Research and Opportunities in Supply Chain Modeling: A Review

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Abstract--- *Supply chain management (SCM) has a long history of incorporating elements of engineering, technology, and management. Extensive research is ongoing in all aspects of SCM. An important research objective is the development and verification of mathematical models. Case studies are used to test the validity of new models. During the past decade, SCM literature has greatly expanded. Considering this vast array of literature, a comprehensive review is appropriate. This paper presents an in-depth review of supply chain (SC) modeling literature. The approach will help researchers, academicians and practitioners alike to take a closer look at the growth, development and applicability of issues related to SC modeling. From the wide selection of 690 papers published in the various aspects of SC modeling during the past decade, 282 papers were selected for this review. Lastly, ten key areas have been identified for future research.*

KEY WORDS: ***Literature Review, Supply Chain Modeling, Review Framework, Future Research***

1. INTRODUCTION

Intense global competition is forcing organizations to offer low-cost, high-quality, reliable products. To compete, products must be delivered on time and with greater design flexibility. Industries strive to satisfy wise customer needs while maintaining acceptable levels of profitability. Intelligently applied, SCM is sufficiently mature to enhance the survival of industries in this era of global competition. According to the council of logistic management, SCM is the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point-of-origin to the point-of-consumption for the purpose of conforming to customer requirements [1]. SCM objectives are to enhance the operational efficiency, responsiveness, and profitability of firms and their supply chain partners. These objectives can be realized by designing, developing, and implementing SCM situational (need-oriented) models. Models must change to accommodate changing scenarios. Review of the prior modeling literature analyzed in this paper revealed a wide range of models. Consequently, no single model captures all aspects of the wide range of SC processes.

Although there are many publications in the SCM domain, only a few authors have attempted to provide a comprehensive review of the SCM modeling literature. Interestingly, most of the review papers have considered only a single aspect, such as simulation, case studies, surveys, or performance measurements. The researchers, Croom et al. [2], Tan Keah [3], Min and Zhou [4], Sergio and Sergio [5], Sachan and Datta [6], Gunasekaran and Kobu [7], Vaart and van Donk [8], and Rajurkar and Jain [9] have authored the review papers in this area. The paper presented by Min and Zhou is particularly informative about SCM modeling. The authors developed taxonomy for classifying the modeling literature. However, their work is restricted to categorizing SCM modeling according to a single-dimension model type, such as deterministic, stochastic, or hybrid. Consequently, there is a need to develop a more extensive review paper that emphasizes the full spectrum of SCM and to classify the literature in additional detail. To that end, this paper presents a comprehensive review and categorization of the modeling literature that encompasses the complete spectrum of SCM. It provides both academicians and practitioners with an in-depth review of current SC issues, existing models, and a clear direction for future research.

In addition to reviewing SCM literature, the other contributions of this paper lie in organizing the current SC modeling work by: i) arranging publications in an orderly manner to facilitate searching, ii) classifying the literature with respect to topical coverage, iii) examining the outcome of publications, and iv) identifying gaps and providing insight for further research.

The remainder of this paper is organized as follows: Section 2 describes the methodology and approach to reviews. Section 3 presents a literature classification framework, along with brief descriptions of each individual's prior work. Section 4 includes critical views and way forward for future research. Finally, section 5 summarizes the paper with concluding remarks.

2. METHODOLOGY AND SCHEME OF REVIEW

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The volume of SCM literature is growing rapidly. For this review, SCM papers from leading international journals were collected from multiple databases like Science Directory, Google Scholar, ABI/INFORMS, and IEEE Explore among others. From the more than 700 papers dated between 2001 and 2010, 302 papers were selected because of their relevance to modeling. A paper's potential relevance to our study was determined by careful examination of its abstract, introduction, and conclusions. Only those papers that reflected modeling on any aspect, activity, or function of SCM were considered for further review. Following the initial selection, each of the 302 papers was reviewed in greater detail. Each paper was assessed independently to determine the area of modeling, methodology, modeling tool(s), product type, production type, year of modeling, stochastic or deterministic, general or IT-driven, type of industry, simulation, and area of IT application (See Table 1).

Table 1. Distribution of 302 Papers from Various Journals

Sr. No.	Name of Journal	No. of Papers	% Cont-ribution	Rank
	International Journal of Production Economics	89	29.47	1
	European Journal of Operational Research	74	24.5	2
	Computers and Chemical Engineering	15	4.97	4
	Expert Systems with Applications	13	4.31	5
	Computers & Industrial Engineering	12	3.97	6
	Mfg Service And Operations Management	08	2.65	7
	IIE Transaction	08	2.65	7
	Decision Support Systems	07	2.32	8
	Omega	06	1.99	9
	Applied Mathematical Modelling	06	1.99	9
	Simulation, modelling, practice and theory	06	1.99	9
	Management Science	06	1.99	9
	Fuzzy Sets and Systems	05	1.66	10
	IEEE Transactions	04	1.33	11
	Robotics and computer integrated manufacturing	04	1.33	11
	Journal of Operations Management (OTM 4)	03	0.99	12
	Computers in Industry (UC)	02	0.65	13
	IJPDLM	02	0.65	13
	Engineering applications of artificial intelligence	02	0.65	13
	Beta	02	0.65	13
	Production Planning and Control	02	0.65	13
	Decision Science	02	0.65	13
	Flexible Services and Manufacturing Journal	02	0.65	13
	Mathematical and Computer Modelling	02	0.65	13
	Others (one paper each)	20	6.62	3

The other journals contributing one research paper each are:
International Journal of Production Research, Advances in Engineering Software Applied Energy, Tsinghua Science And Technology, Information Sciences, Advanced Modelling and Optimization, Journal of Food ,engineering, Journal of Operation Research Society, Computers and Electronics in Agriculture, The Journal of Systems and Software, International Conference on Automation and Logistics, Journal of Process Control, Journal of Chinese Institute of Industrial Engineers, Research communication, Sadhana, System engineering, Winter simulation conference, International Journal of Integrated Supply Management, International Journal of Operations & Production Management and Transportation Research.

3. LITERATURE CLASSIFICATION FRAMEWORK

Figure 1 is the framework used to classify the 302 modeling papers. It depicts a graphical structure to help visualize the growth of publication categories of interest.
The initial classification of SCM literature focuses on the spectrum of SCM planning and management; SC network design and pricing; SC drivers and, coordination and performance measurement. Additional classification is based on analytical tools or methods used by researchers. Product lifecycle aspect like perishability is identified as a potential category on its own right. Finally, the type of model, i.e., stochastic, deterministic, or hybrid is considered as the other major classification category for existing SC modeling literature.

