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Textile and Apparel Supply Chains for the 21st Century

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ABSTRACT

In this paper the author speculates on what global textile and apparel supply chain designs will need to look like in order to meet the assumed 21st Century costs of expensive energy and green environment coupled with assumed market requirements for ever-increasing demands for product variety with ever-decreasing product life cycles.

Keywords: Supply chain design, expensive energy, green textile & apparel environment, product variety, decreasing product life-cycles; ad hoc, vertical and virtual supply chain design

Introduction

In his best -selling book *Sonic Boom: Globalization at Machine Speed* Gregg Easterbrook (2009) pictures a 21st Century global economy of expensive energy and environmental costs coupled with product markets of ever-decreasing life cycles for an ever-increasing mix of products. He speaks to the arrival of new software-driven, robotic production process systems that will be designed to meet the energy, environment greenness and product diversity/flexibility requirements of the 21st Century. Assuming one accepts the general thesis of Easterbrook, the question of future optimal supply chain design under his assumed conditions is raised. In particular the question of future optimal supply chain designs for textile and apparel products under these conditions is of interest to the author.

In today's global economy optimal customer value comes not from individually competing firms but from the harmony of individual firms acting together in concert as a supply chain. Supply chains optimize customer value via the integration of customer perceptions, product design, process design and an overlaying supply chain network design supported by transportation and information channels. Supply chains must be efficient in that they provide products at low prices while having the ability to quickly adapt to changing customer requirements. But supply chains must also be effective by having the ability to consistently deliver high quality products from innovative concept-to-market flow at a rapid pace, all in support of the customer

being able to maximize its satisfaction per money spent.

In support of product and process design, supply chain design can range between wide boundaries. At one extreme is the classic *vertical* integration design with single ownership control over most or all of the supply chain network production and distribution nodes and the connecting network transportation and information channels. At the other extreme, *ad hoc* designs are formed from a group of independently owned suppliers who are bound only by current market needs, market mechanisms and their willingness to cooperate with each other over a given time period. While *ad hoc* designs can be very flexible in meeting rapidly changing market demand, in that some or all of the supply chain network nodes can change with each transaction, unlike the classic *vertical* integration design, the *ad hoc* design can be very difficult to define, control and coordinate in an efficient and effective manner. Somewhere between these two design extremes is the *virtual* design that attempts to capture the flexibility of the *ad hoc* design with the control ability of the *vertical* integration design. Here, ownership focus is on the core competences of a given set of supply chain nodes, adding independent ownership of additional network nodes needed to complete the supply chain design. As one moves from a more unified single ownership towards multiple independent ownership of network nodes the supply chain design becomes more *ad hoc*. However, to overcome the inherent control problems of *ad hoc*, one aims for tighter definition and control through information sharing, cooperation, and win-win partnerships among all supply chain node participants. In theory, *virtual* supply chain designs are capable of walking an optimal middle ground between *vertical* and *ad hoc* designs, offering both control and flexibility. However, for many applications, *virtual* supply chains have shown to be more problematic with respect to information sharing, cooperation, and win-win partnerships required of all supply chain node participants. Too often local rather than global optimization is the outcome of *virtual* supply chain design with the chain being dominated by one or more powerful network nodes to the detriment of total chain optimization for both chain members and customer value.

Textile and apparel industry structure has a history of being determined by a complex mixture of market and non-market forces. In the post World War II United States, textile and apparel supply chain structures were the product of government trade protection and subsidy. These conditions continue to be the case in today's global economy as developing nations optimize textile and apparel supply chain design for maximum employment and foreign currency accumulation. It is understood that under laissez faire market conditions textile and apparel supply chain design would be different from that observed today. But the question of how different has no definitive answer. To forecast what the textile and apparel supply chain structure will look like under conditions of the 21st Century, one must address the uncertainty caused by government policy. Here one can only make assumptions about policy and with these assumptions follow with economic logic. However, during the late 20th Century, when the U.S. Government decreased protection and subsidy for its domestic textile and apparel industry, there was a ten-to-fifteen year period when the world got a brief look at what textile and apparel supply chain design might look like under conditions of laissez faire. During this period, large capital intensive, *vertically* integrated network structures arose to dominate a number of U.S. textile and apparel product markets before giving way to government protected and subsidized production in developing Asian countries. As time has passed many have forgotten the importance of these short-lived structures. A recap of these short-lived structures offers a useful point of departure for the discussion of future 21st Century textile and apparel supply chain designs. That future of expensive energy and

