VALUE CHAIN OPTIMIZATION IN OVERSEAS PROCUREMENT USING LPP

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Abstract—*Logistics cost form a major chunk of product cost for auto parts manufacturing company procuring from vendors in international market. Lot sizes and ordering frequency decisions should be made such that the total logistics cost is reduced. In order to reach to an optimal solution, it is important to identify the relevant costs before building a mathematical model for cost optimization. This case study is aimed at identifying means of cost optimization in supply chain of an automotive firm procuring form vendors in Korea, South Africa & Germany. We define a simple approach of developing linear regression models for transportation and warehousing costs. The role of Linear Programming Problem (LPP) models in obtaining optimum solutions out of the many available solutions and cost savings is shown through a live case of Mahle Behr India Ltd. supply chain. Similar approach can be applied to other industries where transportation and warehousing costs form a big portion of the supply chain costs.*

Keywords—*procurement; LCL; FCL; EOQ; automotive*

I. INTRODUCTION

Global sourcing in automobile and auto parts manufacturing industry is quite a common scenario today. Procurement encompasses sourcing and is one of the important links in the value chain of any manufacturing company. A proper procurement system will enable companies to not only save on inventory and storage costs but also to improve the overall efficiency of its supply chain. In order to optimize the procurement, it is important to identify various costs associated with different process from vendor end to the receipt at company end. One such stage is procurement of raw material from vendors.

Kengpol & Kaoien1 state that one of practical problems in raw material procurement is that the actual amount of raw material is not in level because of the policy setting as the procurement staff lacks knowledge in optimizing the inventory levels of the department. As raw material procurements are not optimized, the procurement budget usually spends higher than needed. Fundamental concepts of managing inventory have remained same over years although magnitude and varieties of businesses have increased. One such concept is Economic Order Quantity or EOQ. Reference to EOQ can be found as early as in 1913 by Ford W. Harris and in 1931 in the book of Ralph Currier Davis & Michael James Jucius, " Purchasing and Storing" where they have referred to Minimum Cost Quantity, which today is better known as EOQ. This model works well for procurement that is of repetitive nature. Additionally, this model is recommended in operations where demand is relatively steady, items with demand variability such as seasonality can still use the model by going to shorter time periods for the EOQ calculation.

For transportation of cargo on international routes, it is important to understand different associated costs. Trade off has to be made between Less Container Load(LCL) & Full Container Load (FCL) conditions in order to find the optimum cubic metric values (cbm) for ordering . The tradeoff can be evaluated by considering following three important points:

1) Timely delivery of cargo
2) Optimization of freight costs
3) Simplicity and ease of process

In this paper, we have discussed a live case of Behr India Pvt. Limited, wherein we have analyzed the data of ordering for components from vendors in Germany & South Africa and devised mathematical models to reach to optimum value of cbm for different ordering frequencies. The analysis focuses on optimization of procurement costs that will enable supply chain managers in taking effective decisions for identifying the desired ordering pattern and quantity.

II. RELEVANCE TO AUTOMOTIVE INDUSTRY

Automotive logistics includes flow of automotive producer's raw materials, components, vehicle and spare parts on steps of automotive purchase, production, sales. The automotive logistics include inbound logistics of raw materials and components, garage logistics of production process, sales logistics of vehicle and spare parts logistics, that is including object purchasing, transportation, storage, loading and unloading, distribution processing delivery and information processing. As the assembly line is continuously running in an automotive manufacturing plant, one of the most important factors in the firm's supply side is to make sure that the inbound logistics functions efficiently. Inbound logistics is not as common a topic to explore as distribution of final products, for instance. It can be argued, that inbound logistics is one of the most crucial field to improve: firstly, inbound logistics is the starting point of the supply process and if something goes wrong at that point, it will affect to all of the following processes. If there are problems in the firm's inbound logistics flow, the worst case is that the assembly line has to stop due to the lack of materials (i.e. parts), which will cost a lot of money.

