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Lessons Learned from the History of Technology Adoption in the US Textile Industry

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ABSTRACT

Frederick Allen, writing in American Heritage of Invention and Technology discusses the nation's technological achievements during the twentieth century. In his article he reminds the young reader that the seeming chaos created for the current generation by an information age, where changes are discontinuous and happening at a geometric rate, are not really new to human history. The same type of chaos was well known to the great-grandfathers of the current generation.

Keywords: Invention, technology, supply and production.

Introduction

"So 100 years ago we didn't have an Internet or cell phones, but we did have networks of telegraphs and telephones for instant communication around the world; we didn't have superhighways or 747s, but we did have trains and steamships that reduced the longest journey to a tiny fraction of the time it had taken only decades before; we didn't have television but we did have motion pictures and we had newspapers bringing us nearly instant news."

From Allen we learn there is something universal about the constant change of technology. We learn that technology has never been, and never will be, good or bad. It is neither inherently good nor bad because it is all about what people ask for and do. It is about human activity. Technology reflects both the best and the worst of humans.

Following Allen's thought process, it follows that technology invention and adoption can be explained by studying human activity and the processes used to channel their activities. It is the bias of this author that while the process of invention is not necessarily about economic survival (necessity is the mother of invention); the adoption process of choosing among alternative available technologies within a competitive business environment is about economic survival. Here, the operative word is *competitive*. The process of invention is often carried out as a non-competitive process of discovery and scholarship. Often the process of invention is governed by a desire to achieve a monopoly position for a process that can be exploited for future monopoly profits. However, given invention, adoption of available features of invention are, within a competitive environment, driven by the desire for economic advantage and long-term economic survival. In a competitive environment, the adoption of technology is about supplying maximum value per consumer dollar to a firm's customers. It is also about the production possibilities trade-offs among resources and the relative factor prices that determine technology's position on a given production possibility curve for a given situation.

In his article Allen does not discuss the significant impact of the new global economy on the technology invention or adoption process. No one that passed from the 20th to the 21st century can deny that the world of today has become significantly more competitive than the world of our parents. To look at the world of today, for better or worse, one sees nation after nation accepting the market system as a primary determinate of human behavior. In general, the world is becoming increasingly economically competitive. Ethical decisions as to exploitation of labor, the environment, etc. are more and more being left to market system determination. One can argue, so too will be the case for future technology adoption decisions. What might one forecast as a "steady state" solution for this increasing reliance on the market place by humans to determine their technology?

Of the three basic needs of humans, food, shelter and clothing, the last two, shelter and clothing, are intimately involved with the production and distribution of textile products. If technology is about human activity, the author can think of few products that are more pervasive to the human existence than textile products. In addition the US textile industry was an early example to the world about how technology adoption behaves in a near perfectly competitive world. So, what is the connection between the textile supply chain and technology? A young university colleague of mine recently indicated to me that "there was nothing to learn about technology adoption from such a backward industry as textiles." It seems that this attitude is pervasive for many people under the age of 40 who view the textile production and distribution supply chain as beginning in Asia and ending at the local shopping center. It is the bias of the author that one has a great deal to learn about the ever-more-competitive global economy by studying the rise and fall of the US textile industry. To understand technology adoption in the 21st century one must understand the basics of global market economics. This was true for the textile industry of the late 20th century and is the reason that one can learn from the technology adoption decisions from the textile experience of that period.