environmental costs, ever-decreasing product life cycles, ever-increasing product mix sizes, decreasing product lead times and process flexibility for textile and apparel chain designs is the focus of this paper. For various reasons there has, in the recent past, been relatively little scholarly interest in questions of optimal industry configurations for textiles and apparel. However, because of its world-wide magnitude of affects under assumed 21st Century conditions, attention to the impact of alternative design configurations becomes imperative. Thus, the paper will concern itself with the delivery of global customer value via optimal supply chain design structures ranging between the extremes of *vertical, virtual,* and *ad hoc* structures.

Looking Back

During the late 20th Century textile and apparel production migrated to the developing world economies with a supply chain structure not significantly different from that used by the textile and apparel industry of post World War II America as it evolved into the 1970s and 80s. For a generation after 1946, support by the Federal Government's policy of *full-employment*, the U.S. textile and apparel industry was composed of hundreds of small, under-capitalized firms. Using low-skill labor-intensive processes, independent yarn, fabric, fabric processing and product-forming units produced output that was used by other independent units to supply final products for apparel, home furnishings and/or industrial uses. Here the supply chains were primarily of the *ad hoc* design, controlled by various agents and brokers. The chains were fragmented and transitory with great power disparities among many buyers and suppliers. Product flow was optimized by independent brokers, factors and retailers for their disproportionate benefit rather than the benefit of the total chain and customer value. As product prices were supported by government-based tariff and quota barriers, prices and supply chain designs were neither optimal for effectiveness of customer value nor efficiency of production and distribution. However, supply chains were design optimized for maximizing numbers of low-skilled labor jobs. Today, after several decades, except on a much expanded global scale with a few product distribution variations, one can observe much the same supply chain structure in today's global textile and apparel supply chain designs. Today, one can see developing economies producing textile and apparel products using process designs dating back to post World War II America, consistent with assumptions about labor, materials, energy, transportation, inflation and environmental costs of production for that earlier time. While many of these supply chains are more *virtual* than *ad hoc*, in that the designs are structured around core competence in retailing (Wal-Mart, etc.) and some node-to-node information and cooperation is attempted, in effect, little is different from the American model of the 1970s and 80s and few if any textile and/or apparel supply chains are optimally configured to meet the above-defined conditions of the 21st Century.

Horizontal Linked, Vertical Textile and Apparel Supply Chains

In the mid 1970s it was well understood by involved U.S. government, education and business officials that the survival of the domestic U.S. Textile/Apparel Industry in the 21st century was going to be more than problematic. Some U.S. 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, U.S. Departments of Commerce and Labor, etc. The presence of various industry associations such as American Textile Manufacturing Institute (ATMI) and others, was pervasive at meetings to discuss the industry's future. Business leaders gave widely diverse opinions about what was required to promote future U.S.

Textile/Apparel Industry survival. Textile schools such as the one at N.C. 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 U.S. Textile/Apparel Industry. A key issue among textile and apparel industry and government leaders of the time was the supply chain structure (Cooper, Hamby, Shaw, Hard 1977).

Taken as a whole, the post World War II U.S. textile and apparel industries were improperly structured to survive a coming global economy. In the U.S. hundreds of under-capitalized firms were ill equipped to meet new government standards regulating cotton dust, noise, waste effluents, product- flammability, etc. among other personal and environmental social costs. They were ill-equipped to meet the rising energy costs of the 1970s and 80s. In addition, supply chain structure was so lacking in optimal control that growing demand for more customized products could only be accomplished by long lead times, while commodity product production was awash in inventories. These under-capitalized firms and their supply chain structures were ill-equipped to meet the unsubsidized world of expensive energy and environmental costs and react to the conditions of ever-decreasing product life cycles for ever- increasing product mixes. Here, the U.S. Government assumed that the domestic economy had reached a point in its development that further subsidization of the U.S. Textile and Apparel Industry in its present form was no longer of prime national interest.