As the automobile market in India is on the verge of an unprecedented growth rate, the demand pressure on the automotive parts manufacturing company is also unprecedented. Not only there is a need to constantly meet the ever growing demand of automotive parts but also to bring down the product cost.

The focus area of the case discussed is inbound. The study aims at finding out an optimum strategy for ordering which will reduce the total costs of logistics and warehousing. Classic example of an automobile parts manufacturing company ordering parts from vendors abroad is studied here. Learning from this research could be applied to automobile and related industries where holding cost and transportation cost form a big proportion of the total costs of a global supply chain.

III. LITERAUTRE REVIEW

Researchers have suggested some mathematical models for optimization of procurement costs. Gutierrez et al.[2] suggests using Bounded/Limited Inventory model to calculate the amount of inventory level. Martel et al.[3] purpose a procurement planning model which converts all decision making decision to mathematical models. Skouri and Parachristos[4] attempt to improve a Continuous Review Inventory Model from Vairaktarakis[5] in order to suggest a way to set procurement qualities within limited budget by using elasticity model. Conventional approaches for solving the production lot size problems are by using the differential calculus on the long run average production-inventory cost function with the need to prove optimality first. Chiu (2008)[6] presents a simple algebraic method to replace the use of calculus for determining the optimal lot size. Gutiérrez et al. (2008)[7] address the dynamic lot size problem assuming time-varying storage capacities. They divided planning horizon into T periods and stock outs are not allowed. For each period, Gutiérrez et al. consider a setup cost, a holding unit cost and a production/ordering unit cost, which can vary through the planning horizon.

IV. FACTORS AFFECTING LOGISTICS COST IN AUTOMOTIVE INDUSTRY

Logistics cost can be affected by a number of factors like how good is the demand forecasting, what is the minimum order quantity that benefits the company, the tradeoff between costs and responsiveness, custom clearances and many more. With regards to overseas procurement, we need to focus on some other important parameters like mode of transport, packaging, Incoterms, point of origin charges, consolidation of LCL shipments.

Our research divides the total logistics cost into three legs, which are further discussed in the methodology section. The other parameters listed above are discussed in the section VII.

V. METHODOLOGY

A. Analysis of current demand & ordering pattern

This research work is dedicated towards identifying various costs incurred in the different legs of procurement from overseas vendors in South Korea, South Africa & Germany along with the warehousing costs in India. The current system of procurement follows either 10 or 14 days of ordering frequency from vendors in Germany & South Africa.

For analyzing the different costs it is important to understand the total costs i.e. inventory holding cost, warehouse costs and general costs of transportation. These are further analyzed for different ordering frequencies for LCL & FCL conditions through mathematical models based on linear programming technique.

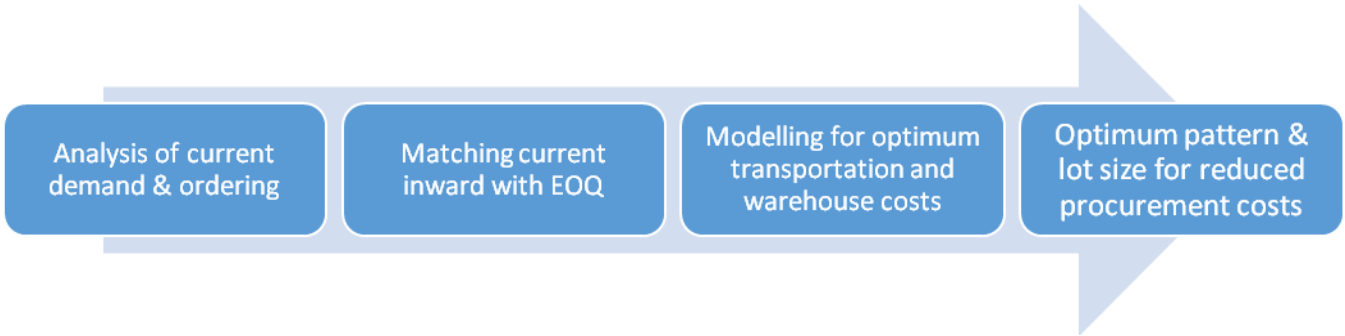

Fig 1. Methodology

General costs of procurement for the automotive firm in consideration have been divided into 3 legs as follows:

