IRJEAS
NURTURING RESEARCH
INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING & APPLIED SCIENCES
ISSN: 2322-0821(0) VOLUME 7 ISSUE 1
ISSN: 2394-9910(P) Jan 2019 - Mar 2019
www.irjeas.org

REDUCTION OF COST AND TIME OF A PRODUCT USING SUPPLY CHAIN MANAGEMENT

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ABSTRACT- Presently, the efficient supply chain is one of the vital issues in the industrial management perspective. In today's world that is confronted with rapid technological changes and high competitiveness, companies are more successful that respond to the customers' needs effectively, regarding the existing opportunities and threats. As a supply chain comprises of various organizations, it can assure customers needs, only when the whole of its parties become incorporated and coordinated. The results showed that one of the important objectives in a supply chain is coordinating all of its parties, so such coordination mechanisms that provide coordination between various members of a supply chain, have more importance. In this thesis comparison is being done between various cases which arise between supplier and producer when they are indulged in exchange of services and also compared the results with and without supply chain management. Especially the coordination problem between suppliers and producer is discussed where supplier play more important role. And this thesis also shows how to reduce the cost and time of a product by using supply chain management.

KEYWORDS - SCM- Supply Chain Management, Cost of Sales, Cost of Service, Customer Service, Customer Service Representative, Cost-to-serve, Customer Experience, ERP-Enterprise Resource Planning, Purchase Order, Proof of Delivery, Quality Control, Quality Management System, Worst Case, Best Case

I. INTRODUCTION

Coming years has experienced a rising globalization of markets and concentrations of companies on their main capabilities on resulting in increasing supply chain coordination in supply chain management. Supply chain management can be defined as combined study to control the total flows of entire business process. A supply chain is made up of trading partners that are interrelated with financial, information and product/service flows. Proper control and management of the flow needs relationship b/w supply partner & delivery partner to provide a profit or every supply chain member with the objective of maximizing customer. As supply chain members are commonly separate and self-regulating economic entities, an important factor in Supply chain management is to make ways which can line up their objectives and improve the performance through controlling the activities so when the chain is completely optimized that all of its parties become coordinated.

What is Supply Chain?

A supply chain is essentially a network of suppliers and customers in which every customer is in turn a supplier to the next organization until a finished product reaches the ultimate end customer. It consists of all parties involved directly or indirectly in fulfilling a customer's requests. A typical supply chain may involve a variety of stages such as component/ raw material supplier, retailers, manufacturers, customer, whole sellers.

Supply chain management (SCM) is based on 5 basic elements called pillars of SCM which are made in order to order the philosophy, outdoor noncore outsourcing, multi tier supply partnership, multi party net logistics and highly sophisticated IT system.

Flows in supply chain:

There are typically three types of flows in a supply chain:

Information flow- The flow of information plays a significant role in SCM. The flow of information occurs in both direction for activation and improvement of the total supply chain system.

Material flow- The flow of material is always in a forward direction ensuring better customer service, supply value, greater market dominance and higher market share.

Money flow- The flow of money in SCM has commercial significance which lfows in a backward direction to keep the business system active.

Supply Networks: In difference to a value chain, a supply network is joined by both vertical and horizontal alignments. A typical supply network is shown in fig 1. There are many suppliers, manufacturers, distributors, & retailers at different levels in the network. Other than these traditional players, non-traditional mediators play a sole role in the partnership. Fig. 1 displays 2 mediators, Industry Process Hub and Logistics Net Market. Internet-based technologies are used for supply network to coordinate and incorporate the collaborative processes from multiple trading partners, i.e. e-supply networks. Definitely, sharing of information enables the functioning of e-supply networks.

II. LITERATURE REVIEW

As it is said before, a supply chain is comprised of units (such as supplier, manufacturer and customer) and processes that flow between these units and effective coordination between processes and units leads to increasing efficiency and productivity in a supply chain.

