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Role of Supply Chain Coordination in OM: Select Experiences from India

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Abstract
Supply Chain (SC) is concerned with the integration (combining into harmony) of processes between various different but dependent SC entities to manage seamless flow of resources and information. Supply Chain Coordination (SCC) helps in managing dependencies, which seems to be often conflicting among various entities, especially in developing countries. It can be a challenging task for teaching community to tackle the problem at the activity and interface level with the existing analytical models, which are highly fragmented, myopic and disjointed. . The utility of these models seem to be limited from practitioners' point of view, for example, a much celebrated OM model newsboy problem! In this paper, a pedagogical framework using heuristics and simulation is proposed with managerial implications and insights, which can act as a learning device-cum- decision support to the practitioners, thereby, bridging gap between "model" and "reality". The framework may also link coordination mechanisms and "performance".

Key words: Newsboy model, supply chain coordination, heuristics, Practice of OM

Introduction

Supply chain management (SCM) as a focus subject has received more and more attention and interest from both academia and industry. Various themes in SC, such as purchasing, sourcing, inventory, distribution, and transportation have been areas of concerns within traditional OM. But with tremendous use of IT, information systems and demanding expectations from variety of quarters, SCM has become more and more relevant and thematic. According to Lee and Ng (1997), distinction between so-called SCM and OM lies in two dimensions of integration and coordination: organizational integration (both vertically and horizontally, enabled by IT) and flow (material/money/Information) coordination. The flows of products, services and information between firms need to be organized and managed as if they belong to one entity. This entity is not the firm but the supply chain or supply network.

The operations management (OM) task is primarily defined by the pragmatic challenges of implementation. The day-to-day production of goods or delivery of services requires

practitioners to continually make decisions and implement changes. OM is supposed to concentrate on various managerial functions so as to cater to the real needs and aspirations of practitioners. However, it appears that the theoretical ideas/concepts of the OM field are fragmented, though it has borrowed many concepts from Operations Research/Management Science. SCM provides an opportunity to integrate and coordinate these 'fragmented' islands to make the flows of products and information between firms a strategic matter.

SCM can also be viewed as a holistic relationship management concept. The supply chain has its own justification outside the interests of the individual firm. This is a radical subordination of individual firms' role in creating customer value and competing in the marketplace. Instead, supply chains compete against supply chains. Integration is a key result area in SCM that transfers decision power to the management of the supply chain rather than to the individual firms constituting the supply chain (Storey et al., 2006).

Supply Chain Management in India

Supply chain management is currently perceived as an effective means to achieving successful international competitiveness. Interest in supply chain management has been motivated by perceived benefits of collaborative relationships. The management concept has also caught attention in India. Sahay et al.(2006) have discussed various factors for India's competitiveness in the domain of SCM.

It seems that Indian organizations have realized the inappropriateness of competing effectively in isolation from their suppliers and other associates of the supply chain. Today, the Indian industry spends an exceptionally high amount of 12 to 15 per cent of its revenue on logistics. Close to 22 per cent of the aggregate sales in the industrial sector, amounting to over US$25 billion , is tied up in inventories in the supply chain network countrywide (Sahay et al., 2004). Indian

organizations have moved from physical distribution to logistics management. They are now on course to graduating to supply chain management, the preferred name for actualization of "integrated logistics" (Prem Vrat, 1998b). More than 15 years have passed since India economy has taken the path to globalization and liberalization and now India is one of the world's fastest-growing economies with diverse markets. . Managing supply chain in such a vast country is most challenging for any organization because of business practices, government regulations, technology capability, transportation infrastructure, etc. The opening up of the Indian economy has thrown many challenges to Indian industry. To take the challenges of liberalization and globalization, the thrust of the industry is moving towards improving quality, cost and response time. To attain this, industry is concentrating on improving their manufacturing competence by better management of technology, supply chains and other resources (Prem Vrat, 1998a). Because of global competitive pressures, manufacturing organizations are finding it worthwhile to develop manufacturing base, in India, especially for manufacturing of automobile and electronic components. This has resulted in growing awareness about OM in the small and medium sectors. This is supplemented by the fast growth of IT, which has made multi-location plants feasible. Recent developments in countries like Japan, Korea, Singapore, etc., seem to have influenced Indian industry to maintain competitive edge on a global scale. The techniques and practices in SCM like quality, information technology, joint decision-making adopted by the industries in these countries in developing their supply chains are being actively pursued by the practitioners in India.

Emerging enablers for enhancing Material, Financial and Information Flows

As stated earlier, the material, money and information flows are being considerably impacted by a variety of enabling developments in India. These are summarized in Table 1.

Table 1: Improvement in Various Flows in Indian Context*

Flow	Enabled by	Evidence
Material Flow	Improvement in infrastructure (road, railways, air)	Golden quadrilateral project initiated liking metro cities Improvement in performance of Indian Railways Container services readily available Many private airlines introduced
	Growth in courier/cargo	Increase in private operators (FedEx, TNT etc.) and volume handled by them
	Warehousing	Concept of 3-rd party warehousing introduced and growth in number of Warehousing companies
Money Flow	Automation in banking	Improved services Easy accessibility to capital Many private lending agencies
Information Flow	Improvement in Communication Use of ERP systems and state-of-the-art softwares in supply chain	Improved connectivity and Mobile penetration density Improved information flow between suppliers and organizations Growing awareness about internet and web based services

*Source: Sahay *et al.* (2004) and Mitra (2007)

All the above development has corroborated the fact that Indian companies are now sensitized towards SC orientation. Generally, in SCM, there are various stages of maturity. SCM initiatives can be visualized across various dimensions: Cooperation, coordination, collaboration and integration. In our view currently, there is an emergent need to view coordination as a priority area. This is due to the following facts:

a) Indian companies are still in an environment, which is guided by tax regime (various types of tax structure exist: central verses state, excise, sales etc.)
b) The IT is emerging as a powerful enabler for coordination of various activities across the SC.
c) Indian mindset is still in the paperwork or bureaucratic set up where the buyer and supplier are more comfortable with contractual arrangements. A strong focus on documentation (perhaps guided by ISO9000) still prevails.

