AN APPLICATION OF THE TRANSPORTATION MODEL IN THE DISTRIBUTION OF UHT MILK: The Case of Kenya Co-operative Creameries Ltd.

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Abstract:This paper, using data from factories and depots of KCC that handle UHT milk, develops a model for the optinal allocation of milk form factories to the depots in various parts of Kenya. In developing of this model, the paper takes into considereation the cahracteristics of individual depots, such as access roads, demand, storage capacities and KCC's distribution policy. By use of a case study approach, a transportation model is developed. It shows how distribution costs can be reduced through the use of operations Research (OR) models. However, given the structure of the industry, the paper suggests that there should be an intergrated transportation model that would analyse the allocation of products to individual depots while minimising both transport and storage costs.

INTRODUCTION

Increased attention in recent years has been focused of physical distribution. According to Okech (1977) a major reason for this attention is that these activities represent a major portion of total marketing costs. Management's traditional focal point for cost cutting has been production. Historically, these attempts began with the industrial revolution of the 1700's and 1800's, when business emphasized that production efficiency has reached a point at which it is empossible to achieve further cost savings. More and more managers are returning to physical distribution activities as a possible area of cost savings.

Christopher (1986), states that, the growing recognition is due to the importance of physical distribution and related activities as a key determinant of corporate performance. That attention has perhaps tended to focus too heavily upon the potential for cost reduction with the distributin activity rather than upon the wider of dividing integrated distribution policies which can impact both upon costs and revenue.

The other reason for the increased attention on physical distribution activities is the role it plays in improving customer services. By storing products in convenient locations for shipment to wholesale and retail customers, firms create time utility and place utility.

A further reason for the growth in importance attached to physical distribution is the awareness of the magnitude of the cost involved in its constituent activities. Various estimates have been made as to the percentage of total corporate costs accounted for by those activities in different industries. Whilst these estimates differ depending upon the nature of the business involved, it seems that they can account for 20 per cent or more of all company costs.

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"Physical distribution" refers to the broad range of activities concerned with the efficient movement of finished products from the end of the production line to the customer. In some cases it involves the movement of raw materials from sources of supply to the beginning of the production line. These activities include freight transportation, warehousing, material handling, protective packaging trasportation, protective packaging, inventory control, warehouse site location, order processing, market forecasting and customer service, according to Markland (1989). The modern view of physical distribution is that various activities should be managed as an integrated system to a provide a defined level of customer service at the lowest total cost. Physical distribution decisions must be made in consideration of their relative effective on the other components of the system.

KCC processes and markets eight other products apart from UHT milk. These are:
1). fresh milk;
2). Cheese;
3). Powder milk;
4). Condensed milk;
5). Cream;
6). Mala milk;
7). Powder milk;
8). Ghee;

Most of this products are identified by the customers by the co-operative's name, like KCC, UHT or KCC butter. KCC derives the greatest revenue from fresh and UHT milk. The policy analysis matrix unit to Egerton University points out that despite the fact that KCC's milk products have a better bradnd recognition, the high demand for the newer products shows that there is something wrong in KCC's marketing department, the products or both. They also say that even as a monopoly, before liberalization, KCC made the tragic mistake of not being able to cultivate a corporate culture of cost consciousness.

An analysis of KCC's costs reflects the following scenario:

Table 1.*KCC's Costs*

Item	*Percentage*
Raw materials	45
Production costs	35
Marketing costs	11
Overheads	09
Total	100

Transportation of raw milk and milk products accounts for 45% of production costs and 34% of marketing costs. The marketing transportation costs are contributed by individual products as follows:

Product	*Percentage*
UHT milk	33
Fresh and Mala milk	53
Others	14
Total	100

It is also important to note that while fresh and mala milk are processed and packaged by eleven factories close to the markets, UHT milk is only produced in four factories for distribution all over Kenya. UHT Milk accounts for 27% of KCC's sales revenue while fresh and mala, and other products account for 62% and II% respectively. Noting that physical distribution represents a large percentage of sales or product cost, there is a need for KCC to consider making use of modem operations research techniques to reduce such costs. Despite KCC managers' concern about the high costs of transportation of UHT and other milk products; there has been little systematic basis for allocating UHT milk from the factories to the depots.