As the 1960s closed it was well understood by involved government, education and business officials that the US textile industry was entering interesting times. At stake was the survival of the industry as the country moved toward the 21st century. 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 associations, representing segments of the industry, such as ATMI, American Textile Manufacturing Institute, and others, were pervasive at meetings to discuss the industry's future. Business leaders had opinions about what was required for the industry's future survival that were diverse and contained a high degree of variability. And textile schools such as the one at NC State University, serving an international student clientele, were poised to do scholarly things to aid the industry's survival. It was the beginning of very interesting times for the future of the US Textile Industry! The central theme of this paper is that while the US textile industry, taken as a whole, was improperly structured to survive a coming global economy, a relatively small number of well capitalized textile firms attempted 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 market disadvantages, the proper utilization of chemical, mechanical and information technology would allow textile firms long-term survival. These few firms aggressively implemented this strategy during the decades of the 1970s and 1980s and it was not until the 1990s that it became clear to most that the strategy was not working. During the 1990s technology oriented textile firms lost ever-increasing market share to global supply chain components who possessed considerably less technological sophistication than those being supplanted. During the 1990s, those that put much faith in technology as a means of continuing business survival learned that technology is not a panacea. These people learned that for some-time-to-come cheap labor and government policies to provide jobs in developing and third-world countries will more-often-than-not trump technology adoption. During the 1970s and 1980s a number of US textile firms created an impressive base of supply chain technology, much of it in the computer-based systems areas of productivity improvement, product quality, supply chain lead times and customer service. As more and more of these firms have become bankrupt, significant amounts of an extremely valuable knowledge base about textile production/distribution supply chain systems, and the expertise of the people who developed and nurtured these systems over a thirty year period has been lost and has generated a future need for the essential features of these systems to be reinvented, redeveloped, reunderstood, at a later date within a more "global" environment. The textile experiment that was based on the assumption that technology was a sure pathway to long-term survival was an edifying process that should not be ignored, but learned from as new more geographically diverse textile supply chains emerges in the decade of 2010. *Will someone please queue the Gone With the Wind Theme?*

What is the Textile Industry?

Writing in 1970 Cooper (6) pointed to the need for a new definition of the textile industry. Anticipating a significant influx of new technology that would greatly alter the classical view of the supply chain that produces and delivers textile products, Cooper proposed the following definition:

"A workable definition for the future would be to define the textile industry in terms of those components that produce and add value to the one basic textile material, the textile fiber (a textile fiber may be natural or man-made, but must have the property of having a length which is several hundred times its width; it must also be capable of being spun into yarns or produced in filament form). The above definition includes the fiber producers, any new process which produces a product from textile fibers (such as the new nonwoven processes for fabric forming) those elements responsible for the marketing and distribution of these products, in addition to the classical components of the textile industry such as yarn spinning, weaving, knitting, etc."

Textiles; A Backward Industry?

It can be argued that the beginning of the end for a competitive, domestic, US textile industry was the decade of the 1980s. In the 1970s this industry was made up of hundreds of small, weakly capitalized firms. During the 1900-1950 period, US textile firms operated in an environment where technological advancements were gradual and non-disruptive to the structure of the industry. Textile technology was built around the production of cotton and/or wool based products. The knowledge base about technology was well diffused and, in the main, mechanically based. Loom manufacturing and the US market for these machines was dominated by two firms. Two different firms dominated the manufacture of yarn spinning equipment supplied to US companies. The Market conditions relative to new technology developments in textile machinery were at such a slow pace and productivity improvements so marginal that seldom was an existing machine put at a major competitive disadvantage by a new machine, until long after the depreciation period for the existing machine. In the mid 1970s, many looms that had been originally purchased in the first decade of the 1900s were still in place and producing fabric in the US. The textile technology of the period was that of purchased replacement parts for machines that had originally been purchased many years earlier. In general, capital cost, technology and associated knowledge were not major deterrents to US production of textile products during the first fifty years of the twentieth century. This slow rate of advancement of technology in the production and distribution of textile products had been a comfort to the many small, weakly capitalized, firms that made up the industry structure. For over a half century, the US Textile Industy exhibited the stability of an industry that was relatively free of decisions imposed on capital owners via technological change. Required decisions to adopt or not adopt new technology for the purpose of competitive advantage were few and far between. It was this lack of progress in technological advancement and a continuing reliance on unskilled labor that prompted the image of textiles as a "backward industry" in the 1970s.

