A Review on Supply Chain Coordination: Coordination Mechanisms, Managing Uncertainty and Research Directions

Kaur Arshinder, Arun Kanda, and S.G. Deshmukh

Abstract The Supply Chain (SC) members are dependent on each other for resources and information, and this dependency has been increasing in recent times due to outsourcing, globalization and rapid innovations in information technologies. This increase in dependency brings some extent of risk and uncertainty too along with benefits. To meet these challenges, SC members must work towards a unified system and coordinate with each other. There is a need to identify the coordination mechanisms which helps in addressing the uncertainty in supply chain and achieving supply chain coordination.

A systematic literature review is presented in this paper to throw light on the importance of SC coordination. The objectives of this paper are to: Report and review various perspectives on SC coordination issues, understand and appreciate various mechanisms available for coordination and managing SC uncertainty and identify the gaps existing in the literature. Perspectives on various surrogate measures of supply chain coordination have been discussed followed by the scope for further research.

Keywords Coordination mechanisms • Supply chain coordination • Supply chain coordination index • Supply chain uncertainty

---

This paper is based on earlier version of the following paper: Arshinder K, Kanda A, Deshmukh SG (2008) Supply chain coordination: perspectives, empirical studies and research directions. Int J Prod Econ 115(2):316–335. This paper is also based on the doctoral research work done by Arshinder (2008) at Indian Institute of Technology Delhi, India.

K. Arshinder (✉)
Department of Management Studies, Indian Institute of Technology Madras, Chennai 600036, India
e-mail: arshinder@iitm.ac.in

A. Kanda • S.G. Deshmukh
Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India
e-mail: akanda@mech.iitd.ac.in; deshmukh@mech.iitd.ac.in

T.-M. Choi and T.C. Edwin Cheng (eds.), *Supply Chain Coordination under Uncertainty*, International Handbooks on Information Systems,
DOI 10.1007/978-3-642-19257-9_3,

1 Introduction

Supply chain has evolved very rapidly since 1990s showing an exponential growth in papers in different journals of interest to academics and practitioners (Burgess et al. 2006). The rise in papers on supply chain (SC) as well as the case studies in different areas in different industries motivates to study SC issues further. Supply chains are generally complex with numerous activities (logistics, inventory, purchasing and procurement, production planning, intra-and inter-organizational relationships and performance measures) usually spread over multiple functions or organizations and sometimes over lengthy time horizons. Supply chains tend to increase in complexity and the involvement of numerous suppliers, service providers, and end consumers in a network of relationships causes risks and vulnerability for everyone (Pfohl et al. 2010).

The continuous evolving 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 its consumption. Also, the practices like globalization, outsourcing and reduction in supply base have exacerbated the uncertainty and risk exposure as well as more prone to supply chain disruption. Earlier literature considers risks in relation to supply lead time reliability, price uncertainty, and demand volatility which lead to the need for safety stock, inventory pooling strategy, order split to suppliers, and various contract and hedging strategies (Tang 2006). But today's supply networks have become very complex and vulnerable to various supply chain risks hence these issues have pulled attention of various academics and practitioners for the last few years (Oke and Gopalakrishnan 2009).

Uncertainty relates to the situation in which there is a total absence of information or awareness of a potential event occurrence, irrespective of whether the outcome is positive or negative. The terms risk and uncertainty are frequently used interchangeably (Ritchie and Brindley 2007). As firms move to leaner operating models and increasingly leverage global sourcing models, uncertainty in both supply and demand is growing along with supply chain complexity.

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.

There seems to be a general lack of managerial ability to integrate and coordinate the intricate network of business relationships among supply chain members (Lambert and Cooper 2000). 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.

Though, there are efforts in literature regarding coordination of different functions of the supply chain, the study of coordinating functions in isolation may not help to coordinate the whole supply chain. It appears that the study of supply chain coordination (SCC) is still in its infancy. Though, the need for coordination is realized, a little effort has been reported in the literature to develop a holistic view of coordination.

It is interesting to note the following perspectives on supply chain coordination as reported in the literature:

- Collaborative working for joint planning, joint product development, mutual exchange information and integrated information systems, cross coordination on several levels in the companies on the network, long term cooperation and fair sharing of risks and benefits (Larsen 2000).
- A collaborative supply chain simply means that two or more independent companies work jointly to plan to execute supply chain operations with greater success than when acting in isolation (Simatupang and Sridharan 2002).
- Kleindorfer and Saad (2005) asserted that continuous coordination, cooperation, and coordination among supply chain partners are imperative for risk avoidance, reduction, management and mitigation such that the value and benefits created are maximized and shared fairly.
- Supply chain coordination is a strategic response to the challenges that arise from the dependencies supply chain members (Xu and Beamon 2006).
- Supply chain coordination can be defined as identifying interdependent supply chain activities between supply chain members and devise mechanisms for manage those interdependencies. It is the measure of extent of implementation of such aggregated coordination mechanisms, which helps in improving the performance of supply chain in the best interests of participating members (Arshinder 2008).

Various perspectives have been presented in the literature for coordinating supply chain (discussed in Sect. 2). These perspectives and classification of coordination literature has been adopted from the review paper by Arshinder et al. (2008a), however, the authors are motivated to revise the paper with view of incorporating uncertainty in SCC and up gradation of coordination mechanisms. The following developments have motivated the authors to upgrade the current review paper.

- Growth in reporting of coordination mechanisms in supply chain.
- Managing uncertainty has become more and more challenging, which can be tackled with SCC.
- Information technology has been evolving and playing an important role in making global supply chain seamless.

To develop a better understanding of the coordination issues in supply chain, a systematic literature review is required to throw light on the importance of SCC and specifically to address the objectives as: to understand and appreciate SCC in different processes of supply chain, to explore various coordination mechanisms to coordinate the supply chain, to understand the role of SCC in managing SC uncertainty and to relate surrogate measures of SCC with supply chain performance. The last objective is to identify the gaps existing in the literature followed by few research directions.

The terms like integration, collaboration, cooperation and coordination are at times complementary and at times contradictory to each other and when used in the context of supply chain can easily be considered as a part of SCC. This assumption can be followed without loss of generality as the elements like integration (combining to an integral whole); collaboration (working jointly) and cooperation (joint operation) are the elements of coordination.

2 Supply Chain Coordination Literature Classification and Observations

The papers related to supply chain coordination were searched using library databases covering a broad range of journals (Appendix). The papers were selected based on the issues addressed by these papers: How to define supply chain coordination and the imperatives of SCC? How to achieve supply chain coordination? Will coordinated supply chain be beneficial to all the individual members of the supply chain? What is the impact of SCC on the performance of various activities and processes of a supply chain? How SCC can help in mitigating supply chain uncertainties?

The papers in response to the above mentioned questions were gathered and classified in categories presented in the following sections. To capture each and every aspect of SCC an attempt has been made to classify the literature on SCC as follows:

- Perspectives and conceptual models on supply chain coordination.
- Joint consideration of functions or processes by supply chain members at different levels to coordinate the supply chain.
- Various supply chain coordination mechanisms adopted in the supply chain.
- Supply chain coordination to manage uncertainties in the supply chain.
- Empirical case studies in supply chain coordination.

A schematic overview of hierarchical classification of literature is shown in Fig. 1 which shows that how the different categories of coordination will help in understanding the importance of SCC, utility of coordination mechanisms and the application of SCC on real life problems.

2.1 Perspectives and Conceptual Models on Supply Chain Coordination

2.1.1 Challenges in Coordinating the Supply Chain

In any system, the smooth functioning of entities is the result of well-coordinated entities. It may be very difficult to define "coordination" precisely, but the lack of

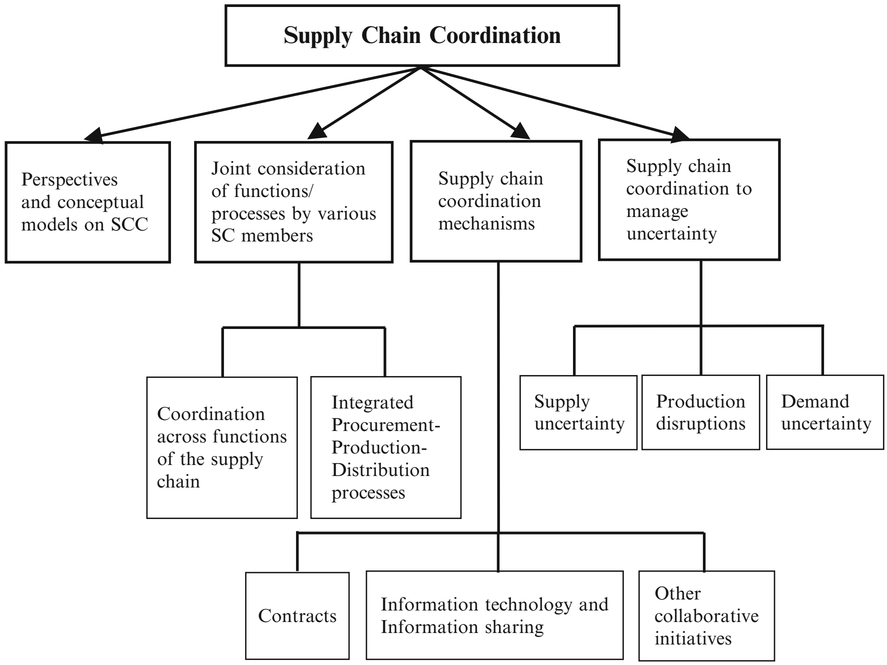

Fig. 1 Overview of the literature classification scheme

coordination can be easily articulated through a variety of surrogate measures. The supply chain members have conflicting goals or objectives and disagreements over domain of supply chain decisions and actions. It must be noted that a typical supply chain also deals with human systems, and hence, which may pose following challenges and difficulties in coordinating supply chain members.

- The individual interest, local perspective and opportunistic behavior of supply chain members results in mismatch of supply and demand (Fisher et al. 1994).
- The traditional performance measures based on the individual performance may be irrelevant to the maximization of supply chain profit in a coordinated manner. Similarly, the traditional policies, particularly rules and procedures, may not be relevant to the new conditions of inter organizational relationship. There has been over reliance on technology in trying to implement IT (Lee et al. 1997; McCarthy and Golocic 2002).
- According to Piplani and Fu (2005), supply chain "plug and play" misalignment is associated with the difficulties involved in dynamically interchanging products (with short life cycle) and partners in the fast changing business environment.
- The organizations want to reach to the best suppliers regardless their location globally, which brings many risks and uncertainties in managing cross border supply chains.

- The benefits accrued by the whole supply chain after joint determination of supply chain performance indicators by supply chain members has no value in the absence of fair share mechanisms.

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).

2.1.2 Various Perspectives and Conceptual Models on SCC

The literature reviewed by Burgess et al. (2006) showed that there is relative paucity of strong multi-theoretic approaches in supply chain. By looking at the problems of managing relationships between supply chain members, a need arises to tackle this problem using coordination theory. The most commonly accepted definition of coordination in the literature is "the act of managing dependencies between entities and the joint effort of entities working together towards mutually defined goals" (Malone and Crowston 1994). Coordination is perceived as a prerequisite to integrate operations of supply chain entities to achieve common goals. Various perspectives are reported in the literature regarding SCC. The researchers have described SCC either in the context of the application of coordination in different activities of supply chain or they are derived from other disciplines, summarized in Table 1.

Several coordination strategies have been developed to align supply chain processes and activities to ensure better supply chain performance. The papers addressing various forms of coordination are Buyer–Vendor coordination by coordinating Procurement–Inventory–Production–Distribution processes (Goyal and Deshmukh 1992; Thomas and Griffin 1996; Sarmiento and Nagi 1999; Sarmah et al. 2006).

Hoyt and Huq (2000) presented a literature review on the buyer-supplier relationship from the perspective of transaction cost theory, strategy structure theory and resource-based theory of the firm. There is abundant literature on conceptual based supply chain partnership but the testing of these concepts is required by utilization of operations research in supply chain (Maloni and Benton 1997). Various models have been discussed presenting various form of coordination such as price changes, quantity discounts (Sharafali and Co 2000), and partial deliveries and establishing their joint policies in context of manufacturing firms (Sarmah et al. 2007), information sharing and decision-making coordination (Sahin and Robinson 2002). Some of the coordination forms can be seen in Table 2. Power (2005) reviewed three principal elements of supply chain integration: information systems, inventory management and supply chain relationships aiming at reducing costs and improving customer service levels.

The emerging area of supply chain coordination is outsourcing practices in case of insufficient production capacity of suppliers (Sinha and Sarmah 2007).