STATEMENT OF PROBLEM

The manner in which an organization distributes its output to its customer is of major concern because of its impact in terms of costs of the final product and also the quality of service to the customer. An efficient system will be reflected by a reduction the transportation costs. This reduction effect will be reflected by a reduction in the prices of the products charged to the customer, the quality of customer services, fewer stock-outs and greater variety.

The determination of the best distribution system is, therefore, a priority policy decision to business organizations. The type of the product being considered, the related costs and organization's distribution network, play an important role in these decisions.

A pilot study revealed that KCC's UHT, Milk distribution presents a case of various sources and destinations where some destinations act as transshipment points. Klincewicz (1990) arguers that with sources and destinations widely dispersed and intermingled, an entirely large number of patterns of direct and indirect shipment are possible. A problem of this sort requires a variation of the transportation problem and location analysis.

This study was concerned with the development of a model for the optimal allocation of UHT milk from factories to the depots in various parts of the country taking into consideration the characteristics of individual depots, such as access roads, demand, storage capacities and KCC's distribution policy.

This study was motivated by the challenges faced by KCC managers in distributing UHT milk countrywide. UHT milk transportation costs constitute about 33% of KCC's product transportation costs and thus has a great significance on the consumer price of UHT milk. A reduction in this costs will not only imply cost saving for KCC but also reductions in UHT milk consumer prices.

OBJECTIVES OF THE STUDY

The study had the following as its objectives:

1) To describe how UHT milk is allocated to the various depots;
2) To formulate a transport model for the distribution of KCC's UHT milk; and
3) To apply the transportation model to the distribution of UHT milk and try to arrive an optimal plan which will help minimize the distribution cost of UHT milk to the depots.

IMPORTANCE OF THE STUDY

1) A key to this study is the focus on the user as the point of knowledge utilization.

There are an estimated 700,000 litres of UHT milk weekly shipments in Kenya. The accompanying costs therefore provides a need for use of quantitative techniques in minimizing transportation costs.

2) The study will be of use to the KCC management as an aid in the planning and control of physical distribution. It will also be useful to other companies dealing with products having similar distribution challenges such as other milk processors.
3) Given the size of KCC, its enhanced efficiency will be of importance in terms of cost savings, increase in GDP and improved services to the Kenyan people, milk being one of the basic food product providing protein to Kenyans country wide.
4) To researchers and academics it will be a further step towards the development of an integrated model for all the transportation of milk and milk products of KCC. In general it will add to research work in relation to the application of operation/ management science in a developing country environment such as Kenya.

The 1950's saw the development of systems theory, operations research, and the computer, each of which furthered the cause of operations management. The computer technology has allowed fast and relatively inexpensive development of management information and expedited the solutions to operations research models for business and formed a basis for automation. Rosenhead (I980), remarks that foremost among the formal decision-aiding practices which have sprung up over the past century is operations research (OR) and the OR is an example, perhaps the exemplar, of rational comprehensive planning.

One of the most important and most used technique of OR is linear programming (LP). LP is a mathematical technique which can be used to determine the best allocation of resources. It deals with either minimization or maximization problems while considering certain constructs. LP is used as a management tool for seeking the solution of problems in conformity with the firms clearly defined objectives. "In its many valuable applications LP has lent itself effectively to the analysis of movement (transportation) systems," Okech (1977).

Like many other OR techniques linear programming uses models to solve problems, hence model building is a major characteristic of OR and an important step in its analysis.

Thus the success of linear programming application of any problem centres on the model chosen, constructed and applied, Rotich (1981).

The acceptability of mathematical modeling, and the extent to which modeling techniques are used, varies considerably from one field to another. According Murray Smith (1995) mathematical models are so extensively used in the physical sciences and engineering, and are so central to the introductory teaching of many topics within those fields, that, for some at least, there is a danger that models can become more important than the systems which they represent. He adds that in the Biological Sciences Mathematical modeling is still viewed with some suspicion, although there are many examples in which models have been used very effectively to help solve important biological problems.

