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Textile and Apparel Supply Chain Management Technology Adoption
The Burlington Industries Case and Beyond

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ABSTRACT

The term supply chain management first appeared in the literature in 1982 with credit to Oliver and Webber (12). However, it can be argued that modern supply chain management began in the mid 1960s with the marriage of some basic, best-practice concepts of production-distribution processes and the 3rd generation of IBM computers; S/3 60 systems. One of the chief players in the early development of supply chain design and management philosophy was a textile and apparel company; Burlington Industries.

Much of the accumulated knowledge about textile and apparel firm contribution in this area has been lost or forgotten with the fall of the US domestic giants of the 1970s and 80s. Thus, the purpose of this paper is to establish a historical document that points to the important role that was played by the firm to the supply chain body of knowledge before the formal development of the "supply chain" term in the 1980s and 90s. It is the author's belief that an understanding the early work in developing large vertically integrated supply chain designs and strategies for textile and apparel firms can give the reader significant insight into global textile and apparel supply chain designs of the future.

A case study involving Burlington Industries and the supply chain information system enabler of the time, IBM, that is not to be found in the academic literature, is chosen as the core of the paper. The paper draws on the development and adoption of a supply chain management strategy for its separate businesses that was an important part of a massive 10-year, $2 billion (1975-85 dollars) capital expenditure program that was launched by Burlington Industries in 1975; a project scope unprecedented in the history of the world's textile industry.

Keywords: Supply chain, database designs, client-server information systems, ERP, MRP global economy, IBM, information technology, employment, Wal-Mart

Introduction

Today, global supply chains and the management of these chains have become an integral part of both popular and academic discussions of the world's political, economic and social problems. Graduate schools of business provide in-depth courses concerning supply chains and the vast amount of technology that is now available to manage these supply chains.

While the term supply chain management first appeared in the literature in 1982 with credit to Oliver and Webber (12), it can be argued that modern supply chain management began in the mid 1960s with the marriage of some basic, best-practice concepts of production-distribution processes and the 3^{rd} generation of IBM computers; S/360 systems. Since that time the supply chain management evolution process has continued through today. One can argue that most, if not all, of today's accepted supply chain management concepts were actively at play in the 1965-1985 period; acting under a technology paradigm and names specific to that time period. However, these same concepts were also in play during the 2000-2005 period and today; acting under a new paradigm and new names specific to that time period. The ten year period between the two paradigms, 1985-1995 was a transition period; a time of global economic change. It was also a time of discovery, development and first-cut application of fundamental changes in supply chain management driven by changes in information systems technology. For the practice of supply chain management it was a time of *paradigm shift*.

The focus of this paper is on textile and apparel production-distribution supply chains. Academicians have been discussing the place of supply chain management in textile and apparel chains for over thirty years. Cooper (04) first treated the textile supply chain as a network flow in 1970. Hudak and Bohnslav (10) were discussing the merits of textile and apparel supply chain consolidation into single-owner, linear, supply chains in 1976. With the realized advantages of large, static supply chains such as those formed by Burlington Industries and others in the 1970s, it was the conventional wisdom of the time that textile and apparel industry structure would follow the Burlington Industries model into the 21^{st} Century. It was assumed that textile and apparel markets in developed countries would be supplied by large single-owner, multi-node, linear, supply chains with production and distribution processes highly optimized in their network flows for specific target market groups. It was assumed that these chains would be supported by state-of-the-art mechanical, chemical, electronic and information technology. However, today it appears that the academic conventional wisdom of the 1970s did not translate well into the 21^{st} Century. At minimum the above conventional wisdom has taken a global detour.

With the coming of the global economy during the 1995-2005 period, textile and apparel industry structure was greatly expanded and reconfigured into a more retail directed, global version of the US textile and apparel structure that existed during the 1950s and 1960s. This backward regression has, once again, led academic researchers to question the optimal global structure for modern textile and apparel production and distribution supply chains (05). Thirty five years after Cooper's initial paper treating the textile and apparel supply chain as a network flow and a world of accomplishments in information technology later, not many questions have been answered with respect to textile and apparel supply chain optimization that were not being asked in 1975. Thus, thirty years later the focus of this paper returns to an old question in search of a new answer.

Is the adoption of modern supply chain management technology an important factor in determining the structure of textile and apparel production and distribution? If so, how does/will the adoption of this technology affect the convergence of the future structure of the industry?

Today, much is known and written about the 1995-2005 growth in supply chain management technology and the impact the applications of this technology have had on today's global economy. It is understood that a major paradigm shift in supply chain management technology evolved during the 1985-1995 period that decreased the cost of modern supply chain technology adoption during the 1995-2005 period. However, less is known, remembered, or written about the place of the important 1965-1985 period as a part of supply chain technology's evolutionary whole. To get a better handle on the above central question of this paper, one needs to fill-in a few knowledge gaps by looking at the important 1965-1985 period where textile and apparel firms were adopting supply chain technology within a very different paradigm than that facing adopting firms today. One needs some historical insight into the similarities and differences under the two paradigms as input before attempting to determine the appropriate supply chain structure for textile and apparel chains as one moves through the 21st Century.

A case study involving Burlington Industries that is not to be found in the academic literature is chosen as the core of the paper. The reasons for choosing this particular case are six:

1. few people would guess that a US textile company (one that, in effect, no longer exists) was, in 1985, one of the leading examples, if not the leading example, of effective supply chain management technology development and application,

2. the expansive (multi-node chain length) and diverse, yet linear, work-center nodes that populated each of the example firm's multiple supply chain networks,

3. the special interaction that existed between Burlington Industries and the supply chain information system enabler of the time, IBM, that was largely responsible for the measured success described in the case,

4. the development and adoption of supply chain management technology by the example firm was an important part of a massive 10-year, $2 billion (1975-85 dollars) capital expenditure program that was launched by Burlington Industries in 1975; a project scope unprecedented in the history of the world's textile industry,

5. almost immediately, within five years of completion of the technology adoption project, the firm was attacked by external forces that eventually led to the effective destruction of the technology base, the associated knowledge base and the supply chains it had developed,

6. the author was an important participant in the 1975-1985 capital expenditure projects and recounts most of the paper's Burlington Industries outcomes either from personal notes or memory.

Post World War II Textile and Apparel Supply Chains

At the end of World War II most of the world's economies lay in ruin. As nations began to rise from the ashes and reinvent their economic selves, America, set about to reconfigure itself as the world's dominate economic power. The economic engine and supply chains that had produced and distributed most of the material resources that contributed to the Allies victory in the World War were in place in the domestic United States, undamaged by the War. All that was needed was to convert supply chain capacity from the supply of military goods and services to meet the demands for consumer goods and services. Under these conditions it was natural for the US Government to think in terms of economic "full employment." The Employment Act of 1946 passed the US Congress by an overwhelming majority and officially added a new dimension to government policy. The Employment Act of 1946 explicitly placed the US Government in a policy role of maximizing employment in the United States. Understanding the economic trade-offs between maximum national employment and inflation and the economic trade-offs between the use of technology as a substitute for people in the production and distribution of goods and services, the US Government made its top priority keeping the US work force employed. Thus, for a generation after 1946, the components of US supply chains were domestic and much of the technology associated with the management of these supply chains supported government policy. Within this environment the US textile and apparel industry was composed of thousands of small, under-capitalized firms using labor-intensive processes and sharing work-center components of the textile and apparel supply chain. Independent mills produced yarn as an input for other independent mills that produced fabrics for other independent mills that produced processed fabrics that were used by other independent mills to produce final products for apparel, home furnishings and/or industrial uses. While various degrees of vertical integration existed, and the industry did by the 1970s contain a few large vertically integrated firms, by the mid 1970s about seventy percent of all US textile and apparel production market share was controlled by thousands of independent mills dealing with each other in a dynamic manner to form short-term, ad hoc, supply chains.