In March of 1970 Dr. Michael Lock of Derring Milliken Company (6) made a presentation to a joint meeting of the American Textile Manufacturing Institute and the National Council for Textile Education on the state of technology in the textile and apparel industries. Here, Dr. Lock pointed to the slow rate of technological growth in these traditional industries during the decades of the 1950s and 60s. Dr. Lock made his point by tracking the number of scientists, engineers and knowledge workers employed in the traditional textile and apparel industries, using data supplied by the National Science Foundation and Bureau of Labor statistics, and showing these numbers to be small and without any appreciable growth. In an earlier 1969 meeting of the American Textile Manufacturing Institute John P. Figh (7) of the Chase Manhattan Bank said:

"Over the next six years the US textile industry will have to spend a minimum of $2 billion more than it earns to remain competitive in world markets. Even in 1975 about 35% of the productive capacity will be outmoded or marginal. To bring this figure down to 10%, an additional $3 billion should be invested."

Writing in 1971, Cooper (7) contrasts the above numbers of John Figh to the fact that during the 1966-70 period the average rate of capital investment growth for plants, equipment and process improvements via all type of technology was a negative 5.4% per year. This he used to seal his argument supporting the need for government tax policy incentives that would encourage major structural changes across the total of US textile production and distribution supply chains.

A US Treasury Department study by Hudak and Bohnslav (2) showed that in 1973 the US textile mill products industry contained over 7,000 different production organizations. This aggregate earned 2.9% on sales as compared with 4.7% for all US manufacturing. The textile industry's return on stockholders equity was almost 4% less than similar returns on all manufacturing equity. In their study Hudak and Bohnslav concluded that in part, the lower rate of investment in performance improving technology, across all US textile production was due to a scarcity of outside equity capital and long-term credit inhibited by the low level of profits. How was the domestic US textile industry going to overcome its perceived image as a "backward industry" and survive within a future global economy? What, if anything, could government policy do to aid the survival of this industry? These two questions were central to the Hudak and Bohnslav study. In general, by the late 1960s and early 1970s, the days of comforting, slow rates of technology advancement were over for textile firms. In the late 1960s and early 1970s things began to change. Advances in chemical, mechanical and information technology became potentially available at a rapid rate for industry adoption during the decade of the 1970s. In the 1970s how the arrival of technology and knowledge and the potential adoption of the fruits of discovery would affect the US textile industry was of great interest to industry leaders, US government officials and the US public in general.

In December of 1976 The National Science Foundation awarded the North Carolina State University School of Textiles a grant for the purpose of studying the factors that would contribute to the advancement of productivity in the US textile industry. This grant supported the organization and development of the *Textile Industry Productivity Workshop* that was held at North Carolina State University in Raleigh, North Carolina on January 18-20, 1977. The *Workshop* was attended by fifty invited participants representing industry, labor, government, and academia. Participants were chosen using a criterion of knowledge and national influence relative to the issues under study. The objective of the workshop was to develop from the industry perspective a listing, in priority form, of those areas of study which were most likely to have the greatest impact on improving productivity through the advanced use of technology and knowledge in the US textile industry. The study priorities were to be used by National Science Foundation and other national research units, both public and private, for a better understanding of the costs and benefits of expending additional research dollars in the pursuit of productivity advancements through science, technology and knowledge. Although funded by National Science Foundation, the results of the workshop were intended to serve as a guide for the support or non-support of future studies by private companies, industry associations, academic institutions, and government research agencies other than National Science Foundation.

Conclusions generated by participants at the *Textile Industry Productivity Workshop* varied across groups of participants. In particular, representatives from the stronger (size and capitalization) US textile firms argued that the major priorities for improving textile productivity were two; foreign competition and industry structure.