Akhavan, R. M., & Beckmann,**M. 2017**, a configuration of sustainable sourcing and supply management strategies. The integration of sustainability into the supply chain is an area of growing research interest. Accordingly, sustainability should be viewed as a holistic and interdisciplinary concept that encompasses environmental, economic, and social issues, as a minimum, at different stages in the supply chain(s). Therefore, it is becoming an essential requirement to assess sustainability in the supply chain context by developing appropriate tools to monitor a supply chain's performance towards sustainability. [1]

de Camargo Fi orini, P., & Jabbour, C. J. C. 2017. Information systems and sustainable supply chain management towards a more sustainable society Global supply chains of food products has different economic and socio cultural conditions from developing countries to end consumers 'industrialized markets(Gold , Kunz & Reiner 2016).Challenges such as population growth showed a crucial demand to destruct the present food supply chains(Chkanikova 2015)[2].

Singh, A. & Trivedi, A. 2016. Area of green supply chain management has always been the interest among the researchers hence there was a need for achieving sustainability through it. It reveals the existence of behavioural issues and its need for adoption such as human resource management.

Zaccour 2013 [6] also express that Uncoordinated decision-making creates inefficiency with the channel members' profits significantly lower for each channel member independently and collectively than what could be achieved with coordination. And finally, **Cachon** [22], **Jeuland & Shugan** [48] & **McDermott, Franzak & Little** [43] show that more inter organizational coordination helps in lowering the cost and higher profit.

Ahi, P., & Searcy, C. 2015 This study identifies and analyses of the metrics published for Green supply chain management of its literature and sustainable supply chain management.

Sahin, F. and E.P. Robinson, **2011**, Information Sharing and Coordination in Make-to-Order Supply Chains. A coordination mechanism is a specific tool made for addressing a particular coordination problem. Classifying coordination mechanisms as tools requires understanding the specific coordination problem and its proposed solution. In an attempt to make progress in this area, Sahin and Robinson [9] proposed price, non-price, buy-back and returns policies, quantity flexibility and allocation rules as major categories of coordination mechanisms. Fugate et al have divided their classification into 3 categories: price, non-price & flow coordination mechanisms.

Coordination & cooperation issues b/w manufacturers and retailers in decentralized distribution systems have succeeded due to the increasing stress on the significance of effective supply chain management. The inspiration for giving quantity discounts could be either price prejudice or coordinating order quantities.

Of course, there are more price coordination mechanisms in addition to quantity discount, but our focus is on another mechanisms. It include quantity flexibility contracts, share policy; promotional allowances, supportive advertising. Quantity flexibility contracts and allocation rules are the most frequently discussed forms of non-price coordination. Quantity flexibility contracts let the buyer to buy a quantity that is different from the estimate previous quantity. Sellers often face huge demand from buyers that cannot be fulfilled with current supplies. In these instances, the supplier makes rules to distribute the limited capacity between the buyers. Buyers, realizing the insufficiency of capacity, deform their orders to get what they want. A diversity of distribution rules has been searched to diminish the adversarial impact of demand distortion as the result of capacity scarcity.

Sahin, F. and E.P. Robinson, **2011** Flow coordination mechanisms are designed to handle product and information flows in supply chains. Sahn and Robinsn [9] provide a widespread literature review on product flow coordination and information sharing in supply chains, to classify the literature based on the degree of information sharing and coordination.

Vendor Managed Inventory (VMI), Quick Response (QR), Collaborative Planning, Forecasting and Replenishment (CPFR), Efficient Consumer Response (ECR) and postponement are among some of the initiatives used for product and information flows. VMI allows the supplier to watch the retailer's inventory levels and make intervallic replenishment decisions which involves order quantities, delivery mode & the replenishment times.

QR focus on to build a joint partnership between manufacturers and retailers by limiting the manufacturer's replenishment lead-time and giving the retailer a chance to place a small order at the start of the season observe demand and choose an optimal replenishment quantity to maximize profits based on the demand.