All Post-World War II textile and apparel supply chains for US production and distribution were a set of linear, individualized processes that linked manufacturers, warehouses, wholesalers, retailers and consumers together in the form of a human/paper chain. People and paper physically connected all of the tiers of the chain together. Information systems were composed of what people carried around in their heads and/or what they could physically put down on paper. The physical limitations of the absence of data, or data redundancy, or data errors resulting from the use of paper as a means of maintaining the data required to manage a supply chain, was profound. The practical limitations of uncoordinated, decision making among individual supply chain managers, acting not on data, but on individual agendas, was equally profound. The ability to coordinate the total supply chain activities of procurement, demand planning and forecasting, inventory management, shipping and tracking was far from a definitive science. These conditions were particularly true across the short-term, ad hoc textile and apparel supply chains that were month-to-month or week-to-week dynamically formed by independent mills to take advantage of a given market opportunity. However, for the period, these limitations were accepted practice for doing business. In the Post-World War II environment world-wide and domestic demand for US textile and apparel products was high, supply was limited and supply chain optimization was not on the front burner of US textile, apparel and other production/distribution firms. Thoughts of supply chain optimization for the textile and apparel industries would not become serious until foreign competition for the market share controlled by US textile and apparel mills became serious in the 1970s.

The 1975 US Textile and Apparel Economy

In the mid 1970s it was well understood by involved US government, education and business officials that the survival of the domestic US Textile/Apparel Industry in the 21st century was going to be more than problematical. Some US government participants that had an interest in determining the future course of the industry were the National Science Foundation, the Treasury Department's Office of Industrial Economics, US Departments of Commerce and Labor, etc. The presence of various industry associations, such as ATMI, American Textile Manufacturing Institute, and others, were pervasive at meetings to discuss the industry's future. Business leaders gave widely diverse opinions about what was required to promote future US Textile/Apparel Industry survival. Textile schools such as the one at NC State University, serving an international student clientele, were poised to do scholarly things to aid the survival process. It was the beginning of very interesting times for the domestic US Textile/Apparel Industry!

While US textiles and apparel, taken as a whole, were improperly structured to survive a coming global economy in the mid 1970s, a relatively small number of well capitalized textile firms were about to attempt to beat the survival odds through the efficient and timely adoption of technology. There was a belief among these companies that in the face of significant price disadvantages with foreign competition, the proper utilization of chemical, mechanical and information technology, in concert with an optimized supply chain, would allow long-term survival for a small number of well structured, capital intensive, textile and apparel firms such as Burlington Industries. These few firms were willing to aggressively implement this strategy during the decades of the 1970s and 1980s. By the mid-to-late 1970s two large textile firms, Burlington Industries and Milliken and Company had already obtained a dominant position in the industry with this strategy. Writing in 1976 for the US Treasury Department's Office of Industrial Economics, Hudak and Bohnslav (10) reported that these two firms, were able to capitalize on the emerging new technologies associated with textile machinery and man-made fibers, using state of the art computer-based systems, and were able to gain a significant competitive advantage over other US and international textile firms. They pointed out that these more-profitable companies had developed complex vertical and/or horizontal supply structures that allowed for significant gains in flexibility, diversification and financial strength. They reported that after a period of acquiring control of smaller firms and absorbing these firms into their supply chain structure, these firms were applying mass production and information-based techniques in consolidating diverse textile supply chain activities into well integrated operations. However, it was noted that these few firms, Burlington Industries included, held a minor share of the domestic US market in the mid 1970s. Cooper (06) reported in 1975 that the total operations of these few firms only represented about 30% of the domestic US textile, apparel market share with small under-capitalized firms sharing the remaining 70%.

<u>Burlington Industries</u>

Through the aggressive pursuit of acquisitions, product diversification and supply chain integration after the Second World War, Burlington Industries became the largest textile firm in the world. For nearly 40 years, it was guided by its founder J. Spencer Love who died in 1962. During his tenure Love and his company were known for bold, innovative ideas (06). Under Love's leadership the company was a pioneer in the development and practice of the latest organizational management concepts and employee relations practices. It patented many unique production processes and related products and zealously pursued new market opportunities as the market populations grew, lifestyles changed and living standards improved. This aggressive pursuit of bold, innovative ideas, continued with post-Love management well into the 1980s, including the belief in the competitive advantage of vertically integrated supply chains. Surrounded by thousands of small independent mills, Love saw optimized, vertically integrated textile and apparel supply chains as the path to economic success for Burlington Industries. Under Love's direction the firm contained multiple product divisions, organized around specific product groupings that could be treated as separate companies. These separate companies produced products for multiple apparel uses, multiple home-product uses and for multiple industrial uses. All of the firm's various textile/apparel supply chains were made up of deep product structure files containing yarn and fiber procurement, yarn-forming processes, fabric-forming process, fabric-treatment process, and final product-forming processes.

In support of Love's vision, the management of Burlington Industries understood that its future success greatly depended on its retail partners; where total-supply-chain flow exited the chain to the ultimate customer. To better define its products relative to its retail customers and develop consumer brand awareness, as early as 1952, Burlington was the first textile company to advertise on network television. In 1975 a good number of Burlington's retail partners were ill-managed and not equipped to be the driving force of a given supply chain. A typical retail company of the time was daily, dealing with multiple purchases from multiple supply chains while being equipped with only a minimal information technology needed to control its destiny and the destiny of the up-stream chain. Under these conditions Burlington Industries saw the logic of taking its destiny in its own hands and out of the hands of its retail partners by positioning itself to play a major role in the vendor management of its product inventories at the retail point of the supply chain. New, emerging supply chain management theory and supporting computer-based systems were deemed by Burlington Industries to be enablers of this corporate strategy.

During the 1970s and 1980s Burlington Industries could be described as a closely-held, firm. The decision makers of the time were textile people with long-term family involvements in successful, well capitalized, production and distribution of textile and apparel products. These were textile people who wanted to remain textile people in the coming global economy. It was the strong belief of the Burlington decision makers in the mid 1970s that through the design and application of effective production and distribution structures (supply chains) and the optimal use of technology within these structures, the firm's business divisions would increase their US market share as other firms no longer could compete. The decision makers of Burlington Industries believed that they would not only survive but prosper in the 21^{st} Century.