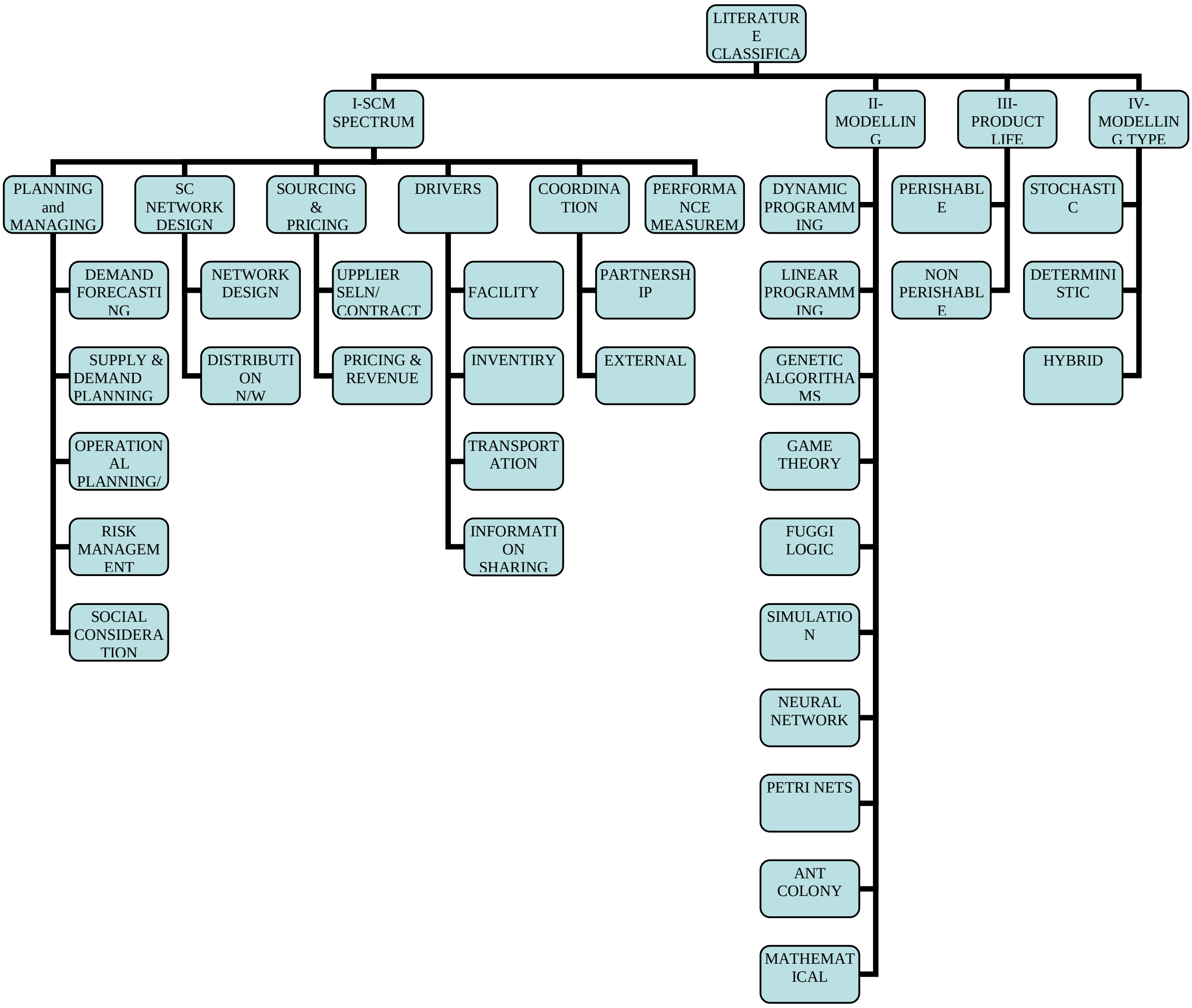

Figure 1: Literature Classification Framework

3.1. Planning and Management

The literature related to supply chain planning and management (SCP&M) covers several key issues that include demand forecasting, planning supply and demand, operational planning and scheduling, risk management and social/environmental consideration. Demand forecasting is a base for future business activities. Consequently, forecasting accuracy has a pronounced impact on management's key decisions. Planning the supply, according to the demand, is a major activity for every stage of SC. Planning has an impact on purchasing raw material and is closely linked to the production of finished goods and transportation. Figure 2 presents a graphical summary of related work published during the past ten years in the planning and management category.

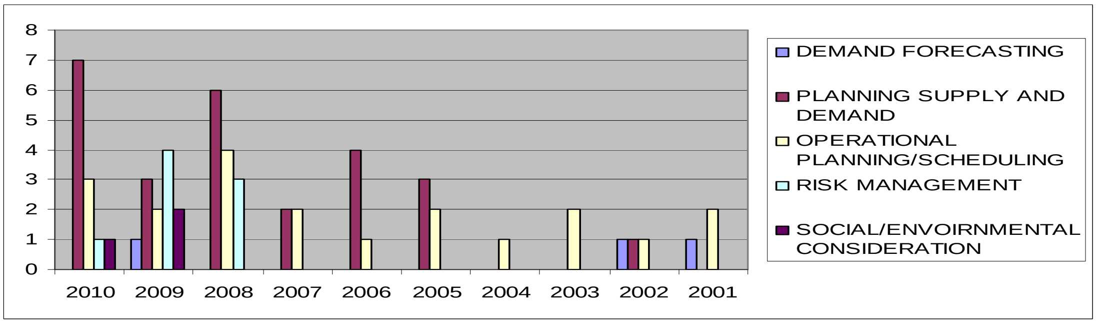

Figure 2: Year-wise Publication Data of Literature on Planning and Management

As shown in Table 2, researchers have focused more on planning supply and demand (such as inventory control, replenishment strategies, ordering policies, and lead-time) than on other aspects (such as demand forecasting and the social and environmental considerations). In addition, there has been a constant stream of publications on operational planning issues (such as production scheduling, procurement, and risk analysis in managing a multi-stage supply chain). Table 2 identifies the elements of research carried out by various researchers in SC planning and management by their decision focus, research objectives, and methodologies. Figure 2 also partitions the work by the area of application such as perishable or non-perishable products.

Table 2. Authors Contributing to Supply Chain Planning and Management

Decision	Authors	Research theme	Methodology used	Other Info.
Demand forecasting	Bongju et al. [10]	Forecasting model	G A	NP CS
	Yossi et al. [11]	Collaborative forecasting	Fluid analogy	NP DT
	Jay et al. [12]	Decision making	Mathematical	NP SM
Planning Supply and demand	Wu et al. [13]	Replenishment model	Linear	NP ST
	Mark S et al. [14]		Programming	NP SM
	Cai et al. [15]	Advanced order strategies	Game Theory	NP DT
	Xie et al. [16]			NP ST
	Chang et al. [17]	Cost effectiveness	Mathematical	PS ST
	Hsieh et al. [18]	Inventory model, cost	Mathematical	PS DT
	Rob A.C.M. et al.[19]	effectiveness	Simulation	PS ST
	Shukla et al. [20]	Overall cost reduction	Taguchi	NP SM
	Jose et al. [21]	Supply management	DP, Simulation	NP ST
	Caroline et al. [22]	Supply management	Simulation	PS SM
	David P. et al. [23]	Ordering policies	Fuzzy sets	NP ST
	Chaharsooghi et al. [24]	Reinforcement learning	Beer game	NP ST
	Xiao et al. [25]	(R, nQ) inventory policies	Mathematical	PS ST
	Torabi et al. [26]	Flexible return policy	MILP	NP ST
	Ding Ding et al. [27]	Master planning	Sensitivity A	NP ST
	Zhao Xiao Bo et al. [28]	Inventory policies	Markov chain	NP ST
	Kuo et al. [29]	Multi-period planning	MILP	NP DT
	Xie et al. [30]	Customer demand and	Fuggy logic	NP ST
	Rao et al. [31]	Inventory status	Mathematical	PS DT
	Hendricks et al. [32]	Demand, supply variation	Mathematical	NP SM
	Chen et al [33]	Cycle time	Fuggy logic	NP ST
	Wang et al. [34]	Demand	GA	NP HY
	Alexandre D et al. [35]	Lead time	Markov model	NP ST
	Venkatadri et al. [36]	e-Commerce	MILP	NP ST
	Wan et al. [37]	Analyzing supply chains	Simulation	NP SM
Operational Planning / Scheduling	Alebachew et al. [38]	Procurement, fabrication	MILP	NP HY
	Tadeusz [39]	Product assembly, distribution scheduling	MILP	NP ST
	Ghaeli et al. [40]	Hybrid systems	Petri net	PS SM
	Drzymalski et al. [41]	System dynamics and	Petri net	NP
	Liu et al. [42]	Managing events	Petri net	NP SM
	Ivanov et al. [43]	Planning and operations	Struc. dynamics	NP CM
	Wang et al. [44]	Coordination	Sensitive Anlysi	NP ST
	Sahin et al. [45]	Production scheduling	Simulation	NP SM
	Mustafa et al. [46]	SC behaviour	Simulation	NP SM
	Oscar et al. [47]	CONWIP SC policy	Simulation	NP SM
	Hung et al. [48]	Operational policies.	Simulation	NP CS
	Spitter et al. [49]	Capacity constrained (SCOP) policy	Linear Programming	NP DT
	Huang et al. [50]	Design constraints of SC	DP, GA	NP DT
	Sérgio et al. [51]	Supply management	Agent-based	NP
	Nirupam Julka et al. [52]		Simulation	NP SM
	Lodree Jr. et al. [53]	Production planning	Mathematical	PS ST
	Yin et al. [54]		Markov chain	NP ST
	Perea-Lopez et al. [55]	Decision policy	DP	NP ST
	Dong et al. [56]	Analysing mfg. SC	Petri net	NP SM
	Wang [57]	Model predictive control	Simulation	NP SM

