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Dissemination of Innovation and Knowledge Management through the Supply Chain Management

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Abstract: Supply Chain Management is a major concern in many industries as Companies realize the importance of creating an integrated relationship with their suppliers and customers. The supply chain management is fundamental for the good functioning of a company. Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that product is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements.

Keywords: Supply Chain Management; Deterministic Analytical; Stochastic Analytical; Economic; Simulation

I. INTRODUCTION

A supply chain may be defined as an integrated process wherein a number of various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in an effort to: (1) acquire raw materials, (2) convert these raw materials into specified final products, and (3) deliver these final products to retailers. This chain is traditionally characterized by a forward flow of materials and a backward flow of information. For years, researchers and practitioners have primarily investigated the various processes of the supply chain individually. Recently there has been increasing attention placed on the performance, design, and analysis of the supply chain as a whole. From a practical standpoint, the supply chain concept arose from a number of changes in the manufacturing environment, including the rising costs of manufacturing, the shrinking resources of manufacturing bases, shortened product life cycles, the leveling of the playing field within manufacturing, and the globalization of market economies. The current interest has sought to extend the traditional supply chain to include .reverse logistics, to include product recovery for the purposes of recycling, re-manufacturing, and re-use. Within manufacturing research, the supply chain concept grew largely out of two-stage multi-echelon inventory models, and it is important to note that considerable progress has been made in the design and analysis of two-echelon systems. The supply chain management for multi-product integrated production distribution consists of four stages.

II. DETERMINISTIC ANALYTICAL MODELS

Williams (1983) develops a dynamic programming algorithm for simultaneously determining the production and distribution batch sizes at each node within a supply chain network. Ishii, et. al (1988) develop a deterministic model for determining the base stock levels and lead times associated with the lowest cost solution for an integrated supply chain on a finite horizon. Cohen and Lee (1989) present a deterministic, mixed integer, non-linear mathematical programming model, based on economic order quantity (EOQ) techniques. A recent study done by the Global Logistics Research Team at Michigan State University (1995), on the logistics aspects of several world class companies, shows that the management of these enterprises recognize the fact that the ability to visualize and develop cooperative relationships with other firms throughout the supply chain is critical to world class logistics performance. The study also shows that leading organizations are developing increased unification among supply chain partners. This increased unification has several implications. Information is more freely shared between partners in the supply chain and between functions within the same company. This facilitates the development of models for a global analysis of operational performance. Managers in the physical distribution system can take advantage of this new information-exchange capability to obtain (i) a broader vision of the logistics system and of its relation to other production functions, and (ii) an enhanced understanding of the impact that decisions taken in the logistics system have on the performance of other functions within the system, such as inventory control, production planning, etc. This enlarged vision of the distribution system can also assist managers in the development of performance improvement programs that could render significant benefits to the organization. However, in spite of the awareness and willingness for cooperative efforts, there seems to be a lack of tools and methods that can help managers in the analysis of the integrated systems (of which their companies are part of) in this emerging collaborative environment. The models reviewed in this paper represent a significant advance in the integrated analysis of production-distribution systems. However, research in this area is still relatively fragmented, showing many gaps that further research must fill. The full potential of the integrated analysis has not been completely explored yet.

Very few researchers have analytically approached the problem presented by the integration of more than two functions. The benefits and difficulties that these kinds of problems present remain as open questions. A methodology to balance the complexity of this kind of problems with the applicability of the results obtained from them could be vital in the development of solution methodologies that remain tractable and at the same time suitable for practical application. Analytical formulation of problems that consider more than two functions and exact or approximate solution procedures are still needed.Researchers should exercise increased creativity in the analysis of the integrated models and in the development of heuristic procedures capable of handling the bigger challenge of integrated analyses. As pointed out the solution obtained from the optimization of the integrated problem is not always more attractive than the sequential optimization of the problem of each function. Depending on system parameters and characteristics, the benefits obtained from an integrated analysis might not offset the increased complexity of the problem and the greater solution effort. More research is needed to identify overall frameworks for which integrated analyses are beneficial and compensate the increased complexity of the problem. To undertake the optimization of integrated problems, researchers can make use of the increasing capabilities of computer technology. The investigation of ways to reduce the computational complexity of the problems, especially of large problems, could be of significant impact in the solution procedures. Simulation models that permit user interaction could also be of interest.

