

NANOTECHNOLOGY AND THE NORTH CAROLINA TEXTILE INDUSTRY

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1. Problem Description

Over the past few years the U.S. textile industry has had to face increased competition from international producers able to lower the price on primary textile products like garments and apparel. These capabilities are based on the access of these companies to cheaper sources of labor and material. Indeed, most of the competitors are located in China and other Asian countries like Vietnam. The competition soon spread throughout the global marketplace, and it has become so hard and price-driven that U.S. companies, even those with large dimensions and economies of scale, have had to adapt or exit the textile business.

Among the strategies chosen, a few powerful companies tried to lobby the U.S. Congress to gain protection in the domestic market through tariff and quota definition; others had to relocate their manufacturing facilities in order to gain access to cheaper labor markets. Many set up plants in Mexico and the Dominican Republic, but also in China (in November 2001, Burlington Inc. established its worldwide headquarters in Hong Kong to manage the outsourcing process and Shakespeare LLC opened a plant in China in April 2005).

This economic situation and the loss of competitiveness has had a significant impact on the United States, especially in the Carolinas, where the textile industrial base is centered. From January 2001 to August 2003, almost 300,000 U.S. textile jobs were lost with a peak in July 2003 of 8,900 jobs lost in one month.

Currently, the trend is still well defined towards stiffer competition, where the traditional strategies are not able to provide any competitive advantage. Indeed, according to the WTO regulations and China's membership, textile import quotas were removed on January 2005 and textile importation was material. The January data show an increase of 1,000% in cotton trousers imported from China. Other major increases were recorded in men's, women's, boys' and girls' cotton shirts and several other categories of trousers and underwear. The data show that China has a 35% share of the U.S. import market for textiles and a 22% share for apparel. The overall market share of 29% is the highest of any single country in history. Somewhat surprisingly, imports from Hong Kong, Macao and Taiwan were down about 25 percent, a development that industry trade officials say is a reflection of China's cutting back on transshipments through those countries. Caribbean Basin Initiative countries showed a 16% increase in what could be a reflection of importers looking to nearby countries for more of their sourcing.

Overall, in February 2005, the trade deficit achieved a record \$61 billion. In the first two months of this year, the trade deficit with China rose by 47% over the comparable period last year, and

industry officials said at that rate it could grow to \$238 billion this year. The U.S. trade deficit in textiles and clothing was \$12.9 billion in the first two months of this year, an increase of 16.5%. If trade continues at its present rate, the textile and apparel deficit could reach \$85 billion this year.

Moreover, as expected, the job loss in the same period trended upward. Employment data released by the Bureau of Labor Statistics in March 2005 show that textile and apparel job losses during the first two months of this year are continuing at a rate higher than last year at this time. The BLS data show that the textile industry lost 4,900 jobs in January and in February apparel job losses were 4,800.

In 2004, the U.S. textile industry lost 4.3% of its jobs, which was down significantly from the 13% in 2003; but the current trend indicates the 2005 job losses are running ahead of last year. Textile representatives in Washington attributed the increasing job losses to the removal of import quotas at the beginning of this year.

“The severe job loss report suggests that the U.S. textile and apparel industry employment is experiencing a downturn associated with removal of quotas, and unless strong emergency safeguard measures are taken soon, the loss of textile and apparel industry production and jobs will accelerate in the coming months,” said Auggie Tantillo, executive director of the American Manufacturing Trade Action Coalition.¹

2. Nanotechnology as a Solution

To salvage North Carolina’s textile industry, the state’s existing plants/mills must innovate through expenditures in nanotechnology research and development. One American textile entrepreneur said it best when he proclaimed, “My industry needs senior managers and researchers with the frontier mentality found at Apple or Intel or biotech startups.” Specifically, textile mills can move up the value chain through the production of textiles endowed with extraordinary properties made possible via nanotechnology. Possible end products may include: stain and wrinkle resistant garments and super strong fabrics that can be used for multiple purposes (e.g., astronaut suits, bulletproof vests, outdoor pavilion tents, etc.).²

The elements of nano-scale products are subminiature compounds that are frequently grown like crystals or dispersed through molecular scale nozzles. The nano-scale compounds are incorporated into ordinary materials during or after the original manufacturing process. In the case of nanotech fabrics that are stain and wrinkle resistant, rolls of woven material from textile mills are immersed in liquids containing trillions of nanotech fibers. Subsequently, the saturated textile matrix is dried in ovens which bind the nanofibers to the larger textile threads. Ultimately, the treated fabric appears unchanged but exhibits wrinkle and stain resistant properties.