There are different functions to look after different activities in a supply chain. For example, ordering activities need complete coordination. In fact, inventory management at a single location consists of two fundamental decisions: how much to order and when to order. Inventory management at a supply chain, has replenishment decisions at different firms. There are three dimensions on which the operational activities of a supply chain can be coordinated in order to maximize system profits or minimize system costs.

First, order quantities that optimize individual performance are often not able to optimize system performance. Second, orders can be synchronized to reduce system inventory. Finally, accurate, timely and easily accessible information can improve decisions.

In SCM, a supplier is able to match inventory supply with demand when the information is on hand on the buyer's inventory status.

Recent studies have reported significant cost savings from information sharing. However, it is better said that the benefit of information depends on how it is used. Although this issue is obvious, it raises an important challenge: optimal policies may change with the information structure. The issue is obviously no longer whether collaboration is beneficial.

Rather, it is how to achieve such benefits. When the whole supply chain is in the control of a solo decision maker, the system is referred to as a centralized system. But, when the supply chain members are part and independent economic entities, they will work independently to make use of their individual benefits. In this case, an action plan has to be complemented with an incentive scheme that can allocate the benefits of coordination among the supply chain members so as to align their objectives of coordination. This system is known as a decentralized supply chain system.

III. METHODOLOGY

According to this new coordination mechanism happens to deal with such evolutions, mainly for farmers, & between farmer's organizations & food industries. These coordination mechanisms are typically based on contractual arrangements with different specifications derived from a give and take process. Strategies and nature of the stakeholder decides the type of coordination. In fact the new context leads a rapid evolution at the production level to improve the quality and stability in order to comply with the demand of food industries and supermarkets. Small farmers face vast challenges to profit from opportunities derived from this new market conditions and to keep away from a barring process. Smallholders should develop new capability and skills, at farm level and at farmers' organization level so as to access markets.

Value of supplier's capacity information

In traditional supply chain models it's usually thought that full information is available to all parties who are involved. As of this seems sensible, there are cases where chain members are independent agents and own different levels of information.

In many industries, it is infeasible for the supplier to build capacity that is sufficient to cover all possible demands of the downstream members of the supply chain, especially when demand is highly uncertain and capacity expansion is costly or infeasible in the short or medium term. Hence, there is always a possibility that orders will exceed capacity.

In this context, let D be the demand faced by a producer in a supply chain for a finished product, this finished product is assembled using a special component or primary product, the primary product is being ordered in quantity q from the supplier assuming producer requires one unit of component to produce for one unit of finished product.

This setting, where producer optimizes its own objective function, is known as 'the rationing game'. In the rationing game, it is usually assumed that producer know all pertinent information, including information about the supplier's capacity.

Specifically, we analyze a two-echelon supply chain with one producer and a single supplier in a single-period model where the supplier has limited capacity to serve the producer. At the beginning of the period, producer simultaneously places his order and pays a down payment for the procurement cost for their entire order.

Without loss of generality, we say that the producer pay for the entire procurement cost of his order the orders are not satisfied immediately as the supplier has a production and transportation lead time.

If the orders cannot be delivered in full, the supplier refunds the procurement cost for the undelivered portion of the orders. It should be noted that the lead time we consider merely reflects the time between the advance payment and the capacity allocation.

That is, the lead time is not long enough to cover more than one decision epoch or resolution of capacity uncertainty, but it is long enough so that tying up a large amount of cash may have financial consequences.

Supplier selection and purchase problem:

In the real production process, some members in the supply chain system infrequently cannot finish their production task because of defects involving the production of components.