Risk Management	Tuncel et al. [58]	Risk management	Petri net	DT SM
	Tiaojun Xiao et al. [59]	Information mechanism	Game Theory	DT
	Kull et al. [60]	Supply risk	Simulation	NP ST
	Wolf et al. [61]	Base-stock policy	Markov chain	NP ST
	Azaron et al. [62]	Multi-objective	Mathematical	ST HY
	Tsai et al. [63]	Cash flow risks	Simulation	NP DT
	Xiao et al. [64]	Price–service competition	Game Theory	NP DT
	Wu et al. [65]	Risk evaluation models	Simulation	NP SM
Social Consideration	Balan S. et al. [66]	Green sc management	Lagrangian	PS ST
	Bojarski et al. [67]	SC planning and design	MILP	PS ST
	Cruz [68]	Corporate (CSR)	MILP	NP ST

3.2 Supply Chain Network Design

Network design decisions are the most important SC decisions because their implications are significant and are long-lasting. When designing an SC network, four drivers (facility, inventory, transportation, and IT) need to be considered. These drivers define competitive strategy and enhance SC profitability. The following authors have presented their work with *respect* to the design of supply chain networks. Table 3 classifies work with respect to research objective, modeling type, and product life.

Table 3: Authors Contributing to Supply Chain Network Design

Decision	Researcher	Research theme	Methodology used	Other Info.
Network Design	Maria Isabel et al. [69]	Multi-product, reverse flow	MILP	ST MM NP
	Shabnam et al. [70]	Equilibrium model	Nash Equi	DT MM NP
	Jack G.A.J. et al. [71]	Dynamic behaviour	Simulation	SM PS
	Kim and Cho et al. [72]	Profit maximization	D P	DT MM NP
	Altiparmak et al. [73]	Solution to problem	G A	HY SM NP
	H.S. Wang [74]	Partner selection	Ant colony	ST MM NP
	Hadi et al. [75]	Equilibrium model	MILP	DT MM NP
	Gumas et al. [76]	Design effectiveness	MILP ANN	HY MM NP
	Fengqi et al. [77]	Responsive/ economic	MILP	ST MM NP
	Ertunga et al. [78]	Profitability	MILP	ST MM NP
	Pierreval et al. [79]	Customer behaviour	Simulation	SM NP
	Che et al. [80]	Qualitative/quantitative	Linear pro	DT MM NP
	Chatfield et al. [81]	Order fulfilment	Simulation	SM NP
	Wang et al. [82]	Products development	GA FS	ST MM NP
	Candas [83]	Logistic Net. Design	Linear pro	ST MM NP
	Sourirajan et al. [84]	Lead time, safety stock	LR	DT MM NP
	Altiparmak et al. [85]	Solution to problem	GA	ST SM NP
	Choudhary et al. [86]	Lead time	Linear pro	ST MM NP
	Lamothe et al. [87]	Product selection	MILP	ST SM NP
	Chakravasti et al. [88]	Supplier selection	MILP	DT MM NP
	Gigler et al. [89]	Product Quality	DP	SM PS
	Lakhal et al. [90]	Strategic issues	MILP	ST NP MM
Distribution Network Design	Liang et al. [91]	Overall cost reduction	FMLP	ST MM NP
	Hill et al. [92]	Ware house	MILP	ST MM NP
	Liang [93]	Cost reduction	FMLP	ST MM NP
	Monthotipkul. et al. [94]	Inventory/distribution	MILP	ST MM NP
	Shaojun Wang et al. [95]	Just in time	MILP	DT MM PS
	Gunther et al. [96]	Logistic centre	DS	DT MM NP
	Vaidyanathan J. et al. [97]	Logistic	MILP	SM NP
	Banerjee et al. [98]	Order shipment	Simulation	SM NP

ANN- Artificial Neural Network, LR-Lagrangian relaxation, FMLP-Fuzzy Multi-objective Linear Programming, DS- Dynamic Sequencing, FS-Fuzzy Set, DP- Dynamic Programming.

3.3 Sourcing and Pricing

Sourcing is the set of business process required to purchase goods and services. Sourcing includes selection of supplier, contract decisions, product design collaboration, and the material procurement and evaluation of the suppliers' performance. Burden-reduction is an important aspect of SCM. However, pricing relates to decisions of setting prices and discounts of the product in order to maintain certain levels of profit margins. Figure 3 shows the number of research papers credited to each category.

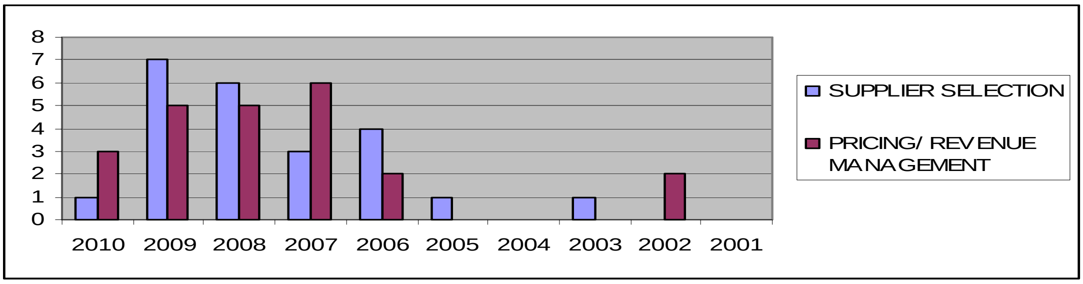

Figure 3: Year-Wise Data of the Literature on Sourcing and Pricing

3.3.1 Supplier selection / contracts

After conducting supplier scoring and assessment analysis, firms can select desirable suppliers using a variety of mechanisms such as off-line competitive bids and reverse auction or direct negotiation. Inadequate supplier and partner selection leads to the lose of trust in all stages of SC. Following the process of supplier selection, contracts between buyers and suppliers are signed. Various types of contracts are possible, such as product availability, buy-back and returns, revenue sharing, quantity flexibility, cost coordination, agent efforts and performance improvement. The researchers like Ru and Wang [99], Xu [100], Zhao and Shi [101], and Li et al. [102] have modelled for supplier selection and contracts and focused on supply chain structure, to accept integration or decentralization and which contracting strategy a business should choose. The authors found that supply chains that decentralize perform better under high degree of product substitution between supply chains. However, Kheljani et al. [103], Pokharel [104], Zhou and Li [105] and Wang and Liu [106] have considered the issues of coordination between buyer and potential suppliers in the supplier selection process. The authors have characterized market demand as a fuzzy variable and proposed single-period and long-term contracts to coordinate the two members, supplier and buyer in the supply chain. And compare the effectiveness of the two contracts, which indicates that a long-term contract is more effective than a single-period contract in improving the profit potential of total SC. Also considered estimated demand from various retail units, capacity commitment by suppliers, assemblers and third party warehouses as constraints in order to develop a two-objective decision-making model for the selection of suppliers and warehouses for a SC network design. Wang et al. characterizes quality, budget, and demand as fuzzy variables in a fuzzy vendor selection expected value model and a fuzzy vendor selection chance-constrained programming model, to maximize the total quality level
It was suggested that the contracts are essential in resolving conflicts in order to reduce global loss of efficiency, Jean-Henet and Adra [107]. Also using market demand as a fuzzy variable, long-term contracts increase the profit potential more than short-term contractswas studied by Frascatore and Mahmoodi [108], Wang et al. [109], Wang et al. [110], Amin et al.[111], Ali et al.[112] and Chen et al.[113],). The authors evaluated the efficiency of different types of contracts between the industrial partners of a SC. It proposes a price compliance regime for contract where the penalties, in the form of price for non-compliance on quantity, are enforceable on both parties. Also their research work is concerned with the coordinating quantity decision problem in a SC contract. The authors proved that the retailer expects to obtain higher profit under proper ordering policies, which can also maximize the expected profit of the SC. Pascal et al. [114] have proposed a multi-behavior planning agent model using different planning strategies. Whereas, Mathur and Shah [115] have proposed a price-compliance regime for contracts where the penalties, in the form of price for non-compliance on quantity, are enforceable on both parties. Researchers Cao and Yao [116] modeled for a retailer's fixed order, call-option purchase, put-option purchase and manufacturer's production, under one order and two-period production mode. Ryu and Lee [117] have reduced lead times at a cost that can be viewed as an investment considering dual-sourcing models with stochastic lead times and constant unit demand. With the intention of providing new dimensions to the SC, Kannan and Tan [118], Robert and Serguei [119], Gilbert and Xi [120], Huang and Sethi [121] Frascatore and Mahmoodi [122], and Xiao and Yang [123], also worked in this regard. Their concern is to analyze the impact of supplier selection and buyer-supplier engagement on the performance benefits attributable to buyer-supplier relationships, and the effect of these benefits on broader measures of buyer performance. Buyer coordination to the supply chain in the presence of default risk. To explore production and outsourcing decisions for two original equipment manufacturers (OEM) that produces partially substitutable products and have opportunities to invest in reducing the manufacturing cost. To study a two-stage purchase contract with a demand forecast update.