On this background, it is necessary to have a serious look at the coordination problem.

Research Opportunities for Coordination in Supply Chain

A typical supply chain (SC) consists of different functions: logistics, inventory, purchasing and procurement, production planning, intra-and inter-organizational relationships and performance

measures. SCs are generally complex with activities spread over multiple functions or organizations over lengthy time horizons. The dynamic structure of the supply chain poses many interesting challenges for effective system coordination. Supply chain members cannot compete as independent members. The product used by the end customer passes through a number of entities contributed in the value addition of the product before consumption. To improve the overall performance of supply chain, the members of supply chain may behave as a part of a unified system and coordinate with each other. Thus "coordination" comes into focus. The primary reasons for coordination is that departments and work groups are interdependent-they depend on one another for information and resources to perform their respective activities efficiently and effectively. These could be sequentially interdependent or reciprocally interdependent.

There are reported attempts in the literature regarding coordination of different functions of the supply chain; however, the study of coordinating functions in isolation may not help to coordinate the whole supply chain. Though, the need for coordination is realized, a little effort has been reported in the literature to develop a holistic view of coordination. There seems to be no unique definition of SCC. Different coordination models have been proposed considering isolated activities or different functions of supply chain. There is no unique perspective on coordination, but the lack of coordination can be easily articulated through a variety of surrogate measures. The most commonly accepted definition in the literature of "coordination" is "the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals" (Malone and Crowston, 1994). According to Simaputang et al. (2002) coordination is a necessary prerequisite to achieve the mutual of goal of supply chain as a whole as well as those of the participating units, given the nature of interdependence between

these units. Supply chains with reduced profit margins, intensive competition, pressure for keeping low inventory and huge cost associated with capacities, coordination becomes imperative.

Typically organizations complement each other in supply chain. Interdependencies may enhance such complementarities. Coordination could also be a source of competitive advantage. SCM coordination in SC can also be perceived as a mechanism to cope with the uncertainty. Ballou et al. (2000) view coordination as a central lever of supply chain management. Stank et al. (1999) studied inter-firm coordination processes characterized by effective communication, information exchange, partnering, and performance monitoring. Lee (2000) proposes supply chain coordination as a vehicle to redesign decision rights, workflow, and resources between chain members to leverage better performance such as higher profit margins, improved customer service performance, and faster response time.

The lack of coordination may result in poor performance of supply chain. The mismatch between supply and demand results in rise in the costs of stock out, markdown, expediting, trans-shipment, advertising and sale preparation, excess inventory, obsolescence, and disposal (Fisher *et al.*, 1994). According to Lee *et al.* (1997), the current policies may quickly become outdated because they are created mainly to suit local company to earn local benefits and not the coordinated supply chain, which results in demand amplification. The asymmetric information transfer between supply chain members may result in interrupted production schedules; longer lead times, higher level of loss and damage and lower customer service levels.

Supply chain (SC) coordination is a productive initiative to manage the complex SC activities with the help of coordination mechanisms like contracts, information sharing, information technology, joint decision-making, etc. In supply chain context coordination can be achieved with joint decision making of all processes of supply chain procurement, production, distribution

and warehousing and economic allocation of the requirement of resources among supply chain members. There are multiple benefits accruing from effective SCC. Some of these include: elimination of excess inventory, reduction of lead times, increased sales, improved customer service, efficient product developments efforts, low manufacturing costs, increased flexibility to cope with high demand uncertainty, increased customer retention, and revenue enhancements (Fisher et al. 1994, Lee et al., 1997). Coordination is perceived as a prerequisite to integrate operations of supply chain entities to achieve common goals. Simaputang et al. (2002, and 2004) have given elaborated on utility of coordination in supply chain.

It may be noted that there could be various coordination mechanisms available. Table 2 gives some of the widely reported and relevant coordination mechanisms and their respective benefits.

Table 2: Various coordination mechanisms

Supply chain coordination	**Description**	**Benefits**
Supply chain contracts	Coordination is achieved based on commonly used supply chain contracts such as buyback contracts, quantity flexibility, quantity discounts and revenue sharing, Buyback contracts: Buyer is allowed to return any leftover units to the supplier at the end of the period at a fraction of purchase price Quantity Flexibility contracts: Buyer is allowed to modify the order within limits agreed to the supplier as demand visibility increases closer to the point of sale	• Increase supply chain profits • Risk sharing among supply chain partners • Reduces the problem of double marginalization
Information sharing	Coordination is achieved by sharing information on inventory data, end customer demand, sales data, production schedule, capacity, quality and lead-time, an information based coordination mechanism. Information sharing may be on line or off-line	• Information can be a substitute of inventory and lead time • Reduces the supply chain costs • Reduces the demand variability • Improves the service level • Enhances responsiveness
Information technology	Coordination is achieved based on use of technologies such as Internet, email, fax, EDI, and ERP.	• Enables rapid exchange of products, information and funds • Allows visibility and accessibility to all supply chain members • Reduces the demand variability • Increases flexibility of response to customer demand
Joint decision making	The supply chain members jointly plan for forecasting, design of product, joint replenishment, profit sharing, ordering and scheduling activities based on joint decision making	• Reduces information asymmetry • Reduces inventory cost • Improves the customer service • Improves the efficiency of replenishment process

Methodology

Keeping the objectives of studying coordination issue, a methodology comprising both qualitative and quantitative models blending both theory and practice was adopted (Fig 1). A theoretical background based on coordination perspective from various angles was developed. Here the basic elements of coordination such as interdependency, coherency and mutuality were mapped into the context of supply chain (Arshinder et al., 2006b). After understanding the theoretical underpinnings, an empirical methodology based on case studies was adopted to investigate and explore various opportunities available for coordination in Indian context. Case study is a powerful tool for exploring and understanding various issues related to SCC. The objective of these case studies was to:

a) understand the extent of coordination in Indian companies
b) appreciate various mechanisms available for coordination
c) document the maturity levels of these organization sin SCM.

