

National Textile Center
FY 2003 (Year 12) New Project Proposal

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Competency: Integrated Enterprise Systems

Strategies for Increasing Competitiveness of the Domestic Textile and Apparel Industries: A Production-Cost Approach

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Objective:

The objective of this research is to identify ways in which to improve the competitiveness of U.S. textiles and apparel industries in the global marketplace. Understanding the competitive situation of domestic textiles and apparel requires an examination technological factors that affect efficiency and cost, such as the production structure of domestic firms, technological change, firm size and innovation, and economic factors, like government policy, NAFTA/CBI, and foreign exchange rates that affect the industries' ability to compete. In a changing global environment U.S. firms face intense competition from "cheap imports," which are the result of a combination of 'low wages' in the exporting countries, and favorable foreign exchange situation vis-à-vis the U.S. A key to improving competitiveness lies in the ability of domestic U.S. firms to find least-cost methods of producing output e.g. through increased "capitalization" to improve labor productivity, efficient use of inputs such as energy, determining optimal 'firm size' and/or reorganizing production as in "lean retailing" and "quick response." Besides cost minimizing measures, product innovation is the key to counteracting shrinking export markets. Further, it is the objective of this project to examine how the industries' R&D decisions, government policy such as NAFTA, and foreign competition, affect profitability of the textile and apparel industries in the U.S.

Relevance to NTC Mission:

The U.S. textile and apparel industries have faced difficult times over the past three decades. This sector has seen large-scale downsizing, with the share of manufacturing employment declining from 12.1% in the 1970s to 8.1% in the 1990s (Francisco, 2000). In 2001 alone, the number of plant closings in textiles was as high as 100 and the industry lost about 60,000 workers, about 10% of U.S. textile workforce (ATMI, 2001). Intense import competition from low wage developing countries in apparel and both developed and developing countries in textiles has been a major factor to contend with. Competition has intensified with the gradual phasing out of the protective barriers (the Multi-Fiber Agreement (MFA)) and the devaluation of Asian currencies since 1997, which further challenges the competitive strengths of this sector.

The crisis facing the domestic textile and apparel industries requires a broad based analysis of the factors that impact the competitiveness of the sector both from the perspective of the industry and that of government policy. Strategies to enhance competitiveness must be based on an understanding of the production characteristics of firms, such as substitution possibilities between inputs, technical change and scale economies, as also an understanding of the larger economic environment in which firms operate. Evidence¹ suggests that while the overall industry may be shrinking in size, firms that have survived in the new environment have done so by re-inventing themselves through shifts in technology, and reorganization of production. The textile industry has responded through greater "capitalization" and increased "product" and "process" innovation. Investment in new plant and state of the art equipment increased from \$2 billion in 1987 to nearly \$3 billion in 1999 (ATMI, 2001). This has included the development and use of shuttle-less looms, robotics, "nanotechnology" (which employs techniques from molecular engineering to improve fabric performance), and the creation of "smart" fabrics etc. The apparel industry on the other hand has turned towards reorganizing production through supply-chain management techniques such as - "quick-response" production structure, minimal inventory "lean retailing", and offshore manufacturing (Mexico,

¹ Levinsohn and Petropoulos (2001), Working Paper, NBER.

CBI countries etc.). Yet, external factors such as trade policies and exchange rates are issues that the industry has to contend with continually. The key to the problem therefore lies in identifying the best strategies that would allow the domestic textile and apparel industries to not only compete, but also lead the way in global arena.

This research is dedicated to accomplish this mission using a sophisticated modeling approach. A cost (profit) function analysis will be used to quantify substitution possibilities among inputs in order to find the optimal input mix, study the nature of technological change and its role in improving competitiveness, and determine optimal “firm size.” The study will be conducted at an industry and plant level. This will allow us to study the behavioral differences between the overall industry, which has been declining, with the potentially productive and competitive elements within it. The results of this research will also shed light on the impact of trade agreements, foreign competition, and overall government policy on the profitability of this sector.

State of the Art:

Production function studies in the textile and apparel industry (Batavia, 1979; Gupta and Taher, 1984; Ramcharran, 2001) have considered only two inputs capital and labor, while optimizing output/cost. However, competitiveness of a firm lies in not only the efficient use of labor/capital but also the minimization of energy and resource cost. Additionally, Cobb-Douglas and C.E.S. production functions used in literature to model the production process assume constant elasticity of substitution between inputs. This restricts the ability of these models to study changes in input mix and technology that occur in response to changes in the external market environment. These shortcomings are overcome by using a *transcendental logarithmic* (translog) cost function approach developed by Christensen, Jorgensen and Lau (1971). This approach has been widely used in recent research to study input substitution, technical change, scale economies and productivity growth in the U.S. Manufacturing. The translog cost function does not impose any *a priori* restrictions on elasticities of substitution between inputs and therefore is easily adaptable to handling multiple inputs.