Burlington's 1975 faith in the future was based on a number of assumptions about geo-political economy, the growth of technology, and future relative opportunities for the investment of their capital during the last quarter of the 20^{th} Century. In 1975 Burlington Industries was betting that its large, optimized, vertically integrated, single ownership supply chain architectures coupled with the most productive production and distribution technology available would be superior to any alternative competitive supply chains, domestic or foreign, that could be cobbled together in the 21^{st} Century. The strategy of Burlington Industries was to make the firm a capital and materials intensive business. At that time it was logical to believe that by replacing expensive US labor with relatively inexpensive materials and capital the firm was insulated against the global "cheap labor" competition of the coming global economy. Thus, in the mid-1970s Burlington launched a 10-year, $2 billion capital expenditure program, a scope unprecedented in the history of the world's textile industry. The objective was to achieve a world-class manufacturing and distribution base that would positioned the company for world-wide competition well into the 21^{st} Century.

Modern Supply Chain Management

In order to demonstrate any differences in the Burlington Industries' 1975-1985 equivalent to today's "modern" supply chain management, consider today's current definition. The text by Chopra and Meindl (02), currently adopted for use in a number of graduate business courses, defines a supply chain as:

"A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited to new product development, marketing, operations, distribution, finance, and customer service."

Given the general definition of a supply chain, it is useful to think of the management of a specific supply chain as encompassing a general body of technology that enables supply chain management. The technology of modern supply chain management can be reduced to four basic components. The first component is a conceptual paradigm that allows for the development of a theoretical structure for a class of supply chains. A second component is a knowledge base of best practices for given classes of supply chains. A third component is a set of optimization tools that can be effectively utilized in the design and control areas of supply chain management. The fourth and most important of the components is an effective computer-based management information system that provides input to enable the optimization of the supply chain process.

In today's global economy Supply Chain Management is involved with the activities of:

1. treating interconnected global work center nodes as networks that produce flows of goods and services at minimal cost and maximum customer satisfaction for customer consumption (*paradigm*),

2. designing these networks for optimal flow and economic return on supply chain capital by balancing, at the margin, the costs associated with inventory, capacity, transportation and customer waiting (*optimization tools*),

3. utilizing the benefits of concepts such as the push/pull boundary, cross-docking, risk pooling, JIT, product design, transfer pricing, mass customization, etc. to achieve optimal supply chain flow and economic return on supply chain capital (*best practices*),

4. integration of "state of the art" database design and client-server network computer-based technology with decision support modeling and time-honored principles of optimal operations management to meet supply chain goals (*management information systems*).

One can argue that most of the theory and decision support modeling was available to Burlington Industries in the 1970s to support three of the above four basic components; paradigm, best practices, and optimization tools. However, it would take more than a quarter century of supply chain evolution to marry these three components with the slowly developing computer-based information components that would result in the modern supply chain theory and practice that is taught in today's graduate programs of business.

<u>The Genesis of Modern Supply Chain Management 1965-1975</u>

Throughout history the standard approach for controlling supply chain flow in a non computer-based environment is a manual, paper-based system that serves as an inventory control system and generates orders for materials up the supply chain. This manual system is always some variant of an order-point system that establishes "when to order" based on average usage for the planned replenishment lead time plus some safety stock to protect against greater than average demand. Almost always, this manual system doesn't work correctly and another informal system is the one that really determines supply chain flow. This informal system is the shortage list. This shortage list overrides the dates that the formal manual system places on production and purchase orders and establishes the true need dates for items up and down the chain. Not surprisingly this order launching and expediting approach often generates a great deal of supply chain chaos because the orders generated by the formal manual system are of the lowest priority and are constantly being overridden by expediting, thus making the formal manual system of little consequence. The resulting chaos described here has been given a name in modern supply chain management; the bullwhip effect. The principle negative consequences of a large bullwhip effect are excessive work-in-process and finished goods inventories in addition to excessive production and distribution lead times. In addition to these main effects, production costs are negatively affected by excessive machine change-over costs, etc. For supply chains where these main and secondary effects are not perceived to be significant or where other supply chain factors are given higher priority, one lives and survives in the face of the bullwhip effect. For those supply chains where these main and secondary effects are significant, minimizing this bullwhip effect is at the center of modern supply chain management.

The best practices of modern supply management is an alternative approach to the one described above. This approach took on the first of several names, MRP, Material Requirements Planning, in the early to mid 1970s. In the early 1970s members of the American Production and Inventory Control Society (APICS) were actively developing the theory and applications of production and inventory control that would lead to today's practice of modern supply chain management. Two of the most prominent of these APICS members were George W. Plossl and Oliver W. Wight. The 1970s was the dawn of computer-based systems and early-on Plossl and Wight saw the potential of these systems, in concert with APICS practices, to solve a good number of the world's industrial problems relating to more effective production and distribution of goods and services. During this period, the major contributions of Plossl and Wight were in visualizing ways the computational efficiency of computer systems could be used to make production and distribution processes more value effective. The focus of the original efforts was the problems caused by the practice of order launching and expediting as a means of managing supply chain flow. They understood that under the best of conditions this practice was problematical and under the worst of conditions, it led to production and distribution chaos. Their first-cut solution approach was MRP.

MRP typically determines "when to order" based on schedules for the items that use the material (dependent demand) and while obviously superior to ordering based on average usage, in practice, without the benefit of a computer system, MRP is a difficult method to use. Without the benefit of computer aid, a company might spend as much as six to thirteen weeks to calculate the dependent demand requirements manually. Because of the time required to manually develop material needs, these companies can only place orders infrequently; say, once every quarter. Considering all the unplanned things that can happen between orders, the MRP approach doesn't work a lot better than the other manual, shortage list alternatives.

The arrival of even the most basic computers, IBM 1440s in the 1960s, and early 360 models in the late 1960s and early 1970s made MRP a workable technique. These machines were able to explode bills of materials using new software packages such as MAPICS and PICS (products from IBM) in the early 1970s. An early APICS concept was the separation of independent and dependent demand through a product-structure file, Bill of Materials, along the production-distribution supply chain. With this file it was possible for the computer to calculate the lower level inputs (dependent demand) for every supply chain level that was created by a unit forecast of demand for a final product (independent demand). Thus, precision in determining these lower level requirements at all points up the supply chain was possible. As computer capabilities increased, a number of companies began to recalculate production and purchase requirements as often as weekly and broke the lead time, time phasing of this ordering process into weeks of lead time that would allow for developing precision in real order "need dates" within the supply chain processes. This ability to precisely determine gross requirements at every level of the supply chain, supplemented with accurate inventory records of units currently on hand or order at each level, created the possibility for the computer to calculate a precise Net Needs to Produce/Order for every level of the supply chain. This ability was an important first step in the development of supply chain scheduling as an alternative to order launching and expediting.

Early on Plossl and Wight made the point that MRP was only a small part of the solution to the problems caused by the practice of order launching and expediting. An important second step to the development of effective supply chain scheduling was the practical development of the critical concept of defining and controlling lead times at every point up and down the supply chain. By definition, order launching and expediting generates variable lead times, up and down the supply chain, that often preclude lower level inputs being available when they were needed. Under these conditions the pieces of the finished product seldom can come together at the right place at the right time. In order for this to happen lead times needed to be defined at each level of the supply chain; stabilized by order release control through-out the entire production-distribution process.