Table 1 Various perspectives on supply chain coordination

Author (year)	Perspective	Context
Narus and Anderson (1995)	Cooperation among independent but related firms to share resources and capabilities to meet their customers' most extraordinary needs	Resource sharing
Lambert et al. (1999)	A particular degree of relationship among chain members as a means to share risks and rewards that result in higher business performance than would be achieved by the firms individually	Risk and reward sharing
Larsen (2000)	Collaborative working for joint planning, joint product development, mutual exchange information and integrated information systems, cross coordination on several levels in the companies on the network, long term cooperation and fair sharing of risks and benefits	Holistic view of coordination
Lee (2000)	Supply chain coordination as vehicle for redesigning decision rights, workflow, and resources between chain members to leverage better performance	Workflow/resource dependency
Simatupang et al. (2002)	Given the nature of the interdependencies between units, coordination is necessary prerequisite to integrate their operations to achieve the mutual goal of the supply chain as a whole as well as those of these units	Mutuality
Larsen et al. (2003)	Where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the production and replenishment processes are determined	Joint promotional activities, forecasting
Hill and Omar (2006)	Coordination can be achieved when the supply chain members jointly minimize the operating costs and share the benefits after jointly planning the production and scheduling policies	Joint decision-making, benefit sharing
Arshinder (2008)	Identifying interdependent supply chain activities between SC members and devise mechanisms for manage those interdependencies. It is the measure of extent of implementation of such aggregated coordination mechanisms, which helps in improving the performance of supply chain in the best interests of participating members	Linking coordination mechanisms with SC performance

Table 2 Different forms of coordination viewed in supply chain

S. No.	Coordination perspectives	Author (year)	Issues in coordination
1	Coordination of functions or process across SC members	Goyal and Deshmukh (1992), Thomas and Griffin (1996) Sarmiento and Nagi (1999)	Integrated procurement, production, distribution and inventory systems
2	Coordination by information sharing	Hoyt and Huq (2000), Sahin and Robinson (2002), Huang et al. (2003), Simatupang et al. (2002)	Value of information sharing and sharing modes, incentive alignment
3	Supply chain partnerships	Power (2005)	Communication, Inventory management and supply chain partnerships
4	Coordination mechanisms and performance	Lee et al. (1997)	Channel coordination, operational efficiency and information sharing
5	Problems in coordinating SC	Fawcett and Magnan (2002), Simatupang and Sridharan (2002)	Lack of information transparency, incentive misalignment
6	Coordination by IT	Li et al. (2002), Mc Laren et al. (2002)	Internet based integration of complex supply chain processes, cost and benefits of different information systems coordinating supply chain
7	Implementation issues in coordination	Barratt (2004)	Cultural, strategic and implementation elements of supply chain coordination

The other pragmatic initiatives such as Collaborative Planning, Forecasting and Replenishment (CPFR) (Larsen et al. 2003) and Supply Chain Operations Reference (SCOR) (Huan et al. 2004) may have relevance from practitioner's point of view.

Even though coordination improves the performance of the supply chain, it may not always be beneficial to coordinate the supply chain members. The high adoption costs of joining inter-organizational information systems and information sharing under different operational conditions of organizations may hurt some supply chain members (Zhao and Wang 2002). Therefore, it is essential to investigate the conditions under which supply chain coordination is beneficial, so that it should not result in higher supply chain costs and imprecise information.

Observations and Gaps Regarding Various Perspectives and Conceptual Models on SCC

(a) There seems to be no standard definition of SCC. Various perspectives on SCC as reported in the literature are testimony to this. The differences in perceptions are there because of the different expectations of the various stakeholders and the respective problem domain. Some of these perspectives present the inherent capability or intangibles required to coordinate like responsibility, mutuality, cooperation and trust. The other perspectives can be visualized, based on the coordination effort required in achieving common goals in different activities of supply chain. Since the activities are different, the coordination requirements also vary with the complexity of the activity. The most challenging coordination perspective is to extend the concept of coordination from within an organization to coordination between organizations.

(b) By looking at these different perspectives, the SCC can be viewed as a set of following steps:

1. *Identify why supply chain members want to coordinate and for which activity/process they are interdependent? Different interdependencies among supply chain members can be: ordering, procurement, inventory management, production, design and development, replenishment, forecasting and distribution.*
2. *Identify which activity or a set of activities needs to be coordinated, complexities in the activity (activities) and degree of coordination required.*
3. *Identify the reason to coordinate. Is it the demand uncertainty and/or supply uncertainty, double marginalization or other external risk in the supply chain, which can be addressed by coordination?*
4. *Identify whether a single or a combination of coordination mechanism are required to tackle the complexities in managing the interdependencies like resource sharing, knowledge sharing, information sharing, joint working, joint decision making, joint design and development of product, joint promotions, implementing information systems, designing risk sharing contracts.*

(c) Though there are attempts to focus on coordinating the different processes of supply chain, most of the papers reviewed have discussed the work done on analytical models with joint decision making of different process. The literature seems to be lacking in developing empirical relationship between coordination means and mechanisms (Information sharing, trust and IT) and SCC.

(d) There is a need to embrace a variety of perspectives on supply chain coordination, various coordination issues and the means and mechanisms to achieve coordination in a holistic manner.

(e) Various coordination mechanisms suggested in these models help in improving the various performance measures of the supply chain. These mechanisms include: joint decision-making, information sharing, resource sharing, implementing information technology, joint promotional activities, etc. The other motivation seems to be the ability of supply chain members to share the risks and subsequently share the benefits.

(f) There is a need to monitor coordination in supply chain because of the adverse effects of lack of coordination on supply chain performance. There seems to be no measure to quantify coordination. Some models can be proposed to quantify and assess the strength of coordination on the basis of coordination mechanisms.

(g) More empirical studies are required regarding the proper implementation of coordination mechanisms, so that combinations of different feasible coordination mechanisms can capture the impact of coordination on various supply chain performance measures.

The above conceptual models on supply chain coordination have been presented in a fragmented manner. It is important to understand various SC functions to be coordinated. The complexity in coordinating various SC members may also depend on the interface to which two supply chain members belong. The following section presents the importance of SC coordination in various SC functions as well as in different SC processes at various supply chain interfaces.

3 Joint Consideration of Functions or Processes by Supply Chain Members at Different Levels to Coordinate Supply Chain

Coordination can be visualized in different functions such as logistics, inventory management, forecasting, transportation, etc. Similarly, various interface such as supplier-manufacturer; manufacturer-retailer, etc. can be effectively managed using coordination.

3.1 Coordinating Functions Across Supply Chain Members

The supply chain members perform different functions or activities like logistics, inventory management, ordering, forecasting and product design involved in management of flow of goods, information and money. In traditional supply chain individual members of supply chain have been performing these activities independently. The supply chain members may earn benefits by coordinating various activities as discussed in following subsections.

Logistics has traditionally been defined as the process of planning, implementing, and controlling the efficient flow and storage of goods, services, and related information as they travel from point of origin to point of consumption. The uncertainty and complexity of decision making regarding logistics operations: diversified customers and their different requirements, different resources required, increasing rate of unanticipated change and level of goal difficulty among logistics provider and the customer (supplier, manufacturer, distributor and retailer), geographically dispersed networks of multiple manufacturing sites lead to the need of coordination in this process (Huiskonen and Pirttila 2002). The challenges lie in managing the network complexities to collectively create value to the end customer

(Stank et al. 1999; Stock et al. 2000) and integrating the logistics with whole supply chain with the help of electronic communication.

The major decisions regarding inventory management include: determination of the order quantity, the timing of order, reorder point and the replenishment of inventory. The factors which are considered while deciding the inventory policy are customer demand (deterministic and random), number of members in supply chain, replenishment lead time, number of different products stored, length of the planning horizon, service level requirements and costs comprised of cost of production, transportation, taxes and insurance, maintenance, obsolescence opportunity cost, stock out, etc. The changes even in one of the above factors affect the decisions regarding inventory policy. The factors related to inventory policy are highly dynamic because of changing market condition, supply uncertainty; different and conflicting inventory policies among supply chain members, and unavailability of inventory information of other members. To face the dynamic situation, the members of supply chain have realized the importance of coordination in inventory management. The supply chain members may coordinate by joint consideration of the system wide costs (Huq et al. 2006; Wu and Ouyang 2003; Gurnani 2001; Barron 2007), sharing cost and price information (Boyaci and Gallego 2002; Piplani and Fu 2005), synchronizing order processing time (Zou et al. 2004; Lu 1995; Yao and Chiou 2004; Barron 2007) and networked inventory management information systems (Verwijmeren et al. 1996). These policies may sometime hurt one of the supply chain members. To compensate losses, different mechanisms have been proposed as quantity discounts, revenue sharing contracts and incentive alignment policies (Li et al. 1996; Moses and Seshadri 2000; Chen and Chen 2005). The different models results in reduction in ordering cost, holding cost, purchasing cost, and supply chain system wide costs and improvement in customer service level and product availability and product variety.

The organization has perceived the need of reviving the traditional purchasing function in view of degree of participation and expertise of suppliers to a new evolving function called "strategic sourcing"(Gottfredson et al. 2005). The suppliers can form strategic partnerships by having common goals and sharing forecast information to have updated single forecasting process, which results in substantial cost reduction in whole supply chain (Zsidisin and Ellram 2001; Aviv 2001).

The increasing rate of changing technologies, innovation, customer expectations, competition, and risk involved with new product entry and at the same time keeping the product design process cost efficient, is a challenging job. Kim and Oh (2005) presented systems dynamics approach to coordinate supplier and manufacturer decisions regarding improvement in quality and the new product development. Petersen et al. (2005) presented the findings from an empirical survey about the capabilities of suppliers required in coordinating the product design process with supplier. The coordination at design stage may result in better design and improved financial performance if the supplier has sufficient knowledge required to design the product.

3.2 Coordinating Different Processes of the Supply Chain

A supply chain process consists of a set of activities taken together. Various processes in supply chain are procurement, production and distribution. These processes can be accomplished when some activities are performed like procurement process comprised supplier management, ordering, acquisition, replenishment, inspection activities, etc. Integration of different processes into a single optimization model to simultaneously optimize decision variables of different processes that have traditionally been optimized sequentially helps in improving the performance of SC (Park 2005). These processes sometimes face conflicting issues which are presented in Table 3. Isolated decision making in functionally related supply chain processes might weaken the supply chain system wide competitiveness. The different supply chain processes can be coordinated by implementing joint production delivery policies, common cycle approach, identical replenishment cycle (Yang and Wee 2002) and joint lot scheduling models (Kim et al. 2006). The coordination problems and the related issues at the interfaces of supply chain are presented in Table 4.

3.2.1 Production and Distribution Coordination

Integration of production and distribution processes may lead to a substantial saving in global costs and to an improvement in relevant service by exploiting scale economies of production and transportation, balancing production lots and vehicle loads, and reducing total inventory and stockout. Chikan (2001) gave a theoretical background of integrated production/logistics systems on the basis

Table 3 Conflicting issues in supply chain processes

SC processes	Conflicting issues in supply chain processes
Production and distribution coordination	The difference in performance metrics such as improvement in quality of production, reduction in cost and improvement in service levels for distribution may also give rise to conflict
	Production sub functions are usually concentrated in the organization, while distribution sub functions are spread over (Chikan 2001)
	Production function is obsessed with low cost production, with large batch sizes and efficient and smooth production schedules (Pyke and Cohen 1993) and the distribution function is concerned with customer service as first priority, small batch sizes and frequent changeovers (Pyke and Cohen 1993)
Procurement and production coordination	Suppliers typically want manufacturers to commit themselves to purchasing large quantities in stable volumes with flexible delivery dates
	Manufacturers require just-in-time (JIT) supply in small batches from their suppliers due to changing demand and their unwillingness to hold inventories

Table 4 Coordination in various activities and interfaces of supply chain

Author	Coordination problem	Coordination mechanism	Structure of supply chain	Methodology used	Performance measure
Logistics					
Stank et al. (1999)	Mismatch goals between shipper and transportation provider	Information sharing and IT	Logistics provider and clients[a]	Empirical survey	Inventory level, transportation costs, warehousing costs, ordering costs, order cycle variance, on time deliveries and unacceptable deliveries
Stank and Goldsby (2000)	Mismatch goals between shipper and transportation provider	Information sharing, aligning goals, EDI, contracts	Logistics provider and clients[a]	Conceptual framework	Channel cycle time and inventory level
Stock et al. (2000)	Lack of integration between logistics and supply chain	EDI	Logistics provider and clients[a]	Empirical survey	Operational performance and financial performance
Huiskonen and Pirttila (2002)	Need of relation improvement between logistics and client	Information sharing, IT, integrating role	Logistics provider and manufacturer	Conceptual survey	Good relationship
Inventory					
Lu (1995) and Yao and Chiou (2004)	Different order intervals	Joint decision making and benefit sharing	Single-supplier–multi-buyer	Analytical model	Minimize costs (ordering + holding + purchasing)
Li et al. (1996)	Need of system cooperation	Quantity discounts	Seller–buyer	Game theoretic model	Maximize profits
Verwijmeren et al. (1996)	Independent management of inventories	IT and mutual benefits	Supply chain network	Network solution	Improving customer service level, increasing product variety, and lower supply chain system wide costs
Moses and Seshadri (2000)	Need of risk sharing, mismatch in stock level and review period	Joint decision making and quantity discounts	Manufacturer–retailer	Optimization	Minimize cost
Gurnani (2001)	Mismatch in timing of order	Joint system cost consideration, quantity discounts	Single-supplier–multi-buyers	Analytical model	Minimize cost

(continued)

Table 4 (continued)