In the mid 1970s, a relatively small number of well capitalized U.S. textile firms began an attempt to beat the survival odds through the efficient and timely adoption of technology and radically different supply chain designs. There was a belief among these companies that in the face of significant price disadvantages with subsidized foreign competition, the proper utilization of chemical, mechanical and information technology, in concert with a number of horizontally connected *vertical* supply chains optimized for customer value, would allow long-term survival for a small number of well structured, capital intensive, textile and apparel firms. By the mid-to-late 1970s two large textile firms, Burlington Industries and Milliken and Company had obtained a dominant position in the industry with this strategy. [Cooper's paper (2006) presents the Burlington Industries view of supply chain strategy of the time.] Writing in 1976 for the U.S. Treasury Department's Office of Industrial Economics, Hudak and Bohnslav (1976) 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 U.S. 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-customization production and information-based techniques in consolidating diverse textile supply chain activities across multiple product lines into well integrated and optimally controlled, profitable operations. Much of the success of the Burlington Industries/Milliken and Company experiment was based in the belief that the natural, *laissez faire*, state of textile and apparel production/distribution did not have to be labor intensive and of *ad hoc* supply chain design. The strategy of Burlington Industries was to develop a supply chain of capital, materials and information intensive business with controlled flexibility. Here, in addition, they were betting that their horizontal connections of optimized, *vertically* integrated, single ownership supply chain designs, 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 21st Century. The fact that these U.S. textile giants did not survive the coming of the global economy does not necessarily mean that their vision was wrong. Complicated political forces played a dominant role relative to market forces in causing these *vertical* chain structures not to survive the 20th Century. Today one might well ask the question: Could it be that as global conditions become more laissez faire with minimal government subsidies, horizontally linked *vertical* supply chains as developed by Burlington Industries and others a generation ago could best meet the dual needs of control and flexibility for the 21th Century?

Virtual or *Ad Hoc* Supply Chain Design

Today most global textile and apparel supply chains that service the U.S. economy lie somewhere between the *ad hoc* and *virtual* definition given above. Most are run, for consumer products, from forecasts of independent demand at the retail level where the core competence of market power resides for the chain. Here, a number of U.S. retailers of textile and apparel products have the most efficient and effective computer-based product distribution systems in the world. These distribution systems of companies, such as Wal-Mart and others, support something called *Distribution Requirements Planning* and represent only a fraction of the total production/distribution supply chain nodes that support flow management for the entire supply chain network. Here, dependent demand for retail needs is, in the main, run under various forms of *ad hoc* design and thus circumvents much of the modern theory and tools of supply chain management. True supply chain management focuses not only on the flow of the independent demand of final product but also on the dependent demand of all production, movement, storage, etc. flows of the components of value that generate the final product. U.S. retailers are very good at telling someone what they want and when they want it, but from that point little by way of modern supply chain management is being practiced up the supply chain of those developing nations producing textile and apparel products for U.S. consumption. The retail-based *ad hoc* supply chain designs for dependent demand are not so much optimized as a function of flow control of lead times, capacities, inventories and transportation cost, as they are of nationally subsidized, labor intensive, production processes that are designed to meet some national economic agenda (i.e. the Chinese/U.S. Government/Wal-Mart connection.) To make this point, consider breaking the cost of U.S. imported textile and apparel products into two terms. Call the first term a *price effect* that is associated with the subsidized, variable cost payments to textile and apparel suppliers for products. Call the second term a *supply chain design effect* that isolates the supply chain opportunity costs associated with control of lead times, production/distribution capacities, inventories and transportation costs. A look at today's magnitude of difference between these two terms shows that the current subsidized *price effect* greatly dominates the *supply chain design effect*. Thus, from the U.S. retailer's and customer's point of view, supply chain design change is not a priority to be wished for, compared to the variable cost price of receipt of the goods. Large inventory and transportation costs are easily tolerated within the comparative advantage of significantly attractive product price effects that are variable costs to U.S. retailers. Thus, it is not surprising that the current global supply chain designs for textile and apparel are being considered optimal by both buyers and suppliers for current conditions. However, are these *ad hoc* supply chain designs for dependent demand textile and apparel items adequate to meet the assumed changing needs of the 21st Century?