In 1973 Plossl and Wight (13) offered a solution to the problem of variable lead times. They argued the main focus of the problem should be placed on the control of capacity. Instead of order launching as a means for generating production, production should be generated through a process that restricts released orders to a measured-amount that is exactly equal to the capacity available to complete those orders within the defined lead time. To accomplish this approach to lead time control, available capacity at each work-center level of the supply chain must be known so that the work load defined by the dependent demand capacity needs at each supply chain level can be measured against available capacity at that level. Plossl and Wight argued that if the dependent demand load is greater than capacity to complete that load within defined lead time then the total supply chain is optimized by pushing out the completion of the final product on the master schedule to a later time that is consistent with the capacity that stabilizes lead times at every point in the chain.

In practice these early concepts advocated by Plossl and Wight began to take hold for early adopters of the approach during the mid 1970s. With the introduction of CRP, Capacity Requirements Planning systems, firms began to understand that if the master schedule contained more production than could really be made (inadequate capacity) then genuine shortages did exist and MRP would not generate valid priorities based on real need dates. Here, the shortage list, with all its shortcomings, was still the real scheduling system with all the excessive inventory, lead time and production changes associated with the system. However, as people learned how to manage the master schedule concept properly, MRP evolved from an ordering system into a priority planning system. While the shortage list had in the past been the real supply chain scheduling system, with MRP, CRP and Master Scheduling technology acting in concert, shortages could be seen in advance in fine increments of weekly or even daily time periods, and acted on.

During the 1965-75 period firms learned that the critical components of an MRP system include a computer-based system for maintaining bills of materials and a computer-based system for tracking work-in-process and finished goods inventories up and down the supply chain. They learned that the critical components of a CRP system include a computer-based system for maintaining product routings files, and a computer-based system for maintaining the standard data required to determine the capacity requirements for a given amount of material needs. They learned that the critical components of a MPS, Master Production Scheduling, system include a front-end (independent demand) computer-based forecasting system. With accurate MPS, it was an easy step to develop an ATP, Available to Promise, system that would indicate to a given customer the amount of each product item that could be delivered to a given customer at a given time. With an accurate MPS, an additional movement to DRP, Distribution Requirements Planning, closed the loop of supply chain planning. It was understood that all of these basic parts must be integrated into a unified system before one could define a supply chain as being “closed loop.” The term “closed loop” during this period really had two meanings. One meaning implied that the missing elements in an MRP system like capacity planning, and master scheduling, etc. were filled in. An additional meaning referred to the feedback from all those involved with supply chain flow, whenever and wherever there was a problem in the execution of the supply chain master schedule plan.

With the arrival of closed-loop supply chain planning all types of production and distribution firms began to understand the importance of forecasting as a crucial input to the master schedule. Marketing sectors in those companies where closed loop MRP really was working learned that closed loop supply chain planning was the best marketing tool that had yet been devised. By working closely with production and distribution elements of the supply chain, a master schedule that best met marketing's requirements, within the constraints of what the supply chain could do, could be worked out. The extension of the master schedule into independent demand forecasting and DRP meant that the supply chain could now translate real marketing plans into real production and distribution plans. At this point one could begin to think of work center notes within network supply chains and the proper way to integrate the best practices of "closed loop" planning into supply chain management. At this point one could practice modern supply chain management.

Today, modern supply chain management is about more than order scheduling. Today's computer-based Enterprise Resource Planning (09) systems that run complex supply chains fold the entire supply chain business into one logical whole. However, ERP is the logical extension of the Plossl and Wight ideas of the 1970s. In his 1981 book, MRP *II; Unlocking America's Productivity Potential* (10), Oliver Wight does an update on his and Plossl's earlier ideas. In the book Wight discusses how these earlier developed ideas lead to improving a supply chain's productivity of money (cash flow), productivity of labor, productivity of buyer-supplier relationships, productivity of product and process engineering, productivity of management, as well as the productivity of supply chain profits. These ideas, of course, were the precursors of the software modules that were later designed with modern client/server and relational database technology to integrate product/service flow with cash flow, labor needs, buyer/supplier management, customer management, etc. into modern supply chain management; modern ERP technology.

By 1975 a new approach to supply chain management was emerging. This new approach forced production and distribution firms to become decision makers relative to the adoption or non-adoption of the emerging supply chain management technology. The new approach required an entirely different approach to management. The approach was based on well defined policies and procedures, discipline in following these policies and procedures, accurate and robust amounts of data, data management and modern computer-based information systems. To enter into the practice of modern supply chain management in 1975 was to enter into a very different world from what was previously known. Entering into this new world was expensive, potentially dangerous because of disruption of the status-quo, and each firm and/or group of firms was forced to consider the costs and benefits of moving, or not moving, to the modern supply chain management approach. Each potential supply chain was forced to balance the negative costs of the bullwhip effect against the costs of minimizing the bullwhip effects with modern supply chain management tools. For many the costs of obtaining modern supply chain management status were deemed prohibitively high relative to the costs of living with the bullwhip effects. In 1975 this was the case for the great majority of textile and apparel firms. However, for a small number of large, vertically integrated textile and apparel firms, such as Burlington Industries, the movement to adopt modern supply chain management technology was an integral part of their future survival strategy.

<u>Optimization Tools and the Development of the Supply Chain Network View</u>

At a typical APICS meeting in the 1970s one could engage in a conversation about how simple and straight-forward the ideas attributed to Plossl, Wight and many others were. One could argue that this simplicity retarded the growth of an academic treatment of supply chains during the 1970s, 80s, and well into the 1990s. During the 1970s graduate programs in business became enamored with mathematicians building mathematical models to describe business systems. The more mathematically elegant the model, the more prestigious was the academic perception of the author. Many graduate business schools, for example, the initial MBA program at Duke University, were organized around a mathematical modeling approach to business problems called Operations Research. The best business practice concepts of Plossl, Wight and many other APICS related people were anything but mathematically elegant. These ideas were little more than adding, subtracting, multiplying and dividing in a basic conceptual way.

Thus, these concepts for improving America's businesses through a new view of supply chain management flew under the academic radar for a number of years and resided in such business practice societies as APICS. Unfortunately, during this period there were minimal connections between academic and practicing business communities. Programs specifically dedicated to the practice of supply chain management did not become common in graduate schools of business until late in the 1995-2005 period.

Operations Research involves the use of systematic quantitative analysis to aid in the making of management decisions. Emphasis is placed on a scientific approach to decision making, with considerable reliance on advanced mathematical techniques and a computer-based technology. By the mid 1970s academic schools of operations research, industrial engineering and schools of business administration had made great strides in developing optimization tools for studying a wide range of business problems. As a partial output of doing their academic thing, linear and non-linear programming, flow and Monte Carlo simulation, and network optimization models, were a few of a number of other optimization tools that were developed and/or refined by academics during the post-World War II period. A most profound contribution, with respect to the development of modern supply chain management that emanated from the operations research area was in the study of networks. Solution procedures that allowed for the optimization of flows in capacitated networks and solution procedures for finding longest and shortest paths through networks would create the pre-conditions for treating supply chains as a network paradigm that could be optimized with computer-based mathematical and statistical tools. However, unfortunately, like the APICS best practices for supply chains that were emerging under the leadership of Plossl, Wight and others, the efficacy of the vast kit of optimization tools available to the 1975 business practitioner dealing with supply chain optimization problems was at the mercy of available data and the computer-based, technology available for dealing with that data.