These participants argued that the existing structure, containing four to five thousand marginally capitalized domestic firms, depressed prices and profit rates to the point where the rate of capital investment by firms with access to investment capital and the general rate of productivity growth were greatly retarded. These representatives argued that private funds spent for technology and knowledge improvements could, over time, lead to a healthy concentration of the industry into fewer business units and these business units would be able to survive in a global market environment within a domestic US structure. This group of participants was in strong support of government tax policy incentives that would aid the more capitalized firms to increase private capital spending across all types of productivity improving technology. Some participants believed that any government policy tax incentives would be "a day late and a dollar short." Several workshop participants concurred with the following point made by one of the discussants:

"while I can see a concentrated, technology, knowledge-based, textile industry that is globally competitive through smart use of productivity and our marketing advantages, I do not believe we have the ability to get there in time to save the domestic industry given our industry structure starting point."

While there was a general consensus among workshop representatives of industry, government, labor and academia as to the major importance and appropriateness of government sponsored studies in areas dealing with the impact of government policies and regulations on the US textile industry, this was not the case for government sponsored studies into technology based productivity improvements. A general agreement was held among industry leaders that government sponsored studies of this type acted as a way to subsidize weaker firms in competition with stronger firms. To survive in a global economy the industry needed to rid itself of these weaker firms and replace them with more concentrated, capital intensive, technology intensive, knowledge intensive firms. It was all about structure!

Writing in 1976, Hudak and Bohnslav's US Treasury Department's study for the Office of Industrial Economics (2) reported findings consistent with the conclusions of the *Textile Industry Productivity Workshop* (4). Addressing those textile industry critics that referred to the textile industry as a "backward industry," Hudak and Bohnslav pointed to the existence of a small number of highly progressive firms such as Burlington Industries, Milliken and Company and Texfi as profitable outliers in the US textile industry aggregate. They pointed out that firms, such as these examples, 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 slower reacting and smaller firms. They pointed out that many of these more profitable companies were integrated vertically and/or horizontally to gain in flexibility, diversification and financial strength. After acquiring control of smaller mills, companies such as Burlington and Milliken had applied mass production and information-based techniques in consolidating diverse textile supply chain activities into well integrated operations. Other companies, such as Texfi sought greater control over its source of fibers and as a consequence began to manufacture man-made fibers for their own knitting mills. Together these events gave these firms, and others, the potential of transforming the textile industry into a small group of expanding, profitable, firms engaged in integrated activities and competing against a massive number of existing small firms who would continue to remain in the industry until survival was no longer possible. However, in 1975 Cooper (3) reported that the Burlington, Milliken, Texfi, etc. group of firms represented only 30% of the domestic US textile market share with small under-capitalized firms sharing the remaining 70%.

Progress and Failures of Technology Adoption in the US Textile Industry

Technology Adoption in Apparel the OAC Solution

A major problem for domestic US producers of apparel products during the 1970s and 1980s was the labor intensive nature of the cut and sew processes involved with the apparel forming process. Using standard production techniques of the time, the labor cost differential of US and foreign wage rates was, in most cases, too pronounced against US apparel firms to maintain a viable presence in the total US textile-apparel supply chain. Thus, many textile firms supported mills in Central America and the Caribbean to cut and sew apparel fabrics as they moved through the supply chain to ultimate distribution among US outlets. During the 1970s and 1980s one could watch daily flights from Greensboro NC and other southern airports where large planes carried locally produced fabric to various non US destinations and return as cut and sewn products.

Just as Burlington Industries and a handful of other textile companies tried to beat the odds for firm survival in the US through technology adoption, during the 1970s and 1980s a few apparel firms flirted with a similar strategy. While the strategy never reached fruition, the various attempts by a few firms was note-worthy. The strategy is referred to in this paper as the *OAC Solution*.