Uncertain market conditions make firms to reduce cost so that they can compete with other firms. Best suppliers are chosen in order to achieve an upper hand on the market. Selecting a supplier is a very crucial point for a company or a firm in today's competitive world. If the suppliers are chosen incorrectly then the firm may face problems in operation and accounts. Proper supply chain design aims towards an effective management of supply chain. This type of problem is an important problem because it is related to strategic operations in supply chain management system. The main challenge faced by the firm is to identify the location, capacity, number, etc so that cost incurred in these can be reduced and profit after tax can be increased of the supply chain.

Selection of set of suppliers is also important in the supply chain so as to identify the no. of contracts. In practice, it is necessary to consider suppliers in the comprehensive design of a supply chain.

Chain system is a complex network which needs cooperation in all the professional levels that is upstream, midstream, and downstream along the line previous one of each echelon is the partner, so the selection of partners is a very important topic for discussion in supply chain management. Every position has a partner so the selection of correct partner is necessary and is a valuable topic in supply chain management.

The supplier selection and purchase problem are governed by two main decisions: which supplier should be selected and how much should be ordered from the selected supplier.

International Research Journal of Engineering & Applied Sciences, IRJEAS
www.irjeas.org, ISSN(O): 2322-0821, ISSN(P): 2394-9910, Volume 7 Issue 1, Jan 2019-Mar 2019, Page 12-18

The supplier selection and purchase problem have attracted the attention of a number of researchers who have proposed various models and solutions. Burke et al. proposed an approach in which set of suppliers are selected and given a limitation on min. Order amount. They should supply to the buyers who are facing an uncertain supply demand. And approach included product prices, supplier costs, supplier capacities, historical supplier reliabilities, and firm-specific inventory costs.

Mathematical formulation:

Quantity Q depends on following parameters:-

(1) Available capacity "αc"

(2) Extra capacity "Δ"

(3) Order quantity "q"

Assumption made: - The capacity consumption rate equals unity.

Therefore the delivery quantity is restricted by the following capacity constraints: $Q \leq \alpha c + \Delta$

Also the supplier does not deliver more than what is ordered hence the delivery quantity Q equals the minimum of the order quantity q and maximum deliverable quantity $\alpha c + \Delta$ based on the available capacity αc.

$Q = \min\{\alpha c + \Delta, q\}$-------------------------(1)

The delivery quantity depends on the extra capacity as well as on the available normal capacity αc of the supplier and might not match the ordered amount at the delivery date.

Worst case /best case analysis:

Different ways of linking the models taking into account first the worst case scenario in which producer and supplier optimize their purpose and work without sharing any information other than the quantity of order.

After that the comparison of the worst and best case is done in which there is only 1 decision making person who takes the required decision that capitulates minimum total cost that will incur in the whole supply chain.

Today's rapidly changing conditions force firms to concentrate on reducing costs to increase their competence. Firms must choose the best supplier(s) to gain a competitive advantage over other companies. Selection of suppliers in the supply chain system is an important matter for an enterprise in today's competitively intensive commercial environment. The challenge is to determine the number, location, capacity and type of production producers and distribution centres (DCs) to use so as to minimize the total cost, or to maximize the after-tax profit, of the supply chain. Producer faces a known demand for a finished product, this finished product is assembled using a special component or primary product, the primary product is being ordered in quantity from the supplier assuming producer requires one unit of component to produce for one unit of finished product.

Therefore to fulfil known demand for the finished product we require units of primary product in total on the other hand the normal capacity (long term) of the supplier is denoted by.

There is a major difference between with and without supply chain coordination information in all costs and benefits. We got more benefits in lower investment using supply chain management.

External demand D = 100 units

The price changed by the supplier to the producer per each unit of the supply product C_p= Rs. 10

The producer must store any unsold supply product i.e. holding cost c_h^p =Rs. 3 per unit

The shortage cost C_s = Rs.60 per unit

The normal capacity of the supplier C = 100 unit

α is the uniformly distributed over the range [0.7,1]

Cost for building up extra capacity i.e. to increase the capacity by one unit costs the supplier

C_e = Rs. 3/-

Holding cost for the supplier c_h^s = Rs. 1 /- per unit

In case the order coincides with the external demand, the supplier can meet the without building up extra capacity only in case of

α = 1.