<u>Available Supply Chain Computing Technology Under the Existing Paradigm</u>

The mid 1950s to mid 1960s saw the first two generations of computers that could be used for business purposes. By this time IBM had taken a dominate position in the world-wide development, production and distribution of computing hardware. During this period computer models were designed as independent machines; often custom modified for a particular customer. A typical IBM 1440 had 8k of core memory with two magnetic disks for data storage. It was an adventure learning how to program the machines and use them for a given business task. Early adopters most often used this limited technology as an aid in the area of accounting and financial records.

It was not until the mid 1960s, with the arrival of IBM's third generation of 360 computer technology that one could first began to visualize the possibilities of modern supply chain management. Soon after the arrival of the 360 technology, during the late 1960s, one saw the birth of the first inventory management software systems; which were typically customized to aid a given firm's inventory control in the manufacturing and distribution sectors. During this period US firms involved in product distribution began experimenting with the inter-relationships among warehousing and transportation functions involved in physical distribution management. Capital spent on improved warehouse facilities, processes, materials-handling equipment and emerging computer-based systems, coupled with improved transportation processes, led to shorter response times and improved forecasts of customer needs. By combining the two functions of warehousing and transportation around computer-based information and control systems, the distribution process began to be optimized for overall cost and customer service.

Also, with the aid of the IBM 360 computer technology, some basic process monitoring and calculation applications began to appear in the late 1960s and early 70s period within various supply chain components. But 1965 to1975 was a learning period for IBM as well as for its customers. IBM's family members of 360 model computers were all different in many ways. Each had a different approach to an operating system. Each was designed with different CPU magnetic core levels and thus implied bounds on the size of application programs that could be run on the machine. CPU magnetic core was very expensive, an IBM 360/30 with 32k of core memory was priced at about $120,000 of 1965 dollars. While expensive CPU core was the weakness of IBM computer technology, big and fast magnetic disk drives for data storage were its strengths. In the early 1970s one could purchase IBM 3330-11 mainframe disks of 400MB storage for about $110,000. Thus, while large quantities of data storage was possible, albeit expensive, with mainframe disks, the ability to utilize applications programs that required a large amount of core memory was a limiting factor to supply chain management applications.

During the 1970s and 80s IBM continued to improve on what it had learned with its 360 family of computers. This learning was incorporated into the System 370 which first became a viable business product in the mid 1970s. While the machines got bigger and faster and multi-processor systems became common during the 1970s and 1980s, the basic machine architecture did not change. Computer-based information systems were "main-frame" based. Each main-frame generation seemed to have a different operating system and/or its own programming language. CPU core remained limited and expensive. As one went through the 1980s, this limitation critically affected the economics of database management and retarded the emergence of modern supply chain management.

Modern relational database technology application only began during the latter part of the 1980s and didn't reach significant potential until the mid 1990s (10). Low-cost CPU processes and Client/Server distributed processing technology that would support effective database management systems over a wide variety of conditions were only to be dreamed of in the 1970s and 80s. The software, middleware and standards to support modern supply chain optimization over the internet and local area networks were only to be dreamed of in the 1970s and 80s. Within this environment, firms that wished to integrate computer-based systems, with their indigenous limitations, into their supply chain optimization practices were required to produce these systems "in-house." These in-house projects required of firms significant expenditures for either a staff of data processing professionals or hires of consultants to produce and implement the systems for them.

In the 1970s, Material Requirements Planning (MRP) software systems first appeared. Following the APICS best practices advocated by Plossl, Wight and others these first systems phased the release of production and purchase orders to match the flow of materials and in-process inventories to production schedules for finished products. These first software systems where both hardware and data dependent. The use of a given software system implied both a given hardware platform and a database structure. Some vendors of these software systems included, American Software, Arista, MacPack by Arthur Andersen Consulting and IBM.

Because of the hardware and data dependent conditions, it was not surprising that the dominant hardware provider was actively attempting to provide a total package of hardware, software and data management system to firms early adopting supply chain management concepts. IBM's hardware was built around the 360/370 technology. Its software solution to supply chain management was COPICS (Communications Oriented Production Information Control System). The name COPICS first appeared in 1972, not as software, but as a set of concept manuals. These manuals were a conceptual explanation of what the authors felt should be included in an on-line computer-based, manufacturing-based supply chain system. From a careful examination of these concept manuals, one can easily see the foundations of modern Enterprise Resource Planning or ERP systems existing in 1972. However, it was not until 1979 that the Data Processing Division of IBM released COPICS as a software package. The COPICS of 1979 was the latest in a series of evolutionary software developments that included IBM's answer to the problems associated with flat-file database structures. IBM's solution was a hierarchical database structure which was named IMS. The COPICS software emphasis was to provide modular software that could be implemented one module at a time using a standard database system and providing on-line management capability. While previous field developed programs were pretty much, "what you see is what you get," adopters of COPICS were assured of future continuing hardware and software support for the system.

IBM's platform for delivering COPICS was the 360/370 hardware technology which by 1979 had evolved into the 370 System that was COPICS compatible. From a marketing point of view IBM saw COPICS as a vehicle for selling a good number of 370 and later to be developed hardware systems. But, as mentioned earlier, the 360/370 technology had a fatal flaw; expensive core memory that restricted the large data-robust application programs that are needed to support modern supply chain management. However, from hands-on learning gathered from early adopters such as Burlington Industries, these first MRP systems extensions gradually evolved into today's software systems for the support of an entire business supply chain; Enterprise Resource Planning, or ERP software.

Improved data communication and analysis techniques allowed for an increasing ability to make complex decisions. The 1970s saw the addition of the manufacturing, procurement, order management functions, and the integration of an increasing number of other production-distribution functions as a few US firms attempted the optimization of a total flow of materials through a production-distribution network. These additions were aided by the emerging technologies, growing at different rates; database design, computer-based distributed processing, data communications and computerized decision support systems. Because of the differential growth rate of the set of technologies needed to support modern supply chain management, early entrance into applying supply chain designs and methodologies was at best problematic and risky for the early adopters.

While most of the principles of good database management for supply chain optimization were the same for the 70s and 80s as compared to today, the computer-based technology, in particular the database technology, to make use of these principles was either lacking and/or expensive. Because of these conditions, incentives to embark on projects to move a firm toward modern supply chain management were, except in a very specific cases, few.

Available Supply Chain Database Management Under the Existing Paradigm

Well into the 1980s file-management database structure was little more than a computerization of the historic metal file cabinet with drawers and manila envelopes stuffed with papers (11). Database structure still exhibited the same data redundancy, data anomaly, flat-file structure of the metal file cabinet managed by a secretary. While each secretary was responsible for a particular filing system (database design) he/she was also responsible for managing that filing system. With the computerization of the metal file cabinet, one lost the secretary and gained a data processing programmer. In general, a computer programmer was required to put data into a database and/or to get data out of a database. This programmer, through a special program, placed the data that historically resided in the metal file cabinet in some place, unknown to the user, on a magnetic medium, tape or disk-pack. If one wanted to see the data, one first had to go find a DP programmer to write a special program to access it for the user. "Hardware, software and data dependence" were the terms used to describe database technology of the time.

