A Study on Optimizing Transportation Cost - An Application of Vogel's Approximation Method

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Abstract

There is a growing trend of eroding business profits among manufacturing firms owing to higher cost of materials and services, and constant shutdown of factory. Profit and profitability are most often used as index for measuring performance. Pricing of a product is affected by many factors; one of them being the transportation cost. Nevertheless, because of the increasing fuel price, transportation cost is also increasing day by day.

This study examines the benefits of following the optimum method of transportation with the help of a case study. The study found out that if the company is adopting a systematic transportation model on the basis of the Vogel's Approximation Method, there will be considerable saving in the transportation cost which will improve the profitability. Reduction in transportation cost will help the company to consider reducing the price of their product which in turn will help them to compete successfully and improve their sales. This would particularly serve beneficial to companies with mounting excess stock.

Keywords: Logistics, Supply Chain, Vogel's Approximation, Optimization,transportation model.

1. Introduction

According to the Council of Logistics Management, logistics is defined as "the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements",which means it includes inbound, outbound, internal, and external movements, and returns of materials for environmental, salvage, repair, and recall purposes.

Every business firm, regardless of what it produces or distributes, requires the movement of goods from one point to another and, therefore, is involved in transportation. Transportation essentially concerns the spatial dimension of the business firm. "The spatial dimension refers to geographical relationships and reflects the juxtaposition of firms with respect to their materials sources, markets, and competitors, plus the spatial relations of the latter to their sources and markets". The purpose or function of transportation is to serve as a connecting link between the spatially separated units within a firm's own organisation (such as between plants and warehouses) and between units of the firm and units of other firms and individuals (such as suppliers and customers). Good transportation has the effect of holding to theminimum time and cost involved in the spatial relationships of the firm.

The role that transportation plays in logistics system is more complex than carrying goods for the proprietors. By means of well-handled transport system, goods could be sent to the right place at right time in order to satisfy customers' demands. It brings efficacy, and also it builds a bridge between producers and consumers. Therefore, transportation is the base of efficiency and economy in business logistics and expands other functions of logistics system. In addition, a good transport system performing in logistics activities brings benefits not only to service quality but also to company competitiveness. Transport system is the most important economic activity among the components of business logistics systems. Around

one-third to two-thirds of the expenses of enterprises' logistics costs are spent on transportation.

2. Literature Review

Globalisation became a blessing to the business and transportation is one of the keys of international supply chain management. Increasingly organisations are taking advantage of modern communications and transportation technologies in order to increase their competitive edge by producing and selling goods in the global market place. To facilitate these activities organisations utilize supply chain management to efficiently connect the parties involved in a value chain to minimize costs, enhance customer service capabilities augment the organisations knowledge base, maximize efficiency and develop barriers to competitors. Transportation is the process of getting the right products to right internal or external party without an effective transportation process, the entire supply chain breaks down. To work well and to facilitate the overall effectiveness of international supply chain, several transportation capabilities are needed: time compression, reliability, standardization, just in time delivery, flexibility, and customization.An account of the many advances of the 21st century has been expressed by Connolly K. P., Sullivan E., Brennan L., and Murray J. (2005) in their paper titled "International supply chain management: A walk around the elephant".

Eedward, A. Murash, and Steven, R. Clinton, (2008) focussed their studies on the role of transportation capabilities in international supply chain management. They defined the meaning of transportation more expansively as an ideal position to integrate and coordinate flows throughout the supply chain. To minimize total costs and maximize customer value, transportation integration is essential within the supply chain. Edokpia, R.O., and Ohikhuare, K.O. (2012) conducted their study using Vogel's approximation method, modified distribution method, linear programming etc. for solving the transportation problem of beverage producing company in Nigeria with a view to minimizing the total transportation cost and obtaining an optimal schedule bearing in mind the present transportation policy of the company.