Today, modern information systems that support Enterprise Resource Planning (ERP) and Advanced Planning and Scheduling (APS) software systems allow properly structured *virtual* supply chain

designs to simulate the positive control features of *vertical* chains, under conditions of node-to-node information sharing and cooperation. However, the non-permanent, short-life, conditions of *virtual* chains coupled with appropriate transfer pricing structures to generate partner-motivation present a major challenge, particularly subject to conditions that are endemic to developing economies. Small under-capitalized firms are ill equipped to purchase and maintain standardized information systems and software that are necessary for *virtual* simulation of *vertically* designed chains. Thus, the current global economy for dependent-demand textile and apparel products are prevalent in *ad hoc* chains some with little across-node visibility but all awash in excess inventory, capacity, transportation cost and/or long lead times and customer waiting. Here, a number of authors are speaking to these and other problems. Bruca, Daly and Towers (2004) call for the effective use of lean and agile process techniques coupled with mass-customization and postponement strategies that are consistent with either *virtual-vertical* or *pure-vertical* supply chain designs. Lam and Postle (2006) discuss textile and apparel supply chain designs by addressing the problems of short product life cycles, long processing lead times and uncertainty of demand. In addition, they discuss the impact of supply chain design in meeting the needs of transport distance and increasingly small production lot sizes, all of which are raising supply chain logistics costs. *Virtual-vertical* supply chain design strategies and designs for functional (commodity) products and innovative (customized) products are also discussed. The ATA Journal for Asia on Textile & Apparel (2009) reports on how Association of Southeast Asian Nations (ASEAN) suppliers are exploring new ways to improve competitiveness in textile and apparel industries. At the heart of their concerns is supply chain design. One section of the report is on the needed development of *"virtual-vertical integration."* In order to increase required innovation and product flexibility need, ASEAN suppliers are cooperating in horizontally linked, *vertical* supply chains consisting of independently owned supply chain network nodes. In general it is becoming clear to this and other observers of the global textile and apparel scene that, like the 1970s and 80s of America, without continuing governmental and environmental subsidization of many textile and apparel products, the *ad hoc* supply chain structure for the dependent demand of the industries of the developing world will not be adequate to meet the assumed needs of the 21st Century.

Textile and Apparel Greening

In a 1975 study sponsored by the U.S. Treasury Department and performed at the North Carolina State University School of Textiles, Cooper and Dyer (1975) documented the inability of under-capitalized textile and apparel firms to meet the required capital investment needs of newly arriving process technology both for new product development and, in particular, rising energy and environmental costs.

During most of the 20th Century technological advancements for textile and apparel production processes were gradual and non-disruptive to the supply chain structure of the U.S. industry. During this period process technology was defined by a mix of machines and chemistry that had remained relatively static over many years, as the processes for producing the primary cotton and wool products had remained relatively static. Information technology was of little to no importance. New machine technology arrived at such a pace that seldom was an existing machine put at a major competitive disadvantage by a new machine until long after the end of the depreciation period for the existing machine. In 1974 looms that had been originally purchased in 1906 were in place producing fabrics for U.S. textile and apparel markets. The major portion of a firm's capital cost for technology was machine maintenance consisting of dollars for replacement of worn-out parts. In general, capital cost for