Under this file-based system one thought of the systems application first and the data second. It was common for a specific application to fit the database data on the magnetic medium to the specific application. It was common to have common data used for multiple applications in multiple places. Because of data dependency, the structure of the data was likely different from application to application. Because of hardware dependency, different applications on different hardware required different approaches for dealing with the data. Depending on the system technology, different programming languages or programming techniques often were used from application to application.

This functional dependency made application programs single-application specific and limited application portability and scalability. Much "re-inventing the wheel" was required from application to application under this paradigm. Because applications tended to be single-application specific, little progress could be made in standardization. Little universality of software development was possible. This lack of standardization tended to limit the expansiveness of supply chain networks by work center location and by ownership. Under these conditions supply chain components needed a dosely held unity of control to optimize the flow of the network.

A firm operating under the conditions of this existing paradigm could expect to place a relatively large emphasis on computer issues other than the development of applications. One could expect to be required to maintain large staffs for high levels of data maintenance, and internal applications development. All of which would contribute to relatively high levels of systems overhead costs. It was under the supply chain database and information technology conditions of this paradigm that Burlington Industries initiated its 1975-1985 technology adoption project.

Burlington Industries; Supply Chain Management Improvement Goals for 1975-1985

In some market areas Burlington Industries acted as a manufacturing vendor for other manufacturing firms in the apparel and industrial products areas. However, in a number of apparel, home furnishings and industrial products, it acted as a vendor for various retail establishments. During the 1975-1985 period many of the large retail firms that were the customers of Burlington Industries, and the apparel manufacturers that were supplied by Burlington Industries, were noted for their poor management.

Modern supply chain management tools were few-and-far-between for most large retail operations. The 1980s and 90s were characterized by a number of bankruptcies and mergers taking place in the US retail industry. Within this environment it was the goal of each Burlington Industries division to be able to offer a given retailer a fully vertically integrated supply chain with state-of-the-art supply chain management technology that would allow for on-time-delivery; customer service levels of all promised orders that approached ninety eight percent. In addition it was the goal of these divisions to protect their position at retail by expanding vendor management of their products at retail. It was understood that poor supply chain management at the retail level was a potential Achilles heel for the large vertically integrated manufacturing firms whose business success was greatly affected by the effectiveness of their retail customers. In the absence of supply chain management leadership coming from the retail establishments, it fell to the large manufacturing firms to supply that leadership.

By 1975 Burlington Industries was on the forefront of the APICS vision of what a modern supply chain should look like. It had been in partnership with IBM and had been an advocate of the APICS vision since the mid 1960s. Together with IBM it had been a key player in developing computer-based solutions for textile production and distribution problems within the limitations of the IBM 360/370 technology. In the absence of software providers for this technology, Burlington Industries had by 1975 internally developed an impressive array of software systems to meet its own supply chain needs. However, these systems were spread over multiple divisions with little standardization. The variability in system applications across the divisions was the logical outcome of each business division choosing to allocate its system development resources in a priority way. These priorities were different from division to division. For the Women's Hosiery division, a computer-based forecasting system was a priority. For the Menswear Fabric division, loom scheduling and an MRP system for developing warp beam needs was a priority. For the Burlington Domestics division an MRP system for developing assembly requirements for bedding products was a priority. Working to these priority needs during the 1965-75 period, a number of computer-based supply chain systems, developed for the specific needs of a given division, were a valuable resource for Burlington Industries.

By 1975 Burlington Industries had developed a time series model, exponential smoothing, forecasting system that was being used in its women's hosiery division. The model was the principle driver of the division's production and inventory control system. The model was fed by the data from an internally developed, computer-based, customer order system and, although the model had the capability to be run weekly, the needs of the hosiery division were such that monthly forecast update runs were sufficient. The model contained most of the features, such as trend correction and seasonal adjustment capabilities that one would expect to have in a system purchased in today's market. Also, the model had the capability of forecasting either at the item level or at an aggregate group level. For the hosiery division, the system had the capability of taking group level forecasts from sales management reconciling these numbers with current sales numbers obtained from the customer order system and, using current percentages of item level sales, convert group forecasts into item level, SKU forecasts. While developed specifically for the hosiery division, the forecasting system had the capability of being adapted for use in other divisions of Burlington Industries. This system represented a good example of the questions it faced with many of its internally developed systems. Should Burlington adapt systems it currently had developed for one division in other divisions or should new software solutions, either internally or externally developed and installed be pursued? These questions needed to be answered for a number of internally developed systems. The various divisions

had an inventory of MRP software designed for various applications. There were various types of loom scheduling and loom monitoring software programs. There were various types of capacity planning systems that met the needs of specific business divisions. Customer order service systems that had been internally developed to meet the specific needs of each division were available. Other systems included a variety of inventory tracking systems, systems for allocating finished inventory to customer orders, and warehouse systems for picking and packing orders.
CAPOSS, a finite scheduler system developed by IBM, was in place scheduling the dyeing and finishing needs of Burlington Menswear. There were dyeing and finishing monitoring systems in the Burlington Sportswear division. Also, various types of Decision Support Systems had been internally developed. Systems using linear programming models for loom scheduling, aggregate planning and a number of additional problem solving areas had been internally developed and were used by a number of the different divisions. One of these systems was used on a monthly basis as the principle input for determining production requirements in two of the firm's Mexican operations. In addition, Burlington Industries had, with the help of outside consultants, developed for two of its divisions, state-of-the-art distribution centers.

Given the decision to spend two billion dollars on new technology during the 1975 to 1985 period, an important part of this project was the defining and optimization of the new supply chains that would be a result of new technology adoption. As new mechanical and chemical processes were being adopted the supply chain technology for each business division needed to be defined and optimized to fit the new processes. With supply chain technology the firm was not starting from scratch. But it was time to analyze what had been accomplished in the various divisions and determine what technology transfer was appropriate and what new supply chain technology needed to be developed or purchased. This was the Burlington Industries supply chain focus during the 1975-85 period. The mission goals for the supply chain focus during this period were the following:

1. Division by division, educate all levels of management and related employees as to the benefits to Burlington Industries of closed loop MRP production and distribution systems.

2. Identify the current supply chain technology application successes of Burlington Industries as to the capability of technology transfer to other Burlington divisions.

3. Develop specific project plans for selected divisions to incorporate closed loop MRP systems using currently developed and newly arriving supply chain technology. Present project plans to selected division management and all involved employees.