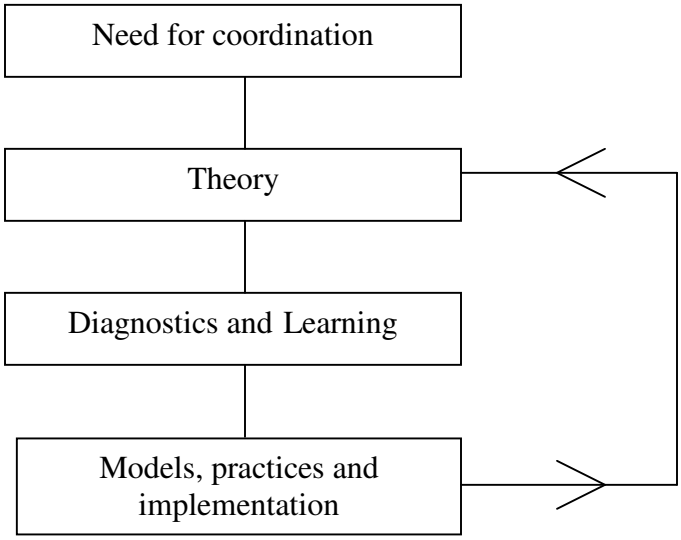

Fig 1: Methodology Adopted

In all, five different companies (labeled as Alpha, Beta etc.) were selected for the above purpose. Field visits, discussions with executives and support from documented literature formed the basis for highlighting these case studies from SCC point of view. Table 3 presents a synoptic view of

the learnings from these case companies. After getting a pragmatic view based on these cases, need for a simulation-based framework was felt. Accordingly, suitable theoretical model base (based on newsboy model) was identified.

Table 3: Summary of case companies

S. No.	Company Brief	Characteristics of Supply Chain	Remarks
1	**Alpha** Auto components (Fuel injection pumps and spark plugs)	• Number of employees is more than 3000, four manufacturing plants with parent company in Europe • Spans across 1000 towns all over India with over 4000 authorized dealers • One Global development center with 250 qualified and experienced engineers and technicians • Different functional departments plan forecasting and production schedules jointly • ERP Information system is installed in one of the plants, rest operate on local software • Organize regular meetings with suppliers • Suppliers always send committed order quantity • Cross-functional team from Alpha select the suppliers • Suppliers are given training and demonstrations for actual requirements of design of products • Only capacity and order information is shared with suppliers • Quantity flexibility contracts are offered to buyers • Implemented supply chain initiatives like QR, EDI, ECR and JIT	• Well coordinated functional departments with the help of joint decision making • Information systems is an issue, mismatch in actual inventory and inventory shown by software • Meetings help in forming long-term partnerships • Trust and commitment is visible with suppliers • Increasing demand shows good customer service provided by Alpha • Knowledge sharing with suppliers helps in improving product design • Information sharing mechanism can be improved • Quantity flexibility contracts with buyer may help to reduce inventory holding costs and shortage costs • Various initiatives help Alpha to coordinate with suppliers and buyers by providing quality service to customers
2	**Beta** Electrical auto components	• Has 70-71 % market share, 25000 employees , 250 suppliers (30-35 international suppliers) • Three plants (very-well coordinated, interplant transfer of inventory, joint decision making regarding ordering) • Conducts exhibitions for all suppliers and give prize for the best suppliers • Organizes frequent meetings with suppliers • Approximately 65% of the value addition is done at supplier • The local suppliers supply JIT, 2-3 times a day • The main objective is cost reduction (3-5% year on year) • Major customer, gives annual estimation of demand • JIT, TPM and TQM initiatives very well implemented • MNC consultants for procurement	• Aggressive on supplier front • Joint decision making is very much evident • Technical assistance is provided to supplier • Multi-plant coordination by joint ordering • Fast information system help in JIT replenishment • Focus on improving customer service and efficiency • Developed suppliers by giving training for best practices, visiting suppliers • Knowledge sharing by exchanging of teams between north and south suppliers • Cost trends are shared with suppliers • Joint initiatives with suppliers for

		• Lead time, sales Vs manpower, stock turn ratio, customer line rejection and space/unit are the performance measures • Supplier performance development team (SPDT) is formed to visit suppliers • Three field representatives are there per customer, who provide daily actual consumption of products • Customers do not want to keep inventory, so JIT supply to customers • Monthly review inventory	quality improvements • Accessibility to the information regarding daily requirement at customers can help in planning production at Beta • Forecast schedules are shared with the suppliers • Coordinated distribution system helps to supply the customers operating Toyota system
3	**Delta** Automobile (Sports and utility vehicles and light commercial vehicles)	• Has more than 50% market share, 11600 people, 8 manufacturing plants, 275dealers, and approximately 700 suppliers • Network is connected to Delta's sales department by an extensive IT infrastructure • Delta has good R & D practices, negligible import content • There is practicing website for 100 suppliers to communicate suppliers for part requirements, status of order, quality and bills by providing passwords to each supplier • SAP (Delta's consultancy: Bristlecon) implementation helps to connect the functional departments of Delta • In the Delta's organization structure, two of the 5 VPs are responsible for vendor management and order management collectively taking care of SCM operations with the help of a team. • The SCM comprised of logistics, scheduling, inventory management, stocking and materials management • The SCM team design and develop supply chain systems, provides training to internal employees and to the suppliers and monitoring auditing • Make to stock items are made as per the one month requirement in pipeline • Make to order are the variant models • Gradually following Toyota production system (pull system) • The modes of transactions are phones, emails and faxes • Delta encourages strategic sourcing by forming groups of teams for close liasioning with suppliers of different components	• Strong network connected through IT streamline physical flow • SAP implementation helps coordinate various functional department by updated inventory information • Suppliers are coordinated with the help of IT which reduces the transaction time and errors related to the orders • Suppliers are encouraged by providing them training and technical assistance • Delta's competitive advantage in strategic sourcing, where specialized employees liaison with the R&D departments of raw materials suppliers by visiting themselves • Strategic partnerships between suppliers are formed by selecting suppliers with good information systems, innovative technologies and expertise in the specialized components • Customers cannot purchase online • After-sales-service is provided by manufacturing spare parts in-house at competitive prices • Less effort for sharing information regarding inventory, capacity with downstream members • Strategic sourcing may lead to standard contracts between Delta and suppliers
4	**Omega** Auto components (Multi point fuel injection (MPF) systems, Air suction valve (ASV))	• 1200 people, 100 vendors • Value based discounts are given to the buyer • Single source to Hero Honda for 90% of ASV • Annual demand is communicated by buyer • There is no software used for operations	• Discounts may help in coordinating buyers • Single sourcing to Hero Honda, shows its commitment to Omega • ERP and new IT systems may reduce lead times.