Operations research techniques are used when relatively simple transport systems can be mathematically expressed, or when traffic can be assigned to the system using specific OR techniques. A transportation problem, typically arises in situations involving physical movement of goods from plants to demand points. Owing to its structure, it lends itself to solutions by special algorithms to optimize an objective (Buildnick, 1991). Its name derives from the original context in which it was formulated which was that of determining optimal shipping patterns between origins (or sources) and destinations (Cooper, 1970). More generally the name "transportation problem" refers to a linear programming program with a certain fixed structure (standard transportation problem structure). Many problems which have nothing to do with transportation but having the same structure are also solved using the transportation models.

The transportation problem considers the shipment of homogenous product from given sources to given destinations. Each source having certain capacity constraints and each destination having certain demand requirement constraints. The costs of shipping from each of the sources to each destination is known. The objective is to minimize the total transportation costs and satisfy the destination requirements within the source constraints.

This may also be achieved through minimizing the total weighted distance or by maximizing the total profit contribution from the allocation.

In scope, the transportation model becomes applicable only when two or more sources of supply are distributing one commodity to two or more destinations. The decision problem is then to select the best plan for distributing the commodity so as to meet the requirements of the destinations and yet remain within the productive capacity of various sources. The decision variables are the quantities of the commodity to be transported from each source to each destination. The parameters are the unit costs of transportation. The constraints are the quantities of the commodity available at each source and required at each destination. So under the given constraints, the problem is to find which supply points should ship their supplies to which destinations in order to minimize total transportation cost.

Classical application of the transportation models include those in the private sector and those in the military. In the commercial environment, transportation models are widely applied to distribution of products to regional warehouses, wholesalers, or retail outlets. In the military, usually referred to as logistic systems, the models are applied in the distribution of personnel and materials to vessels, installations, or troop locations. In recent years transportation models have been applied to the distribution of people, services, money, information and other resources (Dubline, 1991).

The Freight Transportation Problem (FTP) that is addressed in this study is one of given demands, linear shipping costs, sets of sources, storage capacities, terminals and destinations: What should the pattern or direct and indirect shipping be? Problems of this nature which have concave shipping costs have been considered at length by Zangwill (I968), Hall (I987) and Klincemcz (I990).

Algorithms for single product, concave cost network flow problems were considered at length by Zangwill (1963) for production concerns. Lee and Luss (1987) analyzed a multi-product freight transportation problem with similar structure and linear cost functions. A special case of FPT with only one consolidated terminal but more general concave cost functions was considered by Hall (1987) and was implemented at General Motors to plan their freight transport system.

A freight transportation problem with concave cost functions was delt with by Klincewcz (1990). His case had several consolidated terminals where he developed an overall strategy for shipping between multiple sources-destination pairs. He showed how to solve this problem optimally in two cases; either the sources-to-terminal shipping costs or terminal-to-destination shipping costs.

Okech (1977) applied a transportation model to the distribution planning of cottonseed in Uganda Lint Marketing Board. His case was of a single product with linear transport costs but no terminals. Rotich (1981) also developed a transportation model for distribution of a single product from several sources to various destinations with no terminals. Kenduiwo (1988) considered a case of a single product with linear costs and un-capacitated facility problem. He used the excess milk in each factory as the source availability (supply) for transportation to factories with deficits as destinations (demand).

This study followed the approaches of Kenduiwo (1988) and Klimewicz (1990). The UHT milk transportation decisions presented a case of a single product, capacitated locations and terminals with linear cost functions.

RESEARCH METHODOLOGY

Research Design

This study followed a case study approach. A transportation model was developed for the distribution of KCC UHT Milk as a case study. KCC was chosen because of its size and market leadership in the dairy industry, to show how distribution costs can be reduced through the use of OR models. The cost savings would be of benefit not only to KCC but also to the dairy farmers who depend on milk as source of livelihood.

With the given time and resources for the research, it was useful to take a case study design to demonstrate the benefit that can accrue from improving the distribution of goods. Given more time and resources it could have been ideal to study all the firms in the distribution of dairy products and test the applicability of transportation models to improve management distribution decisions. However, with the successful implementation of OR models in the management of Kenyan firms on a case by case basis, it will be possible to demonstrate the usefulness of OR models in the management of industry in Kenya.

