Development of a Cost Effective Supply Chain Framework for a Construction Equipment Manufacturer

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Abstract

Consolidation in supplier markets, rising prices and growing material demand in emerging markets have necessarily changed the traditional purchasing framework. Cost reduction is turned out as the most cited objective in successful running of any business. Despite of its overwhelming importance, attempts to study or analyze supply chain cost reduction are very few in construction equipment manufacturing business. When Customer makes purchasing decision, price remains as the major criteria here. This study addresses various cost reduction methodologies implemented at M/s Volvo CE India, Using a cost effective supply chain framework. This framework proposes various cost effective and smarter ways of working with the suppliers. Here products are categorized based on business volume and supply risk using a purchase portfolio matrix called Kraljic Matrix. It helps company to find which supplier and area to focus more or how the strategies should differ across the supply base. Here Products are categorized in to Routine Items, Leverage Items, Bottleneck Items and Strategic Items. Different purchasing strategies are formulated to put in practice with each category. Proposed framework uses Economic Order Quantity Model, Quantity Discount Model, Complete aggregation model and tailored aggregation model to optimize the cost drivers and achieve an effective cost reduction. Proposed model was validated for determining the degree to which its accuracy in representing real world, by implementing it as pilot projects. It resulted in 3% of supply chain cost reduction. The suggested framework will be of immense help to the company in reducing the supply chain cost—and a prerequisite for building a strong supplier partnership and developing an effective supply chain base.

Key Words: Kraljic Matrix, Inventory Model, EOQ, Quantity Discounts, Tailored Aggregation

1. INTRODUCTION

In current economic pressure, cost reduction is one among the most cited objective in successful running of any business. When customer makes purchasing decision, price remains major criteria over product performance and other parameters [1]. If costs are to be reduced, organizations increasingly turn their attention to their supply chain partners, thus both suppliers and customers reach out for new frontiers of competitiveness and profitability through supply chain cost reduction. Cost reduction in supply chain requires effective cost management [2]. Opportunity for cost reduction lies in storage, packing, forwarding, transportation, wastages, handling etc. Hence to achieve significant cost reduction, scientific methods have to be introduced in these areas of supply chain. Therefore for any business it is necessary to run their supply chain network effectively to reduce the supply chain cost.

2. PROBLEM DEFINITION

In view of competitiveness among major competitors, Volvo CE India has a tremendous pressure on cost reduction of their products. Supply chain is one area where significant cost reduction can be done. Though company is having a supply chain improvement program called, SCIP-Supply Chain Improvement Program; there are only very few initiatives carried out for this purpose. There is no scientific method followed for supplier categorization based on supply risk and business volume, sourcing decisions and inventory levels. Hence this study proposes a cost effective supply chain framework that cause significant cost reduction.

3. METHODOLOGY

A detailed Literature survey is carried out on Supply Chain Management (SCM) and cost reduction in supply chain using web survey, books, journals, technical papers. Using Observation method, Face to face interview and documents and database review, current process is studied. Data Collection is done from company documents and database review. This data is later analyzed with statistical analysis and risk analysis. The end results of this study are; a Kraljic Matrix for supply base categorization, cost effective Purchase strategies, and mathematical inventory models. End results are then validated using result comparison with previous year data and pilot project implementation.

4. SUMMARY OF LITERATURE SURVEY

Major decisive factor in purchasing a construction equipment is price [1], still there are only very few attempts to study or analysis cost reduction in construction equipment manufacturing; hence there is a large room for such studies in this sector. To attempt a reduction in total SCM cost; manufacturing cost, administration cost, warehousing and transportation cost have to be considered [2]. Traditional purchasing trends have to be abandoned and companies have to adapt advanced purchasing strategies for each category of their supply base using appropriate categorization, purchasing policies and inventory models like, Economic Order Quantity (EOQ) model, Tailored Aggregation model, Complete aggregation and quantity discount models can lead to significant cost reduction in supply chain [3, 4].

5. DATA COLLECTION AND ANALYSIS

Data Collected during this stage is readily understood and correctly used in subsequent studies. A Spend analysis is carried out using the data on purchase volume contribution by each supplier. As the total supplier count and purchase volume contribution is high in case of domestic customers; any initial cost reduction efforts should first focus on the domestic suppliers. Thus a current domestic supply chain process mapping is carried out. Mapping out the current processes is one of the most inexpensive ways to make great strides in any improvement activity. SCM process mapping encompasses series of operations and departments involved in every stage of purchase and supply management activity. A strategic supply chain map acts as a basis for supply chain redesign and modification. Process map also helps to visualize the entire procurement activities and identify areas for further analysis. Detailed data collection is further done on this supplier base on various parameter like, part no, part description, annual demand (D), price/unit (C), annual business volume, quality performance, and delivery performance. This data is collected for entire supply base of Volvo (2610 parts) and further used for product categorization, calculating order quantity and cost factors (ordering cost, material cost, holding cost).