The integration of production and distribution brings forth issues pertaining to the scope that each part (production and distribution) will have. For example, should the transportation time of goods be a parameter in the production model prescribed by the transportation model or should it be a variable? Another important issue to consider is the time grid for both functions. It is most likely that there will be a mismatch in terms of time unit between the production and distribution models. This issue must be resolved in order for the decision variables of the two models to interact.The centralized optimization of integrated systems is based on the premise that information is more openly shared between functions on a timely fashion. Research to characterize information systems capable of supporting this interaction is needed. Technological advances, like Electronic Data Interchange (EDI) and Satellite-Location devices could play an important role on the configuration of the information system. Relevant issues about the use of these technologies in relation to integrated analyses have to be identified and studied. The integrated analysis of production-distribution systems has proven to be of significant benefit to companies that have applied it under adequate conditions. Substantial savings and efficiency improvement have been some of the results that the analysis of logistics integrated to other production functions have granted to some companies. Given the number of assumptions and constraints that the analysis of integrated functions can account for, a wide variety of problems and models can arise. The identification of the relevant instances of the integrated problem and their solutions is a task that still needs to be undertaken. The solutions to these problems and their possible implementation into decision support systems can provide companies with valuable tools to gain competitive advantage as they move into higher collaborative and competitive environments.

III. STOCHASTIC ANALYTICAL MODELS

Cohen and Lee (1988) develop a model for establishing a material requirements policy for all materials for every stage in the supply chain production system. Svoronos and Zipkin (1991) consider multi-echelon, distribution-type supply chain systems (i.e., each facility has at most one direct predecessor, but any number of direct successors). In this research, the authors assume a base stock, one-for-one *(S-1, S)* replenishment policy for each facility, and that demands

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for each facility follow an independent Poisson process. The steady-state approximations for the average inventory level and average number of outstanding backorders at each location for any choice of base stock level. Finally, using these approximations, propose of the construction of an optimization model that determines the minimum-cost base stock level.Lee and Billington (1993) develop a heuristic stochastic model for managing material flows on a site-by-site basis. Specifically, this model a pull-type, periodic, order up-to inventory system, and determine the review period and the order up- to quantity as model outputs. Under this model which will either: (1) determine the material ordering policy by calculating the required stock levels to achieve a given target service level for each product at each facility or (2) determine the service level for each product at each facility, given a material ordering policy.

Lee, et. al. (1993), develop a stochastic, periodic-review, order-up-to inventory model to develop a procedure for process localization in the supply chain. This proposes an approach to operational and delivery processes that consider differences in target market structures (e.g., differences in language, environment, or governments). Thus, the objective of this research is to design the product and production processes that are suitable for different market segments that result in the lowest cost and highest customer service levels overall.

Pyke and Cohen (1993) develop a mathematical programming model for an integrated supply chain, using stochastic sub-models to calculate the values of the included random variables included in the mathematical program. It considers a three-level supply chain, consisting of one product, one manufacturing facility, one warehousing facility, and one retailer. The model minimizes total cost, subject to a service level constraint, and holds the set-up times, processing times, and replenishment lead times constant. The model yields the approximate economic (minimum cost) reorder interval, replenishment batch sizes, and the order-up-to product levels (for the retailer) for a particular production network.Pyke and Cohen (1993), research by including a more complicated production network. They consider an integrated supply chain with one manufacturing facility, one warehouse, and one retailer, but now consider multiple product types. The new model yields similar outputs; however, it determines the key decision variables for each product type. More specifically, this model yields the approximate economic (minimum cost) reorder interval (for each product type), replenishment batch sizes (for each product type), and the order up- to product levels (for the retailer, for each product type) for a particular supply chain network.

Tzafestas and Kapsiotis (1994) utilize a deterministic mathematical programming approach to optimize a supply chain, and then use simulation techniques to analyze a numerical example of their optimization model. Towill and Del Vecchio (1994) consider the application of filter theory and simulation to the study of supply chains. In their research, the authors compare filter characteristics of supply chains to analyse various supply chain responses to randomness in the demand pattern. These responses are then compared using simulation, in order to specify the minimum safety stock requirements that achieve a particular desired service level.Lee and Feitzinger (1995) develop an analytical model to analyse product configuration for postponement (i.e., determining the optimal production step for product differentiation), assuming stochastic product demands. That assume a manufacturing process with I production steps that may be performed at a factory or at one of the M distribution centers (DCs). The problem is to determine a step P such that steps 1 through P will be performed at the factory and steps $(P+1)$ to I will be performed at the DCs. They solve this problem by calculating an expected cost for the various product configurations, as a sum of inventory, freight, customs, setup, and processing costs. The optimal value of P is the one that minimizes the sum of these costs.