Author	Coordination problem	Coordination mechanism	Structure of supply chain	Methodology used	Performance measure
Boyaci and Gallego (2002)	Lack of coordination in lot sizing decisions and pricing	Jointly plan pricing and inventory replenishment policies	Single-wholesaler–multi-retailer	Analytical optimization problem	Maximize channel profits (wholesale price-inventory related costs)
Zhao et al. (2002)	Mismatch in timing of order	Order coordination, information sharing	Single-manufacturer–multi-retailer	Simulation	Minimize cost and improve service level
Wu and Ouyang (2003)	Independent cost calculation	Joint cost consideration with shortages	Vendor–buyer	Analytical model	Minimize cost
Zou et al. (2004)	Different order processing times of suppliers and incentive conflicts	Information sharing and revenue sharing contracts	Multi-supplier–single-assembler	Analytical model (extension to newsboy model)	Maximize profits, minimize costs (holding + shortage)
Chen and Chen (2005)	Need of risk sharing	Joint consideration of cost, savings sharing, quantity discounts	Manufacturer–retailer	Mathematical	Pareto improvement
Piplani and Fu (2005)	Misaligned inventory decisions	Cost sharing and service level contracts	Multi-echelon	Multi agent technology and genetic algorithm	Minimize inventory holding cost
Huq et al. (2006)	Independent cost consideration	Joint consideration of cost	Multi-warehouse–multi-retailer	Mathematical model and simulation	Minimize distribution cost and lead time
Barron (2007)	Different cycle times	Joint decision making	Serial supply chain (multi-echelon)	Analytical model	Minimize costs (ordering + holding)
Forecasting					
Aviv (2001)	Independent decision making of forecasting	Joint decision making and demand information sharing	Manufacturer–retailer	Analytical model	Minimize cost
Inventory-distribution					
Haq and Kannan (2006)	Potential lie in reducing costs by considering all costs jointly	Joint consideration of costs at each level	Multi-echelon	Fuzzy AHP and genetic algorithm	Minimize costs (inventory carrying + production + transportation)

Production-distribution					
Jayaraman and Pirkul (2001)	Lack of integration in different processes of supply chain	Joint production distribution cost minimization	Multi-echelon	Lagrangian relaxation scheme	Minimize costs (purchasing + production + distribution)
Pyke and Cohen (1993)	Conflict between large batch size (production) and small batch size (distribution)	Near optimal cost and service level, plan jointly	Single-manufacturer–single-distributor–single-retailer	Constrained optimization problem	Production cost and service level
Chandra and Fisher (1994)	Costs of carrying inventory at multi location, results more inventory level in whole supply chain	Coordinate production scheduling and vehicle routing	Multi-echelon	Local improvement heuristics	Minimize costs (fixed cost of facilities + holding + distribution)
Ganeshan (1999)	Lack of integration in different processes	Joint production distribution cost minimization	Multi-echelon	Mathematical and simulation	Minimize costs (purchasing + production + distribution)
Jang et al. (2002)	Need for coordinating production and distribution	Joint cost minimization with global BOM	Multi-echelon	Lagrangian heuristics and genetic algorithm	Minimize costs (production + distribution)
Production-inventory					
Yang and Wee (2002)	Conflict in finding number of deliveries of an order by vendor and buyer	Joint decision making and quantity discounts	Single-supplier–multi-buyer	Mathematical model	Minimize costs (holding + ordering)
Hill and Omar (2006)	Holding costs increases as goods move downstream in supply chain	For different holding costs of members, find order quantity and share benefits	Single-supplier–single-buyer	Mathematical model	Minimize costs (production + shipping + holding)
Hwarng et al. (2005)	Managing complexities	Synchronizing production cycles and risk pooling effects	Multi-echelon (5 levels)	Simulation	Average stock level, average backlog and average total cost

[a]Clients can be supplier, manufacturer, distributor and retailer

of institutional economics, discussed business issues regarding integration of these two functions and how this connection is handled in education. Jayaraman and Pirkul (2001) developed an integrated production distribution model comprised fixed cost, purchasing cost, production cost and distribution cost, taken simultaneously. Pyke and Cohen (1993) presented an integrated production distribution model and examined its performance characteristics (production cost and service level). Hill (1997) determined the production and shipment schedule for an integrated system to minimize average total cost per unit time.

Kim et al. (2006) developed a mathematical optimization problem in multiple plants in parallel and single retailer supply chain system. The joint optimization of costs was carried out to determine the production cycle length, ordering quantity and frequency, and production allocation ratios for multiple plants. Dotoli et al. (2005) proposed a three-level hierarchical methodology for a supply chain network design at the planning management level. The network is so designed where the members are selected based on the performance followed by optimizing the communication and transportation links of supply chain. The performance measures used were operating costs, cycle time, energy saving, product quality and environmental impact.

3.2.2 Procurement and Production Coordination

Goyal and Deshmukh (1992) reviewed the literature on Integrated Procurement-Production (IPP) systems. The different models of IPP were classified into the categories based on number of products, planning horizon, solution method employed, joint replenishment orders, and algorithmic issues in their study. Munson and Rosenblatt (2001) presented a purchasing-production integrated model and compared the cases of centralized SC and decentralized SC. It was found that decentralized SC gives same results as that of centralized supply chain if quantity discounts are considered at both upstream and downstream interfaces.

3.2.3 Production and Inventory Coordination

Lu (1995) considered heuristics approach for single vendor multi-buyer problem based on equal sized shipments. With the coordination of the replenishments of different items, the vendor can reduce his total annual cost by 30%. The buyers also benefit from the multi-buyer model by reducing their costs. Hoque and Goyal (2000) developed an optimal solution procedure for optimal production quantity in single vendor single buyer production inventory system with unequal and equal sized shipments from the vendor to the buyer and under the capacity constraint of the transport equipment by using simple interval search approach. Arreola-Risa (1996) considered the situation of multi-item production–inventory system with stochastic demands and capacitated production under deterministic or exponentially distributed unit manufacturing times. The observed results are that variation in the production environment increases the optimal inventory levels. The impact of capacity utilization in optimal base stock level is non-linear function of demand rate. Grubbstrom and Wang (2003) developed a multi-level capacity constrained model with stochastic demand. The Laplace transform was used as tool to construct the model and dynamic programming was used to solve and to find out the net present value (NPV) as an objective function. It was observed that for higher levels of capacity, the stochastic solution continues to improve performance of the system, albeit at a very slow rate and then takes advantage of increasing availability of the capacity resources. Kim et al. (2006) considered common production cycle length, delivery frequency and quantity in three level supply chain in joint economic procurement, production and delivery policy.

3.2.4 Distribution and Inventory Coordination

Jayaraman (1998) developed an integrated mathematical programming mixed-integer model for minimization of the total distribution cost associated with all three decision components i.e. facility locations, inventory parameters and transportation alternative selection, all investigated jointly. The integrated model permits a more comprehensive evaluation of the different trade-off that exists among the three strategic issues. Yokoyama (2002) developed an integrated optimization model of inventory-distribution system in which any consumer point can be supplied by multiple distribution centers. The order-up-to-R, periodic review inventory policies and transportation problem are considered simultaneously. Simulation and linear programming was used to calculate the expected costs and a random local search method was developed to determine optimum target inventory, which was then compared with genetic algorithm.

Haq et al. (1991) formulated a mixed integer programming for integrated production–inventory-distribution model. The objective of the model was to determine optimal production and distribution quantities through various channels, optimal levels of inventory at various production stages and at warehouses over 6-month planning periods considering set up time cost, lead time, production losses and recycling of losses with backlogging.

Observations and Gaps in Different Activities and at the Interfaces of Supply Chain

(a) In the literature, different problems in coordinating the activities with various approaches have been discussed. The main objective considered in coordinating different problems in some activity is either minimizing the costs or maximizing profits. The coordination of same activities at different levels of supply chain reduces the supply chain costs.
(b) The common problems addressed in literature are the joint consideration of different costs in an activity. These costs are associated with the supply chain coordination problems of joint ordering by buyers to some supplier, jointly plan order quantity between supplier and buyer, jointly order delivery to the buyers and joint replenishment activities in terms of coordinated lead times.

The coordination problems have also been extended for coordinating different processes to collectively consider the costs of different processes to minimize the overall cost of supply chain.

(c) The methodologies adopted to tackle the problem include: analytical, mathematical and optimization tools. Most of the studies regarding SCC are conducted on a two-level dimension because of the simple supply chain structure (Ganeshan 1999; Hill 1997) and discussed production delivery policies and joint stocking with discounts (Weng and Parlar 1999) at two level supply chain. To effectively allocate the production requirement and capture supply chain dynamics, various models have been dealt with joint purchasing policies in multiple supplier environment (Zou et al. 2004) and considering total cost of logistics. The investigations are required in supply chain encompassing multiple levels that consider the complex interactions between the upstream and downstream sites and gives a more real picture of supply chain.

(d) The following are some gaps, which if considered, may further enhance coordination and performance of supply chain:

- The whole supply chain is required to coordinate, so models can be extended to consider more than one activity.
- The only coordination mechanism used by most of the authors is joint consideration of costs. From the literature regarding coordination models it can be observed that a number of coordination mechanisms (information sharing, roles integration, information technology) are possible to solve the coordination problem. There can be situations where two mechanisms are required to reduce the supply chain costs for example information sharing and quantity discounts.
- The consideration of one performance measure may not justify the value of coordination. So, a number of performance measures are required to capture the impact of coordination in a holistic manner. Along with the measures like costs and profits, the benefits of coordination may also be indicated with the help of performance measures like: improving responsiveness by timely information sharing in whole supply chain, reducing inventory delays and information lead time by implementing good information systems and evaluating risks and rewards due to coordination.
- The analytical and mathematical approaches used to coordinate activities and processes of supply chain may not tackle the dynamics of supply chain. Hence, simulation approach may be a good choice to view the overall coordination scenario of the whole supply chain.
- Most of the studies on coordination are done for two level supply chains. This assumption may restrict the usage of models, as these models may not handle the ever-changing variables of supply chain.
- The assumption of integrated different functions and processes leads to cost reduction, but models are required to evaluate or measure the degree of coordination (which leads to improvement in the supply chain performance).

- The recent trend of outsourcing the logistics operations to third party logistics provider (3PL) has reduced many discrepancies related to replenishment of goods (Jayaram and Tan 2010). The studies are required how to 3PLs can be an information source to coordinate suppliers and buyers. The knowledge and expertise of 3PLs on routes, fleet size and fleet type can be leveraged in optimizing the procurement-production-distribution problems and integrating with 3PLs.
- To gain the advantage of common logistics provider and information systems, the supply chain members at same level may coordinate horizontally. Very few papers have discussed horizontal collaboration (Arshinder et al. 2006; Bahinipati et al. 2009) by using multi-criteria decision making models. Some quantitative models can be proposed to quantify such kind of coordination also.

In this section we can observe that how supply chain coordination is required in each SC process. Various processes have been coordinated by adopting different means mechanisms of coordination. By looking at the need of coordination in SC, the researchers may like to know various existing coordination mechanisms, which can be adopted to coordinate supply chain across different industries. The next section presents various coordination mechanisms, which can be adopted as per the suitable supply chain environment.

4 Various Supply Chain Coordination Mechanisms Adopted in the Supply Chain

The dependencies between supply chain members can be managed by some means and mechanisms of coordination. By utilizing coordination mechanisms, the performance of supply chain may improve. There are different types of coordination mechanisms as discussed in the following subsection.

4.1 Supply Chain Contracts

Supply chain members coordinate by using contracts for better management of supplier buyer relationship and risk management. The contracts specify the parameters (like quantity, price, time, and quality) within which a buyer places orders and a supplier fulfills them. The objectives of supply chain contracts are: to increase the total supply chain profit, to reduce overstock/understock costs and to share the risks among the supply chain partners (Tsay 1999). The contracts counter double marginalization that is by decreasing the costs of all supply chain members and total supply chain costs when they coordinate as against the costs incurred when the SC members act independently. The problem of double marginalization and risks like overstock and understock has been widely been observed single period inventory models with less shelf life of product. Most of the contracts have been proposed as single period models. Various contracts are defined in Table 5.

Buyback contracts or returns policy has been widely used coordination contract in textile and fashion industry. In buyback contracts a manufacturer offers retailer either full credit for a partial return of goods a partial credit for all unsold goods. In case of retail competition the manufacturer will be benefited from the returns policy when the production costs are sufficiently low and demand uncertainty is not too great (Padmanabhan and Png 1997). Krishnan et al. (2004) have analyzed that

Table 5 Definitions of supply chain contracts

S. No.	Supply chain contract	Definition	Author (year)	Remarks
1	Buy back	The manufacturer (seller) agrees to buy back the unsold units from the retailer (buyer) for agreed upon prices at the end of the selling season	Mantrala and Raman (1999), Hau and Li (2008)	Improves the coordination, increases sales, risk sharing
2	Revenue sharing	In a revenue sharing contract, the buyer shares some of his revenues with the seller, in return for a discount on the whole sale price	Yao et al. (2008), Zhou and Wang (2009)	More flexible in terms in terms of whole sale price
3	Sales rebate	The sales rebate provides a direct incentive to the retailer to increase sales by means of a rebate paid by the supplier for any item sold above a certain quantity	Wong et al. (2009)	Provides direct incentives for retailers to increase sales
4	Quantity flexibility	It couples the customer's commitment to purchase no less than a certain percentage below the forecast with the supplier's guarantee to deliver up to a certain percentage above	Tsay (1999)	Gives more flexibility in order quantity
6	Trade policy	This policy deals with how the total profit is shared among supply chain entities	Ding and Chen (2008)	Offers better profit sharing
7	Reservation policy	This policy offers discounts to the products reserved and the products which are not reserved are sold at retail price	Chen and Chen (2009)	Reduces the uncertainty in demand
8	Markdown money (price discount)	After the selling season, the unsold units are sold at discounted price	Lee (2001), Pan et al. (2009)	Improves profit of the channel
9	Quantity discount	During the selling period, the seller offers discounts based on quantity of goods purchased	Weng (2004)	Improves the sales

buyback contract coupled with promotional cost sharing agreements between manufacturer and retailer result in supply chain coordination.