		planning • Supply lead time is 8-16 weeks • 50% of the items follow pull systems	
5	**Phi** Heavy engineering Generators/ Transformers	• Make to stock items (generally of 1200 tonnes of weight) • More than 460 major suppliers and 25 regular suppliers • 70-80% of material is imported • Every order has its own specifications • For the standard items, VMI initiative is used • The lead time of supply is 3-6 months • ERP is used to coordinate all functional departments: Materials, purchasing, Accounts, IT and strategic planning • The items are sold through tenders	• The item characteristics lead to slow down activities of supply chain • Coordinated functional departments

General observations

a) These companies are aware of various facets of SCM. On a conservative footing, these companies seem to have proper SC orientation in place.
b) Though the use of IT and information systems is appreciated, information systems are still evolving.
c) The decision making process seems to be fragmented and not much support for decision-making is taken from IT.
d) Interactions with suppliers are very much evident in most of the cases. Through a variety of initiatives, these companies are involving their suppliers.
e) The inbound logistic part of the SC seems to be developing.
f) Though these companies are aware of various mechanisms for coordination, some mechanisms seem to be more in use.

Table 4 shows different decision that may be affected by various coordination mechanisms.

Based on our understanding of the prevailing situation and the anecdotal evidence available, and various decisions in SC (as shown in Decision-coordination mechanism matrix), we visualize the following hierarchy (Fig 2) which may manifest in terms of a 'sand-cone" model for implementing coordination:

- Coordination through various Contracts
- Coordination through use of information technology
- Coordination through information sharing, and at the highest level of maturity,
- Coordination through Joint decision-making wherein various entities of SC are involved in decision making

Table 4: Decision- coordination mechanism matrix

Sample Decisions	Various mechanisms			
	Supply chain contracts	**Information Technology**	**Information sharing**	**Joint decision making**
Coordination issues in logistic service provider and customer for timing, quantity, pricing, mode of transport etc.		X		X
Integrating the logistics activity geographically dispersed network/ Supply chain	X	X	X	
Coordinated order quantity	X		X	X
Coordinated timing and scheduling of the order	X		X	X
Coordinated timing of replenishment				X
Inventory management in a network		X	X	
Forecasting			X	X
Integrated Production-distribution				
Joint consideration of cost at various levels of SC				X
Integrated Procurement-Production	X			X
Pricing decisions	X	X	X	X
Supplier selection and evaluation	X	X	X	X
Profit /revenue sharing	X			
Flexible ordering	X			X
Joint focus on customer service	X			X

The Sand Cone model suggests that although in the short term it is possible to implement coordination through 'contracts', there is actually a hierarchy amongst the four mechanisms. To build cumulative and lasting coordination capability, management attention and resources should go first towards enhancing terms of contracts, then - while the efforts to enhance quality of contracts are further expanded - attention should be paid to invest in information technology

then- and again while efforts on the previous two are further enhanced – organizations should mature so as to have en environment of information sharing which ultimately results in developing capabilities so as to ensure 'Joint decision making' thereby making the originations mature in coordination efforts. Takala et al. (2006) have illustrated the use of sand cone model in analyzing, evaluating and structuring multi-focused strategies.

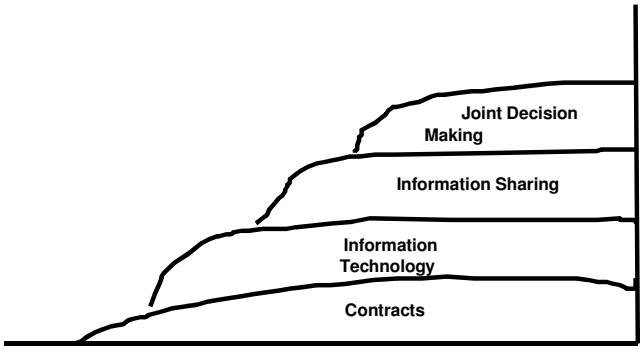

Fig 2: Sand-cone Model for Supply Chain Coordination Maturity

As noted earlier, at the lowest level of maturity coordination may be achieved through contracts. It seems that coordination through contracts has lot of potential for application in Indian companies due to the following reasons:

a) Indian management is very much at home with procedural and contractual arrangements.
b) ISO9000 has provided a good platform for various levels of documentation in these companies.
c) The tax and regulatory environment is conducive for implementation of contracts.

The above facts motivated to study the coordination through contracts.

Coordination through Contracts and Newsboy Model

Supply chain contracts are useful tools to motivate various supply chain actors behave coherently and in a coordinated manner. A contract can be defined as an agreement between the two parties.