3.3.2 Pricing and revenue management

For SC, pricing is an important lever to increase profit by better matching supply and demand. Pricing may influence demand for price sensitive customers. Pricing has an effect on the revenue generated and on revenue management. Revenue management has significant impact on SC profitability. Revenue management is necessary when the product value varies in different market segments, the product is highly perishable, demand is seasonal, or the product is sold in both bulk and the spot market. There are various pricing strategies in response to pricing and profit sharing for coordinating supply chains, transfer pricing and transportation cost allocation, co-investment programs for capital development, advertising and pricing. Many authors explored these pricing strategies and modeled dynamic pricing and pricing in the presence of strategic customers are Wei and Choi [124], Edward [125], Perron et al.[126], Konstantin and Charles [127], Yu et al. [128], Levin Yuri et al. [129] and Gerard and Robert [130]. These researches provide background for changing pricing policies according to the changes in marketing strategies, customers, environment and product life considerations. Reza and Mahsa [131] have developed and solved a model for minimizing costs while minimizing the sum of backorders and surpluses of products in all periods. Mickael et al. [132] proposed to implement Activity Based Costing (ABC) while a mean-variance (MV) analysis of supply chains under a returns policy is carried out by Choi et al. [133].

Gonzalo et al. [134] presented a novel approach for holistically optimizing the combined effects of operations and finances in SCM. Chen and Chen [135] dealt with the joint decisions on pricing and replenishment schedule for a periodic review inventory system. Hammond and Beullens, [136] examined issues surrounding the recent European Union directive regarding waste of electric and electronic equipment. Gjerdrum and Shah [137] have worked on inventory-holding policy. Chang et al. [138] established an economic-order quantity model for a retailer to determine its optimal selling price, replenishment number and replenishment schedule with partial backlogging. However, Yang and Zhou [139] analyzed the effects of duopolistic retailers' different competitive behaviors, including models like Cournot, Collusion, and Stackelberg on the optimal decisions of the manufacturer and on the duopolistic retailers themselves. Federgruen and Heching et al. [140] modeled multi-locational combined pricing and inventory.

In real-life business, for perishable products, the demand is a function of the selling price, the age, and the credit period. Perishability gives rise to intense pressure to follow a dynamic pricing strategy in order to avoid losses due to obsolescence. However, the current papers propose an algorithm for single-period inventory replenishment problems with the expected profit objective are Thangam and Uthayakumar [141], Dye et al. [142], Webster and Weng [143], Li et al. [144], Chung et al. [145], and Bramorski [146].

3.4 Supply Chain Drivers

SC drivers play a vital role in achieving the performance level of a supply chain. Drivers have a great influence on the balance between responsiveness and efficiency of the SC. Major SC performance drivers are facility, inventory, and transportation, and information technology. Year-wise research data are presented graphically in Figure 4.

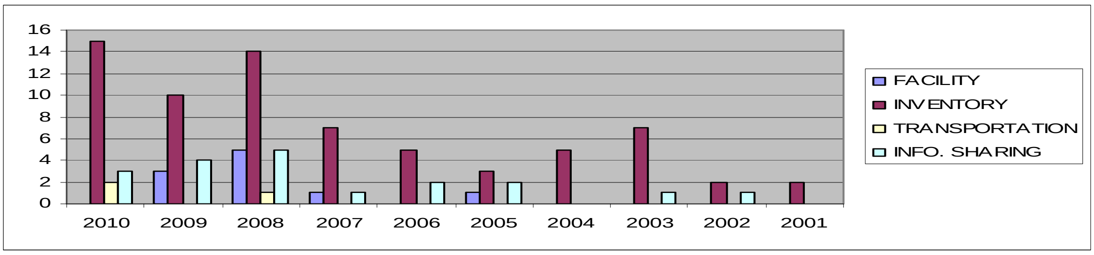

Figure 4: Year-Wise Data of the Literature on SC Drivers

3.4.1 *Facilities*

Facilities and their corresponding capacities are the key drivers of SC performance in terms of responsiveness and efficiency. The researchers like Meng et al. [147], Li et al. [148], and Uster and Keskin [149] have optimized the allocation of capacities among different facilities and product items for a decentralized SC. However, Kaihara [150] formulated a discrete resource allocation problem for a virtual market in a dynamic environment. Panagiotis and Lazaros [151] have explained the constrained-based optimization for production allocation and work-load balance. However, Chew et al. [152], Manuel et al. [153], and Federgruen and Heching [154] has determined the price and inventory allocation for a perishable product with a predetermined lifetime, finite waiting room, and a single server. A number of authors like Hsieh and Wu [155], and Li et al. [156] have developed the model on coordination for capacity allocation, ordering, and pricing decisions with demand and supply uncertainties. Whereas, Yang and Yang [157] explained the importance of a premium-payment scheme involving capacity acquisition in order to build higher capacity.

3.4.2 *Inventory*

Inventory is spread throughout the SC, including raw materials, work in progress, and the finished product. Inventory is a major source of cost in SC and has a pronounced impact on responsiveness. Inventory plays a significant role in finalizing the competitive strategy of the firm (Kannan et al. [158], Shen-Lian et al. [159], and Miner [160]) who analyzed an inventory system with closed-loop SC including product return after recycling. Whereas, Qing long et al. [161] focused on open-loop reverse SC. The researchers, He et al. [162], Olsson and Tydesjo [163], Li and Mao [164], Vila-Parrish et al. [165], Li et al. [166], and Lawrence et al. [167], have modeled the inventory system for perishable products inventory management for a different scenarios. The researchers Sodhi and Tang [168], and Jung et al. [169] have developed a linear programming (LP) model for deterministic SC for different issues like SC planning under uncertain demand and management of integrated safety stock for multi-stage supply chains under production capacity constraints. On the other hand, the implications of coordinating price markdown policies with SC policies of inventory replenishment, including transportation expediting on retail performance of a perishable product has also been studied by Rajurkar and Jain [170], Nair and Closs [171], and Rau et al. [172]. Table 4 summarizes the prior works on inventory modeling with different objectives, methodologies, and modeling type.