Leg 1 includes pick up at suppliers (including storage), Terminal Handling Charges(THC) at origin, export customs clearance, inland freight

Leg 2 includes ocean freight

Leg 3 includes manifest charges, Container Freight Station(CFS) charges, shipping document fee, delivery order fee, customers clearance fee, administration fees, duties & taxes, THC, charges collect, land freight.

On analysis of past data for cbm values, we left out item that were rarely ordered. The analysis is as depicted in the table

Table I. Parts ABC classification

Item	Round Off value	Frequency	Classification	
S2069001	32,319	high	A	X
T5844001	32,319		A	X
Y3628001	32,319		A	X
EH531001	32,319	medium	A	Y
T4464001	32,319		B	Y
V4900002	32,319		A	Y
T4739001	32,319		A	Y
S2068001	32,319	low	C	Z

The highlighted item S2068001 is not considered in our calculations because of the relatively low frequency of ordering. The use of regression methodology assumes that we have been able to find an appropriate set of significant and useful independent variables to explain the behavior of our dependent variable (Freund, Littell & Creighton, 2003).

A high R2 value signifies a high degree of correlation between the dependant and the independent variables. In our case, we have employed regression analysis for finding out relationship between custom clearance costs and CFS charges with cbm (cubic meters) values for Full Container Load (FCL) and Less than Container Load (LCL) conditions.

The results for different regression analysis are as show if Fig 2 to 5.CFS is independent of cbm while custom clearance charges show strong correlation to cbm. For relationship between CFS and cbm, we have taken into account average values per

cbm which give pretty close approximations. We thus assume values as 1030x for LCL and 728x for FCL. The results indicate that LCL shipments charges are lower than FCL shipments charges up till 18-20 cbm. Hence, now we take LCL upto 18-19 cbm easily thus reducing the costs as compared to earlier limit of 11cbm.

B. Matching inward with EOQ

The replenishment system used for procurement by the company is continuous review system. This system helps to continuously monitor on-hand inventory and subsequently order when this inventory reaches a certain level called reorder