The other consideration in buyback contract is the case of information sharing and asymmetrical information between the supply chain members (Yao et al. 2005; Yue and Raghunathan 2007). Bose and Anand (2007) proposed that by assuming transfer price exogenous the buyback contract is Pareto efficient. Yao et al. (2008) proposed an analytical model to analyse the impact of stochastic and price dependent demand on returns policy between manufacturer and retailer. The other variants of buyback contracts discussed in literature are: stochastic salvage capacity in fashion industry (Lee and Rhee 2007); two period contract model in case of decentralized assembly system (Zou et al. 2008); in case of updating of information in supply chain (Chen et al. 2006) and by including the risk preferences of the SC members (He et al. 2006).

In case of quantity flexibility contract, 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. Tsay and Lovejoy (1999) proposed quantity flexibility contracts for two independent members of the supply chain model to design incentives for the two parties to determine system wide optimal outcome. The efficiency can be improved when buyer is ready to pay more to the supplier for increased flexibility. Tsay and Lovejoy (1999) proposed a framework for the design of quantity flexibility in three level supply chains, behavioural models in response to quantity flexibility contracts and the impact on the supply chain performance measures: inventory levels and order variability. More output flexibility comes at the expense of greater inventory cost, so inventory management has been viewed as the management of process flexibilities. It is observed that the quantity flexibility contracts can dampen the transmission of order variability throughout the supply chain.

Milner and Rosenblatt (2002) analysed two period quantity flexibility contract in which the buyer is allowed to adjust second order paying a per unit order adjustment penalty. This contract can reduce the potentially negative effect of correlation of demand between two periods, but the order quantity flexibility reduces the profits of the buyer. Barnes-Schuster et al. (2002) proposed two period options contracts where buyer has flexibility to respond to market changes in second period and coordinate the supply chain channel. Sethi et al. (2004) developed a model to analyze a quantity flexibility contract involving multiple periods, rolling horizon demand and forecast updates including demand and price information updates.

In revenue sharing contract, the supplier charges the buyer a low wholesale price and shares a fraction of the revenues generated by the buyer (Giannoccaro and Pontrandolfo 2004; Cachon and Lariviere 2005; Koulamas 2006). The SC members can design contracts based on discounts: lot size based or volume based. Yao et al. (2008) developed a revenue sharing model in the case of retail competition by considering price sensitivity. vander Rhee et al. (2010) has considered multi echelon (more than two) supply chain members and simultaneously installed revenue sharing contracts between all pairs of adjacent supply chain members to coordinate the supply chain.

A discount is lot size based if the pricing schedule offers discounts based on the quantity ordered in a single lot. A discount is volume based if the discount is based on the total quantity purchased over a given period regardless of the number of lots purchased over that period (Rubin and Benton 2003; Weng 2004). Chauhan and Proth (2005) proposed a profit sharing model under price dependent demand proportional to their risks based on expected customer demand.

4.2 Role of Information Sharing and Information Technology

IT is used to improve inter-organizational coordination (McAfee 2002; Sanders 2008) and in turn, inter-organizational coordination has been shown to have a positive impact on select firm performance measures, such as customer service, lead-time, and production costs (Vickery et al. 2003).

Information technology helps to link the point of production seamlessly with the point of delivery or purchase. It allows planning, tracking and estimating the lead times based on the real time data. Advances in Information Technology [e.g. internet, EDI (electronic data interchange), ERP (enterprise resource planning), e-business and many more] enable firms to rapidly exchange products, information, and funds and utilize collaborative methods to optimize supply chain operations.

Internet and web can enhance effective communication, which helps members of supply chain review past performance, monitor current performance and predict when and how much of certain products need to be produced and to manage workflow system (Liu et al. 2005). Fin (2006) investigated the relation between EDI in apparel industry and three performance levels: operational, financial and strategic. This helped in reduction of lead time from several weeks to 3 days.

According to Soliman and Youssef (2001), e-business strategy refers to the way internet tools are selected and used in relation to the needs of integration and coherent with other organizational and managerial tools: e-commerce (Swaminathan and Tayur 2003) can be used to support processes such as sales, distribution and customer service processes, support to sourcing, procurement, tendering, and order fulfillment processes, and e-manufacturing (Kehoe and Boughton 2001). Devaraj et al. (2007) analyzed the relationship between supplier integration and customer integration with supply chain performance when supported by e-business technologies. E-business capability supporting supply chain technologies such as customer orders, purchasing and collaboration between suppliers and customer enhances the production information integration intensity, which in turn improves the supply chain performance.

Skipper et al. (2008) proposed a conceptual model to link level of interdependence among supply chain with supply chain performance moderated by different types of IT needed to achieve different levels of coordination. The framework is supported by interdependence theory and coordination theory. The coordination processes between globally dispersed and mobile supply chain members is becoming more and more information intensive. The recent trends in intelligent wireless web services have proved enhancement in the mobile real time supply chain coordination (Saroor et al. 2009).

The various coordination problems handled by information systems are: little value to the supplier because of competitive bidding, forced implementation of IT, incompatible information system at different levels of supply chain, greater lead times, inefficient purchase order and misaligned e-business strategies and coordination mechanisms (Porter 2001). Stank et al. (1999) report that the food firms benefit from more accurate and timely information and IT or EDI improves inventory management and helps in comprehension of the order cycle. Yusuf et al. (2004) examined key dimensions of implementation of ERP system in Rolls Royce. The implementation of latest information system only may not be sufficient to integrate supply chain members, since at times; faulty implementation may result in the poor performance of supply chain. Li et al. (2009) carried out an empirical study to explore relationship between IT, supply chain integration and supply chain performance of Chinese manufacturing organization. Supply chain integration mediates the relationship between IT implementation and supply chain performance. Hence, IT can be a good enabler to integrate supply chain. But it is important to take into account the justification of IT in changing business environment. It must take into account the appropriate usage, investment justification and align with business environment to achieve competitive advantage (Gunasekaran et al. 2006).

The supply chain members coordinate by sharing information regarding demand, orders, inventory, shipment quantity, POS data, etc. Timely demand information or advanced commitments from downstream customers helps in reducing the inventory costs by offering price discounts and this information can be a substitute for lead time and inventory (Reddy and Rajendran 2005). The value of information sharing increases as the service level at the supplier, supplier-holding costs, demand variability and offset time increase, and as the length of the order cycle decrease (Bourland et al. 1996; Chen et al. 2000). The higher the level of information sharing, the more important the effective supply chain practice is to achieve superior performance (Zhou and Benton 2007).

Some comparative studies have done in which no information sharing policy is compared with full information sharing policy. Information sharing policy results in inventory reductions and cost savings (Yu et al. 2001). Cachon and Fisher (2000) presented a simulation-based comparative study, where the supply chain costs are 2.2% lower on average with full information sharing policy than with traditional information policy and the maximum difference is 12.1%. Also, this results in faster and cheaper order processing that leads to shorter lead times. The point of sales (POS) data helps the supplier to better anticipate future orders of the retailers and reduces the bullwhip effect (Dejonckheere et al. 2004). The supplier may take advantage of the retailers' inventory information in allocating the stock to retailers optimally (Moinzadeh 2002).

Ding et al. (2011) has investigated the mechanism of providing incentive to retailer by upstream partner for implementing demand information sharing in the context of three-echelon supply chain system. A cooperative game approach is proposed to address the problem of profit allotment between partners to effectively motivate the partners to be cooperative with each other.

4.3 Other Collaborative Initiatives

Joint consideration of replenishment (Yao and Chiou 2004; Chen and Chen 2005), inventory holding costs with dynamic demand (Boctor et al. 2004), collaborative planning (Aviv 2001), costs of different processes (Haq and Kannan 2006; Jayaraman and Pirkul 2001; Ganeshan 1999), frequency of orders (Yang and Wee 2002; Barron 2007), batch size (Pyke and Cohen 1993; Boyaci and Gallego 2002), product development (Kim and Oh 2005) to improve the performance of supply chain. A supply chain member may design a scheme to share profits at the end of period. The supply chain members share profit by determining optimal order quantity of single supplier and multi-buyer supply chain and achieve coordination (Jain et al. 2006). A coherent decision-making helps in resolving conflicts among supply chain members and in exceptions handling in case of any future uncertainty.

There are many factors involved in achieving coordination like human, technology, strategies, relationship, rewards, sharing of knowledge, sharing benefits, aligning goals, scheduling of frequent meetings of stakeholders for conflict resolution, understanding of nature of intermediates and knowledge of supply chain concepts, status or power difference and resistance in following the instructions of other organizations (Lu 1995; Gittell and Weiss 2004). Simatupang et al. (2004) explored a fashion firm to see how coordination is driven by its responsibility interdependence, uncertainty, and inter-functional conflict. By properly identifying different points of coordination, the performance improvement was effected.

Vendor Managed Inventory (VMI) is a supply chain initiative whereby a supplier assumes responsibility for maintaining inventory levels and determining order quantities for its customers. A number of benefits from VMI adoption have been reported in literature: reduction in inventories, shorter order intervals and more frequent deliveries. A VMI program typically involves the use of a software platform, the sharing of demand forecasts and/or cost information, timely communications, set liability levels, and risk-sharing parameters and common goal sharing between the buyer and the supplier. VMI can be particularly beneficial in the products with high demand variance and high outsourcing costs (Cheung and Lee 2002).

Collaborative Planning, Forecasting and Replenishment (CPFR) is a collaboration initiative where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the production and replenishment processes are determined (Larsen et al. 2003). Some of the benefits of CPFR are increased sales, higher service levels, faster order response time, lower product inventories, faster cycle times, reduced capacity requirements, reduced number of stocking points, improved forecast accuracy and lower system expenses. Danese et al. (2004) explored the relationship between the types of interdependencies (one way and two way communications) among the units involved in the CPFR processes and the activated coordination mechanisms (Liaison positions, meetings, task forces, standing committees and integrating managers) in three case studies for all the steps of implementation of CPFR. The case studies were considered from different industries: pharmaceutical, automotive and mechanical. This relationship may help managers in the decision making process to select the most appropriate action to perform to implement CPFR.

Quick response (QR) is another inventory management initiative which can be undertaken to coordinate supply chain members by responding quickly to market changes with reduced lead time. The response time is reduced as a retailer sends POS data to its supplier. The supplier makes use of this information to improve the demand forecast and production/distribution schedules (Iyer and Bergen 1997; Simchi-Levi et al. 2007). Choi and Sethi (2010) have reviewed QR supply chains from both supply and demand perspectives and classified the literature as supply information management, demand information management and supporting technologies. It is concluded that there are challenges to implement QR in multiple decision points, which needs to be met by continuously innovating new technologies like Radio Frequency Identification Devices (RFID).

The Supply Chain Operations Reference (SCOR) model helps in evaluating and improving enterprise wide supply chain performance and management. SCOR is structured on four levels: plan, source, make and deliver. It brings order to the diverse activities that make up the supply chain, and provides common terminology and standard process descriptions. The model allows companies to: evaluate their own processes effectively, compare their performance with other, companies both within and outside their industry segment, pursue specific competitive advantages, use benchmarking and best practice information to prioritize their activities, quantify the benefits of implementing change and identify software tools best suited to their specific process requirements (Huan et al. 2004).

Observations and Gaps in Coordination Mechanisms

(a) The supply chain contracts can be a useful mechanism to resolve the conflict and risk related problems. The use of information technology in handling transactions online between supply chain members reduces the response time. The members can plan their operational activities by sharing or retrieving the data from each other. It helps in streamlining the processes and reduces supply chain costs.
(b) The members might have different technologies, skill and different type of knowledge about market. To handle any future exceptions or uncertainties, the members may jointly plan supply chain activities like ordering, replenishment, and forecasting and product design.
(c) The following gaps regarding coordination mechanisms need attention to enhance coordination:

   - Since the role and utility of all coordination mechanisms is handling different phases of supply chain. To coordinate supply chain as a whole, the consideration of all coordination mechanisms may give very good performance.