Table: 4 Research Work in the Area of Inventory Management

Factor	Authors	Research objective	Methodology used	Modeling type
Bullwhip Effect (safety inventory)	Peidro et al. [173]	Uncertainty reduction	Fuggy Set	MM
	Mehdi M et al. [174]	Uncertainty reduction	Fuggy Set	SM
	Wu et al. [175]	Uncertainty reduction	Nash Equilibrium	MM
	Zarandi et al. [176]	Uncertainty reduction	GA NN Fuggy Set	SM HY
	Xiao et al. [177]	Coordination	Game Theory	MM
	Yanfeng et al. [178]	Demand management	Mathematical	MM
	Copini et al. [179]	Impact of human	Bear Game	MM
	Nienhaus et al. [180]	Behaviour on B E	Bear Game	SM
	Wafa Othman et al. [181]	planning	D P	MM
	Fernando et al. [182]	Effect of disturbances	Simulation	SM
	Saad et al. [183]	Uncertainty reduction	Linear programing	SM PS
	Sheu [184]	Safety stock	Mathematical	MM
	Jung et al. [185]	Customer satisfaction	Linear programing	SM
	Dong et al. [186]	Planning process	Linear programing	MM
	Lin et al. [187]	Demand realizations	Z Transform	MM
	Gupta et al. [188]	Quantify B E	Linear programing	MM
	Potter et al. [189]	Bullwhip reduction	Simulation	SM
	Wang et al.[190]	Impact of lead time	Mathematical	MM
	Spiter et al. [191]	Impact of lead time	Mathematical	MM
	Chopra et al. [192]	Lead time, safety stock	Mathematical	MM
	Rong et al. [193]	Ordering Behaviour	Beer game	SM
Vendor managed inventory (VMI)	Yu et al. [194]	Opt marketing strategy	Nash Game	MM
	Darwish et al. [195]	Opt marketing strategy	Mathematical	MM
	Yu et al. [196]	Opt marketing strategy	Game Theory	MM
	Nachiappan et al. [197]	Opt marketing strategy	GA NILP	MM
	Piplani et al. [198]	Opt marketing strategy	Mathematical	CS
	Paksoy et al.[199]	Multi goals	MILP	MM
	Yang [200]	Impact of inflation	Mathematical	MM
	Gumus et al. [201]	Impact of inflation	MILP ANN	MHY
	Wang [202]	Impact of inflation	Fuggy Set	MM
	Giannoccaro et al. [203]	Impact of inflation	Fuggy Set	SM
	Jiang et al. [204]	Dynamic inv control	Simulation	SM
	Disney et al. [205]	Effect of (VMI) on BE	Z Transform	MM
Cycle inventory	Odonnell et al. [206]	Impact of promotions	GA	MM
	Tsai [207]	Impact of promotions	MILP	MM
	Halati et al. [208]	Incentives	Mathematical	MM
	Chen et al. [209]	Coordination contracts	Mathematical	MM
	Chung et al. [210]	Multi variable problems	Mathematical	MM
	Kaihara [211]	Agent negotiations	D P	MM
	Dhumal et al. [212]	Coca Cola inv. mgt	Game theory	MM
	Kaminski et al. [213]	MTO & MTS strategy	Mathematical	MM
	Stephen et al. [214]	Stock allotment	D P	MM

GA-Genetic algorithms, NN-Neural Network, NILP- Non-integer Linear Programming, MILP-Mixed integer Linear Programming, PS-Perishable

In addition to what is shown in Table 4, the other studies that focused on inventory management with respect to order distribution for customer demand, inventory positioning, and order sequencing include Wong et al. [215] who modelled for the impact of information sharing in VMI partnership that allows the supplier to obtain actual sales data in a timely manner and determine the rebate for retailers. The researchers, Li and Sridharan [216], and Kaminsky and Kaya [217] have developed linear programming model for inventory control and scheduling in uncertain environment and Pitty et al. [218] have simulate the inventory control in refinery. The researchers, Haring et al. [219] and Tempelmeier [220] have proposed MILP and mathematical model for inventory replenishment with certain demand to reduced overall cost. Bai et al. [221] have developed heuristic and metaheuristic for inventory control and shelf space allocation for perishable products. Chiang and Monahan et al. [222] developed the Markove chain based model for inventory management. The following researchers have also worked in this regard and provided the valuable contributions are, Grahovac and Chakravarty [223], Fandela and Stamme [224], Cheung and Yuan [225], Viswanathan and Piplani [226], and Chen and Huang [227]. Their concern inventory distribution in a supply chain with expensive low-demand items, strategic SCM with focus on product life cycles and recycling, order commitment and fulfilment, Coordinating supply chain inventories and fuzzy analysis of order fulfilment in supply chains.

The overall distribution of SC driver literature is presented in Figure 5. It is observed that researchers have shown the most interest in inventory management. This observation reveals that inventory is the most important SC driver, with 70.45% of the total distribution. Next comes IT with 14.77% distribution. IT is considered the heart of SCM and today's requirement for industrial information systems. Facilities are in third position (11.36%) followed by transportation (3.4%). This distribution suggests that in the future researchers should develop models for efficient and economic logistical routes and facilities.

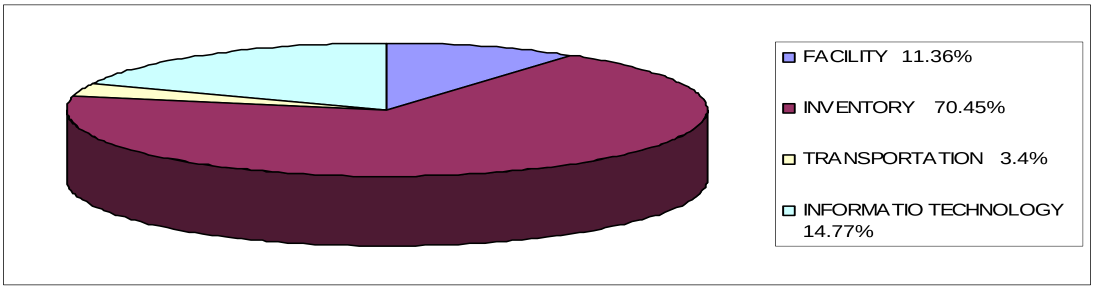

Figure 5: Overall Distribution of Literature on SC Drivers

However, readers should understand that a very strict demarcation in the distribution is not possible. There may be certain overlaps in the publications analyzed. For example, it is observed that literature on transportation is overlapped with inventory management, warehousing, and replenishment policies.

3.4.3 Transportation

Different transportation modes have a significant impact on the responsiveness and efficiency of the SC. Faster transportation can be costlier, but it improves responsiveness. Dell Computer Corporation, for example, uses air freight to reduce inventory and to provide fast delivery. Important contribution to this section of SC has been provided by Jayaram and Tan [228], who proved that information integration, third party logistics provider (3PL), selection criteria, performance evaluation, and relationship building are positively correlated with a firm's performance. Hsiao [229] and Hsiao et al. [230] have developed a model for optimal multi-stage logistics and inventory policies with production bottlenecks in a serial SC. A pull and reverse-pull algorithm was designed to solve the multi-stage logistics and inventory problem with a production bottleneck in a serial SC.

3.4.4 Information sharing

Information does not have a physical presence. However, information thoroughly affects every aspect of SC. It serves as the connection between different stages of the SC, thereby improving coordination among stages, reducing the bullwhip effect, and maximizing overall SC profitability. Information also plays a vital role in performing routine operations of each stage, thereby avoiding false steps. A number of researchers have analyzed the value of demand information sharing and developed the model to quantify the benefits of IT in the SC context, these are Fu and Zhou [231], Wu and Cheng [232], and Raghunathan [233] who have analysed the value of demand information sharing and developed the model to quantify the benefits of IT in the SC context. However, Thonemann [234] have analyzed the impact of sharing advance demand information (ADI) on improvement of supply-chain performance. The researchers Kurata and Yue [235], and Zhang and Zhang [236] have also modeled trade promotion and the trade-off mode of business strategy using demand-information sharing. Zhang et al. [237] have evaluated the benefits of a strategy of sharing shipment information, where one stage in a supply chain shares shipment quantity information with its immediate downstream customers. Whereas, Funda and Robinson Jr. [238] and Chen et al. [239] have investigates the impact of information sharing and physical flow coordination in a make-to-order supply chain comparing the relative impact of both the criterion. And Chu and Lee [240] has modelled the situation and find that, in equilibrium, whether the retailer reveals or withholds the information depends on two things, the cost of revealing the information and the nature of market demand signal that the retailer receives. The researchers David and John [241], Muthusamy et al. [242], Yao and Dresner [243] and Chen and Lee [244] have carried out important research on applicability of information sharing in decision making, resolving conflicts, inventory management and managing the variability in ordered quantity in multiproduct SC and with product substitution.