Approach:

To achieve our major objective, we will examine the production-cost structure of the U.S. textile and apparel industries. This involves developing and estimating a cost-minimization (profit maximization) model in order to

1. Determine the extent or degree to which capital (K) and labor (L) can be substituted within the production process, with the object of minimizing costs. For example if K and L are substitutes, the future growth path may lead to capital deepening and labor saving. However, if they are complements the scope for lowering labor intensity of production may be negligible.
2. Determine the nature of technological change in U.S. textile and apparel industry and its role in improving competitiveness.
3. Measure the elasticity of cost with respect to energy and examine substitution possibilities between energy and non-energy inputs.
4. Measure economies of scale in the industry – whether large-scale or small-scale operations are optimal for improving competitive strength.
5. Measure profitability in U.S. textile and apparel industries, as a function of innovation, market share, trade agreements such as NAFTA, and competition from Asian markets.

We will utilize the translog dual cost function approach (Christensen et. al. 1971) to estimate substitution elasticities between inputs, returns to scale and the nature of technical change in the textile and apparel sector. To do so we specify a *cost minimization* model where unit cost is expressed as a function of the prices of inputs, capital (K), labor (L), energy (E), materials (M), R&D capital (*RD*), total output (*Q*) and technical change (*T*).

$$\min C = f(P_K, P_L, P_E, P_M, RD, Q, T)$$

The general form of the cost function is expressed in its translog form as follows:

$$\begin{aligned} \ln C = & \alpha_0 + \alpha_q \ln Q + \alpha_R \ln RD + \sum_i \alpha_i \ln P_i + \frac{1}{2} \gamma_{qq} (\ln Q)^2 + \frac{1}{2} \gamma_{RR} (\ln RD)^2 \\ & + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j + \sum_i \gamma_{iq} \ln P_i \ln Q \\ & + \sum_{it} \theta_{it} T \ln P_i + \theta_{qt} T \ln Q + \beta_i T + \frac{1}{2} \beta_{tt} T^2 \end{aligned}$$

where $i, j = K, L, E, M$, and $\alpha, \beta, \gamma, \theta$ are the parameters estimated by the model.

The translog cost function is then used to get estimates of *optimal* demands for inputs (K,L,E,M)², substitution elasticities³ (σ_{ij} 's) between K, L, E and M, economies of scale⁴, and the nature of technical change⁵. Whether inputs are substitutes or complements within the production process is determined by the sign associated with the σ_{ij} 's. For example, $\sigma_{KL} > 0$ would suggest that capital and labor are substitutable within the production process, thereby indicating the possibility of lowering cost, by employing more capital and less labor. Further, the magnitude would indicate the extent of substitution possibility. In the technical change equation (see footnote 5), θ 's measure the biases in technical progress. Technical change is *i*th factor saving if $\theta_{it} < 0$ and factor using if $\theta_{it} > 0$. Thus $\theta_{LT} < 0$ or $\theta_{ET} < 0$ would indicate labor-saving or energy saving technical progress. The β 's measure exogenous technical change.

Next, we will examine the role of innovation, government policy and foreign competition in determining profitability of this sector by estimating the following dummy variables model.

$$Profits = \beta_0 + \beta_1 MS + \beta_2 RD + \beta_3 D_{NAFTA} + \beta_4 CUR_{ASIA} + error$$

where *MS* is the market share of U.S. textile (apparel) industry in total world output, *RD* represents total R&D spending by domestic firms, *D_{NAFTA}* is the dummy variable used to capture the effects of NAFTA, which takes the value of zero before 1997 and 1 thereafter, *CUR_{ASIA}* is a trade-weighted currency index of top ten Asian textile exporting countries.

This study will be conducted using time-series data, at a macro- and micro-level. For the industry level study, data will be obtained from the Dept. of Commerce and the Bureau of Labor Statistics (BLS) and ATMI. Plant-level study will be based on U.S. Census' Longitudinal Research Database (LRD), and also data directly gathered from publicly and non-publicly traded firms in each industry. The plant level study will delineate firm behavior through a comparative analysis based on ownership - private versus public, and age - new (entrants) versus old (exiting) firms, thereby providing a characterization of the industry's ability to meet competitive challenges.

This Year's Goal:

In the first year we will focus on the broader macro-level study. As a first step, data will be collected and compiled from the various sources listed above to create the variables for our model. We will then estimate and quantify the productive efficiency of labor, capital and energy inputs, the extent of factor substitutability, nature of returns to scale and the nature of technical change in the respective industries. Additionally, we will study the competitive situation in each industry by examining the effects of NAFTA, Asian currency devaluation and innovation. Sector and plant level analysis, and policy recommendations will follow.

Outreach to Industry:

A crucial part of this study is based on information gathered from companies in the respective industries. The conclusions from this study will provide businesses in the industry with a broader perspective on issues that they deal with at the micro level, thereby helping them make more informed decisions. The results and recommendations from our analysis will be presented to major industry groups like the ATMI, published in related industry journals, and presented at economics conferences for peer review.

New Resources Required: Econometric Software packages; firm and industry level data

² Differentiating cost with respect to input prices yield the cost minimizing levels of input ($\partial C / \partial P_i = X_i$).

³ $\sigma_{ij} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j}$ (S_i 's are cost shares) measures the elasticity of substitution between inputs K, L, E and M.

⁴ Returns to scale is measured as the reciprocal of cost with respect to output ($\partial \ln C / \partial \ln Q_i$)⁻¹ and is used to determine whether large- or small size of firms is more optimal for reducing costs.

⁵ Technical change is measured as $TC = -(\partial \ln C / \partial T) = -(\beta_t + \beta_{tt} T + \sum \theta_i \ln P_i + \theta_q \ln Q)$