- Most of the models describing coordination mechanisms are dealt in two level supply chain, which can be extended to multi-level supply chain. The relation between different coordination mechanisms and the performance measures of supply chain need to be developed. The models handling the problems of coordination have emphasized on single performance measures. The supply chain dynamics may be captured by considering a number of performance measures of supply chain.
- Supply chain contracts are designed to motivate the downstream member to order more than his/her optimal order quantity. The downstream member always faces uncertainty of overstock or under stock. The upstream member always faces uncertainty that whether the downstream member will send the order matching the upstream member's capacity. The contracts like buyback and revenue sharing contracts can enhance expected sales and reduces stock outs. Quantity flexibility contracts can reduce the overstock problems of downstream members. These performance indicators are equally important, which needs more research attention.
- The contract decision variables at different interfaces of the supply chain in multi echelon environment interact with each other. For example the contract adopted by supplier and manufacturer is sometimes dependent on the contract adopted by same manufacturer with his/her distributor in a same supply chain. There is a need to explore such relationship and to explore different combinations of contracts at different interfaces of supply chain.

The major driver of SCC is the conflict or uncertainty, which needs to be addressed by selecting suitable coordination mechanism. But, it is important to understand at the same time, to what extent SCC can help in mitigating supply chain uncertainty (presented in the next section).

5 Supply Chain Coordination to Manage Uncertainty in the Supply Chain

Supply chain uncertainty has been captured in various forms like supply uncertainty, production or operational uncertainty and demand uncertainty. In the supply chain coordination literature, various coordination mechanisms have been adopted to manage supply chain uncertainty like uncertainty in capacity, demand, lead time, quantity and production and supply disruptions (Tang and Musa 2011) as shown in Fig. 2. Many papers have emphasized on supply chain contracts and information exchange/sharing to manage supply chain uncertainties. Whereas, the other set of papers discussed the joint consideration of costs and profits of all supply chain members while taking decisions regarding ordering and replenishment. This joint

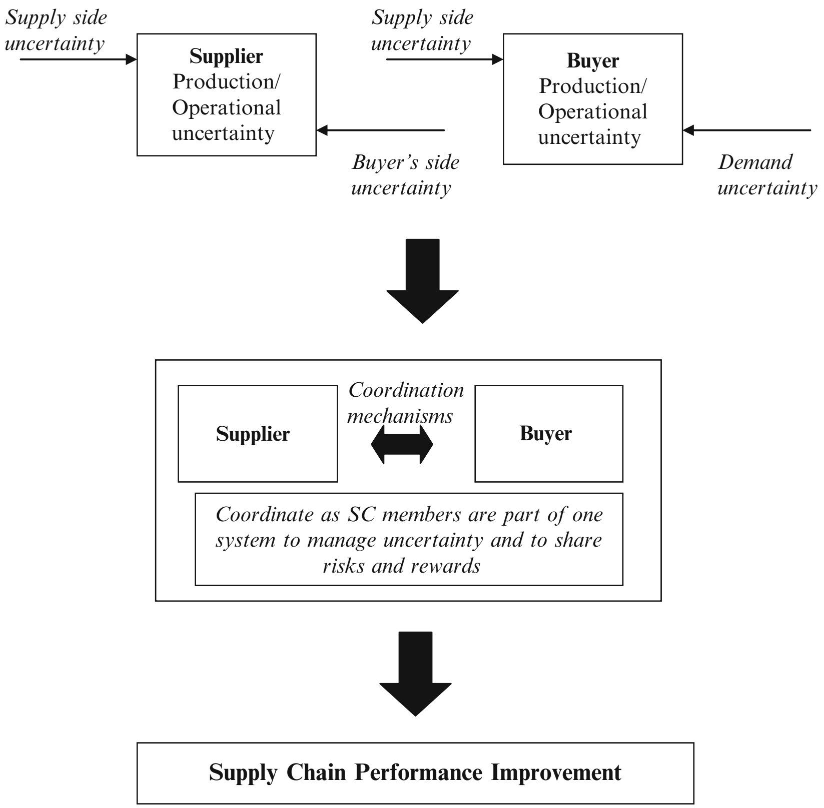

Fig. 2 Managing supply chain uncertainty with supply chain coordination

consideration of costs or profits (centralized system) helps to improve the performance of supply chain over a decentralized case (independent decision making).

Due to the increased technological innovations, the products' lifecycle has largely shortened. Seasonal and perishable goods can be attributed to this kind. Such products have longer production and delivery lead time than their selling season (Mantrala and Raman 1999). So the orders should be placed before the selling season starts. Some of the important challenges in integrating the supply chain are tackling issues such as managing complex supply chain structures, demand uncertainty and leftover units after selling season. In a single period inventory model, better coordination can be achieved by inducing the retailer/buyer to order more in order to avoid their risk of under stocking through some negotiations with the manufacturers/seller. The manufacturer offers integrated decision making policies like returns policy, sales rebate policy, price discount/volume discount policy, etc. to raise the order quantity and improves sales (Yao et al. 2008). Past research has proved that introduction of various contracts improve the performance of the supply chain as well of each entity in supply chain.

The contracts have been discussed for single period inventory models with either deterministic demand or uncertain demand or price dependent demand.

Apart from contracts there can be some incentive function to achieve flexible cost allocation between supplier and buyer to coordinate the supply chain and to manage uncertainty in supply (Zimmer 2004). Hou et al. (2010) have proposed a model considering one manufacturer and two suppliers: the main supplier is cheaper but prone to disruption risk and backup supplier is more reliable but an expensive. The authors have developed a non-linear optimization model to determine the optimal values of buyer's order quantity and optimal buyback price under both supply and demand uncertainty. Early supply involvement reduces the likelihood of supply disruptions and negative supply events (Zsidsin and Smith 2005). The contracts like advanced purchase commitments can help mitigating supply uncertainty, where unsatisfied demand can be backordered from risky supplier (Serel 2007).

The other kind of uncertainty due to disruption can be observed as disruptions in the production process at manufacturer's facility. Qi et al. (2004) proposed a model for short life cycle product with demand as decreasing function of retail price considering disruptions. The model considered the two periods wherein the second period demand change can lead to the disruption, which may affect the production plan of supplier. The wholesale quantity discounts may coordinate the supply chain in this scenario of disruption. The similar kind of disruption can be seen in terms of production costs. Xiao and Qi (2008) developed two-period model for one-manufacturer and two competing retailers supply chain under production costs disruption. The authors have analyzed two mechanisms; an all unit quantity discounts and incremental quantity discounts the under production disruptions for possible coordination scenarios. A risk sharing contract is proposed where at the end of period the retailer compensates manufacturer's losses due to overproduction or manufacturer compensates retailer's losses due to over stock in case of supply chain with two stage demand information updating (Chen et al. 2006).

There can be several benefits of splitting the single period order into multiple ordering to update the demand information and revise the order in the subsequent orderings. It has impact on production costs of the manufacturer due to slow production and fast production as against the multiple different orders (Liu et al. 2004). The other effect of multiple ordering can be seen on holding cost, lead time, backorders, varying wholesale and retail price and consideration of demand for multiple periods. The methodology adopted for handling multiple ordering ranges from newsboy problem to analytical models with simulation to the dynamic programming. The decision variables have been the order quantities and/or the varying wholesale prices, retail prices and buyback prices in multi-period situation (Lee 2007; Zhou and Wang 2009; Pan et al. 2009).

Other aspect of capturing demand uncertainty is by using fuzzy demand. The expected profits of coordinated supply chain outperform the expected profits in the case of no coordination under fuzzy demand (Xu and Zhai 2010). Barbarosoglu (2000) has proposed a decision support model for improving supplier–buyer coordination by using supply contracts where the buyer's commitment is considered as a function of time at the contract renewal time to reduce the supply chain nervousness. A pricing model is formulated to address partnership expectations for a fair sharing of savings of the supply chain members.

Observations and Gaps in Uncertainty and Supply Chain Coordination

(a) Most of the studies are restricted to two level serial supply chains. In reality, supply chain can have divergent and convergent multi-echelon structures. The literature seems lacking to address the uncertainty concerns in such structures.
(b) The literature has emphasized more on demand uncertainty, whereas, supply uncertainty can be of equal concern in the era of globalization and outsourcing. Moreover, the quantitative models can be proposed to explore the impact of supply uncertainty on supply chain performance.
(c) There are very few studies on splitting the single period order into multiple orders. The supply chain members can take advantage of more accurate information over a period of selling season and hence resolve supply chain inefficiencies.
(d) The buyback contract is the only contract which has been discussed in multi ordering models to manage the risk. There is a scope to explore combination of other contracts in multiple ordering over single season.

6 Discussion

A number of difficulties in SCC are identified based on the literature. These difficulties have been identified from different activities, interfaces and the number of levels in the supply chain. It has been realized that the difficulties in SCC and independent working of supply chain members lead to poor performance. The coordination problems are solved by implementing some coordination mechanisms in supply chain activities, which may result in the improvement of some performance measures. The SC activities have been considered in isolation to solve their respective coordination problem. The coordination problems may not be same in all activities of supply chain. The requirements of coordinating whole SC may vary with SC activity, with some interface of SC, with number of echelons in SC and with process of SC. There are different activities and different coordination problems in whole supply chain. Coordinating one activity may not help to improve supply chain system wide performance.

6.1 Existing Models of Coordination and the Gaps in These Models

There are some initiatives and models (such as CPFR and SCOR) which may help in collaboration along the supply chain. These models consist of so many steps and the implementation of such processes takes time. Various guidelines are required to implement these models in practice. It is difficult to link the guidelines directly to the performance of supply chain. It may take a number of years to know the performance improvement by implementing these models, as there is no set measure to quantify coordination which can be linked with practice (or which may result due to implementation of these models) of these models. It is difficult to get a quantitative measure after implementing models like CPFR and SCOR, which may indicate about whether SC is coordinated or not.

The coordination models discussed have different performance measures at single level and at interface of supply chain, which are not aligned with the whole supply chain. To monitor coordination in supply chain, same performance measures throughout will help in evaluating the value of coordination. There are different mechanisms, which when applied, result in different trade-offs of performance measures of coordinated supply chain because of different characteristics of performance measures. The complexity of considering whole supply chain and the performance trade-offs cannot be handled with the models discussed in the literature. These difficulties can be easily tackled by approaches like fuzzy logic (Ross 1997) and multi-objective genetic algorithms (Deb 2002). Fuzzy logic is applied in the situation where understanding is quite judgmental and the processes where human reasoning and human decision making is involved like the complexities in supply chain. The optimum values of decision variables in multi objective environment can be easily determined with the help of tools like Genetic Algorithm.

6.2 Proposed Framework to Quantify Coordination

The controlling parameter of achieving coordination is the impact of application of coordination mechanisms (CMs) on the performance measure. It can be observed from the Decision-coordination mechanism matrix given in Table 6 that how different coordination mechanisms can be used for various supply chain decisions. The proper implementation and usage of coordination mechanisms improve the performance of the supply chain (Arshinder 2008). It can be observed that the problems and conflicts in coordinating the supply chain members can be resolved through coordination mechanisms. The importance of coordination mechanism may help in determining the value of coordination in supply chain.

6.2.1 Framework Using Various Coordination Mechanisms

A framework has been proposed based on the usage of coordination mechanisms and their importance in managing uncertainty and resolving various kinds of conflicting problems in coordination. The coordination mechanisms can be classified as:

Table 6 Decision-coordination mechanism matrix

Supply chain decision	Coordination mechanism					
	Supply chain contracts	Information technology	Information sharing	Joint decision making	Authors	Performance measures
Logistics						
Coordination issues in 3PL provider and customer		X		X	Huiskonen and Pirttila (2002)	Speed of delivery, status of order, accuracy of information, invoicing on delivery, cash-flow improvements, accurate invoicing, transportation costs, warehousing costs, inventory levels, ordering costs, stock-outs, order cycle time, order cycle variance, on time deliveries
Integrating the logistics activity geographically dispersed network/supply chain	X	X	X		Stock et al. (2000)	
Inventory						
Coordinated order quantity	X		X	X	Li et al. (1996), Boyaci and Gallego (2002), Piplani and Fu (2005), Zou et al. (2004), Wu and Ouyang (2003)	Inventory levels, ordering costs, customer service level, holding costs, product variety, purchasing costs, product availability, unacceptable delivery, system wide costs
Coordinated timing of the order	X		X	X	Lu (1995), Moses and Seshadri (2000), Gurnani (2001), Zhao et al. (2002)	
Coordinated timing of replenishment				X	Huq et al. (2006), Barron (2007)	
Inventory management in a network		X	X		Verwijmeren et al. (1996)	
Forecasting			X	X	Aviv (2001)	Bullwhip effect, holding cost, system wide cost
Integrated production-distribution						
Joint consideration of cost				X	Jayaraman and Pirkul (2001), Pyke and Cohen (1993), Kim et al. (2006)	Supply chain system wide cost
Supply chain network		X	X	X	Dotoli et al. (2005)	
Integrated procurement-production	X			X	Goyal and Deshmukh (1992), Munson and Rosenblatt (2001)	Supply chain system wide cost

- Supply chain contracts (M1)
- Information Technology (M2)
- Information sharing (M3)
- Joint decision making (M4)

This is not an exhaustive list of coordination mechanisms. These coordination mechanisms can be different in number as per the requirements of supply chain for example dependent on the type of industry and type of interdependencies between SC members. In the present framework four coordination mechanisms are considered because of their extensive discussion in literature.