6. SOLUTION

A systematic scientific approach is proposed to minimize the total supply costs and to develop a cost effective supply chain frame work using product categorization and inventory models.

6.1 Product Categorization

Entire domestic parts are classified based on two parameters- business volume & supply risk. Business volume is the total money spent in INR for buying the part for the period of one year. To find out the supply risk, a risk assessment mathematical model is developed. It is used for calculating the magnitude associated with the risk factor. It uses a probability index for calculating the risk. Thus Risk Probability Index (RPI) is the rate (or probability) of occurrence multiplied by the impact of the event. quality, delivery performance and financial impact (basic price/piece) are the factors considered for accessing the probability (Table 1). Hence, RPI = Marginal Probability X Financial Impact (FI)

$$RPI = \left[1 - \frac{GoodsAccepted}{Goods\,Received} \times FI\right] + \left[1 - \frac{Goods\,Received}{GoodsScheduled} \times FI\right]$$

Table 1. Product Categorization

Category	RPI	Business Volume
Strategic Items	High	High
Bottleneck Items	High	Low
Leverage Items	Low	High
Routine Items	**Low**	**Low**

6.1.1 Kraljic Purchase Portfolio Matrix

This 2 X 2 matrix classifies the supply base in to 4 categories based on business volume and supply risk. This categorization positions each component in Volvo supply base in to one of the quadrant of Kraljic Matrix based on median of considered attributes.

Fig. 1 represents the proposed Kraljic Matrix. It act as the foundation for choosing distinctive purchasing strategies for each category. Similarly various cost drivers in each category are analyzed. cost of goods, inventory cost, transportation cost, cost of supply chain personnel are the range of elements contributing to total Supply Chain Cost (SCC) or in other words total stocking cost is the summation of material, ordering and holding cost [5]. Hence to reduce total stocking cost, optimization is done on any of these using suitable inventory models for each product category.

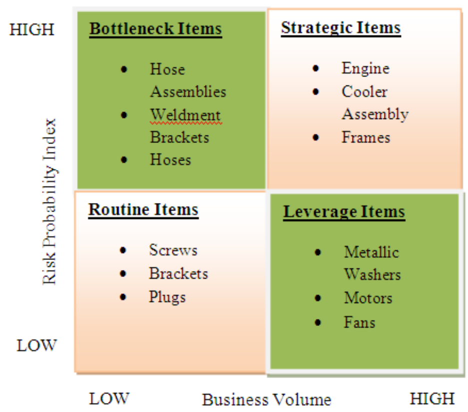

Fig. 1 Proposed Kraljic Matrix

6.2 Inventory models

6.2.1 EOQ Model

EOQ model is used for routine items which have low business impact, risk and strategic potential. These routine items may be important to the business, but it does mean there is little point in developing a deeper relationship with them. For such items customer must obtain the best available deal and these deliverables are met using classic purchasing techniques like executing EOQ models; as it is the most suitable inventory model for low value items that has very low business Impact [4-8]. Parameters considered for EOQ modeling are annual demand of the product (D), fixed cost incurred per order (S), cost per unit (C) and holding cost (h)- 20% of product cost assumed. A Case illustration of washer with steps involved is described.

Step-1 Optimal lot size

$$Q^* = \sqrt{\frac{DhC}{2S}} = \sqrt{\frac{6180 \times 0.2 \times 8.04}{2 \times 100}} = 876.7 \approx 877no$$

Step-2 Optimal ordering frequency

$$n^* = \frac{D}{Q^*} = \frac{6180}{877} = 7.04 \approx 7orders.$$

Step-3 Annual material cost

$$CxD = 6180 \times 8.04 = Rs49687/-$$

Step-4 Annual order cost

$$\left(\frac{D}{Q^*}\right)S = \left(\frac{6180}{877}\right) \times 100 = Rs704/-$$

Step-5 Annual holding cost

$$\left(\frac{Q^*}{2}\right)hC = \left(\frac{877}{2}\right) \times 0.2 \times 8.04 = Rs705\ /-$$

Step-6 Total Annual Cost

= Rs 49687 + Rs 704 + Rs 704.89 = **Rs 51096.98/**

Similarly EOQ model is applied to entire non-critical item category and total SCC is calculated based on it.