The Population

The population of interest in this study comprised all the factories and depots of KCC that handle UHT milk. This formed the basis of collecting the necessary primary and secondary data. There were four factories and twenty five depots in total that are scattered all over Kenya. Because the location of one factory or depot bears little or no relationship to that of another, sampling was of little use. As such there was no sampling.

Although data was available for the production and distribution of other KCC products. TJHT milk was chosen because of its wide distribution challenges. Unlike the fresh milk and mala which are processed and packaged in all the eleven factories, UHT milk is only packaged in four factories for countrywide distribution.

Data Collection Methods

The primary data involved observation and interviews. Scheduled interviews were held with the managers in charge of Nyahururu factory, Nairobi, Thika and Machakos depots. This were chosen as a convenient sample and were expected to be a representation of all the other factories and depots as concerns the primary data. Information regarding production, storage and distribution of UHT milk was sought from these managers. Scheduled interviews allowed the manager to give qualitative information concerning their operations.

The purpose of the primary data was to give an understanding of the operations of KCC and more specifically on the management decision making process as concerns the distribution of products and problems encountered. Scheduled interviews were also held with senior managers at the head office of KCC who are involved in the distribution of products. Information regarding planning and control of products distribution was collected. These managers included the Marketing Manager, Deputy Marketing Manager (sales and distribution), Marketing Analyst, Production Analyst and Cost Accountant.

The information collected assisted in understanding the existing UHT distribution patterns and the related costs, and problems such as stock-outs and storage. All the data used in the application of the transport model in this study is secondary data. These were obtained from the head office of KCC at Nairobi. Data for the actual UHT ml ilk production, distribution, transport costs and sales for the financial year June 1 995 to July 1996 was collected. Although the data for other periods were available, the latter period was chosen mainly due to one ease of data availability. A period of one year was also considered long enough as it included seasons of the year when UHT milk could be in excess supplies or in limited supply.

All the data on UHT milk production distribution and sales were collected in terms of litres, which was considered as a more appropriate measure. However UHT milk is packed in packets which are then packed into cartons of twelve litres. Some of the data collected was not available in readily usable form and had to be transformed. Where UHT milk production figures where not available, the material usage rate was used to compute the quantity produced. While in the case of situations where the requirements of a particular depot were not available, it was computed using the quantities distributed from the factories.

DATA ANALYSIS AND FINDINGS

Description of Data Collection

Data relevant to the distribution of UHT milk within KCC included:- Sources of supply and quantities available. Destinations and their respective requirements. Unit transportation costs from each source to each destination.

The sources of supply are four factories situated at Miritini, Nyahururu, Eldoret and Sotik. All these factories exempt Maritini are in the milk producing areas. Maritini receives most of its raw milk from upcountry factories, and in dry seasons it reconstitutes powder milk into UHT milk.

The destinations are twenty five depots which are spread all over Kenya. These depots receive their UHT milk requirements from the four factories. At this depot milk and milk products are sold directly to customers, or transported further by KCC trucks to the customers shops at various shopping centers within each depots territory.

The unit transpiration costs was not obtained since KCC's policy could not allow them to be used for this study. However since the cost were found to be linear, by use of parametric programming a parameter'R'was used to derived the transportation costs. 'R' represents the transport cost per litter per kilometer.

Existing Methods of Distributing UHT Milk

The physical distribution of milk and milk products in KCC is coordinated by the Assistant Marketing manager (sales and distribution). The depot managers laise with him/her on weekly basis on how to meet their Production Manager on issues of distribution and storage. It was established that whenever the factories have no storage space, the products can be transported to the depots for storage. Mombasa, Nairobi, Naivasha and Kericho depots which have excess storage capacities are used for storage of UHT milk. These depots act as transshipment terminals because the products are later transported to other depots for sales. However data related to this transshipments was not obtained from records available at KCC head office. It was also possible to travel to each of this depots to collect the data due to time and resource constraints. For purposes of this study it was assumed that all excess stocks were stored at the respective factories, and in case it was stored in the depots, it is assumed that the accumulative transport cost would be equivalent to the cost of a direct shipment.