The producer order the quantity order quantity q= 100 units

Without supply chain

The optimal capacity decision of the supplier in a worst case scenario =22 units

The cost for the producer= Rs. 1099.17

The profit for the supplier = Rs. 901.82

The optimal capacity decision in the best case scenario:

= 24 units

The minimal total cost

= Rs.150

With supply chain

The optimal capacity decision of the supplier in a worst case scenario

$\Delta_{optimal}^{worst}$ = D – C $\frac{\mathrm{Ce}(\overline{\alpha}-\underline{\alpha})+\overline{\alpha}\mathrm{Ch}+\mathrm{Cp}\underline{\alpha}}{\mathrm{Ch}+\mathrm{Cp}}$ (from equation 8)

$= 100 - \frac{100\,[\,(3)(1-1.07)+1(1)+10\,(0.7)]}{1+100}$

= 19.09 units

The expected total cost for the entire supply chain E [C_{joint} (q,Δ_{opt}^{worst})] is

= $C_s \int_0^{\frac{(D-\Delta)}{c}} (D-(\alpha c+\Delta_{optimal}^{worst})f(\alpha)\, d(\alpha)$ + min (c_h^p, c_h^s) $\int_{\frac{(D-\Delta)}{c}}^{1} (\alpha c+\Delta_{optimal}^{worst}$ - D)f(α)d(α) + $C_e \Delta_{optimal}^{worst}$ (from equation 10)

= 60 $\int_0^{(100-19.09)/100} \{100-(1(100)+19.09) f(\alpha) d\alpha$ + min (3,1) $\int_{0.8}^{1} \{1(100)+19.09-100)\} f(\alpha) d\alpha$ + 3(19.09)

= Rs. 182.35

The expected cost for the producer

$E(C_{pc})$ = 60 $\int_0^{\min\{0.8,0.8\}} 100-\{1(100)+19.09\} f(\alpha) d\alpha$ + 60(100-100) $\int_{0.8}^{1} f(\alpha) d\alpha 1$ $_{\{D>q\}}$ + 3 $\int_{0.8}^{0.8} \{1(100)+$ $19.01-100\}$ f(α)dα + 3(100-100)$0.81 f\alpha d\alpha 1$ $_{(D\leq q)}$ + 10 $\int_0^{0.8} (1(100)+19.09) f(\alpha) d\alpha$ + 10(100)$\int_{x(q,\Delta)}^{1} f(\alpha) d\alpha$

(from equation 3)

Where $y(\Delta) = \frac{D-\Delta}{c} = \frac{100-19.09}{100} = 0.8$

$x(q,\Delta) = \frac{q-\Delta}{c} = \frac{100-19.09}{100} = 0.8$

= Rs. 1099.17

The expected profit for the supplier

$E(C_{ps}) = C_p\, {}_0\!\int^{x(q,\Delta)} (\alpha c+\Delta) f(\alpha) d\alpha + C_p q\, {}_{x(q,\Delta)}\!\int^{1} f(\alpha) d\alpha - C_h\, {}_{x(q,\Delta)}\!\int^{1} (\alpha c+\Delta-q) f(\alpha) d\alpha - C_e \Delta$

(from equation 5)

$= 10 \, {}_0\int^{0.8}(1.100+19.09)f(\alpha)d\alpha + 10(100) \, {}_{0.8}\int^{1}f(\alpha)d\alpha - 1 \, {}_{0.8}\int^{1} (1(100)+19.09-100)f(\alpha)d\alpha - 3\,(19.09)$

= Rs.916.82

The optimal capacity decision in the best case scenario:

$$\Delta^{joint}_{optionl} = \Delta - C \frac{Ce(\overline{\alpha} - \underline{\alpha}) + \overline{\alpha} \min [c^p_h, c^s_h] + Cs\underline{\alpha}}{\min [c^p_h, c^s_h] + Cs}$$