Supply chain contract is the set of many clauses that offers suitable information and incentive mechanism to guarantee all the firms in supply chain to achieve coordination and optimize the channel performance (Cachon, 2004). Typical parameters of the contract may include: price (wholesale, buyback and product price), quantity (the amount of flexibility given in quantity) and cost (salvage, marginal and goodwill) for which the supply chain members are dependent on each other. Supply chain contracts formally rule the transactions between supply chain members and later utilize incentives (risks and rewards) to make supply chain member's decisions coherent among each other. The supply chain risks may arise from the various sources of uncertainty like market demand, selling price, and product quality and delivery time. Having single optimal order quantity for whole supply chain can reduce these risks and the contracts are expected to modify the profits of all supply chain actors. Table 5 presents justification for using two types of contracts (Buyback and Quantity flexibility)

Table 5: Justification for Usage of supply chain contracts

Type of contract	Advantages to supplier	Advantages to buyer
Buyback contract	• It encourages buyer to order large quantity • It Increases the profits of supplier	• It reduces the cost/risk of overstock • It increases salvage value per unit in the form of buyback price • It increases the level of product availability
Quantity flexibility contract	• It reduces the over stock burden • It increases the profits of supplier • It improves the planning capability • The minimum purchase agreement by buyer shifts some of the demand risk downside	• The buyer's order quantity more in line with actual demand • It increases the profits of buyer • The supplier formally guarantees the buyer a specific safety cushion in excess of estimated requirements • It helps in sharing part of inventory and stock out cost burden with supplier • The buyer gets full protection on unsold but committed order quantity

Having felt the need for SC coordination through contracts, it was perceived that a suitable model be developed so as to enhance the chances of its implementation. The supply chain

contracts may be price-based contracts (buyback contracts) or quantity based contracts (quantity flexibility contracts). In buyback contracts, the buyer is allowed to return any leftover units to the supplier at the end of the period at a fraction of purchase price. The buy back contract increases the order quantity of buyer as the contract increases the salvage value per unit for the buyer. In quantity flexibility contracts, the buyer is allowed to modify the order within limits agreed to the supplier as demand visibility increases closer to the point of sale. The buyer modifies the order as he gains better idea of actual market demand over time. These two coordinated contracts were considered as potential candidate for implementation.

The basis of contract model is originated from the classical newsboy problem. The newsboy problem is a single period model applied to the seasonal products. The objective of newsboy model is to determine the optimal order quantity by setting marginal (expected) revenues equal to marginal costs. Extending the concept of performance improvement, a different stream has been explored, which is coordination by contracts. The basic model of evaluating optimal order quantity will remain same as in newsboy model with some modifications. The modifications are required for a coherent and mutual decision by considering each member's expectations from supply chain. (see Appendix for an abridged version of the model).

A framework based on simulation can be a better tool to capture the more realistic picture of different scenarios of contracts and the value of coordination can be evaluated quantitatively. The contracts can be compared under similar conditions of demand, cost and price to choose the terms of reference for the best contract.

In view of the observations, a model is developed with a view to:

- evaluate the value of coordination based on various performance measures of supply chain contracts and also compare different kinds of contracts under similar parametric conditions such as demand, price, and cost,

- explore different scenarios of coordination and compare these scenarios with the independent or "no coordination" case and explore further the need for other coordination mechanisms in conjunction with supply chain contracts

The primary motivation stems from the fact that the managers find simulation based approach as an easy tool for enhancing their decision-making abilities. According to Van Hoek et al. (2002), managers are the critical dimensions in decision-making.

The strength of the proposed model lies in the fact that the contracts are designed prior to the realization of the actual demand. This may help in projecting the expected behavior of supply chain performance for different scenarios of coordination. The proposed framework helps (Arshinder et al., 2006a) in simulating the different scenarios of coordination by contracts, in which the performance measures are evaluated for the ranges of contract parameters. These performance measures help in evaluating the value of coordination in supply chain and also indicate that which contract is beneficial at different levels of supply chain under similar parametric conditions.

The proposed framework also acts as a decision making tool for choosing contracts for a particular type of demand based on a number of scenarios generated. .The simulation of different scenarios may result in lower bounds and upper bounds for various contract parameters. By implementing the 'what-if' analysis, an appropriate set of performance measures can be determined. The contract parameters from the given range may be chosen so that the profits of all members in case of coordination by contracts are more than the respective profits in independent case

The model incorporates two cases: independent case ("no coordination") and the case of coordination. A three-level SC is considered (Manufacturer-Assembler-Distributor) with the assumption of probabilistic demand valid for a single season. In the independent case, the

member at the extreme downstream end (here "Distributor") determines his optimal order quantity based on his local cost and price parameters. The order quantity optimal to the downstream member may not be optimal to other members or the whole supply chain. The second case of coordination is explored in which first an optimal order quantity of whole SC is determined and then contracts are formulated between SC members to motivate all SC members to coordinate with each other. A coherent and mutual decision is required to coordinate SC members. The contract parameters are determined like buyback prices (between assembler and distributor and between manufacturer and assembler) and flexibility provided by assembler/ manufacturer to distributor/assembler in order quantity. The model is based on the classical newsboy problem. This model is refined to 3-level SC and modified to capture profit equations as shown in Appendix. The model is well applicable for the seasonal demand in which the inventory at the end of season is disposed off. The demand is assumed to follow a normal distribution. By using equations given in Appendix, the model is converted into Excel worksheet. The contract parameters are determined with the help of set of inequalities given in (Appendix). Table 6 summarizes the model.

Table 6: Spreadsheet Based Simulation Model

Scope of the model	3-level SC (Manufacturer (M), Assembler(A) and Distributor(D)
Platform Used	Excel worksheet
Inputs	Various cost parameters, demand distribution
Decision variables	Order Quantities for M, D and A
Expected Outputs	Various performance measures such as : Expected profits, Revenues realized, Salvage value realized, Goodwill incurred, Marginal cost incurred, Wholesale value realized, Expected sales, Left over inventory, and Units short.
Logic of the model	Based on extension of newsboy problem (see Appendix for formulation) with an objective of maximizing the profits
What if scenarios generated	What will happen if buyback price of M is increased by 10 % ? What will happen if marginal cost of M is decreased by 15%? What will happen if demand is increased by 20 %? What will happen if there is a lower/upper bound on price?