4. Implement project plans for selected divisions.

5. Repeat the process for additional divisions of Burlington Industries.

Some Successes and Failures of the Burlington Technology Adoption Strategy

The Burlington strategy of supply chain optimization began as what could be called a "rifle" rather than a "shot-gun" approach. A limited number of the firm's businesses were chosen by corporate management to become examples for all the remaining businesses. As new mechanical, chemical and information technology became available to the US textile industry and met the goals of profit improvements, either through increasing revenues and/or reducing costs, these selected business divisions of Burlington Industries were encouraged to adopt the technology. A second point of the strategy was to utilize knowledge gained from the technology adoption process in the more profitable divisions in carrying out a policy of *technology transfer* to enhance the business competitiveness of all businesses within the company. During the decades of the 1970s and 1980s, the firm dominated the US consumer and military market for worsted menswear fabrics. It had sizeable market share of the US textile home furnishings business (carpets, drapery, upholstery, bed and bath products) and had been an innovator in the development of special purpose industrial fabrics. One of its largest businesses, about 30% of total sales, was in the category of general apparel fabric. Because of the world-wide structure of the apparel supply chain the general apparel fabric business was most vulnerable to both domestic and foreign competition. Thus, an important part of the overall *technology improvement strategy* for the firm was to improve its competitive position in the supply of general apparel products through the knowledge and technology base developed in other parts of the company.

Techniques and tools developed for the example supply chains were to be diffused across other Burlington businesses both domestic and foreign. New technology adoption, including information systems approaches developed for its domestic divisions were to be applied to international businesses in locations that included Mexico, Canada, Germany and the UK.

By the late 1970s one of the companies of Burlington Industries, the operations of Burlington Menswear, contained state-of-the-art computer-based information technology.

This information technology was well integrated into packages of product and process designs that utilized state-of-the-art chemical and mechanical technology. Operations information technology was supported by computer-based monitoring and process control systems across the complete supply chain. Certain of the products used principles of mass customization and postponement while other more commodity items were produced to risk pooled inventories. During the 1975-1985 period, experimentation with point of sale techniques with several retail customers (JCPenney) was common for given Burlington divisions.

For Burlington Menswear, yarn production was driven by a highly sophisticated materials and capacity requirements planning system (MRP/CRP) which had been developed in-house by Burlington staff. Fabric production was driven by a specially developed loom scheduling, warp beam loading algorithm, again, developed in-house. In addition, the dyeing and finishing processes were run by IBM's finite scheduler software CAPOSS. Aggregate planning was accomplished by an, in-house developed, linear programming system and an in-house developed computer-based exponential smoothing forecasting system that allowed for item level and group level forecasts. This forecasting system initiated the planning process for Burlington Menswear with data collected from a state-of-the-art customer order database management system and acted as a Distribution Requirements Planning system (DRP) for the Burlington Menswear distribution center. Most notable about the information technology of the Burlington Menswear division was the high state of system integration that existed among the individual system components. By 1985 conditions of state-of-the-art technology similar to the Burlington Menswear division existed in a number of other Burlington companies.

After, about five years of preparation that included restructuring its supply chains, redefining policies and procedures compatible with the requirements of modern supply chain optimization, the Klopman apparel fabrics division choose to configure its supply chain around the implementation of IBM's COPICS software. This it accomplished during the 1980-1985 period. The COPICS software emphasis was to provide modular software that could be implemented one module at a time using a standard database system and providing on-line management capability. This modular approach was the one followed by the Klopman implementation, the last module being implemented about 1985.

It is fair to say that in its aggressive approach to technology adoption, the firm did not always make the correct decisions. One example is the aborted project to attain the world's most modern customer order servicing system that was undertaken by the Burlington Carpet division in the US. In this project the firm made a decision to enter early with an existing hierarchical database technology, IMS by IBM. This decision was made against an alternative decision to wait for an available relational database technology to be improved. Well into the project and several million dollars later, the IMS project had to be abandoned because it was the wrong technology for the given application. Later applications of a fully relational database technology were more appropriate for the given Burlington application and would have allowed the project to be successful. However, the Carpet project shows the aggressive nature that Burlington approached productivity improvement through technology adoption during the 1975 to 1985 period. This zeal for technological improvement extended to its international operations.

At the beginning of the 1980s, Burlington Industries supported a wide variety of domestic US supply chain operations. It also supported international supply chain operations in Puerto Rico, Mexico, Canada and several countries across Europe. World political conditions were such that Asian operations were not to be considered at the time.

For the international operations, the firm's technology improvement strategy was about to be carried out in Mexico, Canada, Germany and the UK when a world-wide textile recession appeared in the early 1980s. This textile recession delayed these projects into the later part of the 1980s when the attention of Burlington Industries was redirected away from supply chain management issues to those of corporate survival.

During the late 1980s Burlington Industries became the object of several hostile takeover attempts. The end result of actions taken to guard the corporate sovereignty of Burlington Industries against these attempts, coupled with a range of other economic factors, led to a continuous down-sizing of the company, a yearly demise, and eventual bankruptcy of Burlington Industries in 2001.

By the mid 1980s the world-wide textile and apparel recession coupled with the rise of China and other Asian countries as major players in a world textile and apparel economy led to additional rounds of divesture of marginally profitable operations by Burlington and other US textile and apparel companies. During this time much effort was placed on shoring-up the productivity gains of its more profitable operations and focus on technology adoptions was redirected to restructuring operations that they might generate sufficient funds in the short-term to survive. With the NAFTA agreements and growing openings in the former communist world, attention of surviving US textile and apparel companies, including Burlington Industries, shifted from productivity questions within a more static structural environment towards a geographical restructuring of their operations within the new reality of a more open global economy. In general the cost trade-offs of cheap labor and foreign government supported currency manipulations in the emerging global textile and apparel industry greatly outweighed the typical productivity enhancements that could be gained from technology adoption under previous conditions. The end result for companies such as Burlington Industries was either forming partnerships with cheap labor operations in the new economy or declaring bankruptcy.

Lost in the negative aspects of the demise and fall of Burlington Industries in the 1990s, is the technology improvement strategy undertaken by Burlington Industries during the 1970s and 1980s.

Supply Chain Information Systems Technology Under a New Paradigm

If J. Spencer Love were alive today he would see a textile and apparel market structure similar to what he saw in 1950. The difference would be in the global dispersion of the thousands of small under-capitalized mills acting as independent agents in the market place. Love's inclination after World War II was to consolidate a number of the many small independent mills into consolidated, vertically integrated structures that defined product-oriented supply chains. His vision was that these optimized supply chains were more efficient than virtual supply chains formed by ad hoc buyer/supplier market forces. In addition these formal vertical chains could exercise countervailing market power against monopoly forces acting at retail. If Love was true to his vision today the supply chain management control process of these vertically integrated structures would be made considerably easier than was the case during the 1975-85 period for Burlington Industries. Between 1985 and 1995 a good number of information systems limitations that Burlington Industries faced during the 1975-1985 period had been rectified. These advances in information systems technology, in particular, database management technology, would greatly enhance Love's ability to successfully carry out his vision today.

The principle bottleneck that was restricting the potential of modern global supply chain management could be traced to the process of database management under the old paradigm. What was needed was a technology paradigm shift that separated the 1995-2005 period from the 1965-1985 period. What was needed was an improved concept of database management. Here, the answer was the arrival of an effective Relational Database Technology!