The system experiences demands for finished products according to a compound Poisson process, and the inventory levels for inventories (intermediate buffers and finished goods) are controlled according to a continuous review inventory policy, and backorders are allowed. That develop an iterative procedure wherein each of the two-node sub-systems are analysed individually; the procedure terminates once the estimate average throughput for each sub-system are all approximately equal. Once the termination condition is met, the procedure allows for calculation of approximate values for the two performance measures: (1) The inventory levels in each buffer j, and (2) the backorder probability. They concluded that their approximation is acceptable as long as the P(backorder) does not exceed 0.30, in which cases the system is failing to effectively accommodate demand volumes.

IV.ECONOMIC MODELS

Christy and Grout (1994) develop an economic, game-theoretic framework for modelling the buyer-supplier relationship in a supply chain. The basis of this work is a 2 x 2 supply chain relationship matrix, which may be used to identify conditions under which each type of relationship is desired. These conditions range from high to low *process* specificity, and from high to low *product* specificity. Thus, the relative risks assumed by the buyer and the supplier are captured within the matrix. For example, if the *process* specificity is low, then the buyer assumes the risk; if the *product* specificity is low, then the supplier assumes the risk. For each of the four quadrants (and therefore, each of the four risk categories), the authors go on to assign appropriate techniques for modelling the buyer-supplier relationship. For the two-echelon case, the interested reader is referred to Cachon and Zipkin (1997).

Finally, Lee, et. al. (1997) develop stochastic mathematical models describing .The Bullwhip Effect., which is defined as the phenomenon in which the variance of buyer demand becomes increasingly amplified and distorted at each echelon upwards throughout the supply chain. That is, the actual variance and magnitude of the orders at each echelon is increasingly higher than the variance and magnitude of the sales, and that this phenomenon propagates upstream within the chain. In this research, the authors develop stochastic analytical models describing the four causes of the bullwhip effect (demand signal processing, rationing game, order batching, and price variations), and show how these causes contribute to the effect.

V.SIMULATION MODELS

Towill (1991) and Towill, et. al. (1992) use simulation techniques to evaluate the effects of various supply chain strategies on demand amplification. The objective of the simulation model is to determine which strategies are the most effective in smoothing the variations in the demand pattern. The just-in-time strategy and the echelon removal strategy were observed to be the most effective in smoothing demand variations. Wikner, et. al. (1991) examines five supply chain improvement strategies, and thenimplements these strategies on a three-stage reference supply chain model. Their reference model includes a single factory (with an on-site warehouse), distribution facilities, and retailers. Thus, it is assumed that every facility within the chain houses some inventory. The implementation of each of the five different strategies is carried out using simulation, the results of which are then used to determine the effects of the various strategies on minimizing demand fluctuations. The authors conclude that the most effective improvement strategy is strategy (5), improving the flow of information at all levels throughout the chain, and separating orders. Although uncertainty and risk cannot be eliminated, we will explore a variety of examples that illustrate how product design, network modelling, information technology, procurement, and inventory strategies are used to minimize uncertainty, and to build flexibility and redundancy in the supply chain in order to reduce risks.

VI. THE EVOLUTION OF SUPPLY CHAIN MANAGEMENT

In the 1980s, companies discovered new manufacturing technologies and strategies that allowed them to reduce costs and better compete in different markets. Strategies such as just-in-time manufacturing, *kanban*, lean manufacturing, total quality management, and others became very popular, and vast amounts of resources were invested in implementing these strategies. In the last few years, however, it has become clear that many companies have reduced manufacturing costs as much as is practically possible. Many of these companies are discovering that effective supply chain management is the next step they need to take in order to increase profit and market share. Indeed, logistics and supply chain costs play an important role in the U.S. economy: the annual “State of Logistics Report,” which is sponsored by the Council of Supply Chain Management Professionals, first published in 1989, provides an accounting of the nation’s total logistics bill and tracks trends in transportation costs, inventory-carrying costs, and total logistics cost ofproduction.As you can see from Figure-1, U.S. logistics costs were over 12 percent of GDP in the early 80s, steadily decreasing until 2003.These issues span a large spectrum of a firm’s activities, from the strategic through the tactical to the operational level:As the example suggests, an important building block in effective supply chainstrategies