It can be assumed without any loss of generality, that if the coordination mechanism is applied properly, it will help in achieving SCC. Since, supply chain involves certain members who are human beings and the human system is the most complex system to be managed in organization study. There is bound to be conflicts and problems in the traditional supply chain, which call for an urgent need to implement coordination mechanisms in supply chain.

The coordination mechanisms are from different domains, require different conditions and can operate in different situations. But, one thing common in all mechanisms is that all mechanisms are implemented to improve the performance of supply chain and to resolve confusion and uncertainty among SC members due to independent decision making. To know more about the importance of coordination mechanism, one way is to study all the activities in some process, identify the dependent activities in that process and select the coordination mechanism to coordinate all activities of a process (Arshinder et al. 2006). Since, whole supply chain needs to be coordinated; the usage of all four coordination mechanisms and performance improvement achieved by these mechanisms will help in evaluating SCC.

A better way to find some quantitative index of supply chain coordination is by incorporating the strength of coordination mechanisms by following steps shown in Fig. 3.

The quantitative index can be represented as Supply Chain Coordination Index (SCCI) can be viewed as a function of implementation of coordination mechanisms. SCCI for four coordination mechanisms can be represented as:

$$\mathrm{SCCI} = \mathrm{f}(\mathrm{M1}, \mathrm{M2}, \mathrm{M3}, \mathrm{M4})$$

The above function is to be formulated in such a way that the combined impact of performance improvement by using all mechanisms is considered. This formulation poses two challenges:

1. It is required to represent all coordination mechanisms with a unique scale.
2. It is required to evaluate improvement in performance measures qualitatively or quantitatively by using coordination mechanisms.

The methodologies like AHP and Fuzzy logic may help to represent coordination mechanisms with a unique scale. The performance improvement can be captured either empirically with the help of judgments given by managers or

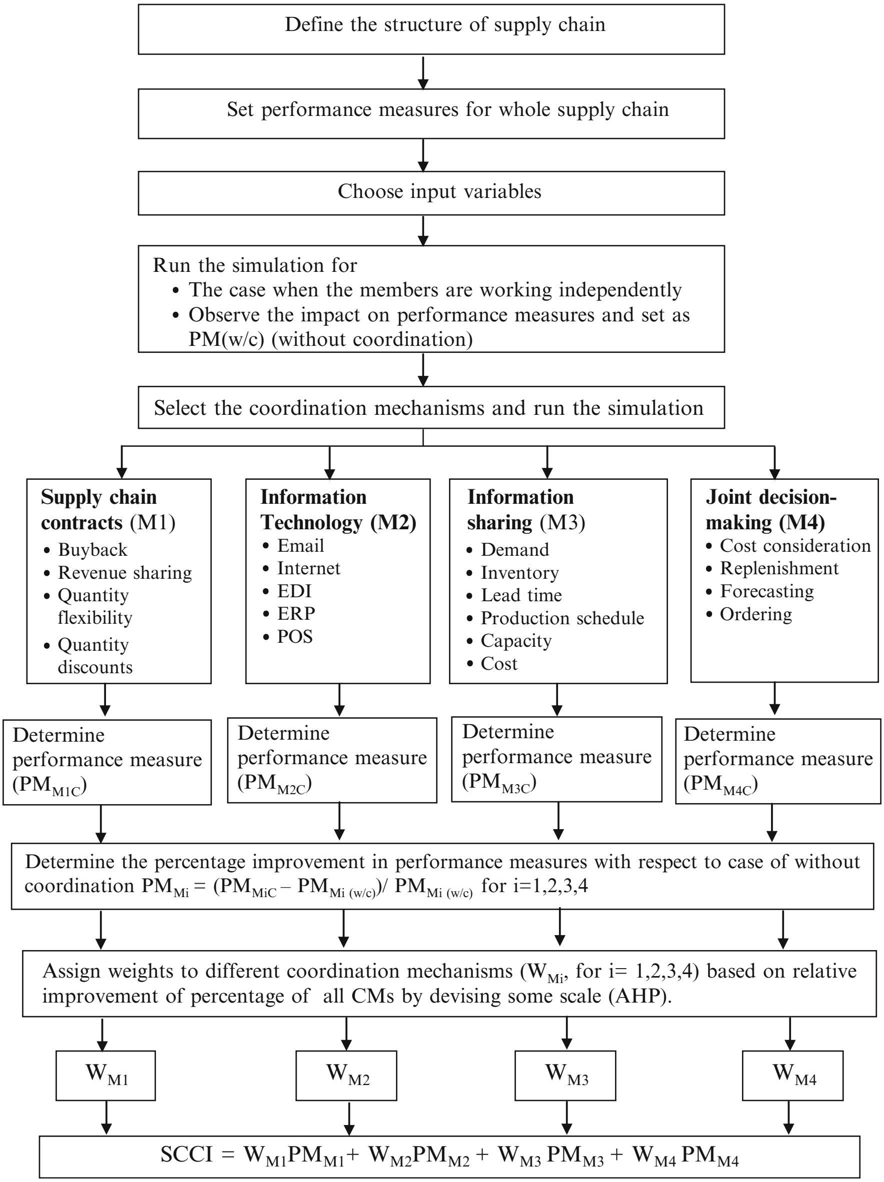

Fig. 3 The proposed model to quantify supply chain coordination index (SCCI)

with the help of simulating the scenarios of using these coordination mechanisms to obtain same performance measures. The improvement in performance measures will motivate supply chain members to implement coordination mechanisms.

One of the efforts has been proposed based on the implementation of all coordination mechanisms with the help of graph theoretic approach (Kaur et al. 2006). This methodology is based on allocation of relative importance of these coordination mechanisms given by the judgments of managers. These judgments are based on the implementation of mechanisms and the importance of mechanisms based on the performance improvement by these mechanisms.

6.2.2 Relation Between Coordination Mechanisms and Performance Measures with Simulation

A simulation approach can also be a useful tool in capturing the different scenarios of coordination mechanisms and their impact on selected performance measures. Certain assumptions can be considered regarding the levels of supply chain, one period or multiple period model and various operational variables like order quantity, holding and shortage costs, etc.

The implementation of various coordination mechanisms can be simulated to analyze same performance measures with same assumptions. Some constraints can be included in the model which takes care of the fact that none of the supply chain member will face losses by implementing coordination mechanisms. The improvement in performance measures will give an idea about the capability of an organization to achieve coordination.

The model proposed in Fig. 3, helps in evaluating SCCI. The first few steps can be used in simulation to determine the performance measures. Some input variables may be selected like different costs, price, inventory policies, lead time, capacity and type of coordination mechanisms at all levels of supply chain in a pre defined structure of supply chain. The assumptions for demand (uncertain and price dependent), lead time and time horizon can be set for the simulation and run the simulation to obtain certain performance measures. The performance measures are function of input variables. The problem may be multi objective based on the selected performance measures of supply chain.

The results of simulation that is improvement in the performance measures by applying different coordination mechanisms can be combined using again some hybrid frameworks like: AHP, Fuzzy logic and/or Graph theoretic approach to determine SCCI.

6.2.3 Hybrid Framework Using Various Coordination Mechanisms and Simulation

The coordination mechanisms (M1, M2, M3 and M4) have different characteristics and their impact on the performance measures may also be different. The simulation can be carried out without implementing coordination mechanisms and then the results are compared with the situation with considering the coordination mechanisms as shown in Fig. 3. A framework is required which can capture and combine the values of performance improvements by coordination mechanisms and their relative importance. To make the results consistent, the performance improvements can be normalized in terms of percentages. This framework may have capability to find the relative importance of respective coordination mechanisms by using AHP and/or Fuzzy logic (Arshinder et al. 2007). A scale can be devised based on the difference in the percentage improvements by CMs. This scale may help in determining the relative importance or weights of CMs. The linear equation of SCCI can be derived from the proposed model to determine the value of SCCI.

6.3 Insights Gained from Proposed Framework

The proposed framework helps in defining and measuring SCC.

Supply chain coordination can be used to enhance system wide performance enabled due to the implementation of coordination mechanisms selected based on the type of industry and the interdependencies between supply chain members keeping in view mutual interests of all SC members.

Supply chains can be coordinated by identifying interdependent activities between supply chain members required to accomplish SC objectives. Once interdependencies are identified, some means of mechanism(s) are devised to manage the decision variables pertaining to interdependent activity. The independent evaluation of decision variables of interdependent activities by SC members represents the case of uncoordinated supply chains. Once, coordination mechanism is selected to manage interdependencies, SC members can simulate and compare the scenarios: one with using CM and other without coordination mechanisms. The expected values of improvement in certain performance measures may help to realize the value of coordination. Same steps can be used for all processes of supply chain.

Various functions can be explored for SCCI depending on the number and implementation of CMs. Suitable techniques can be used such as Multi-Criteria-Decision-Making (MCDM) models to quantify SCCI as a function of various CMs.

6.4 Surrogate Measures of Supply Chain Coordination

To innovate continuously is the base line for all the organizations, which makes the supply chain more dynamic in nature. It is important to capture the performance of supply chain. The highly uncertain environment in supply chain brings in the challenges to have fix kind of performance measures. Gunasekaran et al. (2001) developed a framework for measuring supply chain performance for each activity of plan, source, make and deliver under strategic, tactical and operational decisions. The literature on supply chain performance measures is lacking in presenting standard performance metrics. The problem manifolds when the question comes to measure supply chain coordination. There is scarcity of studies to evaluate coordination in supply chain. The following performance measures can be good indicators of supply chain coordination.

(a) *Supply chain profitability*. Joint consideration of order quantity, costs or profits may lead to improvement in supply chain performance. Regardless of the number of entities in supply chain, the joint consideration of order quantity in supply chain for single period model improves the profitability of whole supply chain (Arshinder et al. 2009a). Most of the contracts reported in literature have expected profits as a performance indicator too.
(b) *Supply chain flexibility*. When the supply chain members coordinate with each other by using contracts, it gives more flexibility to supply chain members to change order quantity, price, cost and lead time. The lower and upper bound can be set for decision variables of contracts (coordination mechanisms) to ensure that the performance of each SC member in a centralized case (consideration of all SC members to be a part of one system) with appropriate coordination mechanism is better than decentralized case (individual supply chain member). Various supply chain contracts present different kinds of supply chain flexibility (Arshinder et al. 2008a).
(c) *Mitigating uncertainty or risk sharing*. The recent issue in supply chain coordination is "How to allocate the total gain in the supply chain achieved due to coordination after mitigating risk?" Many studies have recently developed game theoretic models to fairly share the rewards among supply chain members. The risk mitigation in the form of gain in whole supply chain can be a surrogate measure of SCC. In similar way the extra share of profit allocated out of total gain in SC due to coordination can also reflect the coordinated supply chain. It has also been observed that as the demand variance is increased, the coordinated supply chain due to contracts outperform the independent case of supply chain (Arshinder et al. 2008b). The SC members can devise the contracts in which supplier gives assurance to the buyer to supply emergency orders in case of sudden surge in demand to share risk of losing a customer. Whereas, the buyer can share the extra cost incurred by the supplier in producing emergency orders in view of uncertainty in demand. How well such kind of contracts is designed can be a good indicator of coordination to share risks due to uncertainty in supply chain (Serel 2007).
(d) *Supply chain coordination index*. As it has been discussed that various combination of coordination mechanisms can improve the performance of supply chain. Many situations in supply chain need more than one coordination mechanisms like VMI with quantity discounts, supply chain contracts with information sharing, supply chain contracts with joint decision making (joint consideration of costs). Such kind of index has been developed in Arshinder et al. (2009b) (also mentioned in the proposed framework).

7 Major Challenges and Future Research Directions

Coordinating the supply chain across organizational boundaries may be one of the most difficult aspects of supply chain management. Many firms simply are unaware of the fundamental dynamics of supply chains, but even those firms that are enlightened enough to understand these dynamics are often unable to realize inter-organizational coordination. Often the most effective supply chains have a dominating organization that sees the benefits of SCC and forces the rest of the supply chain to comply (i.e., global leader in retailing such as Wal-Mart). Many supply chains, however, either do not have a dominant organization, or the dominating organization is unenlightened. In these instances, coordinating the supply chain is most difficult. Typically, it is observed that the SCC problems could be due to the conflicting objectives that leads to a short time relationships with SC members, hence the environment and expectations changes frequently with dealing with new members.

On this background, it is essential that the SC members need to appreciate the importance of coordination. This paper has attempted to deliberate on various theoretical perspectives on SCC. The objective to achieve coordination is limited only to the individual functions, to the single coordination mechanism at interfaces of supply chain and to achieve restricted performance measures. A holistic approach towards coordination in whole supply chain is a big challenge, which motivated to propose the issues of SCC in this paper.

The mechanisms for coordination need to be studied in detail. The coordination mechanisms can further be of different sub types. To coordinate the whole supply chain, the aggregation of the impact of all coordination mechanisms on the performance of supply chain is required. Various combinations may be explored with the help of simulation.

Supply chain contracts have proved to coordinate single period supply chains. The research is required to explore the utility of contracts in multi-period cases. In multi period model, the supply chain members are more expose to the uncertainty as they are dealing with supply chain members frequently. How various coordination mechanisms can be allied in multi period problems as well as can we evaluate coordination in such case?