OAC (Operations Analysis Company) was a consulting company based in Atlanta Georgia. Unlike another Atlanta based consulting company, Kurt Salmon and Associates, who only served textile and apparel clients, OAC was an engineering based company that specialized in productivity improvements, irrespective of industry. The basic sewing processes of US apparel firms had in the 1960s adopted the Kurt Salmon concept of *the traveling bundle* as their process of choice. This concept treated the apparel sewing process as a job-shop process, where operators at stationary sewing work centers sewed bundles of processed materials, stored in backlogs behind each work center, as the bundles were differentially routed from work center to work center. In the absence of computer based scheduling of work flow, the traveling bundle system tended to generate large quantities of in-process inventory, long lead times and poor reaction time to the diverse needs of the market place. The OAC approach to the problems of apparel processing was an outside the box, non-conventional wisdom solution. This approach was developed in a small number of operations and tested for the feasibility of the approach.

In a college level Operations Management course, students learn the different approaches to processing. One method of processing is the job-shop approach used by many different types of production firms including those firms producing textile apparel. A second approach that students learn about has to do with various ways machines can be configured and balanced to produce something similar to what might be called an *assembly line*. In general, assembly line approaches to processing tend to generate significant improvements in labor productivity compared to job-shop approaches. For years the conventional wisdom was that assembly line approaches to apparel production were totally out of place in the apparel industry. Thus, any solution to the labor productivity problems of the US textile industry that advocated an assembly line approach was met with a closed mind from the start. That was the case of the OAC Solution.

In the late 1970s and early 1980s robotics and digital computer based methods for optimum fabric cutting were being perfected in non-apparel industries and research institutions. The OAC solution saw the integration of these two emerging technologies as a potential solution for the labor intensive fabric cutting component of apparel processing. For the more important labor component in the sewing process, the OAC solution was to develop a process of flexible machine cells that could be quickly, with computer-based scheduling aid, configured into a labor-balanced assembly line. This solution took advantage of the fact that sewing machines are easily moveable and can quickly be configured and reconfigured as *machine cells*. When coupled with a simple set of moveable, conveyor belt type material handling devices, the experiments with this approach showed the potential for significant labor productivity improvements. What was needed was the development of software that would allow the OAC solution to become a general solution. Rates of Return on investment in the OAC solution were shown to be significant and those involved believed that the approach would allow a number of US based apparel firms to survive and prosper in the coming global economy of the 1990s.

The OAC solution is an example of a technology solution for a major industry that was never adopted. Implementation of the approach was considered too risky by firms that in-the-main were under-capitalized and unable to justify any approach to the improvement of productivity that was not certain. During the late 1980s and the 1990s apparel firms in the US began to disappear and found their way to cheap labor countries dispersed across the new global economy.

<u>Computer-based Monitoring and Process Control</u>

By 1969 a relatively small number of visionary firms in the US textile industry had made significant progress in the adoption of computer-based process monitoring and control technology. This case is well documented in the article <u>Data Collection; Mill Machine Monitoring</u> appearing in the September 1969 publication of *Textile Bulletin* (5). The article treated the emerging technology of:

"sophisticated electronic instruments, data collection systems and computer analysis and control systems not found in mills a few years ago."

Textile Bulletin reported that about 100 US firms had successfully completed projects to implement electronic data collection systems to either monitor and/or control process operations by 1969. These systems included the monitoring of processes across both yarn forming (spinning, twisting and drawing frames) and fabric forming (looms and knitting machines). Some small subset of these firms had extended their monitoring technology in actual process control where, based on monitoring generated data, automatic action is taken to change the current behavior of the on-going process.

In 1969 data collected from computer-based monitoring systems was being used by a select number of firms for decision support and cost accounting. Significant improvements in process productivity were reported across firms adopting these systems. Much of the improvement came from workers being better able to judge actual against standard performance and make on-the-spot adjustments more rapidly to process deviations from standard. By 1969 computer-based process control technology had advanced for some few firms beyond just data collection. It had advanced to the point where systems were being used to initiate corrective action in processes. In this way the computer receives and analyzes data, as in data collection of dye shade in the fabric or yarn dyeing process. But in addition, using data analysis as input, the computer-based technology signals an action message to the process, maintaining the process within given predefined parameters. *Textile Bulletin* reported that electronic instruments and control devices for a significantly increasing number of textile production processes were becoming available for potential adopters.