(from equation 12)

= 28.03 units

The minimal expected total cost $E(c^{joint}_{optimal}, \Delta^{joint}_{optimal})$

$$= C_s \int_0^{(D-\Delta^j_o)} D - (\alpha c + \Delta^{joint}_{optimal})f(\alpha)d\alpha + \min\{c^p_h, c^s_h\} \int_{(D-\Delta^{joint}_{optimal})/C}^{1} (\alpha C + \Delta^{joint}_{optimal} - D)f(\alpha)d\alpha + C_e \Delta^{joint}_{optimal}$$

k	$E(C_{ps})$	$E(C_{pc})$	$E(C_{joint})$
0	979.12	1080.18	101.06
1	971.22	1072.28	101.06
2	964.29	1065.35	101.06
5	948.71	1094.77	101.06
10	932.64	1033.70	101.06

(from equation 10)

= Rs. 101.06

IV. RESULTS AND DISCUSSION

1. Worst Case Vs Best Case

Table 1: Worst Case & Best Case Comparative Analysis

	Q	$\Delta^{worst/best}_{optimal}$	$E(C_{pc})$	$E(C_{ps})$	$E(C_{joint})$
Worst case	100	19.09	1099.17	916.82	182.35
Best case	_	28.03	_	_	101.06

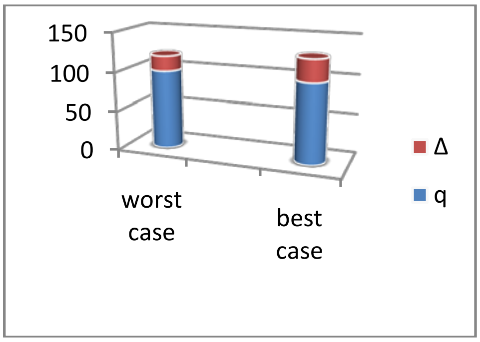

Figure 1 Graphical comparison between Demand & Extra capacity

This graph clearly shows that for the same order quantity we achieve more extra capacity in best case as compared to worst case.

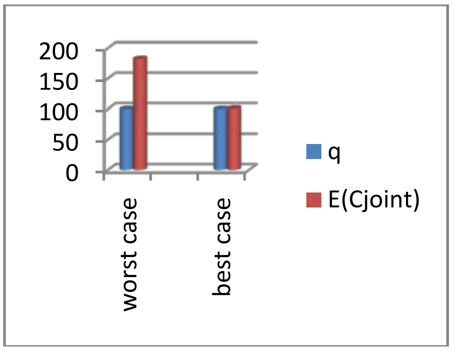

Figure 2 Graphical Comparisons between Demand & the Expected Total Cost for the Entire Supply Chain

The graph shows the result of the considered numerical example in which the total expected cost of the entire supply chain in best case is 55% less than in the worst case.

(2) Comparison Showing the Mutual Dependence of Penalty Cost and the expected costs for Some Specific Discrete Value:

Table 2: mutual dependence of $E(C_{ps})$, $E(C_{pc})$, $E(C_{joint})$ & penalty cost

We observe that by increasing the penalty cost the expected total cost of the producer and the expected profit of the supplier decreases but joint optimal cost remains constant.

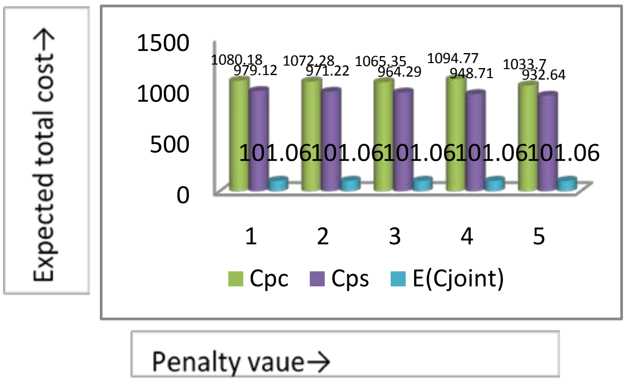

Figure 3 Graphical Comparison between penalty cost and expected profit for the supplier, expected total cost for the producer, the minimal expected total cost for both producer & supplier