Currently, world-class industries are inclined toward the adoption of radio frequency identification (RFID) in their information systems, due to its added advantages. Many researchers are working in this area of interest. However, it is found that most RFID work is in the preliminary stage. Even today in the Indian scenario, the authors have very limited exposure to this area. The adoption of RFID technology is gaining momentum rapidly as technological, societal, and competitive pressures push firms to transform and innovate themselves. In this regards Lee and Lee [245] have presented the SC RFID investment evaluation model. This work provided a basis for enhancing our understanding of RFID value creation, measurement, and ways to maximize the value of this technology. Whereas, Yang et al. [246] studied the robustness of different supply chain strategies under various uncertain environments using signal to noise (S/N) ratios. The simulation results show that e-shopping has the most robust performance in uncertain environments. Another valuable research in this area is carried out by Nikitin and Rao [247], Chande et al. [248], Kazim Sari [249], and Zhou [250]. There concern is to study, backscattering from RFID tags, and impact of RFID on supply chain of perishable products, impact of RFID on SC performance and applicability of RFID in item level information visibility.

3.5 Coordination

Coordination enhances relations between various SC actors. It helps to have access to timely information regarding demand at all stages of SC. Information availability reduces forecasting errors and hence the bullwhip effect. This section is sub-categorized as: partnership, and external (inter-organizational) coordination. The year-wise research work in this area is presented graphically in Figure 6.

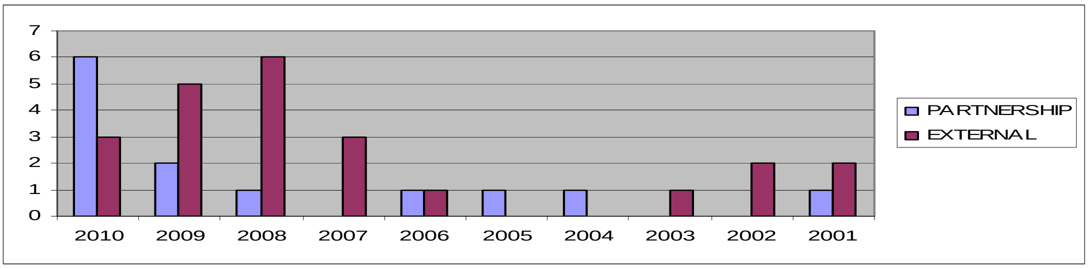

Figure 6: Year-Wise Data of the Literature on Coordination

3.5.1 Partnership

It is understood that a strategic partnership is one of the best ways to reduce the bullwhip effect in the SC. Strategic partnerships enhance coordination at different stages of SC. Chong Wu and Barnes [251] have developed a decision method to use in selecting partners. The authors Wen et al. [252], and Ryu and Yucesan [253] have solved the multi-stage logistic and inventory problem with a production bottleneck in a serial SC. However, Li et al. [254] described a multi-agent simulation model for analyzing the dominant player's behavior of SCs. However, Lodree Jr. et al. [255] have investigated coordination between production and shipment schedules to fulfill the retailer's order as quickly and cost effectively as possible. Other researchers, like Amaro and Barbosa et al. [256], Blackhurst et al. [257], Li and Liu [258], Xu and Zhai [259], Chang et al. [260], Cheung and Lee [261], Balakrishnan et al. [262], NgLeon et al. [263] and Wang and Yigal [264] have worked in this area to account for demand and pricing uncertainty on product portfolios. Their research is focused on selecting SC partners at different phases of the product life cycle; coordinating between warehouses and retailers; discovering SC conflict affecting system performance; coordinating SCs by controlling upstream variability propagation; coordinating stock rebalancing in an SC; and other issues. So also Oh et al. [265], Developed a collaborative fractal-based supply chain management model based on a trust for the automotive industry

3.5.2 External

Coordination among the different stages of SC and among different industries forming SC is very essential to improve SC performance. Every stage shares current information with others and thereby improves SCM decisions. The researchers like Xu and Zhai [266], Zhang and Huang [267], Arshinder et al.[268], Esmaeili et al. [269], Hammami et al.[270], and Chen and Xiao [271] have emphasized in their research the importance of coordination between different stages of SC that leads to reduction of overall cost. Silv et al. [272], introduced a new SCM technique. This new technique was based on modeling a generic SC with suppliers, logistics and distributors using ant colony optimization. Likewise, Choi et al. [273] investigated the issues of channel coordination like risk sharing and pricing policies in a SC. DeBoeck and Vandaele [274] proposed a model for coordination and synchronization of material flows in SCs. A coordination problem in a single-manufacturer with multiple heterogeneous buyers' situation was investigated by Sarmah et al.[275]. Nagarajan and Sosic [276] described the construction of the set of feasible outcomes commonly seen in SC models for SC partners. Lee and Rhee [277] examined return policies in a Newsboy framework. More importantly, Xiao et al. [278] investigated the coordination mechanism for an SC with a single manufacturer and two competing retailers when demands are disrupted. Other researchers who worked in response to the coordination among different stages and actors of the SC are Burer et al. [279], Tullari et al. [280], and Ounnar et al. [281] with the objective of modelling buyer-supplier negotiations and customer supplier relations. Both these models deserve their own importance for the SCM, dealing with such important issues.

The value of intercompany coordination was understood by Roder et al [282], who developed a simulation-based decision support system using a modular modelling concept in order to evaluate the benefits of an inter-company coordination. Gupta and Weerawat [283] compared three different mechanisms that a manufacturer, whose revenues depend on order delays, may use to affect its component suppliers inventory decisions. Author namely Banerjee et al. [284] examined the effects, in terms of some selected criteria, of two lateral transhipment approaches in a two-echelon supply chain network, with a single supply source at the higher echelon and multiple retail locations at the lower. Coordinating producer and supplier is one of the main issues of supply chain management, Zimmer [285]. The authors investigated this issue by means of a single-period order and delivery planning model within a Just-in-Time setting. Whereas, Tamer Boyaci and Gallego [286] analyzed coordination issues in a supply chain consisting of one wholesaler and one or more retailers under deterministic price-sensitive customer demand. Carlos and Mark [287] presented a model for the optimization of a global supply that maximizes the after tax profits of a multinational corporation and that includes transfer prices and the allocation of transportation costs as explicit decision variables. Bogata and Bogata [288], influenced by the earlier research of Girlich (1999) presented the quantitative method of building up the model of spatial hierarchy as the result of spatial games.

3.6 Performance Measurement

Performance measures and matrix management are essential for effectively managing SC operations, particularly in a competitive global economy. Performance measurements provide information necessary for decision-making and for taking corrective actions. It is said that "no measurement, no improvement" Gunasekharan et al. [289]. Chiang et al. [290] modeled the stochastic nature of SC focusing on efficiency and robustness. Lau et al. [291] demonstrated the effects of information sharing and early order commitment on the performance of four inventory policies used by retailers. Angerhofer and Angelides [292] modeled the constituents, key parameters and performance indicators to improve the performance of a collaborative SC. Simulation models have been developed to evaluate alternative SC designs with respect to quality, lead-times, costs, and customer service level by Persson and Olhager [293], and Yoo et al. [294].

