Markov Chain steady-state model was used to determine the theoretical expected optimum (stratcgy) capacity to be maintained by RETCOs in the long run (during steady state) in order to improve profitability.

Table 6. Transition matrix

	KAURU	KAUDO	KAUTA	KAUMU	KAUMA
TATA	0.200	0.200	0.240	0.200	0.160
ISUZU FTR	0.152	0.030	0.212	0.303	0.303
ISUZU CVR	0.172	0.258	0.190	0.190	0.190
NISSAN	0.400	0	0.200	0	0.400
MBISHI	0.197	0.212	0.167	0.167	0.257

The transition matrix **P** (Table 6) was constructed from Table 1. The probabilities in the matrix are determined by dividing each row entry by the total capacity in the same row. From the relationship $\pi = \pi P$ we have

$$(\pi_1, \pi_2, \pi_3, \pi_4, \pi_5) = (\pi_1, \pi_2, \pi_3, \pi_4, \pi_5) \begin{bmatrix} 0.200, 0.200, 0.240, 0.200, 0.060 \\ 0.152, 0.030, 0.121, 0.303, 0.303 \\ 0.172, 0.258, 0.190, 0.190, 0.190 \\ 0.400, 0.000, 0.200, 0.000, 0.400 \\ 0.197, 0.121, 0.167, 0.167, 0.257 \end{bmatrix} \quad (6)$$

The above relationship yields the following equations

$$\pi_1 = 0.200\pi_1 + 0.152\pi_2 + 0.172\pi_3 + 0.400\pi_4 + 0.197\pi_5 \quad (7)$$
$$\pi_2 = 0.200\pi_1 + 0.030\pi_2 + 0.258\pi_3 + 0\pi_4 + 0.121\pi_5 \quad (8)$$
$$\pi_3 = 0.240\pi_1 + 0.121\pi_2 + 0.190\pi_3 + 0.200\pi_4 + 0.167\pi_5 \quad (9)$$
$$\pi_4 = 0.200\pi_1 + 0.303\pi_2 + 0.190\pi_3 + 0\pi_4 + 0.167\pi_5 \quad (10)$$
$$\pi_5 = 0.060\pi_1 + 0.303\pi_2 + 0.190\pi_3 + 0.400\pi_4 + 0.257\pi_5 \quad (11)$$
$$1 = \pi_1 + \pi_2 + \pi_3 + \pi_4 + \pi_5. \quad (12)$$

Rearranging and solving the above equations by using Gauss-Jordan elimination method, we obtain

$\pi_1 = 0.1468, \ \pi_2 = 0.1576, \ \pi_3 = 0.2705, \pi_4 = 0.1713, \pi_5 = 0.2538$

This implies, under steady state, these are the probability of capacity allocation for KAURU, KAUDO, KAUTA, KAUMU and KAUMA respectively. Applying these probabilities in Table 4 we obtain the theoretical expected capacity as shown in Table 7. Applying the simplex algorithm to this transportation problem with running costs per ton-km, we get the theoretical expected optimal capacity allocation with total minimum mining cost of shs 4,014.25 per ton-km under the steady state as shown in Table 8.

Table 7. Expected capacity under stead state

Table 7. EXPECTED CAPACITY UNDER STEADY STATE

TRUCK MODELS	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	SUPPLY
TATA	13.45	32.20	32.00	24.35	18.80	35
ISUZU FTR	11.70	20.00	8.40	8.30	9.80	56
ISUZU CVR	11.10	10.40	16.40	12.40	14.40	115
NISSAN	7.60	6.00	7.70	6.00	4.00	54
MBISHI	6.60	4.90	9.30	7.30	7.90	199
DEMAND	69	64	114	67	145	459

Under steady state, RETCOs are supposed to operate at a capacity of 459 tons (20%) of the actual capacity of 2259 tons. This means there is an excess capacity of 1800 tons (80%). As a result of this excess capacity it means RETCOs are incurring extra total running costs of Shs 19,482.65 under NTC's allocation plan (refer Tables 1 and 3) where as under optimal capacity allocation there is extra total running cost of Shs. 15, 137.20 per ton-km (refer Table 4).

Table 8 Optimal expected capacity under steady state

	KAURU	KAUDO	KAUTA	KAUMU	KAUMA	SUPPLY
TATA	13.45 .35					35
ISUZU FTR			8.40 56			56
ISUZU CVR	11.10 34	10.40 14		12.40 67		115
NISSAN					4.00 54	54
MBISHI		4.90 50	9.30 58		7.90 1	199
DEMAND	69	64	114	67	145	459

DISCUSSION AND CONCLUSIONS

The research findings and results on the problem of optimal capacity allocation reveal that there had been higher running costs and hence decline of profits in some RETCOs due to misallocation of capacity. Truck capacity is allocated to RETCOs as more truck-models come into being, irrespective of performance of both RETCOs and truck-models, and without considering factors such as cost benefit analysis, strategic capacity to be maintained, and RETCOs geographical location.This problem had been compounded by both external and internal restraints such as government transport policy, foreign grants influence, tight liquidity position, trade debtors, poor roads, rapid increase in the cost of new equipment and transport inputs, operating aged fleet, lack of skilled manpower, shortage of spareparts and poor serviceability of vehicles, and truck-capacity allocation policy.

The major emphasis in this analysis was not only to determine the optimal capacity allocation but to determine the theoretical optimal capacity that each RETCO should maintain in the long run (during steady state) in order to make more improvement in reduction of running costs and hence improve further the profits. This strategy would enable RETCOs to operate with predetermined capacity which could be used as a yardstick. This would imply RETCOSs operating below or above this capacity should expect some losses. By adopting this strategy means reducing the idle capacity (i.e. reduce fleet size) in RETCOs. However, the consequences of this decision would require management to take other measures such as reducing the number of employees which conforms to one of the World bank recommendations of reducing employees in the public sector.

The choice of a vehicle and where it should operate is important. It is, therefore, recommended that only few specialised truck-models with optimum capacity should be allocated to RETCOs where running costs per ton-km is minimum. The advantages of this strategy include: it will be easy and cheaper to maintain few truck-models because specialised skills will be utilized effectively, and it will be easy to handle spareparts of few truck-models; the wear and tear costs will be minimized because some vehicles cannot operate efficiently on certain environment such as poor roads, rainy areas, mountainous ares, etc. To effect this, a thorough and coordinated study need to be conducted.

Also the government policy on transport sector which put much emphasis on transport companies should be revised so that RETCOs and other companies should render services which are economically viable in order to ensure that they can be sustained in the long run. These efforts should go hand in hand with the strengthening of management from company (RETCO) level through NTC to the ministry level.

The services of RETCOs need to be further diversified. RETCOs as regional cargo transportation centres should, in addition, perform the following functions: provide a hub for intermodal transfer of shipments; consolidate and breakdown shipments between large quantity long-haul movements and small intra-regional movements; act as port of entry (or exit) for goods moving in international trade; and provide means of processing and packaging operations performed on goods in transit.

The overall objective of optimal capacity allocation is the improvement in communications. Among other things, improvement in communications reduce transport costs and this narrow the possible differential between the peripheral regions and the rest of the country.

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