2.1 Introduction

According to the Council of Supply Chain Management Professionals (CSCMP), Supply Chain Management (SCM) encompasses the planning and management of all activities involved in sourcing, procurement, conversion and logistics management. It also includes coordination and collaboration with channel partners, which may be suppliers, intermediaries, third-party service providers, or customers. Supply chain management integrates supply and demand management within and across companies. Most of the time, many different organizations are involved in different stages and they need to work together to create value and improve SC performance. Managing all functions in different stages along the whole chain – from the supplier’s supplier to the customer’s customer – requires a great deal of coordination among the players in the chain. The objective of every SC is to maximize the performance of the SC. SC performance measures may be classified into two types (qualitative and quantitative). SC profit/cost, service level, etc. comes under quantitative category and the satisfaction of customers and other SC members comes under the qualitative category. SCs are generally complex and are characterized by
numerous activities spread over multiple functions and organizations, which pose interesting challenges for effective SC coordination. Achieving coordination is a big challenge for any SC as it may involve multiple firms with different policies, priorities and objectives. As SC members are often separate and independent economic entities, a key issue in SCM is to develop mechanisms that can align their objectives and coordinate their activities so as to obtain improved system performance. Li and Wang (2007) provide appropriate coordination mechanisms based on SC decision structure and nature of demand. Arshinder et al. (2008) also did a similar study regarding SC coordination issues and available mechanisms in the literature to reveal the importance of SC coordination. Xu (2006) conducted a study on SC coordination and cooperation mechanisms with an attribute based approach and developed a framework that enables organizations to select appropriate coordination mechanisms, based on relative cost and the characteristics of their specific operating environment. Hendricks et al. (2007) conducted an empirical study on the impact of enterprise systems such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Customer Relationship Management (CRM) on corporate performance. They found that ERP systems provide some improvements in profitability but not in stock returns and adopters of SCM system experience positive stock returns as well as improvements in profitability and there is no evidence of improvements in stock returns or profitability for firms that have invested in CRM. They also concluded that although these findings are not uniformly positive across the different enterprise systems, no evidence of negative performance is found out in their study.

A generally accepted goal for an SC is to maximize SC surplus. For this in an SC consisting of many firms with different ownership/management linked to each other, close coordination is essential. The goal is total SC optimization
and not individual firm optimization to obtain a win-win situation for all members in an SC. The decision taken by any SC member will affect the performance of the other members and finally the SC. This shows the significance and necessity to study coordination in SC.

The literature review chapter is devoted to:

i. Present the studies on Supply Chain Coordination (SCC)

ii. Identify the issues of Supply Chain Coordination

iii. Report the available mechanisms and methodologies for coordination

iv. Point out the gaps in the area of SCC and mechanisms

v. Discussion on Supply Chain Performance Measurement

2.2 Supply Chain Coordination

SC coordination (SCC) means that collaborative working for joint planning, joint product development, mutual exchange of information & integrated information systems, cross coordination at several levels in the companies on the network, long term cooperation and fair sharing of risks and benefits (Larsen, 2000). Another perspective on SCC is that it is a win/win arrangement that is likely to provide improved business success for all parties (McClellan, 2003).

During the literature survey in the area of supply chain coordination, it is found that there are some key issues in different areas related to supply chain coordination. On further in depth analysis, sub factors of these issues of supply chain coordination are also revealed. Even though most of these sub factors under each key issue are interrelated, each of these sub factors is relevant in the area of supply chain coordination and are to be addressed further to improve the performance. For example, order quantity and replenishment are components of
inventory and which one is to be varied as a decision variable in the area of inventory control depends on the methodology to be followed. So, each one has to be addressed separately and to some extent, it is addressed in the literature to improve the performance of SC using proper coordination mechanisms. Similarly, two key issues: ‘information sharing’ and ‘technology’ given in Figure 2.1 are different as information sharing can be implemented with and without technology and both the situations have to be analysed to understand the effect of each one and studies of this kind are available in literature.

The necessity of this classification is to understand and analyse the coordination issues and to understand how they have been solved to improve the performance of SC. This is also useful to understand the effect of various coordination mechanisms on supply chain performance. The succeeding sections discuss about the classification and related studies of SC coordination issues.

Surveying the literature, SC coordination issues could be classified into quantitative and qualitative category. Quantitative issues may be classified into five topics namely, 1) operations 2) pricing 3) information sharing 4) technology and 5) disruption. These issues may be further classified into various sub topics. Different topics of quantitative issues in SCC are identified as shown in Figure 2.1. Qualitative issues are behavioural and ethical part of SC which is also important for the improvement in SC performance. In this literature review, studies on quantitative issues are addressed.
In the next succeeding section, the first category of quantitative issues dealing with operations and its sub-categories are discussed.

2.2.1 Operation

It is one of the most important areas of SC coordination which may be again classified into different sub-categories, such as order quantity, fuzziness, capacity, replenishment and inventory. The recent works related to all these subcategories including coordination mechanisms are explained in the following sections.

2.2.1.1 Order quantity

Order quantity is linked to production batch size, price, inventory, transportation etc. Therefore it forms a key variable to be decided between two adjacent members in an SC. Various mechanisms are used to coordinate the
order quantity in an SC system under different context. Most of the studies in the literature are based at a two level SC system as it is the basic structure of any SC. In such a system where the demand and lead time is fixed, a mechanism called delay in payment is used to coordinate order quantity (Jaber et al., 2006) and thereby to minimize the local costs and that of the chain. Coordination using a quantity discount policy under multi period and probabilistic customer demand with shortage cost allowed (Li et al., 2006) is also available in the literature. Profit sharing mechanism of some nature is found in almost all studies to ensure equal rate of return on investment for each player. Sarmah et al. (2007) developed a coordination mechanism through credit option and discount policy such that both parties can divide the surplus equitably after satisfying their own profit targets. They also proved that financially stronger player prefer credit policy and weaker selects discount policy for coordination. Numerical and empirical analysis of influencing factors, such as annual demand, ordering cost, carrying cost, receiving cost, cost rate of losing flexibility, production rate and fixed set up cost on ordering and shipment policy (Kelle et al., 2007) available in literature is useful for taking optimal decisions for managers in actual practice.

Hsu et al. (2008) did a work on SC dealing with short life cycle products & variable selling price and developed an integrated strategy consisting of proper information sharing and a compensation mechanism. According to Jaber and Goyal (2009), coordination of a four-level SC consists of multiple buyers, a vendor (manufacturer), multiple tier-1 suppliers, and multiple tier-2 suppliers with a common and optimal cycle time for all non identical retailers and also through compensation by offering quantity discounts to entice the retailer to order more than EOQ. Coordination for an SC which deals with newsvendor-type-products is another issue found in this area. Zhou et al. (2009) investigates such a system with two ordering opportunities and partial backorders in which
excess demand after the first order is partially backlogged. In this case, two policies are proposed for coordination: 1) a two-part-tariff policy when the buyer pays all the manufacturing cost 2) a revised revenue sharing contract when two parties share the cost. Joint decision making regarding order quantity and reorder point is very important in an SC. For this purpose, Chaharsooghi et al. (2010) developed an incentive scheme based on credit option in which buyer can use it with the condition of jointly agreed order quantity and reorder point.