There is precedent for the use of nanotechnology in this manner. For instance, widespread commercial use began in 2001 when retailers such as Eddie Bauer, Gap, and Levi Strauss began to weave nanofibers into pants, shirts and sweaters to make them water and wrinkle resistant. As is the case with many consumer packaged goods in the United States, consumer demand for convenience is a driving force that will enable the market for nanotech-treated textiles to grow exponentially well into the future.

3. Benefits of Nanotechnology to the Textile Sector

Current commercial nanotechnology applications represent limited opportunities for the North Carolina textile industry to regain a competitive advantage. This is largely because the manufacturing processes remain labor-intensive. However, anticipated next-generation

¹ www.textileworld.com

² Washington Post; April 8, 2005; Innovation Not Quotas; Gary Heiman

nanotechnologies hold the promise of breathing new life into the textile industry in North Carolina, primarily through the development of radically new products. The process of “molecular manufacturing,” that is, precisely building a material molecule by molecule, means that near-perfect textiles can be assembled. Current textiles contain flaws and inconsistencies. At a micro-level, these fissures result in a reduction in textile strength and performance. Flaws visible to the eye also diminish the value of a textile to a consumer. A precisely-engineered, uniform textile will have immensely superior properties. For instance, a shirt could be made that is 10 to 100 times stronger than those available today, with molecular properties that repel flame, water and dirt. The amount of materials used would also be much less, meaning that a garment could be significantly lighter and less bulky.³

This type of manufacturing capability could give a North Carolina-based textile company a great competitive advantage. Consumers would need fewer of these clothes which would resemble their old clothes in appearance only. As a result, manufacturers could charge premium prices and enjoy high margins. This would allow North Carolina-based companies to compete outside the space that overseas manufacturers of traditional, commoditized textiles dominate.

One of the main reasons that textile manufacturing has moved overseas is the low cost of labor. Nanotechnology would level this playing field through a high degree of automation. With nanobots and micromachines doing most of the actual manufacturing at a molecular level, the need for direct labor is greatly reduced. This is an important point, because it demonstrates how this solution will not bring back the thousands of relatively low-paying factory jobs that have been shipped overseas. Rather, new high-value jobs would be created in areas such as design, research and development, and sales and marketing. While these opportunities would enhance the economic vibrancy of the state, they would not solve the employment needs of laid-off factory workers.

4. Environmental Benefits of Nanotechnology

Molecular manufacturing also stands to greatly reduce the environmental impact of textile manufacturing. Waste can be practically eliminated; current manufacturing techniques involve copious use of dyes and harsh chemical cleaning agents which are often dumped into the environment in developing countries with lax regulations. Instead, the manufacturing precision afforded by nanotechnology means that not a single atom has to go to waste. Any unwanted atoms can be neatly repackaged for recycling or be returned to their source.⁴

The technique mirrors what is observed in a natural process such as photosynthesis, whereby plants transform solar energy, water and soil into leaves, stalks and shoots. The impact on the environment will be vastly reduced. Some experts believe that nanotechnology-based manufacturing processes will lead to the reduction of up to 99 percent of the energy and materials used today.⁵

5. Return on Investment

The U.S.-based think tank, Venture Development Corporation, believes that through the use of nanotechnology, textile products ten times as strong and as durable as steel can be developed. In addition, the U.S. National Science Foundation has predicted that the U.S. market for nanotechnology products and services could reach \$1 trillion by 2015. If the textile industry

³ “The Future Impact of Molecular Nanotechnology on Textile Technology and on the Textile Industry,” David R. Forrest and the Industrial Fabrics Association International, 1995-96, www.salsgiver.com/people/forrest/IFAI_text.html

⁴ “Unbounding the Future: the Nanotechnology Revolution,” Foresight Institute, www.foresight.org/UTF/Unbound_LBW/chapt_9.html

⁵ *Natural Capitalism*, Hawken, Lovins and Lovins, Little, Brown and Company, 1999

accounted for just 1% (\$10,000,000,000) of this market, the state's textile industry would experience an economic rebirth.⁶

Niche markets also represent a potential windfall for nanotech-equipped manufacturers. Government contracts could be particularly lucrative. Consider a police department's interest in lightweight shirts and pants that exhibit the strength and bullet-stopping abilities of heavy Kevlar vests. Military contracts could also be worth billions. The U.S. military is more likely to source from in-country suppliers and would be highly interested in lightweight, protecting garments that could insulate soldiers from a variety of environmental conditions, and even possess some adaptive camouflage technology, akin to that found in the skin of a chameleon.

