National Textile Center
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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 of 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.

In order to understand the underlying technological factors that affect efficiency and cost, which in turn affects competitiveness, we develop and estimate a cost-minimization model for the U.S. textile and apparel industries. This model allows us to estimate the *cost-minimizing* levels of inputs (capital, labor, energy, materials), measure substitution possibilities between factors, for example if capital and labor are substitutes in the production process the industry could increase its competitiveness through labor saving and capital using technology. Measure economies of scale to determine optimal firm size and the nature of technological progress. Another econometric model is used to estimate the impact of government policy, innovation, market share and competition from Asian markets on profitability of the domestic textile and apparel industries. These estimates based on factual industry data will provide useful information to firms in guiding their investment decisions.

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). 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. Evidence[1] 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

[1] Levinsohn and Petropolous (2001), Working Paper, NBER.

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, 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:
In order to identify the best strategies that would allow the domestic textile and apparel to compete in the global market 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. We will utilize a twice-differentiable transcendental logarithmic cost function approach (Christensen et. al. 1971) for the purpose. 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 expressed in its translog form is as follows:

$$\ln C = \alpha_0 + \alpha_q \ln Q + \alpha_R \ln RD + \Sigma_i \alpha_i \ln P_i + \tfrac{1}{2}\gamma_{qq} (\ln Q)^2 + \tfrac{1}{2}\gamma_{RR} (\ln RD)^2$$
$$+ \tfrac{1}{2}\Sigma_i \Sigma_j \gamma_{ij} \ln P_i \ln P_j + \Sigma_i \gamma_{iq} \ln P_i \ln Q$$
$$+ \Sigma \theta_{it} T \ln P_i + \theta_{qt} T \ln Q + \beta_i T + \tfrac{1}{2}\beta_{tt} T^2$$

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 for
1. The *optimal* or cost minimizing demands for inputs (K,L,E,M)[2].
2. Substitution elasticities $(\sigma_{ij}'s)$[3] between K, L, E and M. Whether inputs are substitutes or complements within the production process is determined by the sign and magnitude of $\sigma_{ij}'s$. For example, $\sigma_{KL} > 0$ would

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

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

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 degree of substitution possibility. However, if they are complements the scope for lowering labor intensity of production may be negligible.

3. Economies of scale[4], which allows us to determine whether large-scale or small-scale operations are optimal for improving competitive strength.
4. The nature of technical change[5] in U.S. textile and apparel industry and its role in improving competitiveness. In the technical change equation (see footnote 5) $\theta's$ 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.
5. Whether inputs are substitutes or complements within the production process is determined by the sign associated with the $\sigma_{ij}'s$. For example, $\sigma_{KL} > 0$ would suggest that capital and labor are substitutable within

In model 2, we examine the role of innovation, capitalization, government policy and trade agreements like NAFTA, and foreign competition in determining the profitability in U.S. textile and apparel industries, by estimating the following dummy variables model.

$$Profits = \beta_0 + \beta_1 MS + \beta_2\, K\text{-}Intensity + \beta_3 RD + \beta_4 D_{NAFTA} + \beta_5 CUR_{ASIA} + \varepsilon rror$$

where *MS* is the market share of U.S. textile (apparel) industry in total world output, *K-Intensity* represents capital intensity measured by the KL ratio, *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 at three different levels – at the industry level based on 2-digit industry data, sector level study based on 4-digit data on separate sectors within the industry and finally at the plant-level based on firm data. Dept. of Commerce and Bureau of Labor Statistics (BLS) provide time-series data for all at the industry and sector level for the period 1949-1999, which includes aggregated data from both publicly and non- publicly traded companies. Plant-level data for public companies is available through Compustat. However, for data on public and private firms, we have to rely on U.S. Census' Longitudinal Research Database (LRD), access to which is limited to scholarly research under certain disclosure requirements. Our proposal to obtain this data is being completed for submission to the Census bureau. Additional sources of data for the study are the ATMI and company surveys. The industry-, sector- and firm-level analysis are independent of one another, yet comparative analysis of the results from each study will provide important insights into the behavior of the industry and its 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:
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

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[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 $TC = -(\partial \ln C / \partial T) = -(\beta_t + \beta_{tt} T + \Sigma \theta_i \ln P_i + \theta_q \ln Q)$