The graphs give the study of the comparison between K, $E(C_{ps})$, $E(C_{pc})$, $E(C_{joint})$ that with the increase in the penalty cost the expected total cost for the producer also the expected profit for the supplier decreases but on the other hand the minimal expected total cost for both producer & supplier remains constant .

(3) Comparison Showing the Mutual Dependency between Order Quantity and bonus for Some Specific Discrete Value:

Table 3: Mutual Dependency between Order Quantity and bonus

q	A	$E(C_{ps})$	$E(C_{pc})$	$E(C_{joint})$

100	98.33	994.04	1095.10	101.06
101	87.33	990.95	1092.01	101.06
102	76.33	988.22	1089.28	101.06
103	65.33	985.86	1086.92	101.06
108	10.33	979.55	1080.61	101.06

Sr. no	**Objectives**	**Without supply chain**	**With supply chain**
1.	**No. of units in Wor case**	**19.09 units**	**22 units**
2.	**No. of units in Best ca**	**24 units**	**28.03 units**
3.	**Cost for Producer**	**Rs. 1099.17**	**Rs 1099.17**
4.	**Profit for Supplier**	**Rs. 901.82**	**Rs 916.82**
5.	**Minimal total cost**	**Rs. 150.23**	**Rs 101.06**

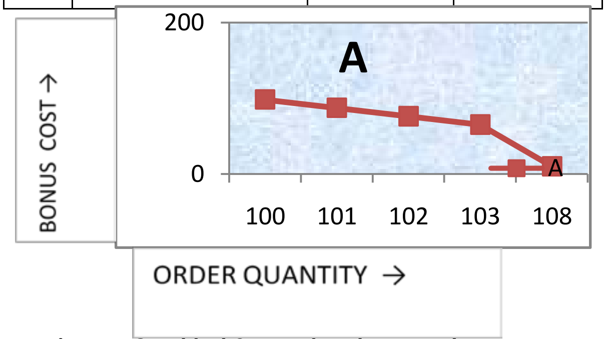

Figure 4 Graphical Comparison between bonus cost and demand

The graphs give the analysis of the comparison between A & q that with the increase in the demand values the bonus cost decreases.

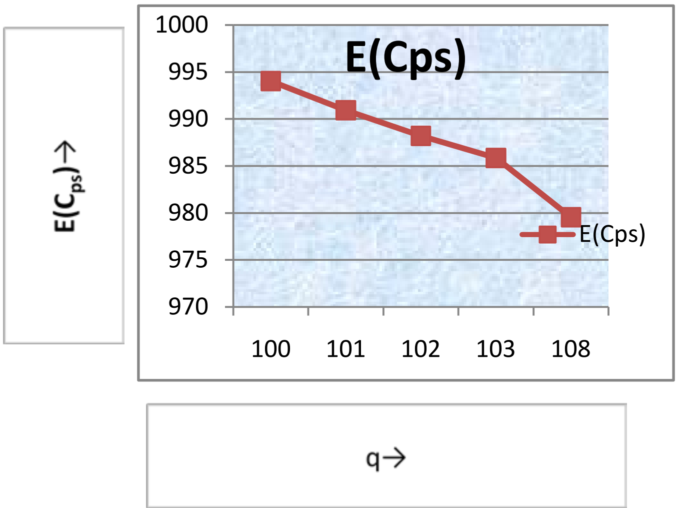

Figure: 5 Graphical Comparison between order quantity and expected profit for the supplier

The graphs give the analysis of the comparison between q & $E(C_{ps})$ that with the increase in the order quantity (decreasing the bonus, respectively) expected profit for the supplier decreases.