2.2.1.2 Fuzziness of Demand

Fuzziness is a complex issue in SC coordination and studies regarding this issue are fewer in literature. The effect of fuzziness of demand can spread over the different stages of SC and reduces its efficiency and responsiveness. Petrovic et al. (2008) considered a single product inventory control in a Distribution Supply Chain (DSC) which operates in the presence of uncertainty in customer demands. In this study, demands are described by imprecise linguistic expressions and modeled by discrete fuzzy sets and inventories at each facility within the DSC are replenished by applying periodic review policies with optimal order up-to-quantities. An iterative coordination mechanism was proposed for changing the review periods and order up-to quantities for each retailer and the warehouse to minimize the cost. Xu et al. (2009) also did a work on the fuzziness aspect of demand uncertainty. Fuzzy numbers were used to depict customer demand in this study and investigate the optimization of the vertically integrated two - stage SC under perfect coordination and non coordination case. In the absence of a clear command and control structure, a key challenge in SC management is the coordination and alignment of SC members. Ryu et al. (2009) used a news vendor model and a fuzzy approach to quantify the cost of this misalignment and to assess the impact of various coordination policies.
Chapter 2

2.2.1.3 Capacity

Production capacity and its utilization is a key issue in SCM. Lee and Rhee (2007) examined return policy in a newsboy framework in the assumption that both the supplier and the retailer have limited and stochastic salvage capacities. To handle this issue, three mechanisms are proposed: i) The manufacturer’s buy back with early salvage capacity (BES) - compensating the retailer for all the retained leftovers after buy back; ii) buy back with price protection (BPP) - compensating for the fraction of the retained leftovers that the retailer salvages after buy back; iii) buyback with final salvage subsidy (BFS) - compensating for the remaining leftovers after the retailer’s salvage. Insufficient production capacity is another problem for coordination. Sinha and Sarmah (2007) developed a Mathematical Model (MM) to analyze the situation of the lost sales when the supplier’s production capacity is less than the annual demand of the retailer. Here, the supplier can procure from external source and satisfy the requirements of retailer. Li and Liu (2008) developed an extended newsboy model in which the retailer can place a second order to avoid the stock out where manufactures reserve capacity for the retailer’s second order is limited. They designed a coordination mechanism and a profit allocation policy (price discount and profit allocating factor) to get more SC profit and allocate the same properly among players. Coordination is also possible for an SC in which manufacturer’s operations undergo learning based continuous improvement (Jaber et al., 2010). It is characterized by enhancing capacity utilization, reduction in set-up time and improved product quality.

2.2.1.4 Replenishment Policy

The issue ‘replenishment’ consists of deciding order quantity, lead time and reorder point. Joint decision making is a suitable mechanism to manage this issue. Chung and Wee (2007) developed an optimal replenishment policy using
a simple algebraic method to solve a three stage SC inventory problem with backorder considering JIT delivery. A procedure for coordinating the inventory replenishment, production and shipping decisions for a single product in an SC (Banerjee, 2007) consisting of a single producer with multiple retailers and suppliers is also suggested in the literature. Such coordination is achieved by linking the inventories at the different echelons of the chain through integrated decision making. Chen and Kang (2007) developed the integrated models with the permissible delay in payments for determining the optimal replenishment time interval and replenishment frequency. SC models for trade credit issues in the existing literature always assume the items produced as perfect. But, Chen and Kang (2010) developed integrated vendor–buyer models that consider a permissible delay in payment and products of imperfect quality to determine the optimal solutions of the buyer’s order quantity and the frequency for each vendor’s production run.

2.2.1.5 Inventory

Management of inventory is actually a separate topic of study and is very important in any SC system as it causes the storage cost and holding cost. Luo (2007) proposed a vendor – buyer with a single product to analyze the benefit of coordinating SC inventories through the use of credit period. Under this strategy, the vendor requests the buyer to alter his current order size through a proper compensation and also though order size dependent credit period mechanism such that the vendor can benefit from lower setup, ordering and inventory holding costs. Shin and Benton (2007) conducted a study in this area and developed a quantity discount model (buyer’s risk adjustment model) which allows the supplier to offer discounts that capitalize on the original economic lot sizes and share the buyer’s risk of temporary overstocking under uncertain demand.
Wong et al. (2009) detailed how a sales rebate contract helps to achieve SC coordination. This study proposes a model for an SC consisting of a single supplier serving multiple retailers in a VMI partnership which facilitates the application of sales rebate contract. The proposed model demonstrates that the supplier gains more profit with competing retailers (with a demand function depending on all retailer’s prices) than without (with a demand function sensitive only to their own price) as competition among the retailers lowers the prices and thus stimulates demand. The study conducted by Kelle et al. (2009) focused on the inventory related costs that can be influenced by adjusting the ordering, setup, and delivery policy to the random yield which is still prevailing in several industries. This study showed that it is not the average yield but the yield uncertainty that plays the critical role mainly in providing an appropriate service level and also in finding the optimal shipment and setup policy.

2.2.2 Pricing

It is another important issue of SC coordination which can also be divided into subcategories. They are price dependent demand, pricing and contracts, uncertainty and pricing schemes. It is actually a key issue as it normally decides the customer demand. Studies related to these are discussed in section below.

2.2.2.1 Price Dependent Demand

Price elasticity of demand is a very fundamental principle of economics and is widely discussed in the literature. Price dependent demand is a significant issue in SCC. The solution is to find out the optimal price discount and selling price to increase the profit. In the literature, for a three-level SC model with price dependent demand, an all unit price discounts scheme is used to coordinate order quantities (Jaber et al., 2006a) and thereby to maximize the SC profit. Hsieh et al. (2010) also analyzed the coordination of ordering and pricing decisions in a two stage distribution system with price sensitive demand
through short-term discounting under two types of demand; linear demand in price and constant elasticity demand in price. They found that for homogeneous retailers, the player’s profits have similar characteristics under both the cases of demand but have different trends for heterogeneous retailers.

Another study found in the literature is the coordination of cooperative advertisement in a manufacturer-retailer SC with price sensitive demand (Yue et al. 2006) and the manufacturer offers price deduction to customers. Game theory was used for analysis and the optimal price deductions are determined. Qi (2007) also studied an SC with price sensitive demand but with multiple capacitated suppliers to maximize the profit by determining an optimal selling price. It is proved that the problem is NP-complete, and proposed a heuristic algorithm and a dynamic programming algorithm and tested by computational experiments.

Many more inventory models under different contexts with price sensitive demand are reported in literature. A finite time horizon inventory model for deteriorating items with price and time dependent demand under permissible delay in payment (Tsao et al. 2008) is developed. The analysis found the optimal price, promotional effort and replenishment quantities throughout a multi-cycle planning horizon to maximize the net profit. Ho et al. (2008) formulated an integrated supplier-buyer inventory model with the assumption that the market demand is sensitive to the retail price. The supplier offers two payment options: trade credit and early payments with discount price to the buyer. By analyzing the total channel profit function, they developed a solution algorithm to determine the best payment period, optimal retail price, order quantity and the number of shipment per production run from the supplier to the buyer.
2.2.2.2 Pricing and Contracts

Coordination of various parameters using different contracts with certain rules of pricing under multilevel structures and dynamic operating conditions of an SC system was found in the literature. A combination of coordination mechanisms consisting of Quantity Discount (QD) and Handling – Charge Reduction (HCR) schemes was used in literature for a manufacturer supplying numerous heterogeneous retailers (Lau et al., 2008). The analytical and numerical analysis in that study reveals the following i) an optimal QD scheme will have a high enough price break so that extremely few retailers will be big enough to get a ‘free’ discount and ii) an optimal HCR scheme produces practically the same magnitude of expected total gains as an optimal QD scheme. Revenue sharing contract is also a good contract for coordinating an SC comprising one manufacturer and two competing retailers (Yao et al., 2008) that faces a stochastic demand before the selling season. In this case, the retailers determine order quantity and retail price and the manufacturer designs revenue sharing contract. Adopting the classic news vendor problem model framework and using numerical methods, this study found that provision of revenue sharing in the contract can obtain better performance than a price-only contract. Ding et al. (2008) studied how to fully coordinate a three level SC with the so-called flexible return policy by setting the rules of pricing. With this contract, unsold products or used modules disassembled from the unsold products are returned level by level from the retailer to the upstream firms and each firm shares the loss due to the overstock.