Relevance of results and managerial implications

The different scenarios of coordination have been generated and simulation is carried out to realize the value of SC coordination. The value of coordination by supply chain contracts can be realized in the form of improvement in the performance measures.

Table 7 presents the template generated to capture these measures.

The simulation model was run for various scenarios. The following are managerial implications based on the results of the simulation (Arshinder et al., 2006a):

a) Impact on the profits of SC as a whole and on the individual SC members

As expected, the total supply chain profits are more in the case of coordination by contracts compared to the case of 'no coordination'. The other performance measures are also improved by contracts. It is interesting to note that individual profits are also increased in case of coordination by contracts.

The optimal order quantity of whole SC reduces the profits of distributor. The contracts act as cushion against the reduction of profits. Also, the manufacturer and assembler generate more profits by encouraging distributor to order more quantity. This increase in total profits may be shared in proportion to the respective value addition of the product by each member.

b) Role of values of contract parameters in SC coordination

The values of different contract parameters can be chosen through simulation. These parameters can be determined by setting inequalities of profits in 'no coordination case' and coordination case. Any member will continue to remain as part of supply chain till the profits in case of contracts are more than the profits in the 'no coordination case'. The improvement in performance by using the contract parameters is due to the price flexibility given in case of buyback contract and the quantity flexibility given in case of quantity flexibility contract.

c) Other performance indicators of SC coordination by contract

The combined effect of performance measures (leftover inventory, units' short and average sales) can also be observed through simulation. These contracts help in reducing the units short and improving the average sales with no impact on leftover inventory. There is scope to design contracts in which the leftover inventory could be an item for negations while drafting the contracts.

d)Flexibility as a new measure of SC coordination

The coordination by contracts provides flexibility (in both price and quantity) in supply chain. This can be observed in Fig 3.

The flexibility can be realized in the above contracts as follows:

i) Buyback contract: The price of unsold goods can be returned at a price more than the distributor/assembler salvage. The difference between buyback price and the salvage value per unit (price flexibility) is the profit improvement of distributor and the increase in order quantity improves the performance of assembler/manufacturer (as the case may be). Hence, this type of contract may provide a cushion against under stock.

ii) Quantity flexibility: Some flexibility in order quantity is provided to the distributor/assembler, which help in reducing the marginal costs and wholesale prices. The range of quantity flexibility is the difference between minimum commitment of order quantity by the distributor/assembler and the maximum quantity committed to deliver by assembler/manufacturer.

Fig 3: Quantity and Price Flexibility Matrix

Table 7: Template for various performance measures for coordination

		No coordination	**Coronation Through**	
Supply chain member	**Performance Measures**		**Buyback**	**Quantity flexibility**
Distributor (D)	Actual Sale			
	Revenue realized			
	Leftover inventory			
	Salvage realized			
	Units short			
	Goodwill incurred			
	Marginal cost incurred			
	Wholesale incurred			
	Buyback value realized			
	Profits			
Assembler (A)	Leftover inventory			
	Salvage realized			
	Units short			
	Goodwill incurred			
	Marginal cost incurred			
	Wholesale value realized			
	Wholesale incurred			
	Buyback value realized			
	Buyback value incurred			
	Profits			
Manufacturer (M)	Leftover inventory			
	(Salvage realized –buyback quantity)			
	Units short			
	Goodwill incurred			
	Marginal incurred			
	Wholesale value realized			
	Profits			
Total Profits of SC (D) + ((A)+(M)				

From the simulation results, it can be observed that flexibility (price and quantity) can also be an important performance measure of coordination. The range of contract parameters help in realizing the amount of flexibility provided to supply chain members, hence a good indicator of supply chain coordination. The contracts are designed at the start of any relationship, and hence may act as a precursor for good relationship. As the relationship between supply chain members become stronger over a period of time, one can think of implementing other coordination mechanisms in place in conjunction with the supply chain contracts in line with the proposed sand cone model.

It must be emphasized that contracts are not the only coordination mechanisms in a supply chain, but there are many other coordination mechanisms, which helps, in achieving coordination. The contracts are generally designed at the start of any relationship between different members of the SC. Once the contracts are implemented, it may be required to introduce other coordination mechanisms. Table 8 presents an overview of various mechanisms available for coordination in the case study of Delta (mentioned in Table 2).

Table 8 : Existing system and proposed system of procurement in Alpha

Process	**Existing System**	**Proposed System**	**Coordination mechanism**
Quotations	Manual handling	Web based system	Information Technology
Supplier Selection	Traditional attributes	Coordination capabilities	Information sharing, information technology, collaboration
Supplier Evaluation	Subjective approach	Analytical approach	Information technology
Contracts	Very less information	Contracts which helps in achieving coordination	Coordination contracts
Order Management	Old communication system	EDI and XML	Information technology
Operations Planning	Individual planning	Joint planning with information sharing	Information sharing, collaboration

The following points may further help in improving the coordination in supply chain:

i. To determine the optimal supply chain order quantity the cost and price parameters need to be known well in advance. The supply chain members may share the information regarding cost and price and may jointly determine the optimal order quantity.

ii. A proper mechanism needs to be evolved to share the profits in proportion to the respective value addition by the members. In this context, Joint planning will play an important role to realize value of such coordination.

iii. Since the flexibility of price and quantity is given by relying on the members, it is important for the members to be loyal with each other in terms of fair sale of products. The flexibility is given at the cost of some parameter, so it is important for the manufacturer/assembler to know the exact sale at the assembler/distributor. The information can be sent through Point-of-Sales (POS) data or through other information systems. Regular monitoring of inventory at the buyer end is very important. In case of quantity flexibility contract, the information on changed order quantity may be required to communicate in short span of time. The fast information systems may help in quick transfer of information regarding order quantity with less lead-time.

iv. The knowledge of market is very important. By changing variability in demand, a noticeable change in the performance measures can be observed. In real case, if all the members forecast their own demand, this will further affect the performance measures. For example the optimal order quantity of supply chain will be different for different demand distributions. A timely information sharing of demand is also very important to realize the benefits of coordination. An initiative such as Collaborative Planning, Forecasting and Replenishment (CPFR) could be of use here. The downstream member has more accurate information regarding demand. By implementing CPFR, the knowledge about market may be shared by the downstream member with other SC members and joint planning of forecasting and replenishment may reduce demand uncertainty

It may be noted that without simulation, the insights gained in this model would not be appreciated. It will also be difficult to visualize effects of various decision variables and parameters through static analytical models! Simulation model enhances utility of such models.