Ahlstedt D. and Hameri (2004) found out that transportation management system is definitely an integral subset of supply chain management system, one that influences the charge and quality on the shipping process. Warren B. Powell and Huseyin Topaloglu (2003) in their studies, explained that high-dimensionality of the decisions involved in a transportation problem has made it a natural application for the techniques of mathematical programming, but the challenge of modelling dynamic information processes has limited their success.

Coyle*et al.* (2003) found that transportation is the physical thread connecting the company's geographically dispersed operations. More specifically, transportation adds value to the company by creating time and place utility; the value added is the physical movement of goods to the place desired and at the time desired.LimaoandVenables (2001) observed that real costs of trade -the transport and other costs of doing business internationally-are important determinants of a country's ability to participate fully in the world economy.

Cukrowski, J., and Fischer, M.M. (2000) suggest that additional gain from trade may emerge from reductions in aggregate delivery cost owing to scale economies. Additionally, trade between two countries may also result from economies of scale to transportation

2.1. Theoretical Review of Vogel's Approximation Method

This method tackles the problem of finding a good initial solution by taking in to account the costs associated with each route alternative. This is something that the northwest corner rule did not do. To apply the VAM, we first compute for each row and column the penalty faced if we should ship over the second best route instead of the least-cost route. It facilitates a very good initial solution—as a matter of fact, one that is often the optimal solution. Vogel's approximation method can be explained using an example. A scooter production company produces scooters at the units situated at various places (called origins) and supplies them to the places where the depots (called destinations) are situated. Here the availability as well as requirements of the various depots are finite and constitute the limited resources. This type of problem is known as distribution or transportation problem in which the key idea is to minimize the cost or the time of transportation.

Steps involved in Vogel's approximation method

1. For each row and column of the transportation table, find the difference between the twolowest unit shipping costs. These numbers represent the difference between the distribution cost on the best route in the row or column and the second best route in the row or column.

2. Identify the row or column with the greatest opportunity cost, or difference.
3. Assign as many units as possible to the lowest cost square in the row or column selected.
4. Eliminate any row or column that has just been completely satisfied by the assignment just made. This can be done by placing Xs in each appropriate square.
5. Recomputed the cost differences for the transportation table, omitting rows or columns crossed out in the preceding step.
6. Return to step 2 and repeat the steps until an initial feasible solution has been obtained.

3. Methodology

A case-based study was undertaken at one of the largest manufacturer of compound cattle feed in private sector in the country. The last three decades has seen this company emerging as a leader in solvent extraction and ready mixed cattle feed in the country. Today it commands the resources expertise and infrastructure to manufacture a range of livestock feed in high volumes, coconut oil from coconut oil cake and refined edible oil. With modern manufacturing facilities spread over three states, the company caters to vast belt stretching across Southern India and enjoys significant presence in exports too.Cattle feed is the main product of the company. The other products are oil- cake, De-oiled cake, jersey, milk ice cream. Since the company is not following any organised transportation method, it is incurring a very high transportation cost. The study was focused on identifying areas where the profitability of the company was affected due to the absence of an optimized model for transportation and suggest the necessary changes. Since there are too many demand centres for their product in the state, study is limited to one centre in every district.

The research design adopted for the study was exploratory research. The first part of the study focused on studying the current supply and demand for the company's produce and ascertaining the existing transportation model being used. The second part of the study aimed at optimising the existing model to result cost savings. Software called management scientist was used to optimize the transportation model. Both primary and secondary sources were explored for collecting data. Management scientist statistical software which works on the principles of Vogel's Approximation, was used to optimize the transportation model.

3.1. Assumptions used while Working with the Software

- The transportation module recognised the condition where supply was not equal to demand, automatically. If supply was greater than demand, the solution indicated which origins have excess supply. If demand exceeded supply, the program found the best solution for the existing supply; the destinations having unsatisfied demand were then displayed.
- If there were origin–destination combinations that were unacceptable, the researcher entered a cost or revenue for each unacceptable combination. To ensure that these unacceptable transportation routes were not included in the optimal solution, the researcher entered very large cost (e.g., 999999) or very small revenue (e.g., –999999) wherever appropriate.