Cooperative advertising is another good contract in practice by which advertisement cost has to be shared by both the manufacturer and the retailer. Xie and Wei (2009) addressed channel coordination by seeking optimal cooperative advertising strategies and equilibrium pricing in a two-member
distribution channel. In this study also, a game theoretic approach is used for modelling and analysis. Integration of consumer return policy and manufacturer buy back policy within a modeling framework is a new approach in the literature. Xiao et al. (2010) investigated coordination of a two stage SC facing consumer return using a buyback/markdown money contract under partial refund policy and found that it plays an important role in the decisions and profitability of the players.

2.2.2.3 Uncertainty and Pricing Schemes

There are a number of cases in the literature where uncertainty and pricing schemes play an important role in the SC coordination. In the recent literature, instead of simple price discount, pricing schemes/pricing schedules are used to coordinate an SC as the degree of uncertainty and dynamism has become very high. Lau et al. (2007) examined how a dominant retailer should operate when his knowledge of manufacturing cost is imperfect. They devised optimal decisions to be taken by retailer and a reverse quantity discount scheme that a dominant retailer can offer to the manufacturer. They showed that it is effective when nature of demand is linear and ineffective when iso-elastic. Lee (2007) designed and tested a model to study the effects of manufacturer and a discount outlet coordination in SC stocking, pricing and promotional markdown operations (product sold in normal sales period and subsequent leftovers markdown sale period). The study provided a numerical analysis to learn how and when coordination helps to increase profits and indicates that the centralized approach outperforms the decentralized one on every occasion.

Uncertainty and competition are very common in business. So the study on the impact of price discount contracts and pricing schemes on the dual channel SC competition (Cai et al., 2009) in an online direct channel is very significant. Coordination through simple discount policy may not be an
efficient solution when the system contains a high degree of uncertainty. So, in such cases, multi pricing schedules to adopt global optimal policy (Sinha and Sarmah, 2010) are suggested in the literature.

2.2.3 Information Sharing

It is unavoidable and a prominent issue of SC coordination which connects various stages of SC to achieve better performance. This issue may also be subdivided into different groups like integration of Information Sharing (IS) and SC practice, inventory and information sharing, information asymmetry, value of information sharing, and vertical information sharing. Each category is discussed below.

2.2.3.1 Information Asymmetry

Information asymmetry is a common issue in almost all cases of SC. Some of the cases are found in literature. A critical assumption made throughout the SC literature in this area is that the supplier has complete knowledge about the buyer’s cost structure. Sucky (2006) provided a bargaining model with asymmetric information about the buyer’s cost structure assuming that the buyer has the power to impose its individual policy. Xu and Zan (2009) studied and analyzed the principle-agent problem under fuzzy information asymmetry condition using the theory of principal-agent (enterprise–seller) and incentive mechanism assuming that the demand depends upon the agent’s effort level and the fuzzy market condition and derived an optimal contract for coordination. Esmaeili et al. (2010) also did a work on asymmetric information structure in which the seller’s setup/purchase cost is unknown to the buyer and the buyer withholds certain information related to market demand. In this study, sharing of marketing expenditure is used as an incentive strategy to reveal information and modeled using game theory.
2.2.3.2 Integration of Information Sharing and Supply Chain Practice

Effective integration of information sharing (IS) is essential to improve the performance in an SC. Proper inter-organizational information sharing (IIS) improves SC performance; but it is a very difficult task to set up a supply network (SN) with the appropriate level of IIS as SNs tend to evolve over time, and are usually not the result of a master plan by any firm. Therefore firms need guidance to utilize resources effectively and implement IIS capabilities properly so that the performance of the individual firms and the whole SC improves a lot. Samaddar et al. (2006) focused on network configuration and partner goal congruence and their potential influence on IIS. Zhou and Benton (2007) did a statistical analysis to analyze the integration of information sharing and SC practice. Sezen (2008) investigated the relative effects of SC integration, SC information sharing and SC design on SC performance.

2.2.3.3 Value of Information Sharing

Literature on the role and value of information sharing helps us to understand its significance. Cachon and Fisher (2000) compared the traditional policy and sharing full information policy with one supplier and N identical retailers and found that SC costs are reduced significantly with information sharing. Viswanathan et al. (2007) investigated the value of various information exchange mechanisms. They concluded that planning inventories based on the planned downstream order schedules resulted in the lowest average inventory compared with demand information exchange mechanisms in a four–echelon SC under a material requirement planning framework. Kaynak and Carr (2012) did an empirical investigation to analyse the relationships among information sharing efficacy between firms, coordination mechanisms between firms and the effects these relationships have on buying firm’s performance. They reported that when the sharing of information occurring along with coordination
of the information between the SC partners provides an opportunity to discuss the information and gain the necessary clarity and completeness to make the information of value to the buyer’s firm, resulting in improved performance. Ganesh et al. (2008) analysed the impact of consumer product substitution on the value of information sharing in SCs and showed that substitutability among products generally reduces the value of information sharing. Another study by Dong and Lee (2013) on the value of information sharing in an SC with seasonal customer demand process showed that seasonal effect has an important impact on optimal inventory policies of the supplier and replenishment lead time must be less than the seasonal period in order to benefit from information sharing. Wu and Cheng (2008) did a study to quantify the impact of information sharing on inventory and showed that both the inventory level and expected cost of the distributor and the manufacturer decrease with an increase in the level of information sharing. A study on actual industrial SC consisting of small-to-medium sized enterprises is conducted by Byrne and Heavy (2006). They highlighted the significant benefits achievable through the use of improved information sharing and forecasting techniques. A comparative study on the value of information sharing under different inventory policies in construction SC is done by Xue et al. (2011). They reported that Q system is better than P system under no information sharing and P system is better than Q system under information sharing for contractor’s service level. Lee et al. (1997) conducted a study on the bullwhip effect in Supply chains and suggested that companies wanting to control the bullwhip effect have to focus on modifying the chain’s infrastructure and related processes rather than the decision makers’ behavior. They have identified four major causes of the bullwhip effect i) Demand forecast updating ii) Order batching iii) Price fluctuation iv) Rationing and shortage gaming and also suggested various initiatives and other possible remedies based on the underlying coordination mechanism,
namely, information sharing, channel alignment, and operational efficiency. Lee et al. (2004) also conducted a study on information distortion in a supply chain and claimed that distortion may arise as a result of optimizing behaviors by players in the supply chain. On the normative side, the combination of sell through data, exchange of inventory status information, order coordination and simplified pricing schemes can help mitigate the bullwhip effect. Agrawal et al. (2009) studied the impact of information sharing and lead time on bullwhip effect and on-hand inventory and reported that some parts of the bullwhip effect will always remain even after sharing both inter as well as intra echelon information. Further, it also showed that the lead time reduction is more beneficial in comparison to the sharing of information in terms of reduction in the bullwhip effect phenomenon. Zhao et al. (2002) conducted a study on the impacts of information sharing and ordering co-ordination on the performance of a supply chain with one capacitated supplier and multiple retailers under demand uncertainty. They found that information sharing and ordering co-ordination significantly impact the supply chain performance in terms of both total cost and service level. It is also found that the value of sharing information and ordering co-ordination is significantly affected by demand patterns and capacity tightness.