Concluding Remarks

Today, supply chain management is emerging as a full-fledged discipline in its own right. In India: departments are being reorganized into ' Supply Chain', 'logistics' headings and a great deal of strategic vision has come into being. Changes unleashed by India's increasing integration into the global supply chains are changing the competitive landscape of business.

a) It seems that Indian organizations are now sold to the idea that SCM is not a traditional improvement technique but a philosophy that leads to improvement not associated with functional /departmental reviews which focus only internally. Management must not only control inputs but also significantly change the processes itself. This may require reengineering efforts (Mohanty and Deshmukh, 1998). Accordingly, OM community has to take note of this and accordingly, modify/amend the curriculum and sensitize the future managers about this.

b) Transforming a business from an inward looking ('what we make will sell') to a flexible and coordinated outward looking business ('what does the customer want us to make and sell') is the motivation for SCM. The coordination attempts are initiated to respond to a combination of factors such as intense competition and demanding set of customers.

c) The ever-increasing competition in today's business world has forced the supply chain members to act coherently and take joint decisions to achieve coordination. Supply chain contracts are very useful coordination mechanism to evaluate the coordination value in supply chain. The proposed framework helped in simulating various scenarios of coordination by contracts (buyback and quantity flexibility). The difference between different performance measures in coordinated case and 'no coordinated case' helps in assessing the value of coordination. The different scenarios generated can be used to compare the contracts under similar market conditions. This has utility for practicing SC managers: to design and select the contract based on the overall profits or some other performance measure. This appreciation stems from generation of various scenarios which otherwise may be difficult to visualize.

It must be noted that a typical supply chain also deals with human systems, and hence, the following difficulties in coordinating supply chain members may be visualized.

- There exist differences in the interest of supply chain members as the members habitually work as an individual firm based on local perspective and opportunistic behavior results in mismatch of supply and demand (Fisher et al., 1994).
- The following types of conflicts may exist: conflicting goals and objectives (goal conflict), disagreements over domain of decisions and actions (domain conflict) and differences in perceptions of reality used in joint decision making (perceptual conflict) between supply chain members.

The above difficulties call for an active attention from POM community. The initiatives suggested in this paper such as simple-to-use and easy-to-understand worksheet based and simulation-oriented approaches may enhance the chances of implementation of models. This will also help in appreciating the role of coordination in supply chains.

It may be noted that a 'bottoms up' approach is advocated in this paper. Realizing the needs and dictates of Indian industry for SCM and then developing a tool kit to meet these aspirations and expectations present unique opportunities and challenges to POM community in India.

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Appendix: *A mathematical model based on Newsboy Model for supply chain contracts*

Manufacturer

c_m : Production cost
g_m : Goodwill cost
s_m : Salvage
W_{ma} : Wholesale price by manufacturer

Distributor

c_d : Marginal cost
g_d : Goodwill cost
s_d : Salvage
p : Price of product

Assembler

c_a : Marginal cost
g_a : Goodwill cost
s_a : Salvage
w_{ad} : Wholesale price

q_d^* : Optimal quantity of distributor
Q_{sc}^* : Optimal order quantity of supply chain
S(q) : Expected sales which can be defined as:

$$S(q) = q - \int_0^q F(y)\,dy$$

The distributor is subjected to random demand D with pdf(f), CDF(F) and $\overline{F} = 1 - F$

Decision variable for buyback contract

β_1 : Buyback price at which distributor returns the unsold units to the assembler at the end of season
β_2 : Buyback price at which assembler returns the unsold units to the manufacturer at the end of season

Decision variable for quantity flexibility contract

$(1-\delta)\,Q_{sc}^*$: Minimum purchase quantity committed by distributor, Where $0 < \delta < 1$
Q_{sc}^* : Maximum order quantity committed by assembler

The following equations may help in determining the contract parameters/performance measures using contracts:

Case I: 'No coordination case'

A.1 The profit equation of distributor

$$P_d(q) = pS(q) + s_d(q - S(q)) - g_d(D - q)^+ - w_{ad}q - c_dq$$

A.2 The profit equation of assembler

$$P_a(q) = -g_a(D - q)^+ + w_{ad}q - c_aq - w_{ma}q$$

A.3 The profit equation of manufacturer

$$P_m(q) = -g_m(D - q)^+ + w_{ma}q - c_mq$$

A.4 The optimal order quantity of distributor

$$F(q_d) = 1 - \frac{c_d + w_{ad} - s_d}{p - s_d + g_d}$$

Case II: Coordination case

A.5 The optimal order quantity of whole supply chain

$$F(Q_{sc}^*) = 1 - \frac{c_m + c_a + c_d - s_d}{p - s_d + g_m + g_a + g_d}$$

A.6 The profit equation of distributor when Q_{sc}^* is ordered

$$P_d(Q_{sc}^*) = pS(Q_{sc}^*) + s_d(Q_{sc}^* - S(Q_{sc}^*)) - g_d(D - Q_{sc}^*) - w_{ad}Q_{sc}^* - c_dQ_{sc}^*$$