production process technology did not restrict entry into the textile and apparel industries. These conditions defined a core of hundreds of small, weakly capitalized firms and their sporadic participation as members of various *ad hoc* designed supply chains. As a result of ease of entry and exit into and out of given chains, across all chains, excess production capacity was the rule rather than the exception. Here, energy costs were relatively modest, environment regulations were lax and product prices were supported by subsidy and trade barriers. However, the 1970s saw significant developments that changed the existing process design paradigm and with these developments changed the way of thinking about textile and apparel supply chain design. The U.S. Government began to impose regulations that mandated process changes. Noise control, cotton dust control and waste disposal control were only three areas of concern. New developments in chemical technology and information technology were significant. Here, the further development of thermoplastic materials for fibers, yarns and composites had a profound effect on production process designs. In addition, the development of computer-based information systems opened new possibilities for production and distribution process linkages. Rising energy costs mandated the purchase of new energy efficient technology.

During the 1970s high productivity shuttleless looms began substantial penetration into U.S. weaving technology driven by advancing labor costs and government regulated noise control in weaving. Additional penetration was generated by demand for the new 'textured wovens" from thermoplastic yarn developments and the wide loom widths required to competitively produce these fabrics. The new thermoplastic yarns also created new markets for knitted outerwear fabrics and the machines to produce them. Across the production process of fiber and yarn, fabric forming, the dyeing and finishing of fabric to the cut and sewn product, the development of thermoplastic materials radically changed textile and apparel process design and the need for capital to support these changes. Meanwhile new technology in the natural fiber materials of cotton and wool were being developed, new "open end" methods of yarn forming being one example. All textile markets including industrial, home furnishings and apparel, their processes and their supply chains, were affected by these developments. Hundreds of small, undercapitalized firms were forced into disrupting technology acquisition and supply chain design (membership) decisions and/or into bankruptcy. The period represents a case study of how an entire industry can be forced to near extinction by its inability to make needed investments. It was during this period that the movement by capital-rich Burlington Industries and others to horizontally-linked *vertical* supply chain designs became a dominate force in U.S. textile and apparel supply chain design. The period represents a rare case study in how U.S. textile and apparel supply chain design was affected by the new conditions requiring product flexibility and control through the innovative use of advanced technology. The answer for the time was horizontally-linked *vertical* supply chains of the type generated by more capital-rich Burlington Industries and others. During the first years of the 21st Century the U.S. textile and apparel industry literally picked up its machines, its processes and its supply chains and moved them to developing countries. Even today, the internet is full of used machine brokers trying to sell used textile and apparel technology around the world. These technology acquisitions find their way into *ad hoc* supply chains directed by agents of retail powers such as Wal-Mart.

Fengfei Zhou (2009), in the paper *Study on the Implementation of Green Supply Chain Management in Textile Enterprises,* speaks to textile and apparel industry environmental problems in today's China and the impact of supply chain design. Here Zhou speaks to the future survival and development of the Chinese textile and apparel industries. Zhou

questions the Chinese supply chain designs and their deficiencies in dealing with future required innovation, product flexibility, energy and environmental costs. Textile Outlook International (09) speaks to the following:

"the expansion of textile production and consumption has contributed to increasing pollution, water shortages, fossil fuel and raw material depletion, and climate change. Production of Polyester fibre, the most widely used manmade fibre, consumes non-renewable resources and high energy levels, and generates atmospheric emissions. Modern automated textile plants consume large amounts of energy. Textile finishing consumes large amounts of water and energy and often produces harmful effluent. Apparel production is more environmentally friendly, but sourcing from low cost countries consumes more fuel for transportation. Among consumers, the trend towards fast fashion and cheaper clothing has led to a throw-away mentality."

Today, a careful reading of global textile and apparel scholarship reminds those of us who experienced the decline and fall of the U.S. textile and apparel industries during the 1970s – 1990s as déjà vu.