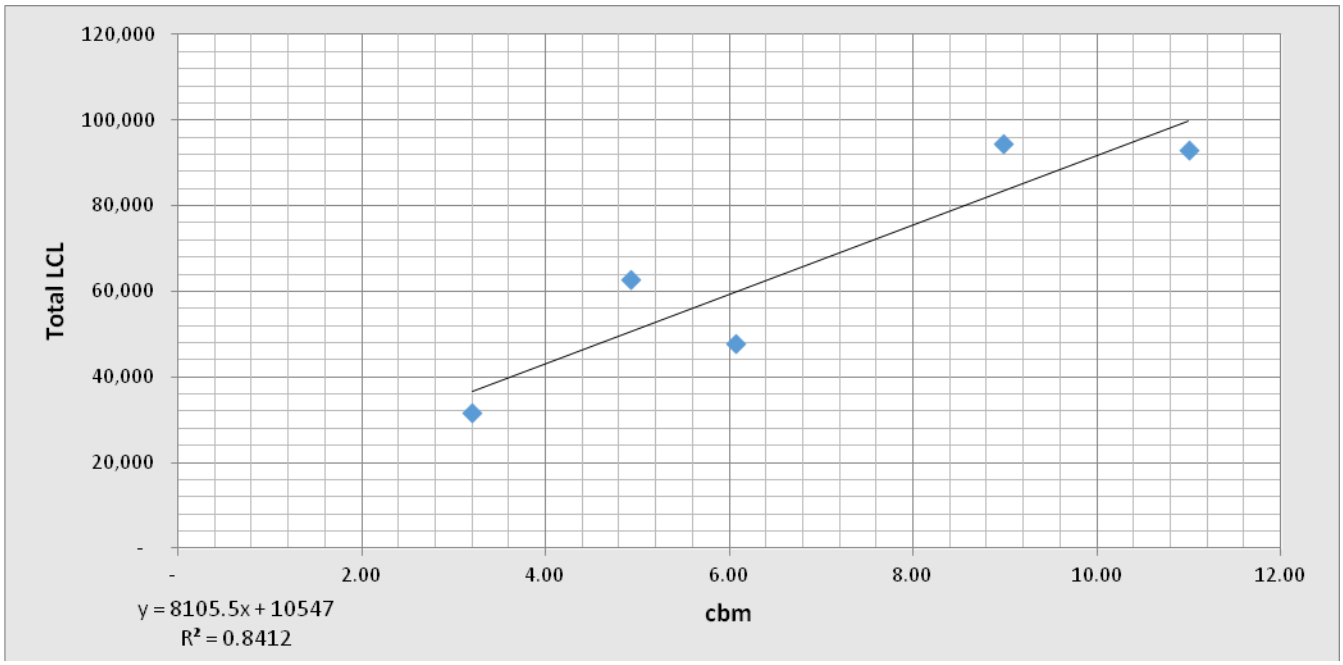

Fig.2. Total LCL vs cbm

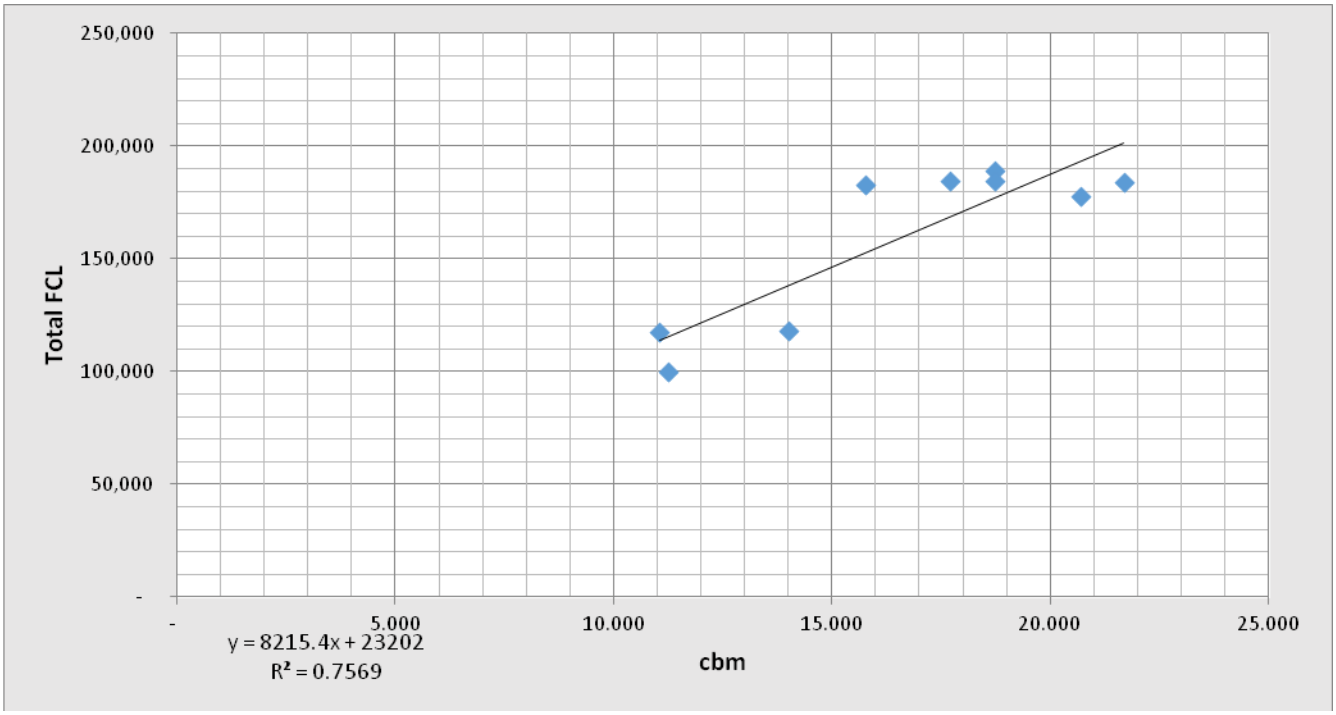

Fig.3. Total FCL vs cbm