With respect to the types of information sharing, Jonsson et al. (2013) conducted a study on point of sales data, customer forecasts, stock on hand data and found that sharing stock on hand information is valuable with stationary demand while customer forecast and planned order information are valuable with non-stationary demand. Chen et al. (2006) used demand information sharing with its updating at a later stage after the demand forecast is improved to study the performance of a two level SC. They proposed a risk sharing contract to compensate the loss due to over production at manufacturer and over
stocking at retailer for the better performance of whole system. Sharing of forecast information is also found in the study of Savedi and Jain (2012) to face the ever increasing threats to its operations from the frequent disruptions in an SC. Apart from this, Ryu et al. (2009) evaluated the SC performance of two different types of information sharing methods: planned demand transferring method (PDTM) and forecast demand distributing method (FDDM) in terms of throughput, inventory level and service level. They found that FDDM performs better in terms of throughput and maintains lower inventory level when there is a high forecasting error or high demand variability. Another study to improve SC performance by sharing advance demand information (ADI) is conducted by Thonemann (2002) in which two types of ADI, aggregated ADI and detailed ADI are considered and they deduced the conditions under which sharing can significantly reduce the cost. They showed that both manufacturer and the customers benefit from sharing ADI, but that sharing ADI increases bullwhip effect. As found in earlier studies, Chen (2013) proved that complete information sharing is possible only with an appropriate contract to take care of the issues of SC partners on information sharing and they used revenue sharing contract in their study to support it. Inventory information sharing is another mechanism used in this area for the improvement of SC performance. Chan and Chan (2009) did a simulation study with cascade information sharing approach in contrast to full information sharing on inventory in a multi-echelon SC and got a result almost equivalent to a complex procedure of full information sharing approach subjected to various service levels.

According to Pundoor and Herrmann (2006), there is a need for standard simulation elements to represent the activities in an SC. They described an SC simulation framework that follows the SC Operations Reference (SCOR) model. They used this framework to build simulation models that integrate discrete event simulation and spreadsheets. These simulation models are hierarchical and use
sub models that capture activities specific to SCs. Jain and Ervin (2005) described an effort utilizing modeling and simulation for evaluating the improvements in business process and systems including a move towards e-business for a logistics and distribution SC and quantified the benefits out of it along with some insights applicable to SCM. Wong (2009) introduced the Data Envelopment Analysis (DEA) SC model in combination with Monte Carlo simulation to measure the SC performance in the stochastic environment and a GA-based heuristic technique to improve the prediction of the performance measurement. Bottani et al. (2012) presented a simulation model to assess the performance of supply networks, and investigated economic order interval and economic order quantity policies under several different operating conditions of the networks. They primarily focused on the comparison of different reordering policies in terms of their impact on supply network performance and derived some guidelines to identify the most appropriate reordering policy to be adopted in the network as a function of its operating conditions. Xu and Zhai (2010) focused on the fuzziness aspect of demand uncertainty for a two stage vertically integrated SC coordination problem. In this study, they used fuzzy numbers to depict customer demand and investigated the optimization under perfect coordination and contrast with the non-coordination case. Petrovic (2001) described a special purpose simulation tool, SCSIM, developed for analyzing SC behavior and performance in the midst of uncertainty. The uncertainties are described by imprecise natural language expressions and they are modeled in SCSIM by fuzzy sets. The two types of models combined in SCSIM are (1) SC fuzzy analytical models to determine the optimal order-up-to levels for all inventories in a fuzzy environment and (2) an SC simulation model to evaluate SC performance achieved over time by applying the order-up-to levels recommended by fuzzy models.
2.2.3.4 Vertical Information Sharing

The significance and effects of vertical information sharing on the supply chain coordination are also found in the literature. Yao et al. (2008) considered an SC consisting of one supplier and two Value-adding heterogeneous retailers with each retailer having full knowledge about his own value-added cost structure that is unknown to the supplier and the other retailer. Under the assumption that there is no horizontal information sharing between two retailers, they modeled an SC with a three–stage theoretic framework in which each retailer decides to vertically disclose his private cost information first and the supplier announces the wholesale price to the retailers in the second stage and finally the retailers optimize their own retail prices and the values added to the product. They obtained the conditions under which both retailers have incentives to reveal their cost information with the supplier and for not sharing their private information. The first attempt to incorporate buyer’s expectations into SCC problem is by Karabat1 and Say1n (2008) in which they addressed the coordination problem in a single-supplier/multiple-buyer SC with vertical information sharing. They shaped each buyer’s net savings expectations based on her limited view of the entire SC which consists of herself and the supplier only, and then incorporated these expectations into the modelling of the SC conducted by the supplier. They have considered both price discriminatory approach and non–price discriminatory approach to design the quantity discount schemes that achieve time coordination without any additional requirement for buyers to comply with the supplier’s replenishment period in choosing their order quantities.

2.2.3.5 Inventory and Information Sharing

Literature also deals with how proper information sharing helps to coordinate under different inventory policies. Gavirneni (2006) considered an
SC consisting of one supplier with finite production capacity and a retailer facing independent and identically distributed demands (iid) from end-customers. Their study showed that SC performance can be improved by the supplier offering fluctuating prices and proper information sharing. Studies to reduce average ordering and inventory related cost under the centralized decision making paradigm where there is a single decision maker and complete information of the system are available in literature. Chu and Leon (2008) conducted a different study to analyze the problem of coordinating a single-warehouse multi-buyer inventory system with private information, and found a replenishment policy for each facility in the system, such that the total average ordering and inventory-related cost of the entire system is minimized. Modified Power of-two inventory theory is used to develop a heuristic for coordinating the above inventory system under private information.

### 2.2.4 Disruptions

SC systems however well designed, will face disruptions in operations. Disruption happens due to various factors such as information sharing, technology, pricing, etc. But these disruptions are reflected in various stages/factors of operations such as demand, supply, production and some spread over more stages of supply chain in multiple forms which are presented under ‘General Disruptions’. As we have dealt the above mentioned factors (Information sharing, technology, pricing) separately in the literature review, concerned issues are discussed under each category.

Disruption management is a comparatively new and challenging field. There are many disruptive accidents in the SC operations system, such as demand disruptions, production cost disruptions, supply disruptions and other general/multiple simultaneous disruptions which are explained briefly in this study.
2.2.4.1 Demand disruptions

Demand forecasting methods are available in plenty. But, the actual end customer demand may vary from the forecast one and this will cause demand disruptions at different stages of the chain. Demand disruption results in losses in different ways for each player in a chain. Xiao et al. (2007) investigated the coordination of an SC with one manufacturer and two competing retailers when the demands are disturbed. They analyzed the effects of the changed amount of market scales on the coordination mechanism and the optimal decision making. Apart from the case of competing retailers, coordination of SC under demand disruption with a dominant retailer (Chen and Xiao, 2009) is also available in literature. This SC model with one manufacturer and dominant retailer under demand disruption incorporated the deviation cost that affects the objective functions of the SC members. The analysis showed that linear quantity discount schedule is better when production cost is sufficiently low and when it is high, wholesale price schedule is better.

2.2.4.2 Production Cost Disruptions

Production cost disruptions may occur due to change in the cost of tools, technology, materials, variation in salaries & wages, production quantity, quality requirements, etc. Xu et al. (2006) studied an SC coordination problem under production cost disruptions. In this study, a single product is considered which requires two major operations and it was assumed that during the second operation, anticipated production cost has changed. In their study, modeling the production cost disruptions and their impacts, design coordination schemes under disruptions are discussed and developed expressions for optimal values of retail price, production quantity and optimal SC profit. Another study in this area is the coordination of two-level SC with production interruptions (Ahmed Saadany et al., 2008) to restore process quality. Three cases that describe the
behavior of the manufacturer’s inventory level were considered in this study. They are: 1) restore the production process after delivering a lot to the retailer 2) restore the production process before delivering a lot to the retailer and 3) restore the production process at any time during production. This study suggested that order in smaller lots more frequently is better when production is imperfect.