Very few studies have been reported to quantify risk or uncertainty in supply chain. The Bullwhip effect has extensively been discussed in the literature. Actually, there can be many variations seen in supply chain like supply uncertainty, delay in delivery having cascading effect as we go downwards in the supply chain, which is similar to the order variation in Bullwhip effect. How SCC can help in mitigating such uncertainties is one of the important research issues?

Acknowledgements The authors are grateful to the reviewers and the whole editorial team of International Journal of Production Economics, Elsevier for constructive suggestions and for considering our paper for publication. The authors are also thankful to the referees of Springer's Research Handbook Series on "Innovative Schemes for Supply Chain Coordination and Uncertainty" for the comments and suggestions to improve the quality of our paper.

Appendix

List of Journals Refereed in Review Paper

1. Computers & Industrial Engineering
2. Computers & Operations research
3. European Journal of Operational Research
4. IIE Transactions
5. International Journal of Logistics and System Management
6. International Journal of Logistics Management
7. International Journal of Operations and Production Management
8. International Journal of Physical Distribution & Logistics Management
9. International Journal of Production Economics
10. International Journal or Production Research
11. Journal of Operations Management
12. Management Science
13. Omega
14. Supply Chain Management: An International Journal
15. Transportation Research (Part E)
16. Other Journals from Emerald, Inderscience and Sciencedirect portal

References

Arreola-Risa A (1996) Integrated multi-item production-inventory systems. Eur J Oper Res 89(2):326–340
Arshinder K (2008) An integrative framework for supply chain coordination. Unpublished doctoral thesis, Indian Institute of Technology Delhi, New Delhi,
Arshinder K, Kanda A, Deshmukh SG (2006) A coordination based perspective on the procurement process in supply chain. Int J Value Chain Manage 1(2):117–138
Arshinder K, Kanda A, Deshmukh SG (2007) Coordination in supply chains: an evaluation using fuzzy logic. Prod Plann Control 18(5):420–435
Arshinder K, Kanda A, Deshmukh SG (2008a) Supply chain coordination: perspectives, empirical studies and research directions. Int J Prod Econ 115(2):316–335
Arshinder K, Kanda A, Deshmukh SG (2008b) Development of a decision support tool for supply chain coordination using contracts. J Adv Manage Res 5(2):20–41
Arshinder K, Kanda A, Deshmukh SG (2009a) A coordination theoretic model for three level supply chains using contracts. Sadhana Acad Proc Eng Sci 35(5):767–798
Arshinder K, Kanda A, Deshmukh SG (2009b) A framework for evaluation of coordination by contracts: a case of two-level supply chains. Comput Ind Eng 56:1177–1191
Aviv Y (2001) The effect of collaborative forecasting on supply chain performance. Manage Sci 47(10):1326–1343
Bahinipati BK, Kanda A, Deshmukh SG (2009) Horizontal collaboration in semiconductor manufacturing industry supply chain: an evaluation of collaboration intensity index. Comput Ind Eng 57(3):880–895

Barbarosoglu G (2000) An integrated supplier-buyer model for improving supply chain coordination. Prod Plann Control 11(8):732–741
Barnes-Schuster D, Bassok Y, Anupindi R (2002) Coordination and flexibility in supply contracts with options. Manuf Serv Oper Manage 4(3):171–207
Barratt M (2004) Understanding the meaning of collaboration in the supply chain. Supply Chain Manage Int J 9(1):30–42
Barron CLE (2007) Optimizing inventory decisions in a multi stage multi customer supply chain: a note. Transp Res E 43(5):647–654
Boctor FF, Laporte G, Renand J (2004) Models and algorithms for the dynamic joint replenishment problem. Int J Prod Res 42(13):2667–2678
Bose I, Anand P (2007) On returns policies with exogenous price. Eur J Oper Res 178(3): 782–788
Bourland KE, Powell SG, Pyke DF (1996) Exploiting timely demand information to reduce inventories. Eur J Oper Res 92(2):239–253
Boyaci T, Gallego G (2002) Coordinating pricing and inventory replenishment policies for one wholesaler and one or more geographically dispersed retailers. Int J Prod Econ 77(2):95–111
Burgess K, Singh PJ, Koroglu R (2006) Supply chain management: a structured review and implications for future research. Int J Oper Prod Manage 26(7):703–729
Cachon GP, Fisher M (2000) Supply chain Inventory management and the value of shared information. Manage Sci 46(8):1032–1048
Cachon GP, Lariviere MA (2005) Supply chain coordination with revenue sharing contracts: strengths and limitations. Manage Sci 51(1):30–44
Chandra P, Fisher ML (1994) Coordination of production and distribution planning. Eur J Oper Res 72(3):503–517
Chauhan SS, Proth JM (2005) Analysis of a supply chain partnership with revenue sharing. Int J Prod Econ 97(1):44–51
Chen TH, Chen JM (2005) Optimizing supply chain collaboration based on joint replenishment and channel coordination. Transp Res E 41(4):261–285
Chen LH, Chen YC (2009) A newsboy problem with simple reservation arrangement. J Comput Ind Eng 56(1):157–160
Chen F, Drezner Z, Ryan JK, Levi DS (2000) Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead times, and information. Manage Sci 46(3):436–443
Chen H, Chen J, Chen YF (2006) A coordination mechanism for a supply chain with demand information updating. Int J Prod Econ 103(1):347–361
Cheung KL, Lee HL (2002) The inventory benefit of shipment coordination and stock rebalancing in a supply chain. Manage Sci 48(2):300–306
Chikan A (2001) Integration of production and logistics – in principle, in practice and in education. Int J Prod Econ 69(2):129–140
Choi TM, Sethi S (2010) Innovative quick response programs: a review. Int J Prod Econ 114:456–475
Danese P, Romano P, Vinelli A (2004) Managing business processes across supply networks: the role of coordination mechanisms. J Purch Supply Manage 10(5):165–177
Deb K (2002) Multi-objective optimization using evolutionary algorithms. Wiley, Chichester
Dejonckheere J, Disney SM, Lambrecht MR, Towill DR (2004) The impact of information enrichment on the Bullwhip effect in supply chains: a control engineering perspective. Eur J Oper Res 153(3):727–750
Devaraj S, Krajewski L, Wei JC (2007) Impact of eBusiness technologies on operational performance: the role of production information integration in the supply chain. J Oper Manage 25(6):1199–1216
Ding D, Chen J (2008) Coordinating three level supply chain with flexible returns policies. Omega 36(4):865–876
Ding H, Guo B, Liu Z (2011) Information sharing and profit allotment based on supply chain coordination. Int J Prod Econ 133(1):70–79

Dotoli M, Fanti MP, Meloni C, Zhou MC (2005) A multi-level approach for network design of integrated supply chain. Int J Prod Res 43(20):4267–4287
Fawcett SF, Magnan GM (2002) The rhetoric and reality of supply chain integration. Int J Phys Distrib Logistics Manage 32(5):339–361
Fin B (2006) Performance implications of information technology implementation in an apparel supply chain. Supply Chain Manage Int J 11(4):309–316
Fisher ML, Raman A, McClelland AS (1994) Rocket science retailing is almost here: are you ready? Harv Bus Rev 72(3):83–93
Ganeshan R (1999) Managing supply chain inventories: a multiple retailer, one warehouse, multiple supplier model. Int J Prod Econ 59(1–3):341–354
Giannoccaro I, Pontrandolfo P (2004) Supply chain coordination by revenue sharing contracts. Int J Prod Econ 89(2):131–139
Gittell JH, Weiss L (2004) Coordination networks within and across organizations: a multi-level framework. J Manage Stud 41(1):127–153
Gottfredson M, Puryear R, Phillips S (2005) Strategic sourcing: from periphery to the core. Harv Bus Rev 83(2):132–139
Goyal SK, Deshmukh SG (1992) Integrated procurement-production systems: a review. Eur J Oper Res 62(1):1–10
Grubbstrom RW, Wang Z (2003) A stochastic model of multi-level/multi-stage capacity-constrained production-inventory systems. Int J Prod Econ 81–82(1):483–494
Gunasekaran A, Patel C, Tirtiroglu E (2001) Performance measures and metrics in a supply chain environment. Int J Oper Prod Manage 21(1–2):71–87
Gunasekaran A, Ngai EWT, McGaughey RE (2006) Information technology and systems justification: a review for research and applications. Eur J Oper Res 173(3):957–983
Gurnani H (2001) A study of quantity discount pricing models with different ordering structures: order coordination, order consolidation, and multi-tier ordering hierarchy. Int J Prod Econ 72(3):203–225
Haq AN, Kannan G (2006) Design of an integrated supplier selection and multi echelon distribution inventory model in a built-to-order supply chain environment. Int J Prod Res 44(10):1963–1985
Haq AN, Vrat PA, Kanda A (1991) An integrated production-inventory-distribution model for manufacture of urea: a case. Int J Prod Econ 25(1–3):39–49
Hau Z, Li S (2008) Impacts of demand uncertainty on retailer's dominance and manufacturer-retailer supply chain coordination. Omega 36(5):697–714
He J, Chin KS, Yang JB, Zhu DL (2006) Return policy model of supply chain management for single-period products. J Optim Theory Appl 129(2):293–308
Hill RM (1997) The single-manufacturer single retailer integrated production-inventory model with a generalized policy. Eur J Oper Res 97(3):493–499
Hill RM, Omar M (2006) Another look at the single-vendor single-buyer integrated production-inventory problem. Int J Prod Res 44(4):791–800
Hoque MA, Goyal SK (2000) An optimal policy for a single-vendor single-buyer integrated production-inventory system with capacity constraint of the transport equipment. Int J Prod Econ 65(3):305–315
Hou J, Zeng AZ, Zhao L (2010) Coordination with a backup supplier through buy-back contract under supply disruption. Transp Res E 46:881–895
Hoyt J, Huq F (2000) From arms-length to collaborative relationships in the supply chain: an evolutionary process. Int J Phys Distrib Logistics Manage 30(9):750–764
Huan SH, Sheoran SK, Wang G (2004) A review and analysis of supply chain operations reference (SCOR) model. Supply Chain Manage Int J 9(1):23–29
Huang G, Lau J, Mak K (2003) The impacts of sharing production information on supply chain dynamics: a review of the literature. Int J Prod Res 41(7):1483–1517
Huiskonen J, Pirttila T (2002) Lateral coordination in a logistics outsourcing relationship. Int J Prod Econ 78(2):177–185
Huq F, Cutright K, Jones V, Hensler DA (2006) Simulation study of a two-level warehouse inventory replenishment system. Int J Phys Distrib Logistics Manage 36(1):51–65

Hwarng HB, Chong CSP, Xie N, Burgess TF (2005) Modelling a complex supply chain: understanding the effect of simplified assumptions. Int J Prod Res 43(13):2829–2872
Iyer AV, Bergen ME (1997) Quick response in manufacturer-retailer channels. Manage Sci 43:559–570
Jain K, Nagar L, Srivastava V (2006) Benefit sharing in inter-organizational coordination. Supply Chain Manage Int J 11(5):400–406
Jang YJ, Jang SY, Chang BM, Park J (2002) A combined model of network design and production/distribution planning for a supply network. Comput Ind Eng 43(1–2):263–281
Jayaram J, Tan K (2010) Supply chain integration with third-party logistics providers. Int J Prod Econ 125(2):262–271
Jayaraman V (1998) Transportation facility location and inventory issues in distribution network design. Int J Oper Prod Manage 18(5):471–494
Jayaraman V, Pirkul H (2001) Planning and coordination of production and distribution facilities for multiple commodities. Eur J Oper Res 133(2):394–408
Kaur A, Kanda A, Deshmukh SG (2006) A graph theoretic approach to evaluate supply chain coordination. Int J Logistics Syst Manage 2(4):329–341
Kehoe DF, Boughton NJ (2001) New paradigms in planning and control across manufacturing supply chains: the utilization of internet technologies. Int J Oper Prod Manage 21(5–6):582–593
Kim T, Hong Y, Lee J (2006) Joint economic production allocation and ordering policies in a supply chain consisting of multiple plants and a single retailer. Int J Prod Res 43(17): 3619–3632
Kim B, Oh H (2005) The impact of decision making sharing between supplier and manufacturer on their collaboration performance, Supply Chain Management: An International Journal 10 (3-4):223–236
Kleindorfer PR, Saad GH (2005) Managing disruptions risks in supply chains. Prod Oper Manage 14(1):53–68
Koulamas C (2006) A newsvendor problem with revenue sharing and channel coordination, Decision Sciences 37(1):91–100
Krishnan H, Kapuscinski R, Butz DA (2004) Coordinating contracts for decentralized supply chains with retailer promotional effort. Manage Sci 50(1):48–63
Lambert DM, Cooper MC (2000) Issues in supply chain management. Ind Mark Manage 29(1): 65–83
Lambert DM, Emmelhainz MA, Gardner JT (1999) Building successful partnerships, Journal of Business Logistics 20(1):165–181
Larsen ST (2000) European logistics beyond 2000. Int J Phys Distrib Logistics Manage 30(6): 377–387
Larsen TS, Thernoe C, Anderson C (2003) Supply chain collaboration theoretical perspective and empirical evidence. Int J Phys Distrib Logistics Manage 33(6):531–549
Lee HL (2000) Creating value through supply chain integration. Supply Chain Manage Rev 4(4): 30–36
Lee HC (2001) Coordinated stocking, clearance sales, and return policies for a supply chain. Eur J Oper Res 131(3):491–513
Lee HC (2007) Coordination on stocking and progressive pricing policies for a supply chain. Int J Prod Econ 106(1):307–319
Lee CH, Rhee BD (2007) Channel coordination using product returns for a supply chain with stochastic salvage capacity. Eur J Oper Res 177(1):214–238
Lee HL, Padmanabhan V, Whang S (1997) Information distortion in supply chain: the bullwhip effect. Manage Sci 43(4):546–558
Li SX, Huang Z, Ashley A (1996) Improving buyer-seller system cooperation through inventory control. Int J Prod Econ 43(1):37–46
Li Z, Kumar A, Lim YG (2002) Supply chain modeling: a coordination approach. Integr Manuf Syst 13(8):551–561
Li G, Yang H, Sun L, Sohal AS (2009) The impact of IT implementation on supply chain integration and performance. Int J Prod Econ 120(1):125–138