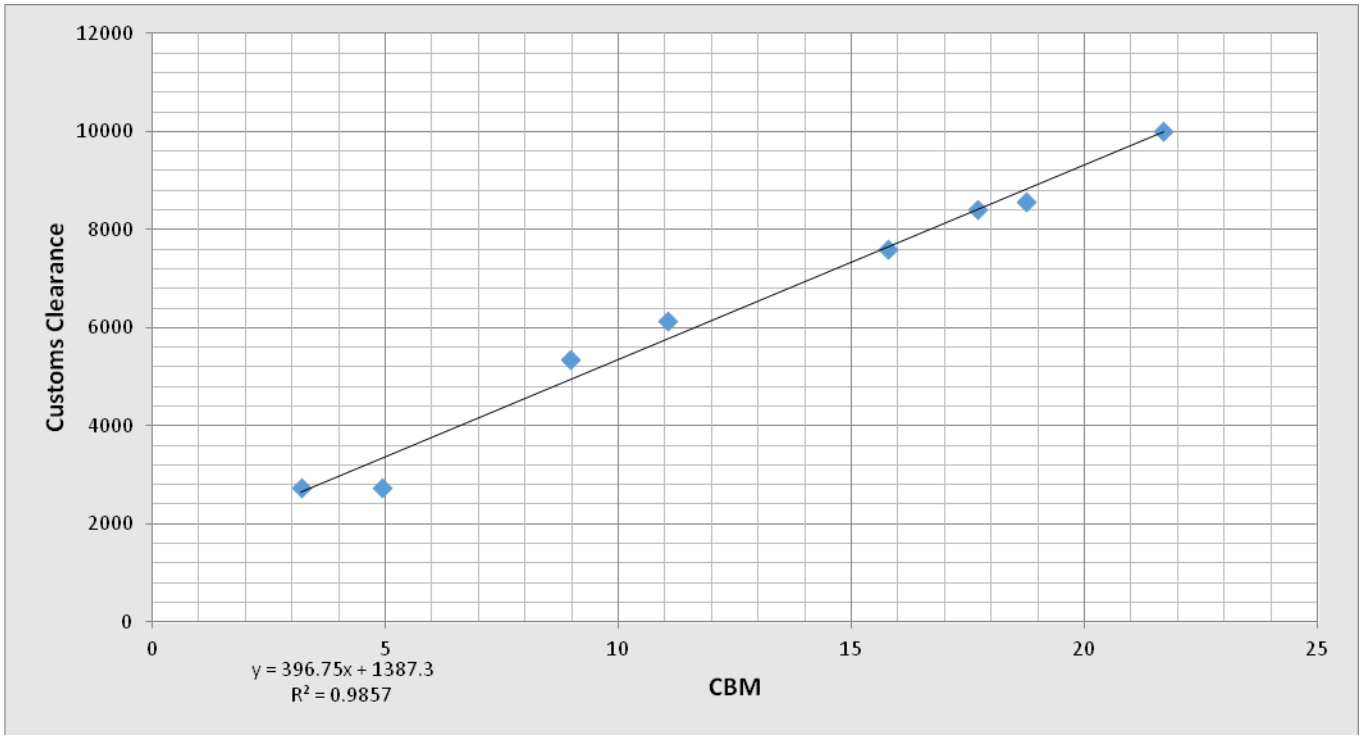

Fig. 4. Customs clearance vs cbm

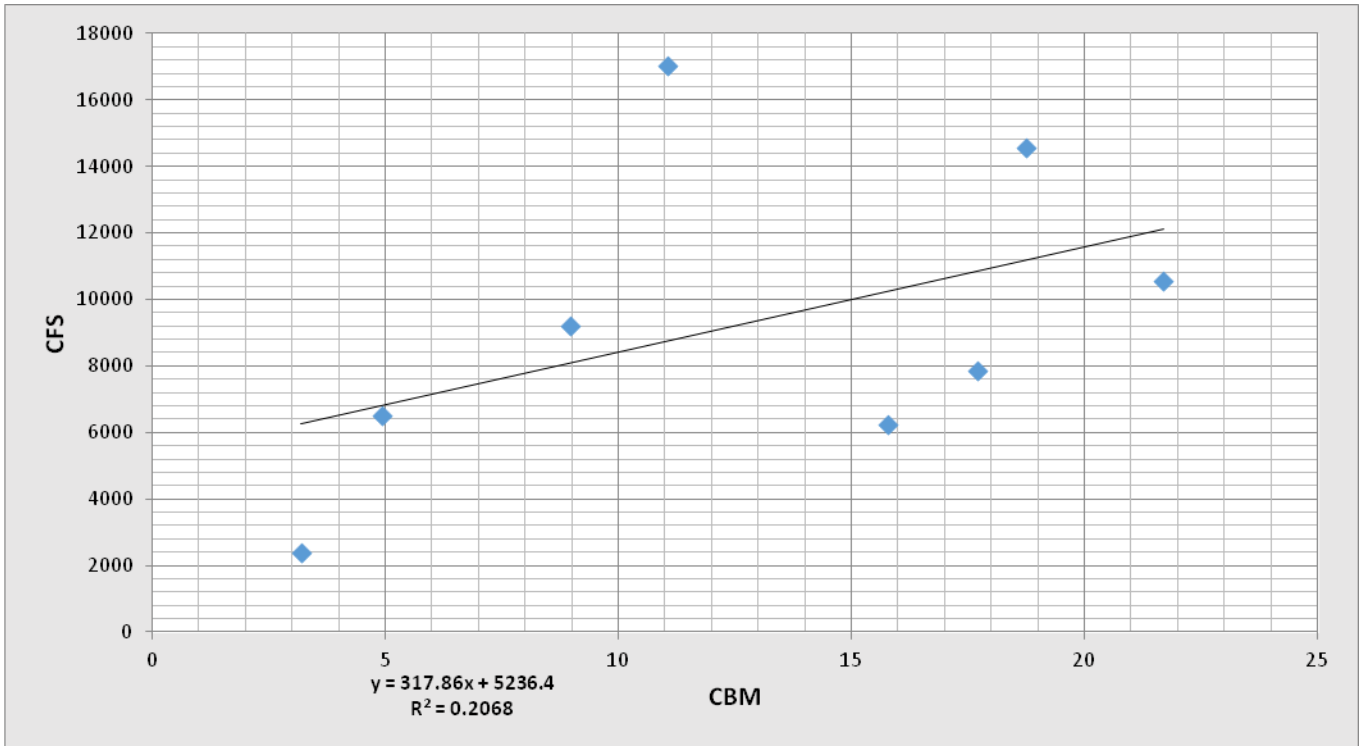

Fig. 5. CFS vs cbm

point. The system employs EOQ model wherein the optimal order quantity is obtained when the total of inventory and holding costs is minimum.