As the federal government increases funding for space exploration with the goal of putting astronauts on Mars, advanced spacesuits that can withstand space debris and extreme environments will be needed. A final idea centers around "smart" fabrics that read a person's vital signs and provide biometric feedback to the wearer. This could be of great value to athletes, or any of the target markets mentioned above. Such a fabric could also be designed with a medical application in mind - to provide medicine directly to wounds, or even to inject medicine into the body when particular viruses or bacteria are detected.

However, the investment needed to compete in this space will be heavy. North Carolina's textile industry has been decimated over the last 20 years and may need to look to venture capital or to raise debt equity. Major costs include training employees on new technology, the capital investment in new manufacturing techniques and machinery.

In addition to these costs, the largest expense is likely to be the investments in research and development needed to move from the current nanotechnologies (e.g. those used by Levi Strauss) to the next-generation molecular manufacturing plants. This technology leap is demonstrated in Exhibit 1. Current nanofiber weave technology is in the commercial phase, and represents the current competitive environment. Eventually, these manufacturing techniques will be surpassed by molecular manufacturing, where cheap labor is no longer a competitive advantage and the door will be open for the North Carolina industry to compete with vastly superior products. In order to make this leap, up-front large investment in research and development is needed, since these technologies are currently only in the invention or even the theoretical stage.

⁶ Technical Textiles International, March 2003, pages 13-15.

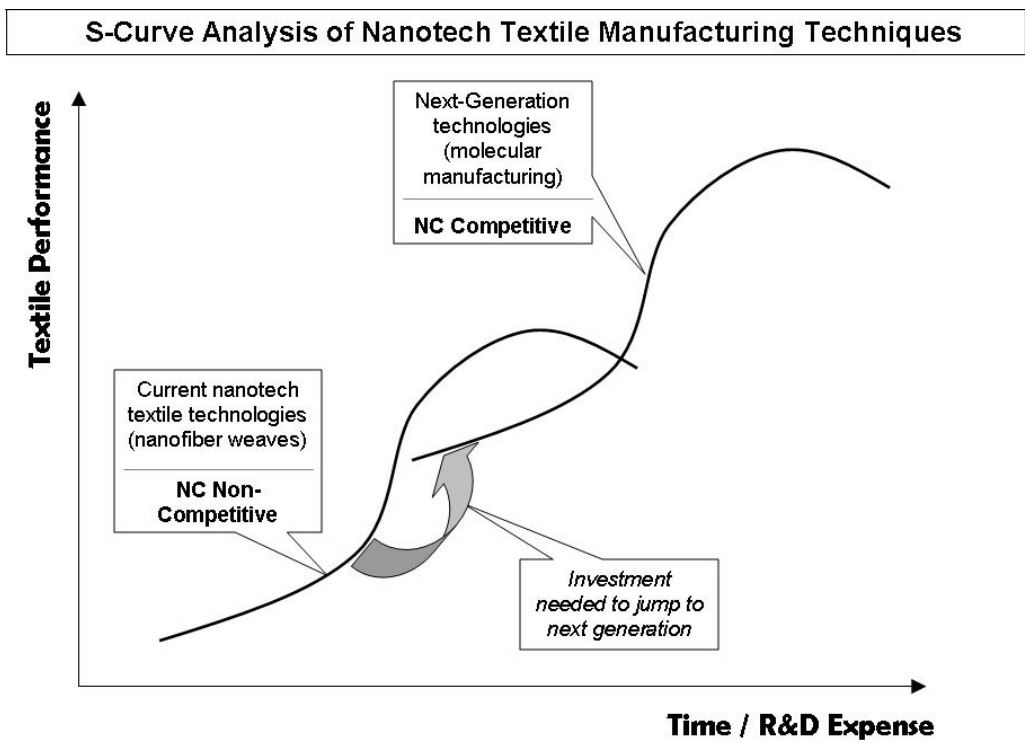


Exhibit 1: S-Curve Analysis of Nanotech Textile Manufacturing Techniques

6. Case Studies

Nano-Tex Inc.

The nanotechnologies applied to the textile industry can be a viable way to gain new competitive advantage. The U.S. companies are able to provide the consumers with innovative products, thus shift the competition from price to differentiation. The current level of knowledge and achievements in the scientific framework are significant to support the integration into the product design and manufacturing processes.

One of the leaders in this strategy is Nano-Tex. The company is based in Emeryville, CA, was founded in 1998 and in 1999 became controlled by Burlington Inc., which now has 51%. The company developed several treatments based on nanotechnologies and is able to enhance the performance of the fabric without reducing the comfort. Nano-Tex has begun applying the technology in readily-available natural fibers such as cotton, wool and silk, as well as synthetics including polyester and nylon.