If UHT milk total supply were equal to total demand KCC's transportation problem would be formulated as:-

1. Objective function

$$\text{Min. } Z = \sum_{i=1}^{M} \sum_{j=i}^{n} x_{ij} = \sum_{i=1}^{4} \sum_{j=1}^{25} C_{ij} X_{ij}$$

Where 'z' is the total transportation cost subject to:

a) Factory supply constraints

$$\sum_{j=1}^{N} X_{ij} < a_{ij} \quad \text{for } i=1,2,3,....26$$

b) Depot demand constraint

$$\sum_{i=1}^{M} X_{ij} > a_{ij} \quad \text{for } j = 1,2,3 \text{ and } 4$$

c) Non negativity constraint.

$Xij \geq 0$

For all values of i and j

In actual situations total supply rarely equals to total demand and hence we would expected surplus or shortages. In case of surplus/shortage of stocks the same formulation of the transport problem would be applied with a dammy source or destimation n+1 or m+ 1 respectively. This dammy would absorb the differences.

When UHT produced in thefactories requires to be stored in some depots, KCC's transport problems would be formulated as:

1. Objective function

$$\text{Min. } Z = \sum_{i=j}^{n+1} \quad \sum_{j=1}^{m+1} C_{ij} X_{ij}$$

Where 'Z' total transportation cost.

2. Subject to:

a) Source constraints

$$\sum_{j=1}^{n} X_{ij} = a_i$$

b) All depots with excess storage capacity constraints.

$$\sum_{1=1}^{n} X_{ij} >= b_j$$

c) Other depots constraints

$$\sum_{j=1}^{m} Xij = b_j$$

d) Non-negativity constraint

$X_{ij} \geq 0 \quad i=1 \text{ to } m \text{ and } j=1 \text{ to } n$

Analysis of Data

Table 4.2 shows the total cost incurred for each month in the financial year 1995/96.

Table 4.2: *KCC Actual monthly UHT transportation costs for the financial year 1995/96 (Kshs. '000's)*

Year	*Month*	*Amount*	*Year*	*Month*	*Amount*
1995	July	647769R	1996	Jan.	623677R
1995	Aug	764643R	1996	Feb.	628326R
1995	Sept.	927364R	1996	Mar.	681875R
1995	Oct.	890663R	1996	Apr.	763959R
1995	Nov.	1039186R	1996	May	649904R
1995	Dec.	582134R	1996	June	612736R

NB: 'R' - stands for the unit transport rate per litre per kilometre.

The monthly distribution were solved using a transportation programme and the optimal transportation cost by MODI are given on the table below:-

Table 4.3: *KCC monthly model UHT in transportation costs (Kshs. 000's)*

Year	*Month*	*Amount*	*Year*	*Month*	*Amount*
1995	July	558974R	1996	Jan.	575183R
1995	Aug	703257R	1996	Feb.	575183R
1995	Sept.	835638R	1996	Mar.	613109R
1995	Oct.	800648R	1996	Apr.	646034R
1995	Nov.	909564R	1996	May	588742R
1995	Dec.	529697R	1996	June	485164R

This hypothetical distribution plan is what would have been achieved if KCC management had used a transport model. It shows how individual depots would have met their UHT milk requirements. Compared to the actual distribution pattern there are notable differences. Kibwezi depot would receive its supplies from all the factories.

Makueni depot which receives its requirements from Nyahururu factory would receive some of its supplies from Miritini and Sotik factories.

Machakos depot which receives its supplies from Nyahururu and Eldoret factories would also get some supplies from Sotik factory. While the actual distribution pattern indicates that Thika depot receives 47% of its supplies from Eldoret factory, the model shows it would receive all its supplies from Nyahururu factory.

Another notable chaiage is Nairobi depot which would receive its supplies from Nyahururu and Sotik factories instead of being supplied from Nyahururu and Eldoret factories. Similarly Kisumu depot which receives its supplies from Eldoret and Sotik factories would be allocated all its requirements from Eldoret factory.

Nakuru depot would be supplied all its UHT milk requirements from Nyahururu and Sotik factories, according to the model, instead of receiving some of its supplies from Eldoret factory. Naivasha depot which is supplied all its UHT milk requirements from Nyahururu factory would receive 27% from Eldoret and Sotik factories according to the model plan.