The various ordering parameters are governed by the following equations:

Q= sqrt (2* D*S/H) (1)

N= D/Q (2)

Order cycle time= Q/D (3)

d= D/ (Working days/ year) (4)

ROP= d*L (5)

where, D= demand per order , S= set up cost i.e ordering cost, H= holding cost i.e carrying cost, d= demand per day, L= lead time in day

Inward data for different ordering system was analyzed for five items for the three vendors. Decision making models based on linear programming helped in finding out optimum values of cbm for reducing costs by suggesting 14 days & 10 days ordering system in case of Korean Vendor, 14 days & 21 days in case of vendor in South Africa and 7 days in case German vendor.

C. Modeling for transportation and warehousing cost

TABLE II. Unit price of parts considered

Item	Quantity	Volume(cbm)	Unit Price
S2069001	X1	V1	6.28
T4464001	X2	V2	6.99
T5844001	X3	V3	6.41
V4900002	X4	V4	7.38
Y3628001	X5	V5	5.54

Total transportation and warehousing costs are modeled using linear equations assuming X quantity and V volume.

For 1 order of LCL:

a) Holding cost= (0.15*45/365)*(6.28x1 + 6.99x2 + ...)
b) Warehouse cost= (5000000*7/13000/365)*(v1x1 + v2x2 + v3x3+.....)
c) Leg1 cost= 1785*(x1v1 + x2v2 + x3v3+ .....) + 5975
d) Leg2 cost= 1674*(x1v1 + x2v2 + x3v3 + ...)
e) Leg3 cost= 4864*(x1v1 + x2v2 + x3v3 + ...) + 5917

Total variable cost item wise= 0.308867132*x1 + 0.322119324*x2 + 0.311276789*x3 + 0.329268776*x4 + 0.295258022*x5

Total variable cost pallet wise= 9982.276836*x1 + 10410.57442*x2 + 10060.15456*x3 + 10641.63756*x4 + 9542.444023*x5

LP in case of 14 days ordering model:

Objective: Minimize Z= 9982.276836*x1 + 10410.57442*x2 + 10060.15456*x3 + 10641.63756*x4 + 9542.444023*x5

Constraints:

32319* (x1v1 + x2v2 + x3v3 +x4v4 + x5v5) <=25.....(1)

32319 x1 >= 149968.....(2)

32319 x2 >= 13454.....(3)

32319 x3 >= 98084.....(4)

32319 x4 >= 9436.....(5)

32319 x5 >= 292194.....(6)

32319* (x1v1 + x2v2 + x3v3 +x4v4 + x5v5) >=5.....(7)

LP in case of 10 days ordering model:

Objective: Minimize Z= 9982.276836*x1 + 10410.57442*x2 + 10060.15456*x3 + 10641.63756*x4 + 9542.444023*x5

Constraints:

32319* (x1v1 + x2v2 + x3v3 +x4v4 + x5v5) <=25.....(1)

32319 x1 >= 107120.....(2)

32319 x2 >= 9610.....(3)

32319 x3 >= 70060.....(4)

32319 x4 >= 6740.....(5)

32319 x5 >= 208710.....(6)

32319* (x1v1 + x2v2 + x3v3 +x4v4 + x5v5) >=5.....(7)

Similar calculations were done for the FCL conditions and other vendors in Germany & South Africa. LP Solver shows that optimum cbm for 14 days ordering is **15.7 cbm** and for 10 days ordering, it's **11.98 cbm** which is used in formulating the new ordering pattern. The most optimum ordering pattern is the one which has least standard deviation from the mean**.**

VI. REDUCED PROCUREMENT COSTS

Our study shows that our statistical approach can help managers save logistics cost by determining the optimum ordering pattern along with the optimum cbm size.