The significance of Nano-Tex technology lies in the fact that it only takes general factory equipment and water, facilitating mass production without capital investment required in principle. The company has achieved successes in the development of finishing agents and methods that allow an outstanding degree of durability through a permanent, direct or mutual bonding with fiber, whereas in many of the conventional finishing methods, binders or coating agents are applied on the fabric surface to give special functions and characteristics. Minimum alteration of hand and color is expected in each of the finishing methods.

The most famous technological achievements are Nano-Care, Nano-Pel, Nano-Dry, Nano-Touch, Nano-Press. However, Nano-Tex continues the development effort and in 2005 released three fabric treatments: Resist Static, Coolest Comfort and Repels & Releases Stains. The company has brought all these technologies registered, or currently being applied for, trademarks, integrated under the brand name Nano-Tex. With trademark rights having already been established in the U.S., Japan

and Europe, it will target the whole world for the promotion of licensing contracts under the single brand name.

Its strategy concerning the brand name includes the affixation of a Nano-Tex tag on every piece of fabric and garment produced through licensed technologies to promote recognition of their particular advantages among consumers. The company's business model is focused on the development of the technologies and the registration of the patents (more than 70 so far).

The control ownership of Burlington is an opportunity to test the technologies and the feasibility of the transfer to mass production, but it does not hinder the sale to competitors.

Currently several leading groups are commercializing products enhanced by Nano-Tex technologies. Burlington, Galey & Lord and Dan River were the first to buy the license. Nano-Dry has been adopted on a full scale by the three major U.S. trouser manufacturers, Levi's Dockers, Savane and Haggar, leading to the on-going rapid expansion hitting the front shelves of most department stores and national chain stores (Sears and JCPenny). Having also included the uniform manufacturers Elbeco and Blauer among its users, Nano-Dry application is considered to become requisite for synthetic uniforms. In the area of nylon and polyester sportswear, Burlington with a view to cost reduction has started the production of Nano-Dry fabric in plants located in China and the surrounding areas, with favorable responses from major sportswear manufacturers.

Nano-Tex has been able to expand in Asia and Europe. Due to the peculiar differences and the broad coverage, Nano-Tex decided to partner with specialized consulting firms, to whom exclusivity was guaranteed for the licensing sale in the region. International Textile Management Consulting was appointed to expand in Japan; several Southeast Asian (China, South Korea and Taiwan) mills have joined in mass production, licensed to produce thick Nano-Care cotton fabric. A number of major shirt and shirting fabric manufacturers in SE Asia are currently preparing for the commercial production of 100% cotton Nano-Care shirts, also through licensing contracts. In Europe, Martelli Lavorazioni Tessili, Italy, one of the world's largest laundry and garment finishers, was first to become licensed (Nov. 2001).⁷

Koranaka Technologies Inc.

Kornaka is based in Lowell, MA and develops new fabrics with innovative features and applications. One of the recent projects relates to the integration of the photovoltaic process into the fabric design and manufacture through a nanotechnology program. The company will develop a photovoltaic fabric in which solar power-generating properties are woven into the fabric rather than applied to the fabric surface.

The smart fabric will be able to convert the solar energy into electricity. Such opportunity might not be readily accepted by the large consumers but will offer new perspective for mobile electronics manufacturers and users. The fabric may work as a recharger for appliances, and using the fabric for garments, tents and coverings will significantly increase the power duration. Moreover, since it is solar dependent, therefore renewable, it can be particularly useful in constrained conditions for scientific and emergency applications, where electricity is not available or reliable. Currently the project is supported by the Swiss University of Technology and represents a trend towards the regeneration of the fabric concept from commodity for basic traditional applications into valuable mean to access and transfer innovative technologies to the end consumer.⁸

⁷ "Nano-Tex (U.S.) starts sales of finishing agents in Japan through its sole agent ITMC"
<http://textileinfo.com/en/tech/nanotex/page01.html>

⁸ www.textileworld.com

7. Implementation Plan

In order for the state's textile industry to make an informed decision regarding the implementation of our advised nanotech conversion, the following scenarios must first be considered. Key uncertainties include whether the North Carolina textile industry will make this up-front investment in technology, and whether consumers will embrace the radically new products (see Exhibit 2).

Scenario 1 (Most Likely):

North Carolina's textile industry takes immediate action to make itself a world class producer of nanotechnology enhanced textiles.

Necessary steps and ramifications: The initial cost of conversion will be high as textile companies will have to retrain their employees and must hire additional personnel with expertise in nanotechnology and operations. In addition, many of the existing plants will have to be renovated and enhanced with new technology in preparation for the new product output. Statewide costs associated with the aforementioned activities may surpass \$1 billion dollars.