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is *strategic partnerships* between suppliers and buyers,partnerships that can help bothmanufacturerssuch asProcter & Gamble and Kimberly-Clark and giant retailers like Wal-Mart have used strategic partnering as an important element in their business strategies. Firms such as 3M, Eastman Kodak, Dow Chemical, Time Warner, and General Motors turned over large portions of their logistics operations to third party logistics providers.At the same time, many supply chain partners engage in *information sharing* so that manufacturers are able to use retailers' up-to-date sales data to better predict demand and reduce lead times.

Figure-1.

The Cost of the Business Logistics System in Relation to Gross Domestic Product

$ Billion Except GDP

YEAR	NOMINAL GDP $ TRILLION	VALUES OF ALL BUSINESS INVENTORY	INVENTORY CARRYING RATE	INVENTORY CARRYING COSTS	TRANSPOR-TATION COSTS	ADMINI-STRATIVE COSTS	TOTAL U.S. LOGISTICS COST	LOGISTICS % OF GDP	INVENTORY AS A % OF GDP	TRANSPOR-TATION AS A % OF GDP	INV. AS A % OF GDP 1980 BASE	TRAN AS A % OF GDP 1980 BASE	TOT. AS A % OF GDP 1980 BASE	GDP AS A % OF GDP 1980 BASE	TRAN AS A % OF TRAN 1980 BASE
1981	3.13	747	34.7%	259	228	19	506	16.2	8.3	7.3	100	100	100	100	100
1982	3.26	760	30.8%	234	222	18	474	14.5	7.2	6.8	87	93	90	104	97
1983	3.54	758	27.9%	211	243	18	472	13.3	6.0	6.9	72	94	82	113	107
1984	3.93	826	29.1%	240	268	20	528	13.4	6.1	6.8	74	94	83	126	118
1985	4.21	847	26.8%	227	274	20	521	12.4	5.4	6.5	65	89	77	135	120
1986	4.45	843	25.7%	217	281	20	518	11.6	4.9	6.3	59	87	72	142	123
1987	4.74	875	25.7%	225	294	21	540	11.4	4.7	6.2	57	85	70	151	129
1988	5.11	944	26.6%	251	313	23	587	11.5	4.9	6.1	59	84	71	163	137
1989	5.44	1005	28.1%	282	329	24	635	11.7	5.2	6.0	63	83	72	174	144
1990	5.80	1041	27.2%	283	351	25	659	11.4	4.9	6.1	59	83	70	185	154
1991	5.99	1030	24.9%	256	355	24	635	10.6	4.3	5.9	52	81	66	191	156
1992	6.32	1043	22.7%	237	375	24	636	10.1	3.8	5.9	45	81	62	202	164
1993	6.64	1076	22.2%	239	396	25	660	9.9	3.6	6.0	43	82	61	212	174
1994	7.05	1127	23.5%	265	420	27	712	10.1	3.8	6.0	45	82	62	225	184
1995	7.40	1211	24.9%	302	441	30	773	10.4	4.1	6.0	49	82	65	236	193
1996	7.81	1240	24.4%	303	467	31	801	10.3	3.9	6.0	47	82	63	250	205
1997	8.32	1280	24.5%	314	503	33	850	10.2	3.8	6.0	46	83	63	266	221
1998	8.78	1317	24.4%	321	529	34	884	10.1	3.7	6.0	44	83	62	281	232
1999	9.27	1381	24.1%	333	554	35	922	10.0	3.6	6.0	43	82	62	296	243
2000	9.87	1478	25.3%	374	590	39	1003	10.2	3.8	6.0	46	82	63	315	259
2001 R	10.08	1486	22.8%	339	581	37	957	9.5	3.4	5.8	41	79	59	322	255
2002	10.47	1444	20.6%	298	577	35	910	8.7	2.8	5.5	34	76	54	335	253

Data Sources: National Income and Products Accounts - Levels; Survey of Current Business March 2003. U.S. Statistical Abstract U.S. Department of Commerce
Transportation in America. Rosalyn Wilson, 2003. ENO Transportation Foudation, Washington, DC

Methodology: Business Logistics: Heskett, Ivie, Glaskowsky. 2nd Edition, 1973. The Ronald Press, New York, NY

R The Bureau of Economic Analysis increased their estimate for Nominal GDP and the Value of All Business Inventory/
Final Numbers for Trucking revenues were substantially lower that the previous three quarters indicated.