3.2. Objectives

The objective of the study was to optimize the transportation cost in the current situation.

3.3. Limitation

- The study was conducted in a short period and could was not be detailed in all aspects.
- There were too many demand centresin the state, so study was limited to one centre in every district.The company has more than 500 selling points spread over 14 districts. To consider transportation cost to all these centres will become cumbersome. Hence distance to the major centre in every district within the Kerala state alone is considered. All the bordering depots have been avoided.
- Transportation cost varies from place to place in the state.

4. Analysis and Discussion

Operational efficiency is the capability of an enterprise to deliver its product or services to its customers in the most cost effective manner possible. Likewise transportation cost is another important factor which affects a company's profitability. The study examines the transportation method followed by the company and tries to find out whether the method followed is optimal.

4.1. Production at Origins Per Month

Table 1 represents the production of cattle feed at each production units. This shows that Irinjalakuda unit has the maximum production capacity and it produces about 21300 tonnes cattle feed per month. And both Trivandrum and Palakkad units have the least production capacity of 3000 tonnes per month.

Table 1. Production from origins per month

Origin	Production (Tonne)
Irinjalakuda	21300
Kottayam	7500
Ernakulum	7500
Palakkad	3000
Trivandrum	3000

Source: Secondary Data

4.2. Summary of Demand for the Month of March 2013

Table 2 represents demand of cattle feed at various destinations in the month of March 2013.It can be observed that the maximum demand was at Ernakulum and minimum demand was at Kasaragode.

Table 2. Summary of Demand for the Month of March 2013

Destinations	Demand (Tonne)
Trivandrum	3586
Kollam	4302
Pathanamthitta	1301
Alappuzha	3665
Kottayam	3392
Idukki	1088
Ernakulum	4958
Thrissur	2399
Palakkad	762
Malapuram	952
Kozhikode	1150
Kannur	461
Wayanad	534
Kasaragode	65

Source: Secondary Data

Table 3. Distance from Production Units to Various Demand Destinations

Origin	Distance to Destination (Km)													
	TVM	KLM	PTA	ALP	KTY	IDK	EKM	TCR	PKD	MLM	KZD	KNR	WYD	KGD
IJK	269	200	181	117	118	129	65.2	24	90	117	136	226	212	317.2
KTY	162	105	68	46	10	91.2	56	125	183	207	225	315	309	406
EKM	195	137	95.2	64	42	70	40	102	160	185	221	311	286	402
PKD	348	279	260	196	197	208	141	75.2	12	93.2	139	229	190	320
TVM	8	63.2	109	147	153	234	207	279	337	358	376	466	452	557.2

Source: Data Analysis

Table 4. Estimation of Unit Transportation Cost

Ship from origin	To Destination (Rs.)													
	TVM	KLM	PTA	ALP	KTY	IDK	EKM	TCR	PKD	MLM	KZD	KNR	WYD	KGD
IJK	673	500	453	293	295	322	163	60	225	293	340	565	530	793
KTY	405	263	170	115	25	228	140	313	458	518	563	788	773	1015
EKM	488	343	238	160	105	175	100	255	400	463	553	778	715	1005
PKD	870	698	650	490	493	520	353	188	30	233	348	573	475	800
TVM	20	158	273	368	383	585	518	698	843	895	940	1165	1130	1393

Source: Data Analysis

4.3. Assumptions for Calculating Transportation Cost

For the purpose of the study the transportation cost is calculated on the basis of some assumptions. The assumptions are described below:

4.3.1. Distance from Production Units to Various Demand Destinations

Table 3 explains the assumed distance from each production centre to various demand destinations across the state. This assumption is essential for calculating unit transportation cost in order to work out transportation model.

4.3.2. Estimation of cost for transporting 1 tonne/Km

- One load is assumed to be a minimum of 10 tonnes.
- Cost for transporting one load is assumed to be Rs.25/Km.