The concerns of various other researchers for performance measures of the SC are presented. Jain et al. [295] worked on flexibility, profitability, quality, innovativeness, pro-activity, speed of response, cost and robustness. Kainuma and Tawar [296], worked on multiple attribute assessment of an SC. Chan and Chan [297] studied flexibility and adaptability in delivery quantity. Rong et al. [298] focused on food quality. Gong [299] and Das and Abdel-Malek [300] studied total system flexibility as measured by an economic index. Campuzano et al.[301] evaluated the behavior of fuzzy estimations. Franca et al. [202] studied the impact of quality defects. Tsai [303] researched performance of R&D and quality design for cost reduction. Lin et al. [304] studied quality management. Reiner [305] reported on food quality. Fleisch and Tellkamp [306] researched inventory inaccuracy and performance in a retail SC. Wang et al. [307] studied multi-warehouse and multi-retailer scenarios. Erol and Ferrell Jr. [308] researched qualitative and quantitative factors. The authors Petrovic, [309] and Georgiadis and Vlachos [310] have reported on SC behavior and performance in the presence of uncertainty and fuzzy demand for strategic SCM. Capkun, et al. [311] have studied the relationship between inventory and financial performance in manufacturing companies. Whereas, Zhu, et al. [312] have highlighted the impact of information on SC flexibility and its performance.

The broad spectrum of SC literature is illustrated by Figure 7. This diagram shows that SC driver research accounted for 34.11% of the total literature reviewed. SC drivers are further divided into facilities, inventory, transportation, and IT.

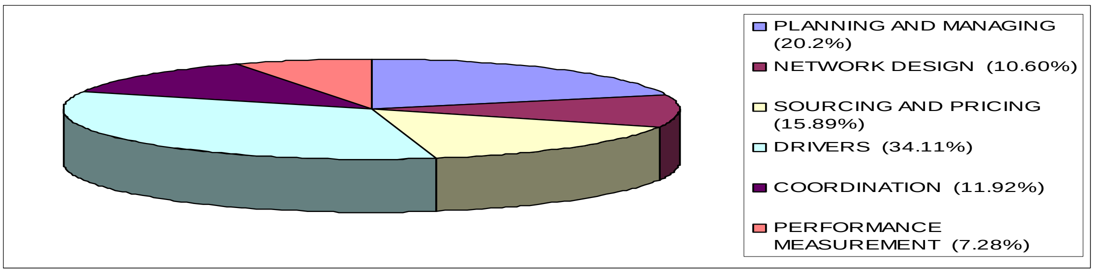

Figure 7: The Overall Distribution of Literature According to the Spectrum of SCM

The next largest category of research accounts for 20.2% of the literature. The primary components of this category include SC planning and management. Specific areas are discussed in their respective sections. Sourcing and pricing account for 15.89% of the overall literature. Network design accounts for 10.60%. Coordination, which is the essential component of all SCs, accounts for 11.92%. Performance measurement is last with 7.28%.

3.7 Modeling Tool / Analytical Method Used

A year-wise research work that uses various analytical methods and modeling tools is presented in Table 5. It is seen that most of the researchers are inclined toward optimization modeling using linear programming (LP) or mixed-integer programming (MIP). It is also observed that the trend of optimization modeling increased from 2001 to 2010, with 59 papers in this category.

Table 5: Literature Classification According to Analytical Methods and Modeling Tool.

S. N.	Modeling Tool	10	09	08	07	06	05	04	03	02	01	Total
1	Dy. programming	3	4	2	2	1	3	-	2	1	3	21
2	Genetic algorithm	2	2	1	1	2	-	-	-	1	-	9
3	Linear programming	8	12	15	7	4	1	6	3	2	1	59
4	Game theory,	10	13	6	2	4	-	-	2	1	2	40
5	Simulation	5	5	11	2	4	6	-	1	3	5	42
6	Fuzzy logic	4	5	4	4	5	1	-	2	-	-	25
7	Neural network	-	3	-	-	-	-	-	-	-	-	3
8	Taguchi/ DoE	1	1	-	-	-	-	-	-	-	-	2
9	Petri net	1	-	3	1	-	-	-	-	-	1	6
10	Ant colony	-	2	-	-	-	-	-	-	-	-	2
11	Mathematical	13	10	19	9	8	5	2	5	3	2	75
12	Markov chain	-	1	1	1	1	1	-	2	1	-	8
13	Sensitivity analysis	3	-	3	1	1	-	-	1	1	-	10

Simulation modeling depicts future process performance, which provides a strong base for design and development of the system. Researchers have given due importance to simulation methodology in the recent years with 42 papers. Simulation plays an important role in multi-decisional context of SC, Sergio and Sergio [228]. Game theory, the classical evolutionary technique, has 40 papers. However, the genetic algorithm, neural network, Taguchi, ant colony, and Petri Net show minimal use. The numbers of papers in these categories are 9, 3, 2, 2, and 6 respectively. Fuzzy logic provides a strong base to model in uncertain environments, with 25 research papers. Dynamic programming, Sensitivity analysis, and Markov chain have 21, 10, and 8 papers, respectively. However, researchers who rely on mathematical modeling using differential equations, integration, matrices, linear equations, and calculus account for 69 papers.

3.8 Product Life Consideration

Product life literature is classified according to products that are perishable or non-perishable. Readers should understand that out of 302 papers we identified 35 papers on perishable products. In the perishable category, the authors developed a pricing framework, discounted pricing schemes, consideration of product shelf life, temperature impact analysis, carbon footprint, inventory management and replenishment, and managing fresh food quality, etc. Very few papers are cited in perishable SCM that explored the impact of new technologies like RFID. The perishable products involved are agricultural, meat, and milk. The reviewed year wise data on perishable products is presented graphically in Figure 8.

Figure 8 shows that research work has changed its trend beginning in the year 2004 to the present. From 2004, research activities increased consistently for both the categories. Year 2008-9 is observed to be a peak for both categories. A perishable product's shelf life puts intense pressure on SC planning and design. Many authors have recognized the need for model development. Recently considerable research is being carried out on perishable product supply chain. However, no literature was found that signified and quantified the benefits and losses of incorporating cold storage to improve the shelf life of products, and accordingly to design and develop the model. Hence, more attention must be paid toward the SCM of Perishable products. There is a need to manage quality, quantity, and price of perishable products. There is an immediate requirement to satisfy the demands of the world's drastically increasing population.

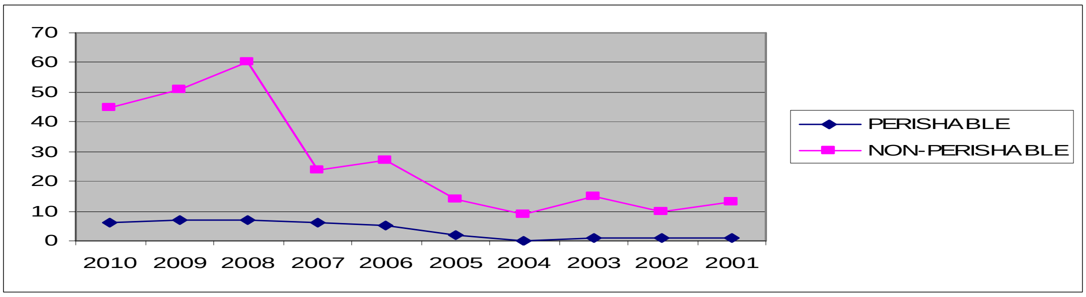

Figure 8: Graphical Presentation of Literature According to Perishable, Non-Perishables

3.9 Modeling Type

Three classes of modeling types are identified: deterministic, stochastic, and hybrid. Deterministic models assume all of the model's parameters are known and fixed. There is no scope for uncertainty involved. Deterministic models repetitively produce only a single value for a given set of conditions. Stochastic models, on the other hand, allow for uncertainty in the model's parameters. There parameters are susceptible to the changing environment. Stochastic models are optimal control theoretic and dynamic programming models. Hybrid models represent a category introduced to take in to account mixed characteristics. Hybrids include both deterministic and stochastic parts. Also, hybrid models depend on multi modeling tools and multi-objective models. It was observed that the authors are more inclined to build stochastic models where the demand remains uncertain. The number of stochastic models is seen to increase rigorously to the end of the decade. Significant research was carried out during the period of 2007 onward, the years 2008-09 at the peak. Deterministic modeling follows the stochastic modeling at nearly the same trend but the number of research papers lies far below the stochastic modeling. The numbers of research papers with hybrid (multi-tool, multi-objective) modeling are the least of all.