This information sharing also allows manufacturers to control the variability in supply chains and by doing that reduce inventory and smooth out.

VII. KEY ISSUES IN SUPPLY CHAIN MANAGEMENT

The*strategic level* deals with decisions that have a long-lasting effect on the firm. This includes decisions regarding product design, what to make internally and what to outsource, supplier selection, and strategic partnering as well as decisions on the number, location, and capacity of warehouses and manufacturing plants and the flow of material through the logistics network. The*tactical level* includes decisions that are typically updated anywhere between once

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every quarter and once every year. These include purchasing and production decisions, inventory policies, and transportation strategies, including the frequency with which customers are visited. The*operational level* refers to day-to-day decisions such as scheduling, lead time quotations, routing, and truck loading. Below we introduce and discuss some of the key issues, questions, and trade-offs associated with different decisions.

Distribution Network Configuration Consider several plants producing products to serve a set of geographically dispersed retailers. The current set of warehouses is deemed inappropriate, and management wants to reorganize or redesign the distribution network. This may be due, for example, to changing demand patterns or the termination of a leasing contract for a number of existing warehouses. In addition, changing demand patterns may require a change in plant production levels, a selection of new suppliers, and a new flow pattern of goods throughout the distribution network. How should management select a set of warehouse locations and capacities, determine production levels for each product at each plant, and set transportation flows between facilities, either from plant to warehouse or warehouse to retailer, in such a way as to minimize total production, inventory, and transportation costs and satisfy service level requirements? This is a complex optimization problem, and advanced technology and approaches are required to find a solution.

Inventory Control; conside**r** a retailer that maintains an inventory of a particular product. Since customer demand changes over time, the retailer can use only historical data to predict demand. The retailer's objective is to decide at what point to reorder a new batch of the product, and how much to order so as to minimize inventory ordering and holding costs. More fundamentally, why should the retailer hold inventory in the first place? Is it due to uncertainty in customer demand, uncertainty in the supply process, or some other reasons? If it is due to uncertainty in customer demand, is there anything that can be done to reduce it? What is the impact of the forecasting tool used to predict customer demand? Should the retailer order more than, less than, or exactly the demand forecast? And, finally, what inventory turnover ratio should be used? Does it change from industry to industry?

Production Sourcing In many industries, there is a need to carefully balance transportation and manufacturing costs. In particular, reducing production costs typically implies that each manufacturing facility is responsible for a small set of products so that large batches are produced, hence reducing production costs. Unfortunately, this may lead to higher transportation costs. Similarly, reducing transportation costs typically implies that each facility is flexible and has the ability to produce most or all products, but this leads to small batches and hence increases production costs. Finding the right balance between the two cost components is difficult but needs to be done monthly or quarterly.

Supply Contracts In traditional supply chain strategies, each party in the chain focuses on its own profit and hence makes decisions with little regard to their impact on other supply chain partners. Relationships between suppliers and buyers are established by means of supply contracts that specify pricing and volume discounts, delivery lead times, quality, returns, and so forth. The question, of course, is whether supply contracts also can be used to replace the traditional supply chain strategy with one that optimizes the entire supply chain performance. In particular, what is the impact of volume discount and revenue-sharing contracts on supply chain performance? Are there pricing strategies that can be applied by suppliers to provide incentives for buyers to order more products while at the same time increasing the supplier profit?

Distribution Strategies An important challenge faced by many organizations is how much should they centralize (or decentralize) their distribution system. What is the impact of each strategy on inventory levels and transportation costs? What about the impact on service levels? And, finally, when should products be transported from centralized locations to the various demand points? These questions are not only important for a single firm determining its distribution strategy, but also for competing retailers that need to decide how much they can collaborate with each other. For example, should competing dealers selling the same brand share inventory? If so, what is their competitive advantage?