Liu K, Li JA, Lai KK (2004) Single period, single product news vendor model with random supply shock. Eur J Oper Res 158(3):609–625

Liu J, Zhang S, Hu J (2005) A case study of an inter-enterprise workflow-supported supply chain management system. Inf Manage 42(3):441–454

Lu L (1995) A one-vendor multi-buyer integrated model. Eur J Oper Res 81(2):312–323

Malone T, Crowston K (1994) The interdisciplinary study of coordination. ACM Comput Surv 26(1):87–119

Maloni MJ, Benton WC (1997) Supply chain partnerships: opportunities for operations research. Eur J Oper Res 101(3):419–429

Mantrala MK, Raman K (1999) Demand uncertainty and supplier's returns policies for a multi-store style-good retailer. Eur J Oper Res 115(2):270–284

McAfee A (2002) The impact of enterprise information technology adoption on operational performance: an empirical investigation. Prod Oper Manage 11(1):33–53

McCarthy S, Golocic S (2002) Implementing collaborative planning to improve supply chain performance. Int J Phys Distrib Logistics Manage 32(6):431–454

Mc Laren T, Head M, Yuan Y (2002) Supply chain collaboration alternatives: understanding the expected costs and benefits, Internet Research 12(4):348–364

Milner JM, Rosenblatt MJ (2002) Flexible supply contracts for short life cycle goods: the buyer's perspective. Nav Res Logist 49(1):25–45

Moinzadeh K (2002) A multi-echelon inventory system with information exchange. Manage Sci 48(3):414–426

Moses M, Seshadri S (2000) Policy mechanisms for supply chain coordination. IIE Trans 32(3):254–262

Munson CL, Rosenblatt MJ (2001) Coordinating a three-level supply chain with quantity discounts. IIE Trans 33(5):371–384

Narus JA, Anderson JC (1995) Rethinking distribution: adaptive channels. Harv Bus Rev 74(4):112–120

Oke A, Gopalakrishnan M (2009) Managing disruptions in supply chains: a case study of a retail supply chain. Int J Prod Econ 118(1):168–174

Padmanabhan V, Png IPL (1997) Manufacturer's returns policies and retailer's competition. Mark Sci 16(1):81–94

Pan K, Lai KK, Liang L, Leung SCH (2009) Two period pricing and ordering policy for the dominant retailer in a two echelon supply chain with demand uncertainty. Omega 37(4):919–929

Park YB (2005) An integrated approach for production and distribution planning in supply chain management. Int J Prod Res 43(6):1205–1224

Petersen KJ, Handfield RB, Ragatz GL (2005) Supplier integration into new product development: coordinating product, process and supply chain design. J Oper Manage 23(3–4):371–388

Pfohl H, Kohler H, Thomas D (2010) State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice. Logistics Res 2(1):33–44

Piplani R, Fu Y (2005) A coordination framework for supply chain inventory alignment. J Manuf Technol Manage 16(6):598–614

Porter ME (2001) Strategy and the internet. Harv Bus Rev 79(2):63–78

Power D (2005) Supply chain management integration and implementation: a literature review. Supply Chain Manage Int J 10(4):252–263

Pyke DF, Cohen MA (1993) Performance characteristics of stochastic integrated production distribution systems. Eur J Oper Res 68(1):23–48

Qi X, Bard JF, Yu G (2004) Supply chain coordination with demand disruptions. Omega 32:301–312

Reddy AM, Rajendran C (2005) A simulation study of dynamic order-up-to policies in a supply chain with non-stationary customer demand and information sharing. Int J Adv Manuf Technol 25(9–10):1029–1045

Ritchie B, Brindley C (2007) Supply chain risk management and performance: a guiding framework for future development. Int J Oper Prod Manage 27(3):303–322

Ross TJ (1997) Fuzzy logic with engineering applications. McGraw Hill, Singapore

Rubin PA, Benton WC (2003) A generalized framework for quantity discount pricing schedules. Decis Sci 34(1):173–188
Sahin F, Robinson P (2002) Flow coordination and information sharing in supply chains: review, implications and directions for future research. Decis Sci 33(4):505–536
Sanders NR (2008) Pattern of information technology use: the impact on buyer–suppler coordination and performance. J Oper Manage 26(3):349–367
Sarmah SP, Acharya D, Goyal SK (2006) Buyer–vendor coordination models in supply chain management. Eur J Oper Res 175(1):1–15
Sarmah SP, Acharya D, Goyal SK (2007) Coordination and profit sharing between a manufacturer and a buyer with target profit under credit option. Eur J Oper Res 182(3):1469–1478
Sarmiento AM, Nagi R (1999) A review of integrated analysis of production–distribution systems. IIE Trans 31(11):1061–1074
Saroor J, Tarokh MJ, Shemshadi A (2009) Initiating a state of the art system for real-time supply chain coordination. Eur J Oper Res 196(2):635–650
Serel DA (2007) Capacity reservation under supply uncertainty. Comput Oper Res 34(4): 1192–1220
Sethi SP, Yan H, Zhang H (2004) Quantity flexibility contracts: optimal decisions with information updates. Decis Sci 35(4):691–712
Sharafali M, Co HC (2000) Some models for understanding the cooperation between supplier and the buyer. Int J Prod Res 38(15):3425–3449
Simatupang TM, Sridharan R (2002) The collaborative supply chain. Int J Logistics Manage 13(1):15–30
Simatupang TM, Wright AC, Sridharan R (2002) The knowledge of coordination for supply chain integration. Bus Process Manage J 8(3):289–308
Simatupang TM, Sandroto IV, Lubis SBH (2004) Supply chain coordination in a fashion firm. Supply Chain Manage Int J 9(3):256–268
Simchi-Levi D, Kaminsky P, Simchi-Levi E (2007) Designing and managing the supply chain, 3rd edn. McGraw Hill, New York
Sinha S, Sarmah SP (2007) Supply chain coordination model with insufficient production capacity and option for outsourcing. Math Comput Modell 46:1442–1452
Skipper JB, Craighead CW, Byrd TA, Rainer RK (2008) Towards a theoretical foundation of supply network interdependence and technology-enabled coordination strategies. Int J Phys Distrib Logistics Manage 38(1):39–56
Soliman F, Youssef M (2001) The impact of some recent developments in e-business on the management of next generation manufacturing. Int J Oper Prod Manage 21(5–6):538–564
Stank TP, Crum MR, Arango M (1999) Benefits of interfirm coordination in food industry in supply chains. J Bus Logistics 20(2):21–41
Stank TP and Goldsby TJ (2000) A framework for transportation decision making in an integrated supply chain, Supply Chain Management: An International Journal 5(2):71–77
Stock GN, Greis NP, Kasarda JD (2000) Enterprise logistics and supply chain structure: the role of fit. J Oper Manage 18(5):531–547
Swaminathan JM, Tayur SR (2003) Models for supply chains in E-business. Manage Sci 49(10):1387–1406
Tang CS (2006) Perspectives in supply chain risk management. Int J Prod Econ 103(2):451–488
Tang O, Musa SN (2011) Identifying risk issues and research advancements in supply chain risk management, International Journal of Production Economics 133(1):25–34
Thomas DJ, Griffin PM (1996) Coordinated supply chain management. Eur J Oper Res 94(1): 1–15
Tsay A (1999) The quantity flexibility contract and supplier–customer incentives. Manage Sci 45 (10):1339–1358
Tsay AA, Lovejoy WS (1999) Quantity flexibility contracts and supply chain performance. Manuf Serv Oper Manage 1:89–111
vander Rhee B, vander Veen JAA, Venugopal V, Nall VN (2010) A new revenue sharing mechanism for coordinating multi-echelon supply chains. Oper Res Lett 38(4):296–301

Verwijmeren M, Vlist PV, Donelaar KV (1996) Networked inventory management information systems: materializing supply chain management. Int J Phys Distrib Logistics Manage 26(6):16–31

Vickery SK, Jayaram J, Droge C, Calantone R (2003) The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. J Oper Manage 21(5):523–539

Weng ZK (2004) Coordinating order quantities between the manufacturer and the buyer: a generalized newsvendor model. Eur J Oper Res 156(1):148–161

Weng ZK, Parlar M (1999) Integrating early sales with production decisions: analysis and insights, IIE Transactions, 31(11): 1051–1060

Wong WK, Qi J, Leung SYS (2009) Coordinating supply chains with sales rebate contracts and vendor-managed inventory. Int J Prod Econ 120(1):151–161

Wu K, Ouyang L (2003) An integrated single-vendor single-buyer inventory system with shortage derived algebraically. Prod Plann Control 14(6):555–561

Xiao T, Qi X (2008) Price competition, cost and demand disruptions and coordination of a supply chain with one manufacturer and two competing retailers. Omega 36:741–753

Xu L and Beamon B (2006) Supply Chain Coordination and Cooperation Mechanisms: An Attribute-Based Approach, The Journal of Supply Chain Management 42(1):4–12

Xu R, Zhai X (2010) Analysis of supply chain coordination under fuzzy demand in a two-stage supply chain. Appl Math Model 34:129–139

Yang PC, Wee HM (2002) A single-vendor and multiple buyers production-inventory policy for deteriorating item. Eur J Oper Res 143(3):570–581

Yao MJ, Chiou CC (2004) On a replenishment coordination model in an integrated supply chain with one vendor and multiple buyers. Eur J Oper Res 159(2):406–419

Yao D, Yue X, Wang X, Liu JJ (2005) The impact of information sharing on a returns policy with the addition of a direct channel. Int J Prod Econ 97(2):196–209

Yao Z, Leung SCH, Lai KK (2008) Analysis of the impact of price sensitivity factors on the returns policy in coordinating supply chain. Eur J Oper Res 187(1):275–282

Yokoyama M (2002) Integrated optimisation of inventory-distribution systems by random local search and a genetic algorithm. Comput Ind Eng 42(2–4):175–188

Yu Z, Yan H and Cheng TCE (2001) Benefits of information sharing with supply chain partnerships, Industrial Management and Data Systems 101(3):114–119

Yue X, Raghunathan S (2007) The impacts of the full returns policy on a supply chain with information asymmetry. Eur J Oper Res 180(2):630–647

Yusuf Y, Gunasekaran A, Abthorpe MS (2004) Enterprise information systems project implementation: a case study of ERP in Rolls-Royce. Int J Prod Econ 87(3):251–266

Zhao W, Wang Y (2002) Coordination of joint pricing-production decisions in a supply chain. IIE Trans 34(8):701–715

Zhao X, Xie J, Zhang WJ (2002) The impact of information sharing and ordering coordination on supply chain performance. Supply Chain Manage Int J 7(1):24–40

Zhou H, Benton WC Jr (2007) Supply chain practice and information sharing. J Oper Manage 25(6):1348–1365

Zhou YW, Wang SD (2009) Manufacturer-buyer coordination for newsvendor products with two ordering opportunities and partial backorders. Eur J Oper Res 198(3):958–974

Zimmer K (2004) Supply chain coordination with uncertain just-in-time delivery. Int J Prod Econ 77:1–15

Zou X, Pokharel S, Piplani R (2004) Channel coordination in an assembly system facing uncertain demand with synchronized processing time and delivery quantity. Int J Prod Res 42(22):4673–4689

Zou X, Pokharel S, Piplani R (2008) A two-period supply contract model for a decentralized assembly system. Eur J Oper Res 187(1):257–274

Zsidisin GA, Ellram LM (2001) Activities related to purchasing and supply management involvement in supplier alliances. Int J Phys Distrib Logistics Manage 31(9):629–646

Zsidsin GA, Smith ME (2005) Managing supply risk with early supplier involvement: a case study and research propositions. J Supply Chain Manage 41(4):44–57

http://www.springer.com/978-3-642-19256-2

Supply Chain Coordination under Uncertainty
Choi, T.-M.; Cheng, T.C.E. (Eds.)
2011, XIV, 654 p., Hardcover
ISBN: 978-3-642-19256-2