Efficient vs. Flexible Supply Chains

Taylor (2004) says that the first step of supply chain design is to understand the pattern of product demand a given supply chain has to serve. Textile and apparel products serve a wide variety of different patterns of product demand. Thus, a discussion of textile and apparel markets implies multiple approaches to optimal supply chain design. It is important for the reader to understand that one supply chain design strategy for a given product group may be a poor fit for another given product group. Industrial textile products have many variants but are, in the main, components of final products. They are price sensitive, and require more efficient, fixed path supply chain designs. In addition, a portion of home furnishing and apparel products are aimed at more functional (commodity) product markets that compete on low-price and also optimize on more efficient, fixed path, supply chain designs. However, a growing portion of home furnishing and apparel products are aimed at more innovative (customized) product markets that optimize around more highly flexible, variable path, supply chain designs that can deliver products with short lead times under conditions of uncertainty. Many textile and apparel products fall between the two design extremes. Efficient, fixed path, supply chain designs are optimized on the basis of material-process-working capital productivity and low unit cost. Flexible, variable path, supply chain designs are optimized around lead times under uncertainty with acceptable unit costs. Taylor points out that product customization shifts the push-pull boundary further up the supply chain. Standard, more functional products allow the boundary to be set close to the final consumer so these products can be made to stock and pushed all the way down the chain in anticipation of demand. More customized products move the push-pull boundary up the chain, as the definition of the end product is defined early and pulled down the chain by existing customer orders. It is important to align the interaction of customer-product-process-supply chain to a given efficiency vs. flexibility supply chain design strategy for a given textile and/or apparel product. Taylor breaks this alignment process into the following four steps:

1. Decide how to make the strategic trade-off between flexibility and efficiency,
2. Analyze existing chain design for its ability to meet the strategy,
3. Use mathematical and simulation models to evaluate options,
4. Use experience insights into the nature of the business in firming design.

A close examination of available tools to support trade-off analysis for global textile and apparel supply chain design alternatives shows these tools greatly lacking. While King, Hodgson, Little and Thoney (2002) have done some good work in the area of

Decision Support Models for design analysis and option evaluation for textiles and apparel, not enough work has been done in support of good research in this area. In order to attack supply chain design questions of the 21st Century, more research in this important area is needed.

The P&G and Wal-Mart Model

One may argue, as does the author, that the lessons of history teach that future laissez faire textile and apparel supply chain designs will be *vertical or virtual-vertical* with horizontal links across product variants. Supply chain network nodes will be populated by capital intensive, information intensive partners using communication and transfer pricing policies that provide win-win solutions for network node participants and optimize customer value for the supply chain. The Graen and Shaw paper (2006) about the Procter and Gamble/Wal-Mart partnership supports this thesis. In the paper the authors describe a supply chain partnership between two equals: a capital and information rich manufacturer (Procter and Gamble) and a capital and information rich retailer (Wal-Mart). The paper details their win-win cooperation of information-sharing across their mutual supply chains that is making their total chain designs more efficient and better coordinated. The partnerships have resulted in increased total product sales and reduced needs for inventories. The authors point to the increasingly important need for relationships such as these, both for total supply chain product flow control improvement and for increasing the volume of customization required in future commerce.

Summary

In this paper the author argues that the current global textile and apparel supply chain structure is ill-designed to meet the coming problems of the 21st Century. It is suggested that supply chain design changes will be required to relieve the structure from continuing high levels of government subsidy. It is suggested that laissez faire textile and apparel supply chains for the 21st Century must be optimized via combinations of capital intensive firms operating in win-win partnerships within power-balanced *virtual-vertical* supply chain designs operating across horizontal links of product variety. Here, manufacturing firms must be sufficiently capital rich to purchase and maintain the required energy and environment protection technology. In addition, both manufacturing and distribution firms must possess the financial resources required to support the information and logistics technology for enhancing supply chain network node-to-node communication for supporting increasing volume and customization needs for customer value. An example model for future supply chain design might be one that mirrors the essential features of the current P&G/Wal-Mart model in a more regional rather than global lead time logistic.

The point in 21st Century time when the observer can expect to see evidence of more laissez faire efficient and effective textile and apparel supply chain designs depends on how long the governments of developing nations are willing to subsidize the current structure. Here economic research of developing nations can only point the way to the timing of future textile and apparel supply chain design planning.

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