6.2.2 Quantity Discount Model

It is used for leverage item which combines a low supplier strategic potential with a high business volume. Such items allow the company to exploit its full purchasing power through purchase strategies. It is suitable where pricing schedule displays EOQ with price decreases as lot size increases. A quantity discount mathematical model helps to choose the most appropriate inventory decisions and pricing decision that gives the best cost advantage. [4-8]. A case is illustrated where supplier B offers a 2% discount on 500-1000 Nos and 5% discount on the order above 1001-2000 Nos. Where D = 33012 no, S = 100 Rs, q0 = 0, q1 = 500, q2 = 1000, C0 = 45.6 Rs, C1 = 43.3 Rs, C2=41.0 Rs.

Step-1 Optimal lot size without any discount i=0

$$Q_i = \sqrt{\frac{2\,\mathrm{D}\,S}{hC_i}} = \quad Q_0 = \sqrt{\frac{2 \times 33012 \times 100}{0.2 \times 45.6}} = 850\,no$$

Step-1.2 Total Annual Cost

$$TC_0 = (C_0 \times D) + \left(\frac{D}{Q_0}\right) \times S + \left(\frac{Q_0}{2}\right) hC_0$$

$$= (45.6 \times 33012) + \left(\frac{33012}{851}\right) \times 100 + \left(\frac{851}{2}\right) \times 0.2 \times 45.6$$

$$= Rs.151310\text{/-}$$

As Q_0, 850 > q_2 = 500 we move on to the case i=1,

Step-2 Optimal lot size with 2% discount For i=1

$$Q_i = \sqrt{\frac{2\,\mathrm{D}\,S}{hC_i}} = \quad Q_1 = \sqrt{\frac{2 \times 33012 \times 100}{0.2 \times 44.68}} = 859\,no$$

Because 500 < 859 < 1000 we set the lot size at Q1 = 859 evaluate the total cost

$$TC_1 = (C_1 \times D) + \left(\frac{D}{Q_1}\right) \times S + \left(\frac{Q_1}{2}\right) hC_1$$

$$= (44.7 \times 33012) + \left(\frac{33012}{859}\right) \times 100 + \left(\frac{859}{2}\right) \times 0.2 \times 44.7$$

$$= Rs.\,1482922/-$$

Step-3 Optimal lot size with 10% discount

$$Q_i = \sqrt{\frac{2\,\mathrm{D}\,S}{hC_i}} = \quad Q_2 = \sqrt{\frac{2 \times 33012 \times 100}{0.2 \times 43.32}} = 873\,no$$

Because 873 < q2 = 1000 set the lot size q2 as 1000 and find out the total annual cost

$$TC_2 = (C_2 \times D) + \left(\frac{D}{Q_2}\right) \times S + \left(\frac{Q_2}{2}\right) hC_2$$

$$= (43.3 \times 33012) + \left(\frac{33012}{1000}\right) \times 100 + \left(\frac{1000}{2}\right) \times 0.2 \times 43.3$$

$$= Rs.\,1437713/-$$

Hence this model helps to identify the cost effective order size with discounts by considering all cost factors.

6.2.3 Complete Aggregation

It is used for bottleneck items that have a low profile with the supplier. They don't possess supplier's strategic attention, as spend on this category is comparatively low. To have significant cost advantage in this category we can aggregate multiple products in a single order [4, 7]. It allows a reduction in lot size for an individual product, as fixed ordering and transportation cost are spread across multiple products. Parameters considered here are annual demand of the product i(Di),order cost incurred each time an order is placed(S), additional order cost incurred if product i is included in the order(s), cost per unit(C), holding cost as a fraction of product cost (20% assumed)(h).27 parts supplied by Supplier X is in bottleneck category is illustrated.

Step – 1 Calculate the combined fixed order cost 'S*' per order

$$S^* = S + \sum_{i=1}^{k} s_i = 2750 + 250 = Rs3000\text{/-}$$

Step – 2 Identify the optimal ordering frequency for 27 parts 'n*' such that it reduces the total annual cost

$$n^* = \sqrt{\frac{\sum_{i=1}^{k} D_i hC_i}{2S^*}} = 12.38$$

It means Optimum ordering Frequency for all the components is 12 times in a year.

Step – 3 Compute optimum order size

$$Q = \frac{D}{n^*} = 12$$

Step – 4 Annual ordering cost

$$S^* \times n^* = 3000 * 12 = Rs36000\text{/-}$$

Step – 5 Annual holding cost

$$\sum_{i=1}^{k} \frac{DihCi}{2n^*} = Rs34076\text{/-}$$

Step – 6 Total annual cost

$$\sum_{i=1}^{k} \left[\frac{DihCi}{2n^*}\right] + S^* \times n^* = 36000 + 34076 = Rs70076\text{/-}$$

6.2.4 Tailored Aggregation

It is used for strategic items that have greatest potential in organization's business. Such category items have suppliers to whom organization matters [4, 7]. Complete aggregation aggregates all the products from the supplier irrespective of demand. Here low demand products are aggregated with high demanded products in every order. Thus complete aggregation results in high cost if the product specific order cost for low demand product is large. Tailored Aggregation method is used in such situation. In this model low demand products are ordered less frequently than high demand products and reduce product specific order cost associated with low demand products [4, 7]. A case is illustrated by sub setting the products of Supplier Y on each truck. Supplier Y is having 69 parts whose product specific fixed cost is large fraction of joint fixed cost.