A.7 The profit equation of assembler when Q_{sc}^* is ordered

$$P_a(Q_{sc}^*) = -g_a(D - Q_{sc}^*) + w_{ad}Q_{sc}^* - c_aQ_{sc}^* - w_{ma}Q_{sc}^*$$

A.8 The profit equation of manufacturer when Q^*_{sc} is produced

$$P_m(Q^*_{sc}) = -g_m(D - Q^*_{sc}) + w_{ma}Q^*_{sc} - c_m Q^*_{sc}$$

A.9 The profit equation of distributor in case of buyback contracts

$$P^b_d(Q^*_{sc}) = pS(Q^*_{sc}) + \beta_1(Q^*_{sc} - S(Q^*_{sc})) - g_d(D - Q^*_{sc}) - w_{ad}Q^*_{sc} - c_d Q^*_{sc}$$

A.10 The profit equation of assembler in case of buyback contracts

$$P^b_a(Q^*_{sc}) = -g_a(D - Q^*_{sc}) + w_{ad}Q^*_{sc} - c_a Q^*_{sc} - w_{ma}Q^*_{sc} - \beta_1(Q^*_{sc} - S(Q^*_{sc})) + s_a(Q^*_{sc} - S(Q^*_{sc})) + \beta_2(Q^*_{sc} - S(Q^*_{sc}))$$

A.11 The profit equation of manufacturer in case of buyback contracts

$$P^b_m(Q^*_{sc}) = -g_m(D - Q^*_{sc}) + w_{ma}Q^*_{sc} - c_m Q^*_{sc} - \beta_2(Q^*_{sc} - S(Q^*_{sc})) + s_m(Q^*_{sc} - S(Q^*_{sc}))$$

A.12 By setting following inequalities, the parameters β_1 and β_2 can be determined

$$P^b_d(Q^*_{sc}) \geq P_d(q),\ P^b_a(Q^*_{sc}) \geq P_a(q),\ P^b_m(Q^*_{sc}) \geq P_m(q)$$

$$\beta_1 \geq \frac{(p - s_d)S(q) + (s_d + g_d - w_{ad} - c_d)q + (w_{ad} + c_d - g_d) - pS(Q^*_{sc})}{Q^*_{sc} - S(Q^*_{sc})}$$

$$\beta_2 - \beta_1 \geq \frac{(g_a + w_{ad} - c_a - w_{ma})q + (c_a + w_{ma} - g_a - w_{ad} - s_a)Q^*_{sc} + s_a S(Q^*_{sc})}{Q^*_{sc} - S(Q^*_{sc})}$$

$$\beta_2 \leq \frac{(g_m + w_{ma} - c_m + s_a) - s_a S(Q^*_{sc}) + q(c_m - g_m - w_{ma})}{Q^*_{sc} - S(Q^*_{sc})}$$

A.13(a) The profit equation of distributor in case of quantity flexibility contracts when demand D< =(1-δ) Q^*_{sc}

$$P^q_d(Q^*_{sc}) = pS((1 - \delta)Q^*_{sc}) + s_d((1 - \delta)Q^*_{sc} - D) - w_{ad}(1 - \delta)Q^*_{sc} - c_d(1 - \delta)Q^*_{sc}$$

(b) The profit equation of distributor in case of quantity flexibility contracts when (1-δ) Q^*_{sc} <D<= Q^*_{sc}

$$P^q_d(Q^*_{sc}) = pS(Q^*_{sc}) + w_{ad}(Q^*_{sc} - D) - w_{ad}Q^*_{sc} - c_d Q^*_{sc}$$

(c) The profit equation of distributor in case of quantity flexibility contracts when D> Q^*_{sc}

$$P^q_d(Q^*_{sc}) = pS(Q^*_{sc}) - w_{ad}Q^*_{sc} - c_d Q^*_{sc} - g_d(D - Q^*_{sc})$$

A.14(a) **The profit equation of assembler in case of quantity flexibility contracts when demand D< =(1-δ) Q^*_{sc}**

$$P^q_a(Q^*_{sc}) = w_{ad}(1 - \delta)Q^*_{sc} - c_a(1 - \delta)Q^*_{sc} - w_{ma}(1 - \delta)Q^*_{sc}$$

(b) The profit equation of assembler in case of quantity flexibility contracts when (1-δ) Q^*_{sc} <D<= Q^*_{sc}

$$P^q_a(Q^*_{sc}) = w_{ad}Q^*_{sc} - c_a Q^*_{sc} - w_{ma}Q^*_{sc} - w_{ad}(Q^*_{sc} - D) + w_{ma}(Q^*_{sc} - D)$$

(c) The profit equation of assembler in case of quantity flexibility contracts when D> Q^*_{sc}

$$P^q_a(Q^*_{sc}) = w_{ad}Q^*_{sc} - c_a Q^*_{sc} - w_{ma}Q^*_{sc} - g_a(D - Q^*_{sc})$$

A.15(a) profit equation of manufacturer in case of quantity flexibility contracts when demand D<=(1-δ) Q^*_{sc}

$$P^q_m(Q^*_{sc}) = w_{ad}(1 - \delta)Q^*_{sc} - c_m(1 - \delta)Q^*_{sc} - w_{ma}(1 - \delta)Q^*_{sc}$$

(b) profit equation of manufacturer in case of quantity flexibility contracts when (1-δ) Q^*_{sc} <D<= Q^*_{sc}

$$P^q_m(Q^*_{sc}) = w_{ma}Q^*_{sc} - c_m Q^*_{sc} - w_{ma}(Q^*_{sc} - D) + s_m(Q^*_{sc} - D)$$

(c) profit equation of manufacturer in case of quantity flexibility contracts when D> Q^*_{sc}

$$P^q_m(Q^*_{sc}) = w_{ma}Q^*_{sc} - c_m Q^*_{sc} - g_m(D - Q^*_{sc})$$

From inequalities of A.12 $$(1 - \delta) \geq \frac{q}{Q^*_{sc}}$$

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