2.2.4.3 Supply Disruptions

It needs the earliest and immediate attention as it is the starting point of any SC and without solving this issue properly, the system cannot move further. Yu et al. (2007) studied how the disruptive accidents affect the coordinated SC. Based on the SC coordinated by the negative incentive mechanism; they analyzed the impacts of supply disruption on the SC system by using simulation approach where two different distribution functions of random variable were used to express the supply disruption. They compared these two simulation results and suggested a possible coordination mechanism for handling supply disruption. It is very important to analyze that how sourcing can be done in the presence of SC disruption risks. Yu et al. (2009) examined the complexity of the sourcing decision in the presence of SC disruptions; in particular, the famous debate between single sourcing and dual sourcing is revisited by taking supply disruption risks into account under price sensitive demand and the market sale increases when a supply disruption occurs. This study indicates that sourcing decision depends on the magnitude of the disruption probability and also provides the closed form solutions and critical values to help the decision making process under disruption. Determination of optimal size of supply base considering the risk of supply disruption is a significant issue. Sarkar et al. (2009) determined the optimal size of supply base. They analyzed the risks of supply disruptions due to occurrence of super, semi super and unique events.
and formulated a model in a decision tree-like structure to determine the optimal size of supply base. The study of buyer’s perceptions of supply disruption risks (Ellis et al., 2010) is also found in the literature. In this study, the validation of buyers’ perceptions of magnitude of disruptions, probability of disruptions, and overall supply disruption risk facilitate the translation of situation to decision.

2.2.4.4 General/Simultaneous Disruptions

There are general or common disruptions and some of which can be recognized at the initial stage itself and the same solved so that it will be easier to tackle the major disruption occurring in between the various operations or stages. Tang (2006) presented certain robust strategies to enable SC to manage the inherent fluctuations efficiently regardless of the occurrence of major disruptions and to make an SC become more resilient in the face of major disruptions. The proposed strategies are postponement, strategic stock, flexible supply base, make or buy, economic supply incentives, flexible transportation, revenue management, dynamic assortment, silent product rollover.

Multiple disruptions are also discussed in the literature. Xiao et al. (2008) analyzed the coordination of an SC consisting of one manufacturer and two competing retailers with price competition, cost and demand disruptions and analyzed how disruption cost affects the two coordination mechanisms: all unit quantity discount and incremental quantity discount. Thus, strategies are formulated to handle both cost and demand disruptions. The effect of operational slack, diversification and vertical relatedness on the stock market reaction (Hendricks et al., 2009) to SC disruptions is another useful study found in the literature. This study used a sample of 307 SC disruptions announced by publicly traded firms during 1987-1998 to analyze the effect of various strategies on the stock market reaction to SC disruptions. Their analysis showed
that more slack in the SC and high degree of vertical relatedness experience less negative stock market reaction and business diversification has no significant effect on the stock market reaction. But, geographically diversified firms experience a more negative stock market reaction. These findings surely influence the design and operation of SCs to mitigate the negative effect of SC disruptions.

Case studies related to management of disruption are also available in literature. Oke et al. (2009) conducted a case study of a US retail SC and categorized various risks into inherent or high frequent risks and disruption or infrequent risks. Finally, they found out some generic and specific strategies for handling various types of risks. Skipper et al. (2009) also examined the use of a strategic approach to minimize the risk exposure to SC disruption. Based on the sample used in this survey, top management support, resource alignment, information technology and external collaboration enhance the flexibility in the system and found that this flexibility can reduce disruptions.

2.2.5 Technology

SC coordination without proper technology is extremely difficult in a competitive and dynamic business environment. Information technology is a key issue to be considered in an SC without which the three main flows (product flow, information flow, fund flow) in an SC are not possible in an optimal manner. This issue can also be viewed as different groups which are Internet, SC collaboration with new technologies, and impact of Information Technology (IT) on SC process.

2.2.5.1 Internet

It is clear from the literature that Internet can be utilized for the coordination in different ways among SC members as it is the fastest and
Chapter 2

cheapest way for communication and source of information and economical. Internet companies extensively use the practice of drop-shipping. Netessine and Rudi (2006), developed a dual strategy whereby the retailer uses local inventory as a primary source (in which retailer stocks and owns the inventory) and relies on drop-shipping (in which the wholesaler stocks and owns the inventory and ships products directly to customers at retailer’s request) as a back-up and model it as a non cooperative game among the retailers and wholesalers. They analyzed this model and obtained insights to the structural properties of the equilibrium solution to facilitate the development of recommendations for practicing managers. Now, regarding SC for the construction industry, a qualitative study is there in literature regarding coordination mechanisms for Construction Supply Chain (CSC) management (Xue et al., 2007) in the internet environment. This study defined the concepts of construction supply chain and CSC management and also the inter-organization problems that affect CSC coordination. They presented two types of Internet-enabled coordination mechanisms: market mechanism, such as auction contracting and coordination flow, including information hub and electronic market place, for improving construction performance and to accelerate the innovations in the construction industry.

2.2.5.2 Supply Chain Collaboration with New Technologies

In the SC coordination, quick response, timing, accuracy are very important which necessitate the SC collaboration with new technologies. In the literature, there is a statistical study on the impact of ERPII. Koh et al. (2008) presented a set of clear business benefits and impediments, hindrances to success through an extension of pertinent literature on ERP and through logical deduction (cause and effect) of the current literature on ERP II. The research identified three collaborative structures suitable to aid information exchange in
a real-time collaborative scenario, namely joint ventures, networks and Japanese–style ‘purchasing partnership’. Another methodology/technique for SCC is distributed optimization. Gaudreault et al. (2009) studied the case of an SC made up of autonomous facilities (represented by software agents) that need to coordinate their manufacturing operations. The coordination problem represented as a tree by considering the entire coordination space (by generalizing the coordination mechanisms) can be optimized using a distributed tree search algorithm (e.g. SyncBB). This allowed for the exploration of alternative solutions by the agents while maintaining current business relationships, responsibilities and local decision making algorithms. This study found that SyncBB improved the quality of the solution compared to the current practice. The main contribution of this study is multi agent concurrent discrepancy search (MacDs) that uses the concept of discrepancy and permits the agents to find the optimal solution.

Radio Frequency Identification (RFID) features high storage capacity, remote access, excellent data security and multiple-tag reading. Pramatari (2007) provides an overview of SC collaboration practices and the way the underlying enabling technologies have evolved, from the classical EDI (Electronic Data Interchange) approach, to web-based and RFID-enabled collaboration. They derived interesting lessons regarding the suitability and criticality of the technological approach used to support collaboration, especially regarding the use of a centralized web-platform as compared to the EDI approach and to a decentralized solution based on web services. Lin (2009) constructed an integrated framework for the development of RFID technology in the logistics and SCM which includes the hierarchy of factors, structural procedure, and sequence of adoption.
2.2.5.3 Impact of IT on Supply Chain process

An analysis on the impact of IT on SCM is very much needed to take corrective measures for further improvement. Drawing from the resource-based view, Wu et al. (2006) proposed that IT-enabled SC capabilities are firm-specific and hard-to copy across organizations. This study provided a new perspective in evaluating IT investment in the SC process. The implications of the different types of institutional isomorphism, namely coercion, mimesis and norms, are explored from both the perspectives of firms that have taken the initiatives to adopt IT and those that have followed their SC partners to adopt IT. A Study on institutional isomorphism and the adoption of IT for SCM is very important topic. Lai et al. (2006) analyzed and discussed the implications of institutional isomorphism on the adoption of IT for SC management in their study. Fin and Oklahoma (2006) empirically investigated the moderating effects of firm size on the relationship between the level of IT adoption and three performance levels: operational, financial and strategic, for an apparel SC and found that firm size was a significant moderator variable for operational (lead time), but not strategic and financial performance.