Table 6: Classification According to Modeling Type

TYPE/YR	10	9	8	7	6	5	4	3	2	1	TOTAL
STOCHASTIC	26	29	30	15	13	4	4	10	4	4	139
DETERMINISTIC	14	8	13	8	9	4	1	3	3	3	66
HYBRID	2	5	2	1	1	1	1	00	1	1	15

4. The Way Forward

This literature review shows there has been a proliferation of literature on the topic of SC management during the last 10 years. Considering the number of publications, it can be said that the SC management has seen a steady growth and appears to be heading toward a level of maturity. A scrutiny of the publications shows that several aspects of SC management, along with many interesting and diversified applications, have been covered in sufficient detail. These publications can serve a great purpose of improving design, development and implementation of an SC network. Thus, academicians, practitioners, researchers, and managers have a sufficient number of sources in the form of 302 articles, to focus on many aspects of SC management.

4.1 Need for Integrated and Coordinated SCM

While there is an abundance of SC management literature, it is realized that research at the inter-organizational level is less prevalent. However, the objective of SCM is to integrate all the firms in the value chain and treat them as a single entity (global supply chain). Notwithstanding, the current research has failed to look at that perspective of the SCM. There is a requirement to develop and implement the strategies such that all actors of the SC can act globally rather than thinking as a local SC. New incentive schemes, merit-based benefits and new performance measures can enhance the integration among different organizations. Selection of partner or superior performer, their duties and responsibilities, legal and business aspects are to be explored. Each partner should focus on global SC profitability rather than individual parameters. This perspective will result in better coordination among the various stages, will reduce uncertainty, and hence reduce the bullwhip effect.

4.2 Incorporation of Performance Measures

Performance measures and metrics are essential for effectively managing logistics operations, particularly in a competitive global economy, Gunasekharan and Bulent [289]. Performance measures provide the information necessary for decision-making and actions. However, it is observed that the recent literature encompasses only traditional performance measures such as cost, quality, efficiency, and responsiveness. Few researchers have proposed new performance measures and metrics that reflect the changes in markets and enterprise environments either industry or country wise. The analysis indicates that the majority of performance measures are function-based instead of value-based. Some of the missing and most critical performance measures for the successful development and operations of the SC should include information productivity, cost of data processing and information, risk of not using an IT and IS, and the implications of outsourcing.

In the future, attention should be given to both financial, non-financial and decision making level performance measures as well as tangibles that identify success, whether customer needs are met, to help the organization to understand its processes, and to confirm what they know or realize what they do not know. It is necessary to identify where problems, bottlenecks and waste exist. In addition, it is critical to identify where improvements are necessary to ensure that decisions are based on facts and not on supposition, emotion, faith or intuition. Finally, it is necessary to determine if planned improvements were actually implemented.

4.3 Implementation of Information Technology

It is observed recently that IT implementation is the major driving force that enables SCM to revolutionize the business processes and SC activities. IT-driven models integrate and coordinate various phases of SC planning on a real-time basis using application software. These models include transportation management systems (TMS), collaborative planning forecasting and replenishment (CPFR), enterprise resource planning (ERP), and material requirement planning (MRP). Global information systems (GIS) and radio frequency identification (RFID) are gaining popularity, due to their important role in facilitating information flow across the chain. Many authors are involved in research on implementing RFID. However, at present, their work is in the preliminary stage. More rigorous and consistent efforts are needed to explore the benefits of RFID through modeling and performing case studies to validate the models. RFID can prove the most powerful tool to enhance the efficiency and responsiveness of SC in the local as well as global perspective. Today the literature on the utility of RFID in SCM is scare. Constant and consistent efforts are required to quantify the benefits of RFID in SC Management to bust up the performance in the positive direction. Many world-renounced companies like Wal-Mart, FEDEX, have experienced the positive effect of RFID, and have informed all their suppliers to expedite the use of RFID.

4.4 Perishable Products SC

SC research on perishable products is comparatively scarce. Only 35 papers out of 302 were found on perishability. Shelf life exerts large pressure on SC designers to acquire optimization between cost and quality. Around 32% of the agricultural products get spoiled due to inadequate perishable supply chain management. Many of the studies suggested that the key to success in perishable SCM lies in the integration of activities involved, cooperation, as well as coordination and information-sharing throughout the entire SC (Rajurkar and Jain 2011 and Ming-Feng 2010). Increasing competitive pressures and market globalization are forcing firms to develop SCs that can quickly respond to customer needs. To remain competitive, these firms must reduce operating costs while continuously improving customer service. This can be possible by incorporating new techniques such as game theory, genetic algorithms, fuzzy logic, ant colony, dynamic programming, fuzzy linear programming, stochastic linear programming, simulation and other soft computing techniques to solve the problems in SC.

The development of a methodology or framework to formulate strategies for perishable SC and implementation of suitable planning and scheduling systems for effectively managing operations of SC is required to achieve the objectives. There is a need to design and implement a suitable information system network. For example, RFID is a must for improving the effectiveness of financial supply chain management (FSCM). The development of new pricing strategies must occur in order to reduce waste and maintain profitability of the SC. More consistent efforts are needed to design, develop, and implement appropriate models. These models should justify cost, quality and quantity to the mixed economic and explosively increasing population of the several countries.

4.5 Need to Design and Develop Humanitarian SC for Disaster Management

There were 6637 worldwide natural disasters between 1974 and 2003. These disasters affected more than 5.1 billion people. The results were more than 182 million homeless, more than 2 million deaths, and a reported damage of 1.38 trillion USD (Centre for Research on the Epidemiology of the Disasters). In 2005 alone, over 180,000 deaths and 200 billion USD in economic disaster losses occurred (Disaster Resource Network Humanitarian Relief Initiative). The September 11 attacks (2001), tsunami in South Asia (2004), Hurricane Katrina (2005), earthquakes in Pakistan (2005), Java (2006) and recently in Japan (2011), are just some examples of the deadliest disasters witnessed by humankind in the past few years.

The consequences of these disasters underscore the need for the design and implementation of a humanitarian SC. Unfortunately, not a single research paper (out of 302 considered) focused on this extremely essential world issue. Since disaster SC management is a newly emerging research area, there are many problems to be solved. There are new directions to be discovered for future research, beyond the limited literature so far. Most of the current research on disaster operations management focuses on the pre-event phase, which covers planning, mitigation, and preparedness processes. There is limited research in recovery planning phases. Furthermore, when a specific problem within a disaster context is modeled, that model usually focuses on one specific stage (pre-event, response, and post-event). However, there is an undeniable interaction between the decisions made at different stages, that is, what is done today affects what can be done tomorrow. Therefore, more comprehensive models that integrate multiple disaster stages are needed to develop and to check its viability.

5. Conclusions

A comprehensive review of the literature on supply chain modeling in the last decade (2001-2011) has been presented. Out of initial review of more than 700 papers, 302 papers were selected for further review and analysis. In order to facilitate the review process and identify the potential gaps for future research, a review framework has been suggested by classifying the SC literature into four main groups: supply chain management, product lifecycle, modeling tools used, and types of models used. Ten areas have been identified for future research. Furthermore, we strongly believe that future research work should focus on assessing the current level of the SC processes. It is important to identify critical SC business areas and establish performance measures for continuous assessment of profitability, efficiency, responsiveness, and improvement. One must incorporate new technologies, including GPS and RFID. Finally, further research is required on mutual process benefits that collaborative planning forecasting and replenishment (CPFR) can bring to SCM.

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