Societal and miscellaneous influences: Investors and consumers alike become enamored with the innovative products and consumer demand rises exponentially. Subsequently, the investor class begins to pour money into nanotech/textile companies based in North Carolina which, in turn, further stokes demand, innovation and job growth.

Benefits: The state's textile industry will be able to produce premium products for global consumers at a price that presumably manufacturers in India and China will not be able to match. In addition, North Carolina's early entry into this market will enable it to create increasingly innovative products and services that will provide it with a sustainable competitive advantage relative to competing entities.

Scenario 2 (Medium Probability):

North Carolina's textile industry decides to employ a wait-and-see strategy with respect to nanotechnology adoption/conversion.

Ramifications: Manufacturers in other American states, Southeast Asia and elsewhere will take advantage of the technology. As such, these entities will gain first mover advantage and will establish market share that North Carolina's textile companies may be unable to usurp. With respect to innovation, North Carolina's textile companies may never be able to surpass competitors if it forgoes the first mover advantage.

Benefits: It is possible that the market for nanotech textiles may never flourish as our predictions indicate. In this case, North Carolina's textile makers could forgo needless expenditures germane to plant conversion and would not risk losing money.

Scenario 3 (Least Likely):

Identical to Scenario 1 with the exception of societal and miscellaneous influences.

Societal and miscellaneous influences: Global activists seize information which indicts nanotechnology as an ecologically dangerous form of technology. Real or perceived environmental damage occurs (in accord with nanotechnology pioneer, Eric Drexler's "Gray Goo Hypothesis") and consumer demand approaches zero. In addition, investment in nanotechnology comes to a halt and nanotech textile manufactures encounter a barrage of litigation germane to product liability concerns.⁹

⁹ USA Today; 9/27/2004, *Nanoproponents Square Off Against Specter of Gray Goo.*

Scenario Analysis for N.C. Textile Industry Nanotechnology Conversion

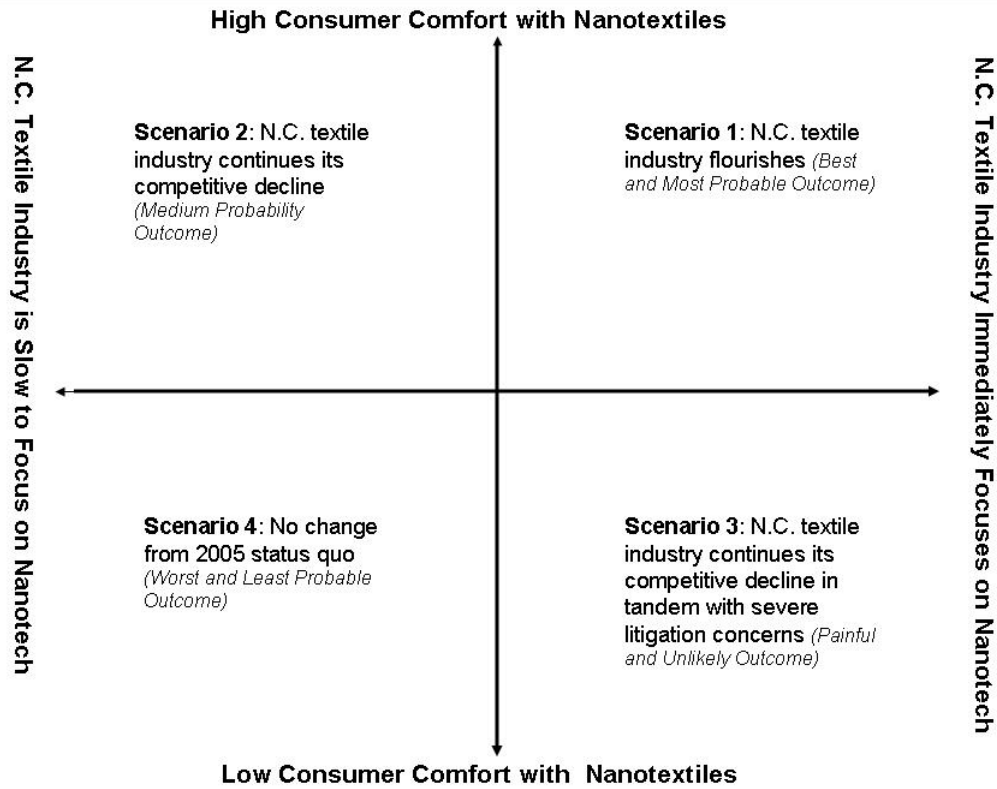


Exhibit 2: Scenario Analysis for N.C. Textile Industry Nanotechnology Conversion

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