Burlington Industries

In 1980, Burlington Industries contained over 20 business divisions, both domestic and international. Its total sales were approaching 3 billion 1980 dollars of sales. During the 1970s the management of Burlington Industries adopted a *technology improvement strategy* that was to be phased across its various business operations over time through the 1980s. Its strategic plan was to allow its most profitable divisions to reinvest profits in productivity improving, cost reduction, technology. 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 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 base developed in other parts of the company.

In retrospect the technology improvement strategy undertaken by Burlington Industries during the 1970s and 1980s was a significant success. Interviews with the responsible management of the time, personal involvement with the business decisions of the time and access to intra-office management documents, allow the writer to clearly comment on the progress of the *technology improvement strategy* for Burlington Industries during this period. During the 1970s and first half of the 1980s Burlington Industries developed a number of its businesses into "state of the art" operations through the adoption of the world's most modern production and information technology. In addition to the world's most modern yarn and fabric production machines, the Menswear (worsted fabric) operations contained state of the art computer-based information technology. Operations information technology was supported by computer-based monitoring and process control systems across the complete supply chain. Yarn production was driven by a highly sophisticated materials and capacity requirements planning system (MRP/CRP). Fabric production was driven by a specially developed loom scheduling, warp beam loading, algorithm. In addition, the dyeing and finishing processes were run by IBM's finite scheduler CAPOSS. Aggregate planning was accomplished by a linear programming system and a computer-based exponential smoothing forecasting system that allowed for item level and group level forecasts initiated the planning process with data collected from a state of the art data base management system. Most notable about the information technology of the Burlington's Menswear division was the high state of system integration that existed among the individual system components. By 1985 similar conditions of state of the art technology such as the case in the Burlington Menswear division existed in a number of other of Burlington's companies. It is fair to say that in its aggressive approach to technology adoption, the firm did not always make the correct decision. 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 hieararcheral database technology, IBM's CICS/DL1, 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 CICS/DL1 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 1970s and 1980s. This zeal for technological improvement extended to its international operations.

At the beginning of the 1980s, Burlington Industries supported international 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.

New technology adoption, including information systems approaches developed for its domestic divisions were to be applied to international businesses in locations that could not be called "cheap labor" countries and were already negatively impacted by a global textile economy that was in a state of significant excess capacity. For these international operations, the firm's *technology improvement strategy* was to be carried out in Mexico, Canada, Germany and the UK when a world wide textile recession appeared in the early 1980s. By the mid 1980s this recession and the rise of China and other Asian countries as major players in a world textile economy led to a first round of divesture of marginally profitable operations by Burlington and other US textile companies who had chosen an aggressive approach to technology adoption. 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 opening markets in the communist world, attention of many of the surviving US textile companies 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-off of cheap labor in the emerging global textile industry greatly outweighed the typical productivity enhancements that could be gained from technology adoption at existing locations. The end result was either forming partnerships with cheap labor operations in the new economy or declaring bankruptcy.

What Was Learned From the Textile Experience?

View of Technology Adoption in the US Textile Industry

During the 1970s, Cooper, Hudak and Bohnslav all made the point that technology adoption in the US textile and apparel industries was about, in the first place, having the resources to consider technology adoption and, given the available resources, having the required knowledge base to assess the risk of using or not using the available resources to adopt a given technology at a given point in time. These authors point to multiple case studies of textile technology investment behavior during the 1970s and 1980s where the great majority of US firms were unable to take advantage of available opportunities in technology advances because of lack of available investment capital. For the small number of firms that could take advantage of these opportunities, the correct adoption strategies depended to a large degree on risk assessment knowledge of the technology potential and the appropriate timing to adopt the technology.