Step-1 Identify the most frequently ordered part

$$\overline{n} = \sqrt{\frac{hC_i D_i}{2(S + s_i)}} = \sqrt{\frac{0.2 \times 65524 \times 497}{2(2750 + 10)}} = 34$$

The Part with Highest ordering frequency (26) is identified

Step-2 Identify the frequency with which other components are included with most frequently ordered parts

$$\overline{\overline{n}} = \sqrt{\frac{hC_iD_i}{2s_i}}$$

$$\overline{\overline{n}} = \sqrt{\frac{hC_2D_2}{2s_2}} = \sqrt{\frac{0.2 \times 44531 \times 34}{2 \times 10}} = 88$$

$$\overline{m_i} = \frac{\overline{n_i}}{\overline{\overline{n_i}}} = \frac{\overline{n_2}}{\overline{\overline{n_2}}} = \frac{34}{88} = 0.38 \cong 1No$$

Step-3 Recalculate ordering frequency of most frequently ordered product

$$n = \sqrt{\frac{\sum_{i=1}^{k} hC_i m_i D_i}{2(S + \sum \frac{s_i}{m_i})}} = 32$$

Step-4 Evaluate the frequency of all components

$$n_i = \frac{n}{m_i} \qquad n_2 = \frac{n}{m_2} = \frac{32}{1} = 32$$

Similarly for all the components optimum ordering frequency is calculated and a set of components are ordered at a common frequency to exploit cost advantage.

Step-5 Compute the optimum order size for all components

$$Q = \frac{D}{n_i} = \frac{D}{n_1} = \frac{436}{32} = 14\,No$$

Step-6 Finally the total annual cost is calculated

$$\sum_{i=1}^{k} \frac{DihCi}{2n*} + nS + \sum n_i s_i$$

$$= 5374890Rs + 84000Rs + 193610Rs = Rs852500/-$$

7. RESULTS AND DISCUSSION

Proposed framework results a well-organized purchase portfolio matrix that categorizes each part in Volvo supply base (2610 parts) in to 875 strategic items, 400 bottleneck items, 430 leverage items and 905 routine items. This framework also includes differential cost effective purchase strategies for suppliers in each category as described in Fig. 2.

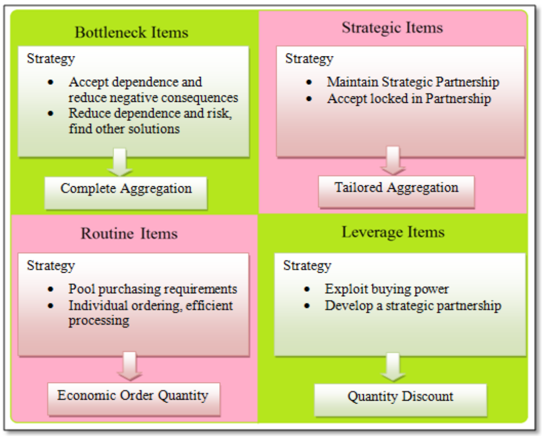

Fig. 2 Proposed Kraljic Portfolio Matrix

Current scenario in part categorization (ABC analysis) concentrates only on the financial value of the items and ignores the risk associated with supply, including quality and delivery related risk. It is just a classification tool, not a portfolio model; hence it does not provide any differential purchase and supply strategies. Whereas proposed matrix aids in discussing, visualizing and illustating the possibilities of the development of differentiated purchasing strategies.It also minimizes supply vulnerability and make the most of potential buying power using the combination of two dimenssions [7]. Estimated cost reduction from EOQ model is 3%,quantity discount model 3%, complete aggregation 4% and tailored aggregation 6%.This results were obtained by comparing the data with previous year data. Model validation is done by implementing pilot projects.

8. CONCLUSION & RECOMMENDATION

Proposed Kraljic matrix and inventory models result an overall costs savings of 3% for the company (Savings calculated based on annual supply chain cost). This percentage accounts to an estimated annual savings of Rs. 12.5 Lakhs.

A supplier risk assessment model is recommended for future with additional calculation attributes like Relationship with supplier, human resource, supply chain disruption and financial health. tailored aggregation and complete aggregation model also can be extended to all the suppliers in respective category.

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