Drawing from organizational theories of learning, Sanders (2008) proposed a model that evaluated how two patterns of IT use by suppliers (exploitation and exploration) impacts two specific types of coordination activities with their buyers (operational and strategic coordination). Using data from 241 first tier OEM suppliers in the computer industry, they found that each pattern of IT use directly promotes a specific type of coordination activity and to achieve a complete set of benefits, suppliers must ultimately use IT for both exploration and exploitation.
2.3 Simulation Modelling

Simulation is a very useful tool for predicting SC performance. Some of the advantages of SC simulation (Chang and Makatsoris, 2001) are i) it helps to understand the overall SC process and characteristics by graphics and animation. ii) able to capture system dynamics: using probability distributions, the user can model unexpected events in certain areas and understand the impact of these events on the SC. iii) It could dramatically minimize the risk of changes in planning process by what-if simulation process and the user can test various alternatives before changing the plan.

Simulation modelling helps the researcher to study the SC coordination with a realistic structure and operating parameters under dynamic environment. Kuhal et al. (2005) presented the development of conceptual models that can be used in the creation of four level SC simulation projects to study the collaboration practices. Ingalls et al. (2004) developed a system to aid professionals from management and logistics areas to evaluate the performance of SCs through computer simulation. Thierry (2010) also provided an overview of the main concepts that relate to simulation studies of SCM systems. They highlighted some of the modelling and simulation challenges with respect to SC design decisions, control policies, degree of systematic decomposition of SCM system and distribution level of the system with possible solutions. Swaminathan (1998) developed a SC modelling frame work to overcome the time and effort required to develop models with sufficient fidelity to the actual SC of interest. Using this approach, SC models are developed from software components that represents types of SC agents (e.g., retailers, manufacturers transporters etc), their constituent control elements (e.g., inventory policy), and their interaction protocols (e.g., message types). Min (2002) synthesizes past SC modelling efforts and identifies key challenges and opportunities associated with SC modelling. This study also
Chapter 2

provided various guidelines for the successful development and implementation of SC models. Persson (2002) presented a SC simulation study concerned with manufacturing of mobile communication systems to evaluate alternative SC designs with respect to quality, lead times and costs as the key performance parameters and to increase the understanding of the interrelationships among these and other parameters relevant for the design of the SC structure. Klimov (2008) investigated the problems related to SC risk identification and simulation based risk evaluation. Initially, this study dealt about the risk recognition in SCM and additional risks connected with SC reliability. In the second part of the study, a numerical example within which a simplified SC system is defined and corresponding risk evaluation is performed. Johansson et al.(2010) studied the issue of channel coordination for an SC consisting of one supplier and two retailers, facing stochastic demand that is sensitive to both sales effort and retail price and developed a decision support tool using simulation optimization for SC coordination with revenue sharing or buyback contract to find out the optimum decision variables. Paes (2012) proposed a framework to model a SC where each SC entity is modeled as a system, hierarchically composed of sub-systems to the required level of abstraction. Each system has operations which determine its inputs, outputs, time and capacity. The framework was tested in DELMIA V6 Production System. Performance is evaluated using system utilization, throughput, order fulfillment time, inventory collected during simulation. This framework allows incremental modelling and easy modification of system structure and operations. Lee (2002) considered the issue that SC systems are neither completely discrete nor continuous and developed a model with the aspects of both discrete event and continuous simulation.

Arena is one of the simulation softwares found in the literature to model the SC and it has been used in this research to model a network supply chain. Altiok and Melamed (2007) and Kelton et al.(2001) provide the details about
various modules in Arena and how to model a system using Arena simulation software.

2.4 Mechanisms vs. Stages and Flows in Supply Chain

Different mechanisms used in literature at different stages of an SC for ensuring the smooth and efficient flow of product, fund and information to improve the performance of the system are summarized in table 2.1.

Table 2.1: Mechanisms corresponding to different Stages (S) vs. Flows (F) in a supply chain

<table>
<thead>
<tr>
<th>S</th>
<th>DESIGN</th>
<th>OPERATIONS</th>
<th>DISRUPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>*F</td>
<td>Joint market survey</td>
<td>*Joint forecasting, ordering and replenishment policies</td>
<td>*Information technology</td>
</tr>
<tr>
<td></td>
<td>Joint product design</td>
<td>*Joint contracts like buyback, quantity flexibility, quantity discount</td>
<td>*Robust strategies such as postponement, strategic stock, flexibility enhancement, make or buy, flexible transportation, assortment planning, etc</td>
</tr>
<tr>
<td></td>
<td>Joint product policies &amp; strategies, such as market promotion techniques</td>
<td>*Learning based continuous improvement</td>
<td></td>
</tr>
<tr>
<td>PRODUCT</td>
<td>*Joint trade credit policies</td>
<td>*Joint pricing schemes</td>
<td>*Cost sharing</td>
</tr>
<tr>
<td></td>
<td>*Joint decision on trade off between cost and quality</td>
<td>*Joint decision on profit sharing methodology</td>
<td>*Robust strategies, such as economic supply incentives, revenue management via dynamic pricing and promotion, make or buy</td>
</tr>
<tr>
<td>FUND</td>
<td>*Joint decision on technology for fund transaction</td>
<td>*Joint price contracts, such as quantity discount, price discount, delay in payment</td>
<td></td>
</tr>
<tr>
<td>INFORMATION</td>
<td>*Joint decision on technological investment for information sharing</td>
<td>*Joint information sharing on demand, inventory lead time production schedule, capacity, etc.</td>
<td>*Incentive schemes for information sharing</td>
</tr>
<tr>
<td></td>
<td>*Centralized/decentralized structure</td>
<td>*Information sharing tools like ERP, MRP, Email, EDI, RFID</td>
<td>*supply chain contracts, Joint decision making, information technology</td>
</tr>
<tr>
<td></td>
<td>Design of supply network and inter organizational information sharing</td>
<td>*Joint order and production policy</td>
<td>*Risk categorization and Risk mitigation strategy formulation</td>
</tr>
</tbody>
</table>

2.5 Policies and Risks in a Supply Chain

The different policies & influencing factors as well as their risks and decision option available in a supply chain are briefly depicted in figure 2.2.
Figure 2.2: Influencing factors – Policies – Risks - Decision option available in a supply chain

2.6 Supply Chain Coordination Obstacles

The major drivers of SC performance are facilities, inventory, transportation and information. Each driver affects the balance between efficiency and responsiveness of an SC. So, the investment on drivers must be done based on the requirement of level of efficiency and responsiveness.
A consolidated form of the typical cases of SC coordination obstacles available in literature are provided in figure 2.3. These obstacles can be removed or minimized from the SC scenario using appropriate mechanisms. All these obstacles may not occur in each and every SC. Some of these are qualitative and others are quantitative in nature. However, these obstacles have been identified from different activities, interfaces and the number of levels in the SC. It has been realized that the obstacles of SCC and independent working of SC members lead to poor performance.