A. Vendor in South Korea

The new ordering pattern gives a 27% cost reduction when 10 days ordering period is followed and 44% cost reduction when 14 days ordering period is followed. Average cost per cbm is reduced from 9746 to 9232.

comparison of total transport and inventory holding cost		
total actual cost for 6 months		21,21,534
proposed ordering model for 6 months		14 days model
avg transportation cost	15,52,295	
avg savings in inventory	3,65,778	
average savings for 6 mnths	9,35,017	44%
proposed ordering model for 6 months		10 days model
avg transportation cost	1806307	
avg savings in inventory	2,64,649	
average savings on transport 6 mnths	5,79,876	27%

Fig 6. Savings for South Korean Vendor

B. Vendor in South Africa

The new ordering pattern gives a 48% cost reduction when 21 days ordering period is followed and a 37% cost reduction when 14 days ordering period is followed. Average cost pr cbm is reduced from 7951 to 7521 in case of 14 days ordering system and 5781 in 21 days ordering system**.**

comparison of total transport and inventory holding cost			
past 5 months actual data			
total cost			
		29,88,053	
approx for 6th month		5,97,611	
total actual cost 6 months		35,85,664	
proposed model 6 months		21 days model	
avg transportation cost	21,70,092		
avg savings in inventory	2,92,496		
average savings for 6 mnths	17,08,068	48%	
proposed model 6 months		14 days model	
avg transportation cost	25,70,940		
avg savings in inventory	3,14,028		
average savings on transport 6 mnths	13,28,752	37%	

Fig 7. Savings for South African Vendor

C. Vendor in Germany

The current system for vendor was already optimized, so only a little improvement was possible here. The new ordering pattern gives a 0.14% cost reduction when 7 days ordering period is followed. The lower savings in this case as compared to other vendors can be attributed to lower transaction value, import volume shifting from Germany to South Africa and South Korea, and higher LCL imports from Germany.

comparison of total transport and inventory holding cost			
past 5 months actual data			
total cost			
		15,50,934	
approx for 6th month		3,10,187	
total actual cost 6 months		18,61,121	
proposed model 6 months		7 days model	
avg transportation cost	1979230		
avg savings in inventory	1,20,655		
average savings for 6 mnths	2,546	0.14%	

Fig 8. Savings for German Vendor

VII. FUTURE SCOPE

Our study has focused on determining a simple model for reducing logistics cost by developing LPP models for past one year data. Although the research is not very extensive, this study can be used as a base to reduce overseas procurement by automotive firms. Further here we discuss some of the important factors that could be further explored in order to achieve higher efficiencies in supply chain:

i) **Mode of transportation**: The mode of transportation depends on weight of the shipment, quantity, volume of the minimum requirement, frequency of pick up in peak requirement, nature of product, and value of the product.

ii) **Packaging of product**: It is the most important parameter in determining the cost of logistics. The numbers of pallets that can go in one container depend on the size and the weight of product. It is interesting to note here that although a container may bear the load of shipments but road transportation to final destination may not be possible due to road weight constraints.

iii) **Consolidation of LCL shipments:** The consolidation of LCL shipments can serve as a win-win strategy for shipping line, freight forwarder, buyers, and sellers. In this regard we suggest supply chain managers to choose the freight forwarder that has the maximum console importing in India for optimum rates. Also, it is advisable to negotiate for overall supply chain like origin, sea freight and destination charges and not just one part of the import.

CONCLUSION

Inbound logistics forms the core of supply chain of a company importing material from vendors in international market. The reduced freight costs and inventory costs can translate into reduced cost of production. This helps the firm in a competitive market like India. We took into consideration certain items and vendors for an automotive firm to show how costs can be identified and reduced by following an optimal strategy. It is to be kept in mind that the strategy followed has been based on assumptions of EOQ concept and the total savings may change with the volume change in LCL and FCL. It is to be noted that the demand in the automobile component industry is very dynamic in India and hence the data considered here is of the past one year only. We believe that this simple yet accurate LPP model can be applied in similar industries or similar domains for a cost effective procurement strategy. This study can serve as a base to further investigate as to how LCL consolidation into FCL can reap benefits for an automotive firm.

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BIOGRAPHY

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