Table 4.4: Below shows the monthly transport cost saving that could accrue through the use of the model.

Table 4.4. *KCCs Actual and model transportation costs for the financial year 1995/96 (Kshs. '000's)*

Year	Month	Actual	Model	Saving	%
1995	July	647769R	558974R	98795R	15.0
1995	Aug.	764643R	703257R	61886R	8.20
1995	Sept.	927364R	835638R	91996R	10.1
1995	Oct.	890663R	800648R	90015R	10.0
1995	Nov.	1039186R	909564R	129622R	12.2
1995	Dec.	582134R	529697R	52427R	8.40
1996	Jan.	623677R	575183R	48494R	7.70
1996	Feb.	628326R	575183R	53143R	8.50
1996	Mar.	681875R	613109R	68766R	10.1
1996	Apr.	763959R	646034R	117925R	15.4
1996	May	649904R	588742R	61162R	10.6
1996	June	12736R	485164R	127572R	20.8

The implications to KCC of applying a transportation model in the distribution of UHT can be appreciated through a comparative analysis of the actual and model monthly transportation costs as outlined in table 4.4. above. The table also shows the cost savings and their percentages that would accrue to KCC. The company could achieve an average of 11.4% transport cost savings.

It should be noted that apart from the direct transport cost saving, the application of a transportation model would assist KCC's management in planning. It would assist to avoid product shortages or oversupplying other depots when others have no stocks.

CONCLUSION AND RECOMMENDATION

Conclusion

The company and its customers are separated by space and time. The spiritual separation is geographic and can be overcome by an efficient transport network, but the temporal separation results from the more fundamental lad between the time of production and the time of consumption. The two considerations of space and time are obviously linked and distribution strategies must recognize the effects of a decision taken affecting the one upon the performance of the other.

The physical distribution of goods and services from supply locations to several demand locations is an extremely common and important business problem. This study has shown how a transportation model can be applied to the distribution of UHT milk by KCC, and how it can help reduce total transportation costs. Such a model would facilitate the specification of how many units should be shipped from each origin to each destination to satisfy demand requirements while minimizing the total transportation costs.

A comparison of the results of the model and the actual distribution costs for the financial far 1995/96 indicate that the company can achieve significant cost savings by an application of OR techniques in planning. However attention should not focus too heavily on the potential of cost saving within the physical distribution activity but rather look upon the wider issue of dividing integrated distribution policies which can impact both on costs and revenue. Central to an understanding of the possibilities that an integrated approach to physical distribution can provide is the concept of the corporate system. It requires a company - wide orientation in both policy determination and organizational structure. The company would thus achieve great benefits from OR techniques when they are applied in all sections and all products of the company.

Typically, managerial attempts to handle the problems of growing distribution costs should not be of a piecemeal nature. That is the individual activities centres should not be examined for possible improvements without regard to the effects of any changes in the single activity on other activities. For example cost cutting on transportation might lead to higher costs elsewhere in the system, for instance inventory holding costs might grow. It is because of the dangers of such sub-optimization that in distribution management the emphasis on trade-off analysis and total cost analysis come in to provide the framework for a global/systems approach to the problems of managing a complex network of flows. This therefore calls for a trade-off analysis of the cost saving from single activity versus its effect on the costs of the total system, i.e. cost savings from applying a transportation model to the distribution of UHT milk versus the total transportation costs of KCC products.

Wedded to the possibility of cost savings through the introduction of transportation models is the prospect of revenue improvement through the provision of a more efficient distribution capability. This means in effect that a coordinated approach to distribution can result in higher level of customer services that may impact upon KCC's performance in the market place indeed there can be situations where higher distribution costs can be justified because of the increase in market effectiveness. Therefore management should not put too much emphasis on cost cutting in distribution and little regard to the total costs benefit of system performance. KCC's management can enhance their long term profit by considering the implications on both costs and revenue of specific logistic strategies.

A company wide orientation in distribution policy the would ensure for instance the transportation of raw milk from plants to factories is planned in conjunction with the distribution of finished products tot he final customer. This then calls for an integrated transportation model that would analysis the allocation of products to individual depots while minimizing both transport and storage costs.

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