IBM gave birth to the modern relational database management system. In 1970 E.F. Codd of IBM published a paper, "A Relational Model of Data for Large Shared Data Banks." In this paper Codd (03) proposed a new database architecture that would free application developers from having to know details about the data being managed. This architecture would allow applications programmers to fit the application to the data rather than the data to the application. Through proper database design it was possible to have database structures where one piece of data could be in only one place and be accessed by multiple users and multiple applications. With the relational database structure it was possible to develop relational database management software that would free applications development from the ills of hardware, software and data dependency. In 1974 Chamberlin and Boyce of IBM published a paper, "SEQUEL; A Structured English Query Language." This paper (01) introduced the concept of a relational algebra and a programming language standard that would allow for the potential benefits of Codd's database architecture to realize its potential.

Although IBM gave birth to the modern relational database management system it was not the major player in the development of modern supply chain management technology under the new paradigm. In the 1970s and early 80s IBM's main business focus was on its 360/370 hardware systems. These systems were getting bigger and faster and multi-processor systems were becoming common, however, the basic architecture of the hardware did not change. This hardware with its multiple operating systems, expensive core memory and minimal application software support, was not an optimal platform for the coming of modern relational database management systems. However, IBM became a player in 1983 when its version of a relational database management system, DB2, was introduced on its MVS 370 technology. In 1987 it introduced the DB2 technology for distributed systems.

However, a number of years were required for all the necessary elements to support modern database management systems to fall into their proper place. The arrival of inexpensive RAM, hardware operating systems standards and local area networks that would transition into the Internet were needed. In addition, communications standards for moving data across networks, and, most importantly, software development of user-friendly relational database management systems needed to be developed before the full effects of the paradigm shift could be felt in the area of supply chain management. The enabler of modern supply chain management is modern supply chain information technology which includes modern LAN and internet technology, modern Client/Server technology and modern relational database technology. These technologies could only be dreamed of during the supply chain era facing the 1975-1985 Burlington Industries.

Under the conditions of the new paradigm one can fit supply chain applications to the data where one database can be common to multiple users and multiple applications. Applications are portable and scalable. One can place emphasis on applications development rather than on non-application computer-based issues. Development and implementation of supply chain management systems can be accomplished with a relatively small amount of overhead cost. With the arrival of Internet technology supply chains become more expansive in location. With standardization of applications and database management systems and software, ownership of supply chain work centers becomes more expansive. Location of work center nodes in a given supply chain has the potential to be a trivial concern. Work center nodes half-way across the world can be treated as if they were next-door. In addition with the arrival of the relational database, relatively inexpensive transactions data can be collected and stored in data warehouses for use with decision support system optimization tools. Thus, the supply chain optimization process is funded with data-rich environments that allow for all components of a given supply chain to see and know their potential relative to the market place.

The Burlington Industries Legacy and Beyond; Summary and Research Questions

Post World War II J. Spencer Love and others looked at a structure of thousands of small, independent textile and apparel mills in the United States and concluded that future market success for the industry would come to firms with consolidated, vertically integrated, optimized, supply chains. Burlington Industries and others carried that business policy as part of their investment strategies through most of the second half of the 20th Century. Today, potential capital investment groups look out on a global economy containing thousands of small, independent, textile and apparel mills across that global economy and wonder if J. Spencer Love had the right idea.

Are there, or will there be, market incentives that will cause future consolidation of independent textile and apparel mills into vertically integrated supply chains similar to those developed by firms like Burlington Industries in the last half of the 20th Century? If so, what geographical structure are these consolidations likely to produce? In the absence of Burlington Industries type consolidations, what is the likelihood of dynamic, virtual consolidations of independent textile and apparel mills into vertically integrated supply chains, where total supply chain flow may be optimized, becoming viable market structures. For both cases, what role will supply chain management technology play in the consolidation process?

With the demise of large vertically integrated textile and apparel manufacturing firms during the 1990s, supply chain structure for textile and apparel became dominated by retail firms with monopoly power. This monopoly power is based on economies of scale and supply chain

management technology. ComputerWorld (08) reports that:
"Wal-Mart Stores Inc. has built an inventory and supply chain management system that changed the face of business."

In the production and distribution of textile and apparel products, these retail firms, such as Wal-Mart, deal with a structure of relatively subservient, globally dispersed, small mills that upon demand dynamically form ad hoc virtual supply chains to meet the needs of the dominant retail firm. This form of doing business is supported in the global economy by foreign governments who are willing to subsidize local production in various ways to obtain benefits of employment, foreign exchange, etc. Here, product prices are low enough for product consumers and profits are high enough for retailers that the benefits of total textile and apparel supply chain optimization are not, at this time, considered of significant importance to adopt network flow optimization approaches as defined in today's supply chain management courses. A study by KPMG and the Massachusetts Institute of Technology (15) concludes that retailers buying from manufacturers with supply chain nodes in the Far East receive little-to-no factory information from the Far East, and those factories received little-to-no long-term information on consumer demand at retail. The study concludes that efforts to improve this lack of information flow fail to support the entire spectrum of the total supply chain.

Specifically, these efforts fail to allow retailers to review factory status information needed to assess likely arrival dates and substitutions, and adjust accordingly. In addition, these efforts fail to allow manufacturers the increased visibility into their factories' production. Also, these efforts fail to allow factories to begin receiving retail plans and forecasts needed to predicate their capacity decisions on more than purchase orders. Thus, the inability to create the immediate visibility of highly detailed and accurate information to all trading partners across the total supply chain precludes the optimization of supply chain flow.

In the absence of best practice, supply chain management scheduling reverts to the shortage list and the entire supply chain reverts to the order launching and expediting process that generates the bullwhip effect discussed earlier in this paper. While order launching and expediting creates non optimal inventory, lead time and production change-over costs, to minimize these costs with modern supply chain management technology does require significant investment by participating firms. Given the modern paradigm conditions the technologies required to develop systems which truly links all components from raw material straight through to the consumer in one trading network are available to anyone that wants to use them.

The study by KPMG and the Massachusetts Institute of Technology (15) concluded that:
"while most consumer goods companies have improved their internal supply chain operations through the use of various new technologies, true supply chain integration is still embryonic."
One can argue that this conclusion is particularly true for global textile and apparel supply chains.

It is not the purpose of this paper to argue the merits of the current structure of the global textile and apparel economy (16). Questions of job creation in developing economies as opposed to economic exploitation of workers are not considered here. Of interest here is the fact that retail firms manage independent demand and modern supply chain management is mostly about dependent demand. If modern supply chain demand stops at defining independent demand, then only a small portion of modern supply chain management takes place; that portion that benefits the more powerful firms. This paper only concerns itself with the question of the vision of Burlington Industries founder J. Spencer Love as to the optimum structure of textile and apparel supply chains. As supply chain management technology has made the formal or virtual vertical integration of textile and apparel supply chains possible, will this structural change take place? Are the economic benefits that caused Burlington Industries to adopt an optimum supply chain strategy based on a formal vertically integrated structure alive and well in today's global economy? One can argue that multiple ownership supply chains can only optimize activities in the presence of strong leadership and this leadership will not come from the retail firms. If this is the case, where does the leadership to integrate modern supply chain technology into the global economy of textile and apparel production and distribution come from? Does the global textile and apparel market have another Burlington Industries attempt(s) to shape the future in its future?

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