**Figure 2.3**: Supply chain coordination obstacles (Modified from Arshinder et al., 2008)

Basically, these coordination obstacles can be classified with respect to its areas as i) policy related ii) planning related iii) operation related. It is also
clear from the literature that all the issues are interrelated and combination of mechanism may have to be tried to solve an issue. Operational and pricing issues are found most common in the supply chain coordination and information sharing is most probably a part of other issues. Even though ‘logistics’ is a separate area, of SCM, all the other issues can be found in the case of logistics also in different forms. IT issues are mainly a part of operational and information sharing areas. The studies in literature in the IT and SCC area provide the importance of proper implementation of IT without which the result can be opposite to that of desired one. Behavioral issue is qualitative in nature and it will have an effect on any issue throughout the supply chain coordination. Disciplines, such as SRM, CRM, and CRM are related to this area and proper execution of these management techniques along with other trust mechanisms can be a solution for solving behavioral issues. To have an overall improvement in SCC, a holistic, cooperative, and mutually trusted and risk sharing approach with other quantitative mechanisms is required.

2.7 Classification of Mechanisms

Table 2.2 shows various categories of mechanisms and examples under each category. Supply chain contracts are mainly meant for resolving issues, such as lot sizing, capacity utilization, and inventory management, pricing, etc. Information technology provides the tools to gather accurate and right information in a timely manner to analyse it to make the best supply chain decisions. It is a supporting mechanism for all others. Selection and implementation of IT is very important. Select an IT system that addresses the company’s key factors and take incremental steps and measure its value. It is very important that align the level of sophistication with the need for sophistication required considering the future also. It is to be ensured that use IT systems is to support decision making, not to make decisions. If these factors
are not taken into consideration, IT will become rather a nuisance than an advantage. Information sharing helps the supply chain members to take appropriate decisions regarding any issue to improve the overall performance in this dynamic and competitive environment. But, if the information is not right, accurate and timely, the result will be negative. Joint decision making resolves almost all obstacles to coordination. But, there must be a trust and ethics mechanism along with Joint decision making policy. Otherwise, the dominant member may play over the other(s) and gain more advantage from coordination and finally the SC may not be successful. This is applicable for information sharing mechanism also. Mechanisms under miscellaneous category are of qualitative nature and are applicable to reducing different kinds of disruptions occurring in SC during the business process. The implementation of these mechanisms can also be done only after in-depth study of disruptions occurring during the process as it is random in nature.

Table 2.2: Classification of Mechanisms with Examples ((Modified from Arshinder et al., 2008)

<table>
<thead>
<tr>
<th>Supply chain contracts</th>
<th>Information technology</th>
<th>Information sharing</th>
<th>Joint decision making</th>
<th>Miscellaneous mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Buy back</td>
<td>i) Internet enabled mechanisms such as Email, Online auctions &amp; contracting, fund transactions and services</td>
<td>i) Demand</td>
<td>i) Cost aspects</td>
<td>i) Management tools and techniques such as CRM, SRM, and ISCM</td>
</tr>
<tr>
<td>ii) Revenue sharing</td>
<td>ii) EDI</td>
<td>ii) Inventory</td>
<td>ii) Replenishment</td>
<td>ii) Dual sourcing</td>
</tr>
<tr>
<td>iii) Quantity flexibility</td>
<td>iii) Lead time</td>
<td>iii) Production schedule</td>
<td>iii) Forecasting</td>
<td>iii) Economic supply</td>
</tr>
<tr>
<td>iv) Price discount</td>
<td>iv) Production</td>
<td>iv) Capacity</td>
<td>iv) Ordering</td>
<td>iv) Incentives</td>
</tr>
<tr>
<td>v) Delay in payment</td>
<td>v) Cost</td>
<td>v) Out sourcing</td>
<td>v) Ordering</td>
<td>v) Postponement</td>
</tr>
<tr>
<td>vi) Sales rebate</td>
<td>vi) Backorder</td>
<td>vii) Advertising</td>
<td>vi) Strategy</td>
<td>vi) Strategic stock</td>
</tr>
<tr>
<td>vii) Multiple pricing schemes</td>
<td>viii) Point of sales data</td>
<td>viii) Pricing</td>
<td>viii) Flexibility</td>
<td>vii) Flexible supply base</td>
</tr>
<tr>
<td>viii) Effective multi-stage inventory linkage</td>
<td>ix) Sales date</td>
<td>ix) Promotion schemes</td>
<td>ix) Make and buy</td>
<td>ix) Make and buy</td>
</tr>
<tr>
<td>ix) Flexible return-policies</td>
<td>x) Supply chain performance</td>
<td>x) Market research</td>
<td>x) Dynamic assortment</td>
<td>x) Dynamic assortment</td>
</tr>
<tr>
<td>x) Single, dual, and multiple sourcing</td>
<td>xi) Design collaboration</td>
<td>xii) Learning based continuous improvement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
that knowledge for conscious selection of coordination mechanism is created for users. There has been a lot of work in the area of SC coordination and bridging the gap between models with rigid assumptions and reality will be a constant challenge to researchers in this area. Figure 2.4 shows a framework for SC coordination study.

![Figure 2.4: A framework for SC coordination study (Modified from Arshinder et al., 2008)](image)

The above framework has been modified from Arshinder et al., 2008 based on the literature we have reviewed. During the literature review, we have found different coordination issues, various coordination mechanisms, and also different types of modelling approaches to solve the problem. We have
consolidated the approaches of these studies and put in a framework expecting that to be useful for further supply chain coordination studies and some of these methodologies (mathematical modelling and simulation modelling) were adopted in our work.

This literature review is intended to open up the issues dealt in the recent past studies to get a picture about the present stage of SC coordination and further areas to be addressed. The details of various obstacles being faced by the different SC to achieve coordination, and mechanisms to overcome such issues are presented. Various categories of mechanisms are also provided in this chapter to get an overall idea about it. Finally, a framework to conduct an SC coordination study is also given to get an outline of how to start with and pursue the research work in the area of supply chain coordination.

As discussed in the preceding sections, a detailed literature survey was conducted in the area of supply chain coordination. During the literature survey, various gaps or topics still to be studied were found and it is decided to address the following gaps.

Individual studies on the effect of ‘price discount and delay in payment’ on a dynamic network SC were not available in the literature. It is to be noted that the combined effect of these mechanisms on a simple SC was also not found in the literature. As mentioned earlier, information sharing is very important to SCC. But, the effect of various types of information sharing on SC performance with the comparison between each other in detail was not available. Study on the effect of various types of information sharing on SC performance using simulation game with live players is also very important as it involves a reality factor of live players. So, this kind of study can be conducted to make it advantageous for the SC practitioners. Most of the businesses in the world have a characteristic of either lost sale or backorder. So, if the studies
mentioned above can be conducted under these two cases, it will be very relevant and useful for the users as it was not available in the literature. Sensitivity analysis is really an essential part of these kinds of studies to make it really worthy to all related academicians and SC managers. But, it is also not up to the required level in the literature. So, detailed sensitivity analysis also can be incorporated with above mentioned studies to be addressed in the research work. The decision to study and analyse the above mentioned gaps in the literature prompted us to have the objectives as mentioned in section 1.11 of chapter 1 in this thesis report.

2.8 Supply Chain Performance Measures and Tools

The classification of performance measures and tools are provided in Chapter 1 under the section 1.3.6. In this section, each one of the performance measures and tools are discussed as follows

2.8.1 Supply Chain Performance Measures

The performance measures related to various activities or operations (provided as subsections) of SC discussed under each category are highlighted in bold letters and explained below as discussed in Gunasekaran, et al., 2004.