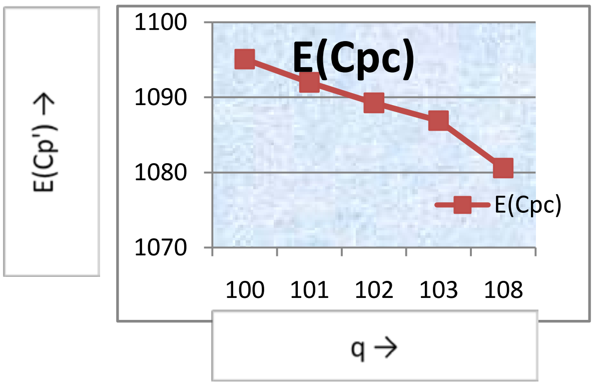

Figure: 6 Graphical Comparison between order quantity and expected total cost for the producer

The graphs give the analysis of the comparison between q & $E(C_{pc})$ that with the increase in the order quantity (decreasing the bonus, respectively) expected total cost for the producer decreases.

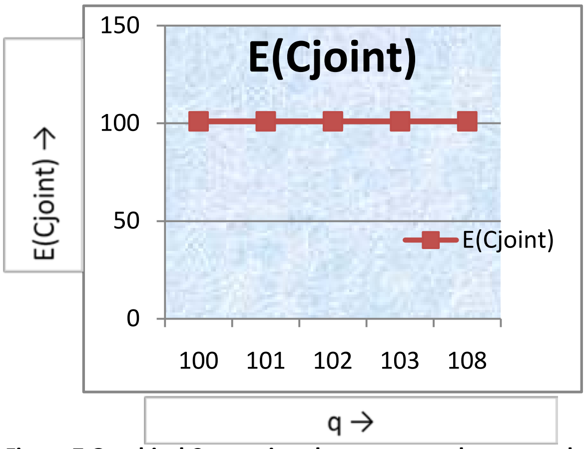

Figure 7 Graphical Comparison between penalty cost and the minimal expected total cost for both producer & supplier

The graphs give the analysis of the comparison between q & E (C_{joint}) that with the increase in the order quantity the minimal expected total cost for both producer & supplier remains constant.

V. CONCLUSION

As the expected total cost of the entire supply chain using the coordination mechanism is equal to the expected total cost of the best case the gap between the worst and the best case shows the cost savings which can be achieved through the considered coordination mechanism. A point to be noted is that in the existing supply chain partnership the expected total cost will always be situated between the best and worst case.

The figure shows that in case of the maximal bonus value A_{max} the producer must bear almost the whole expected total cost of the supply chain while in the case of maximal penalty cost C_{hmax} the supplier has to bear the expected total alone.

Assuming the producer orders precisely what he requires, he has to offer a bonus payment at a value of A_{max} or change a penalty cost at the value of C_{hmax} per unit in order to minimize the overall expected total cost of the entire supply chain.

The case study shows on one hand which substantial cost savings might be achieved in practice by implementing the developed coordination mechanism. The result which occurred while comparing with or without supply chain management gave better results from general point of view of SCM.

Since the cost savings refer to the overall cost of the entire supply chain. On the other hand, the study shows that the coordination mechanism is flexible enough to enable the different allocations of these overall costs thus allowing both parties in an existing supply chain partnership to make a profit.

VI. FUTURE WORK

Since the thesis primarily focused on finding general analytical results, the supply chain was described on a highly aggregated level and the results are based on assumptions which might not completely hold in practice. But it can be shown that the coordination mechanism is also applicable to realistic situation where the parties of the supply chain have some private information.

Another important extension to consider is the coordination of more than two parties in a supply chain. In particular it would be worth pursuing whether the concept of combining an execution-oriented decision with a control-oriented decision leads to similar flexible cost allocations for these observed multiple decisions.

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