Supply Chain Integration and Strategic Partnering As observed earlier, designing and implementing a globally optimal supply chain is quite difficult because of its dynamics and the conflicting objectives employed by different facilities and partners. Nevertheless, Dell, Wal-Mart, and Procter & Gamble success stories demonstrate not only that an integrated, globally optimal supply chain is possible, but that it can have a huge impact on the company's performance and market share. Of course, one can argue that these three examples are associated with companies that are among the biggest companies in their respective industries; these companies can implement technologies and strategies that very few others can afford. However, in today's competitive markets, most companies have no choice;

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they are forced to integrate their supply chain and engage in strategic partnering. This pressure stems from both their customers and their supply chain partners. How can integration be achieved successfully? Clearly, information sharing and operational planning are the keys to a successfully integrated supply chain. But what information should be shared? How should it be used? How does information affect the design and operation of the supply chain? What level of integration is needed within the organization and with external partners? Finally, what types of partnerships can be implemented, and which type should be implemented for a given situation?

Outsourcing and Off shoring Strategies Rethinking your supply chain strategy not only involves coordinating the different activities in the supply chain, but also deciding what to make internally and what to buy from outside sources. How can a firm identify what manufacturing activities lie in its set of core competencies, and thus should be completed internally, and what product and components should be purchased from outside suppliers, because these manufacturing activities are not core competencies? Is there any relationship between the answer to that question and product architecture? What are the risks associated with outsourcing and how can these risks be minimized? When you do outsource, how can you ensure a timely supply of products? And when should the firm keep dual sources for the same component? Finally, even if the firm decides not to outsource activities, when does it make sense to move facilities to the Far East? What is the impact of off shoring on inventory levels and the cost of capital? What are the risks?

Product Design Effective design plays several critical roles in the supply chain. Most obviously, certain product designs may increase inventory holding or transportation costs relative to other designs, while other designs may facilitate a shorter manufacturing lead time. Unfortunately, product redesign is often expensive. When is it worthwhile to redesign products so as to reduce logistics costs or supply chain lead times? Is it possible to leverage product design to compensate for uncertainty in customer demand? Can one quantify the amount of savings resulting from such a strategy? What changes should be made in the supply chain to take advantage of the new product design? Finally, new concepts such as mass customization are increasingly popular. What role does supply chain management play in the successful implementation of these concepts?

Information Technology and Decision-Support Systems Information technology is a critical enabler of effective supply chain management. Indeed, much of the current interest in supply chain management is motivated by the opportunities that appeared due to the abundance of data and the savings that can be achieved by sophisticated analysis of these data. The primary issue in supply chain management is not whether data can be received, but what data should be transferred; that is, which data are significant for supply chain management and which data can safely be ignored? How frequently should data be transferred and analysed? What is the impact of the Internet? What is the role of electronic commerce? What infrastructure is required both internally and between supply chain partners? Finally, since information technology and decision-support systems are both available, can these technologies be viewed as the main tools used to achieve competitive advantage in the market? If they can, then what is preventing others from using the same technology?

Customer Value Customer value is the measure of a company's contribution to its customer, based on the entire range of products, services, and intangibles that constitute the company's offerings. In recent years, this measure has superseded measures such as quality and customer satisfaction. Obviously, effective supply chain management is critical if a firm wishes to fulfil customer needs and provide value. But what determines customer value in different industries? How is customer value measured? How is information technology used to enhance customer value in the supply chain? How does supply chain management contribute to customer value? How do emerging trends in customer value, such as development of relationships and experiences, affect supply chain management? What is the relationship between product price and brand name in the conventional world and in the online world?

Smart Pricing Revenue management strategies have been applied successfully in industries such as airlines, hotels, and rental cars. In recent years, a number of manufactures, retailers, and carriers have applied a variation of these techniques to improve supply chain performance. In this case, the firm integrates pricing and inventory (or available capacity) to influence market demand and improve the bottom line. How is this done? Can "smart" pricing strategies be used to improve supply chain performance?As you will see, the focus in each case is on either the development chain or the supply chain and the focus is on achieving a *globally optimized* supply chain or managing risk and uncertainty in the supply chain, or both.

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VIII. CONCLUSION

A supply chain is defined as a set of relationships among suppliers, manufacturers, distributors, and retailers that facilitates the transformation of raw materials into final products. Although the supply chain is comprised of a number of business components, the chain itself is viewed as a single entity. Traditionally, practitioners and researchers have limited their analyses and scope to individual stages within the larger chain, but have recently identified a need for a more integrated approach to manufacturing system design. Consequently, the supply chain framework has emerged as an important component of this new, integrated approach.

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