2.8.1.1 Order plan

“The order entry method” is one of the measures under order plan which determines the way and extent to which customer specifications are converted in to information exchanged along the supply chain. “Order lead-time” is another measure which determines the total order cycle time, the reduction in which leads to reduction in supply chain response time. It is an important performance measure and source of competitive advantage as it directly interacts with customer service in determining competitiveness. “The customer order path” is the path that an order traverses is another important
measure whereby the time spent in different channels can be determined. By analyzing the customer order path, non-value adding activities can be identified so that suitable steps can be taken to eliminate them.

2.8.1.2 Sourcing

Unlike earlier periods, presently evaluation of suppliers is done in the context of the supply chain (efficiency, flow, integration, responsiveness and customer satisfaction) which involves measures important at the strategic, operational and tactical level. **Strategic level** measures include lead time against industry norm, Quality level, Cost saving initiatives, and supplier pricing against market. Tactical level measures include the efficiency of purchase order cycle time, booking in procedures, cash flow, quality assurance methodology and capacity flexibility. Operational level measures include ability in day to day technical representation, adherence to developed schedule, ability to avoid complaints and achievement of defect free deliveries.

2.8.1.3 Make/Assemble

This stage/activity is very important as their performance has a major impact on product cost, quality, speed of delivery and delivery reliability, and flexibility. As it is quite an important part of the supply chain, production needs to be measured and continuously improved. Suitable measures for the production are as follows: **range of product and services, capacity utilization and effectiveness of scheduling techniques**

2.8.1.4 Delivery/Customer

In a supply chain, the link that directly impacts customers is delivery. It is a primary determinant of customer satisfaction; hence, measuring and improving delivery is always desirable to increase competitiveness. Measures
for delivery performance evaluation are i) **number of faultless notes invoiced** (an invoice shows the delivery date, time and condition under which goods were received ii) **Flexibility of delivery systems to meet particular customer needs.** Another important measure under delivery is **total distribution cost**

### 2.8.1.5 Measuring customer service and satisfaction:

To assess supply chain performance, supply chain metrics must centre on customer satisfaction. **“Flexibility”** is one of the factors by which supply chains compete and can be rightly regarded as a critical one. Being flexible means having the capability to provide products/services that meet the individual demands of customers. Some flexibility measures include: (i) product development cycle time, (ii) machine/toolset up time, (iii) economies of scope -refers to the production of small quantities of wider range (e.g. JIT lot size) and (iv) number of Inventory turns. **“Customer query time”** is another important measure which relates to the time a firm takes to respond to a customer query with the required information. **“Post transaction measures of customer service”** is next important measure. The function of a supply chain does not end when goods are provided to the customer. Post transaction activities play an important role in customer service and provide valuable feedback that can be used to further improve supply chain performance.

### 2.8.1.6 Supply chain and Logistics cost:

The efficiency of a supply chain can be assessed using the total logistics cost—a financial measure. It is necessary to assess the financial impact of broad level strategies and practices that contribute to the flow of products in a supply chain. Since logistics cut across functional boundaries, care must be taken to assess the impact of actions to influence costs in one area in terms of their impact on costs associated with other areas (Cavinato, 1992). For example, a change in capacity has a major effect on cost associated with inventory and
Literature Review

order processing. Some of the measures under this category are i) **Cost associated with assets and return on investment** and ii) **Information processing cost**

### 2.8.2 Performance measuring tools

As mentioned in the beginning of the section 1.3.6, the most popular supply chain performance measuring tools are detailed as follows (Agami et al., 2012). ‘**Financial accounting**’ is the traditional, regularly used tool as a part of any firm’s fund flow operations and mostly concerned for all the firms as it measures costs attributable to different areas of operations or elements and finally measures the total cost/profit. This tool is still a very useful one as its output (cost/profit) provides a clear picture regarding the areas to be improved or the percentage of improvement obtained in different areas of business which will help the supply chain practitioners to take appropriate decisions accordingly for further improvement.

#### 2.8.2.1 The Activity-Based Costing (ABC)

This approach was developed in 1987 by Kaplan and Bruns (1987) in attempt to tie financial measures to operational performance. It involves breaking down activities into individual tasks or cost drivers while estimating the resources, such as time and costs, needed for each one. Costs are then allocated based on these cost drivers rather than on traditional cost accounting methods such as allocating overhead either equally or based on less relevant cost drivers. The approach was designed in such a way to allow for better assessment of the true productivity and costs of a supply chain process. However, it still suffered the major limitation of relying only on pure financial metrics.
2.8.2.2 The Economic Value Analysis (EVA)

EVA is an approach developed in 1995 by Stern et al. (1995) for estimating a company’s return on capital or economic value added. EVA approach is based on the premise that the shareholder’s value is increased when a company earns more than its cost of capital. The EVA measure attempts to quantify the value created by an enterprise basing it on operating profits in excess of capital employed (through debt and equity). Though useful for assessing high level executive contributions and long-term shareholder value, EVA metrics fail to reflect operating supply chain performance since it only considers pure financial indicators.

2.8.2.3 Supply Chain Balanced Scorecard (SCBS)

SCBS was introduced by Kaplan and Norton in 1992 as an indispensable performance management tool. It enables managers to observe a balanced view of both operational and financial measures at a glance. The authors proposed four basic perspectives that managers should monitor as follows: Financial (e.g., cost of manufacturing and cost of warehousing), Customer (e.g., on-time delivery and order fill rate), Internal Business Processes (e.g., manufacturing adherence-to-plan and forecast errors) and Innovation and Learning perspectives (e.g., APICS-certified employees and new product development cycle time). Bearing these four perspectives in mind, managers can translate strategies into specific measures that can monitor the overall impact of a strategy on the enterprise. The goals and measures in each perspective are extracted from the enterprise strategy. Brewer and Speh (2000) demonstrate how a supply chain management framework is linked to the balanced scorecard. Even though SCBS is powerful tool, it suffers two basic limitations i) it is not participative and might fail to detect existing interactions between different
process metrics. ii) It gives a framework only and lacks an implementation methodology and thus deviates from the merit of concept itself.

2.8.2.4 Supply Chain Operations Reference (SCOR)

SCOR was created by the Supply Chain Council (Stephens, 2001; Huang et al., 2004; Lockamy and McCormack, 2004). This model defines a supply chain as being composed of five main integrated processes: Plan, Source, Make, Deliver and Return. Performance of most processes is measured from 5 perspectives: Reliability, Responsiveness, Flexibility, Cost and Asset. As the model spans the chain from supplier’s supplier to customer’s customer aligned with operational strategy, material, work and information flows, it is considered an exhaustive system that requires a well defined infrastructure, fully dedicated managerial resources and continuous business process re-engineering to align the business with best practices. The SCOR model framework can be found in Huang et al. (2004).

2.8.2.5 Logistics Scoreboard

It is a also a performance measuring tool in which recommended performance measures focus only on logistical aspects of the supply chain (Lapide, 2000). They fall into the following general categories: logistics financial performance measures (e.g., expenses and return on assets), logistics productivity measures (e.g., orders shipped per hour), logistics quality measures (e.g., shipment damage) and logistics cycle time measures (e.g., order entry time).

In our study, we have used Supply chain cost/profit for measuring and analysing the performance of supply chain. The reason for the selection is that firms are mostly concerned with supply chain profit/cost as it reflects the performance of the supply chain operations in totality as it is an overall performance measure. The mechanisms selected for study are those which have
direct impact on costs and hence a financial performance measure was thought to be most appropriate. Hence the overall performance measure “supply chain profit/Cost” has been taken in this study.