Cooper, in his 1975 (3) writings, looked at investment in textile and apparel technology as a high stakes game limited to a select few firms that had the resources to play. He argued that the very existence of the game had a significant impact on the structure of the US industry. He explained the typical technology adoption process in the textile industry as follows:

"Consider a situation where technological advances come so rapid that new technology A makes old technology B obsolete within a very short period after technology B is purchased. Starting in the late 1960 and continuing through the 1980s into the 1990s these conditions will be present within the US textile industry. These conditions put small, weakly capitalized textile firms in uncomfortable positions. With a given advance in technology all affected textile firms are required to make decisions. The alternatives are:

1. Purchase the advancement before competing firms and, under successful conditions, exploit a monopoly position with that advancement.

2. Wait for a competing firm to purchase the advancement and make purchase decisions on the basis of the success or failure of the advancement in other firms.

3. Wait for an additional advancement over the present and, in the present, postpone adoption decisions.

The above decision process forces firms into risk taking decisions where the decision taken is based on expectations of the ability to exploit a new technology with sufficiently high expected rates of return that justify allocating capital in this way. The process largely favors those firms with larger access to financial capital and access to the human capital resources that allow firms to better understand the technology cost/benefit environment at a given time in the decision process. In general, under conditions of accelerating technology, the firm making the most correct decisions from alternatives 1, 2 and 3 above, will likely be in the most favorable market position, thus, maximizing its expected survival, over time."

Students of game theory may relate the above adoption process to a game where the player with the most information about how to play the game and the largest pool of funds for playing the game, in the long run, in theory, will always win.

In the case of the textile industry, the lead time required to exploit new technology advancement was important. In the late 1960s and 1970s technology absorption by a given company was affected by the structure of the industry supplying textile technology. During this period, technological advances in textile production were primary mechanical and this technology was being monopolized by European machinery producers. Thus US firms were required to get in line behind foreign product producers and wait to purchase the newest technology. Some US firms chose to "buy" their way into a favorable queue position in order to assure themselves of short lead times for the receipt of the new advances. Other firms were forced into the above decision 2, or decision 3 statuses because of their poor position in the technology vendor queue and the lead time required to absorb the advance. These conditions when viewed on a global basis created world market capacity shifts that led to excess world capacity and depressed prices for US produced textile products.

In general, during the 1970s, 80s and 90s, a textile firm's profitable investment in new technology depended on the ability of that firm to exploit the advance over a lead time that justified the investment. Given the competitive conditions facing US textile firms at the time, as the initial cost of new exploitable technology increased, either the rate of profit flow from that investment had to increase or the lead time available to the firm to exploit the new technology had to increase. Also, as the initial cost of new exploitable or non exploitable technology increased, the cost of making the wrong decision at decision point 1,2 or 3 above increased. At some point of increasing initial cost for new textile technology the risk of a wrong decision became prohibitive for many or most of the four or five thousand weakly capitalized US firms (mentioned earlier) so they continued to choose decision 3; to not adapt new technology and wait for the inevitable day when they are driven from the market by an inability to compete. Such was the case for much of the US textile industry during the decades of the 70s, 80s and 90s.

The experience of the US Textile industry raises a number of researchable questions. One obvious question has to do with the degree of market competition and the level of technology adoption. The textile experience may imply that as markets approach a state of pure competition, technology adoption greatly decreases. Conversely, as firms discover ways to gain degrees of monopoly power, technology adoption is encouraged. Is there some minimum level of market pricing power required to cause a positive flow of technology adoption? Does the textile experience point to more competition means less technology adoption? If so, does that mean that as the global economy becomes more and more competitive there is a tendency towards a steady state that slows down the technology adoption process? The textile experience points to the understanding of risk levels as a major factor in the technology adoption process. If one uses the surrogate of Investment Dollars Required per Lead Time to Exploit Advantage for a measurement of risk, does not the smaller lead time available as markets become more competitive argue for less investment in technology adoption as global competition becomes more intense? These and other research questions are implied by the US textile industry experience. Whether trivial or not, one does gain insight from the study of one of the world's most competitive industries and how its behavior might be used as a learning tool.

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