Thus cost for transporting 1 tonne per kilometre

$$= ₹ 21\,50/$$

$$= ₹ 2.5$$

4.3.3. Estimation of unit transportation cost

Table 4 represents unit cost for transporting cattle feed from different production units to various demand destinations. The unit cost will differ since the distance from each production centre to various demand destinations varies. Here we assumed that the cost for transporting one tonne of cattle feed is about Rs. 2.5.Now unit transportation cost can be found out by multiplying distance from the origin to destination with cost for transporting one tonne of cattle feed per kilometre.

Unit transportation cost = Distance from the production unit to the demand destination * cost for transporting one tonne per kilometer.

4.4. Existing Transportation Model

It is observed from the table that the company is not following any organised form of transportation model. Because from the table we can see that demand at most of the destinations is being satisfied by the supply from Irinjalakuda unit even though the distance from that production unit to the demand destination is more. Here we can see Trivandrum district has a total demand of about 3586 tonne cattle feed per month. Out of that, 90% of the total demand is met by supplying the cattle feed from the Irinjalakuda production unit. Only 10 % of the total demand at Trivandrum is being supplied from Trivandrum unit. Likewise anunorganised method of transportation is followed by the company to meet the demand at most of the destinations. This in turn is resulting in increased transportation cost, which has a negative impact on the profitability of the company.

Here we can calculate total cost incurred for transporting cattle feed from various production centres to demand destinations by multiplying unit transportation cost from production centre to the demand destination with supply amount of cattle feed at that destination. For example, from Table 4 we get unit transportation cost incurred for transporting cattle feed from Irijalakuda unit to Trivandrum, one of the demand destinations of the company. And from Table 5 we get demand at Trivandrum destination.

Table 5. Existing transportation model

Ship from origin	Demand at various destinations (tonnes)													
	TVM	KLM	PTA	ALP	KTY	IDK	EKM	TCR	PKD	MLM	KKD	KNR	WYD	KGD
IJK	3218	2981	485	537	342	23	1487	2319	37	254	1151	461	535	65
KTY	0	661	611	2346	1525	533	1736	0	0	0	0	0	0	10
EKM	0	661	204	782	1525	533	1736	0	0	0	0	0	0	0
PKD	0	0	0	0	0	0	0	81	725	0	0	0	0	0
TVM	370	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Secondary Data

Table 6. Optimized Transportation Model

Ship from origin	Supply to destinations													
	TVM	KLM	PTA	ALP	KTY	IDK	EKM	TCR	PKD	MLM	KKD	KNR	WYD	KGD
IJK	0	0	0	0	0	0	4292	2399	0	0	1151	461	0	66
KTY	586	3522	0	0	3392	0	0	0	0	0	0	0	0	10
EKM	0	780	1301	3665	0	1088	666	0	0	0	0	0	0	0
PKD	0	0	0	0	0	0	0	0	762	952	0	0	534	0
TVM	3000	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Data Analysis

Table 7. Comparison of the situation before and after optimization of transportation cost

Destinations	Total demand(Tonnes)	Before optimization		After optimization	
		Supply pattern	Total Cost(Rs.)	Supply pattern	Total Cost(Rs.)
Trivandrum	3586	IJK(3218) TVM(370)	21,73,114	TVM(3000) KTY(586)	2,97,330
Kollam	4302	IJK(2981) KTY(661) EKM(661)	18,90,405	KTY(3522) EKM(780)	11,93,826
Pathanamthitta	1301	IJK(486) KTY(611) EKM(204)	3,73,960	EKM(1301)	3,09,638
Alappuzha	3665	IJK(537) KTY(2346)	6,22,631	EKM(3665)	5,86,400
Kottayam	3392	IJK(342) KTY(1525) EKM(1525)	3,03,715	KTY(3392)	84,800
Idukki	1088	IJK(23) KTY(533) EKM(1736)	2,22,205	EKM(1088)	1,90,400
Ernakulum	4958	IJK(1487) KTY(1736) EKM(1736)	6,64,229	EKM(666) IJK(4292)	5,66,196
Thrissur	2399	TCR(2319) PKD(80)	1,54,125	IJK(2399)	1,43,940
Malappuram	952	IJK(254) PKD(699)	238687	PKD(952)	238687
Kozhikode	1150	IJK(1150)	3,91,340	IJK(1150)	3,91,340
Kannur	461	IJK(461)	2,60,465	IJK(461)	2,60,465
Wayanad	534	IJK(534)	2,83,550	IJK(534)	2,83,550
Kasaragode	66	IJK(66)	52,338	IJK(66)	52,338
Total cost			Rs.78,82,710		Rs.47,74,659

Source: Data analysis

Therefore,

Unit transportation cost to supply cattle feed from Irinjalakuda production unit = Rs. 673

Supply amount of cattle feed from Irinjalakuda unit to Trivandrum = 3218 tonnes

Now,

Total cost incurred to transport cattle feed to Trivandrum
= 3 2 1 8 * 6 7 3

= Rs.21, 65,714

Likewise we can calculate total transportation cost incurring to each demand destinations. By summing up all the cost we get over all transportation cost incurring for the company for a month.

Therefore,

In the month of March total transportation cost incurred is estimated to be Rs.78, 82,710.

4.5. Optimized Transportation Model

Table 6 represents the optimum transportation model for the current situation of the company. This optimized model suggests a model which incurs lesser transportation cost than the current transportation model used by the company. Before optimization 90% of the total demand at Trivandrum is being supplied from Irinjalakuda unit and only 10% was supplied from the Trivandrum unit. But after working out the transportation model here we can see that 90% of the total demand at Trivandrum should met by supplying from Trivandrum itself which will reduce the transportation cost than the current situation. Likewise an optimum method which reduces the transportation cost to a minimum level is being suggested by the transportation model.

Here also we can calculate total transportation cost incurring for the company, if the company is adopting the above suggested optimized transportation model, as explained in the above section.Therefore, in the month of March total transportation cost incurred is estimated to be Rs.47, 74, 659.This model also found out that there is an excess production at Irinjalakuda unit and Palakkad unit.

4.6. Comparison of the Situation Before and After Optimization of Transportation Cost

Table 7 shows a comparison of the situations before and after the optimization of transportation cost. Here we can see that transportation cost incurred before optimization is Rs.78, 82,710 and transportation cost incurred after optimization is Rs.47, 74,659. Thus the company can make a cost saving of Rs 31, 08,051 by adopting the optimized transportation model. This is estimated just for a month. So in the long run there will be a positive effect on the profitability of the company.

5. Summary

It can be inferred that the model suggested in the study resulted in total cost savings of Rs 31, 08,051 for the company while meeting the demand for all its centres. However at Malappuram, Kozhokode, Kannur, Wayanad, and Kasaragode the company's existing transportation model proved to be equally cost effective.

References

Ahlstedt, D.,& Hameri, A.P. (2004). Review of supply chain management research: Practical business value and international aspects. *Supply Chain Forum, 5*(1), 38-48.

Connolly, K. P., Sullivan, E., Brennan, L., & Murray, J. (2005).International supply chain management: A walk around the elephant. *The Irish Journal of Management, 26*(1), 149-162

Coyle, J.J., Bardi, E.J., & Langley, C.J. (2003). Management of business logistics: A supply chain perspective. *South-Western College Publications*, 34-45.

Cukrowski, J., & Fischer, M.M. (2000).Theory of comparative advantage: Do transportation costs matter. *Journal of Regional Science,40*(2), 311-322.

Edokpia, R.O., & Ohikhuare, K.O. (2012).Transportation cost minimization of a manufacturing firm using linear programming. *Advanced Materials Research, 367*, 685-695

Eedward, A. M., & Steven, R. C.(2008). Management consulting integrated supply chain management. *American Shipper: International Logistics, 37*(5), 68-70.

Limao, N., &Venables, A.J. (2001).Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank Economic Review,15*(3), 451-479.

Powell, W. B.,&Topaloglu, H. (2003). Stochastic programming in transportation and logistics.*Handbooks in Operations Research and Management Science, 10* (C), 555-635.