

# National Textile Center

## FY 2003 (Year 12) Continuing Project Proposal

**Project No.: S01- PH13**

Competency: Management Systems

### **Optimal Investment Strategies for Enhanced Productivity in the Textile Industry**

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#### **Project Team:**

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#### **Objective:**

The object of this research is to increase the market share of the US textile industry by identifying investment strategies to achieve maximum manufacturing productivity. Market share can be gained if textile firms are more competitive, either through product development to satisfy dynamic consumer needs or improved productivity to decrease costs (make stuff better or make better stuff). Yet textile firms face a plethora of demands in a complex world where the optimal investment strategy depends on foreign industry dynamics, tariff changes, uncertain R&D pay-offs, evolving information and production technologies among other things. Our statistical analyses mitigate the uncertainty by estimating the impact of various investment decisions.

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#### **Progress Statement:**

We have developed models for assessing competing investments in a very complex world using data we gathered on productivity in the textile industry. Productivity, measured by the multi-factor productivity (MFP) index for the years 1949 – 2000, is a useful barometer of success as it indicates efficiency gains in production as well as successful product introductions to the market. We have analyzed the impact of foreign competition, innovative effort, production structure, technological change, and economies of scale. As the basic model is refined, it can be extended to include more difficult to quantify factors such as vertical integration (acquisitions within the supply chain) and out-sourcing. A brief discussion follows of the rationale for choosing the initial factors.

The importance of foreign competition on conditions in the domestic textile industry is obvious and must be taken into account, especially as trade barriers erode, thus we look at the impact of imports. Innovation may be the result of R&D investment but the lure of innovation is matched by the difficulty of assessing potential pay-offs. Not only does one not know if the R&D will succeed, but market uncertainties come into play if other firms are attempting to develop similar innovations thus it is very difficult to project profitability. Additionally, new products and processes are costly to implement, requiring the diversion of productive resources from elsewhere. Adjustment costs for R&D related projects are estimated to be seven times the adjustment costs of investment in new plant and equipment. A similarly problematic investment is Information Technology (IT). Recent studies on productivity growth for the U.S. have identified the importance of IT to reduce transactions cost and improve market information. This is particularly important in the textile industry for “supply-chain management” and “quick response”. Again the difficulty in assessing the investment is matched by the importance attached to such investment; there are extremely long lags and high implementation costs. Lastly we look at scale effects, that is, the size of the firm and industry. Denny, Fuss and Waverman (1981) have shown that for large, capital-intensive industries, cost savings can result from realization of scale economies and increased competition, besides technical change. According to Griliches (1998), these are “the most complex yet vital issues in today’s business world”.

We are conducting this study at three levels: using overall industry data ( SIC22), four-digit SIC level data and firm level data. The progress of the project is thus reported in corresponding sections.

**Industry Level Estimation:** Equation (1) is estimated using level values for the variables:

$$MFP_t = a_0 + a_1 Output_t + a_2 KLRatio_t + a_3 R\&D-Intensity_t + a_4 Import\ Competition + a_5 ITKRatio_t + e_t \quad (1)$$

*MFP* is the multi-factor productivity index for the textile industry at the 2-digit level at time *t*; *Output* (real value) captures the role of firm size, which indicates whether or not there are economies of scale, *KLRatio* indicates changes in the production structure as firms substitute capital for labor. The potential for innovation and technological change are indicated by *R&D-Intensity*, the ratio of R&D employment to total employment, while *ITKRatio* measures the value of real IT capital as a share of total capital. Finally *Import Competition* is captured by the ratio of imports to exports. Comparison of the following results reveals the regression analysis is robust. *Note: Figures in parentheses represent t-statistics.*

$$MFP_t = 2.025 + 0.378 LnQ_t + 0.855 K/L_t + 0.0025 Import/Export\ Ratio + e_{1t}$$

(17.51)\*\* (9.91)\*\* (11.02)\*\* (2.9)\*\*

$R^2$  (adj.) = .98

$$MFP_t = 0.604 + 0.717 LnQ_t + 0.778 K/L_t + 3.148 R\&D-EmplRatio_t + 0.0016 Imp/ExpRatio - 0.0002 IT/K_t + e_{1t}$$

(1.70)\* (7.95)\*\* (8.07)\*\* (2.18)\*\* (2.13)\*\* (-2.68)\*\*

$R^2$  (adj.) = .98

Both models have a high overall significance of 0.98 and all coefficients are significant at the 5% and 1% level.

The positive correlation of the capital-labor ratio indicates that increased capitalization and downsizing have a positive impact on productivity. Although the impact is small, the coefficient of Import Competition indicates increased competition forces domestic firms to become more efficient. *RDEmp* measures the share of R&D employment to total employment and shows investment in human capital (R&D scientists) improves productivity.

*IT/K* measures the extent to which investment in computers and software, relative to overall capital investment, improves productivity. The coefficient value is small but significantly negative. While one might expect investment in IT to enhance productivity, we find the opposite. The cost of investment in computers etc. may outweigh the returns in the initial stages. This result is in keeping with the predominance of studies that find no relationship, or a negative one, between investment in information technology and growth for these time periods. Positive impacts may be identified for studies covering the last ten years only; we will bifurcate the data to explore this further.

Exploring alternate specifications, the following estimates use Import Penetration, the ratio of imports to domestic production, rather than the Import/Export ratio, and R&D Expenditure rather than R&D employment.

$$MFP_t = 1.233 + 0.586 LnQ_t + 0.430 KLRatio_t + 0.132 R\&Dexp_t + 0.0011 Import\ Pen. - 0.0052 IT/K_t + e_t \quad (1)$$

(3.49)\*\* (8.72)\*\* (4.83)\*\* (2.99)\*\* (0.176) (-2.20)\*\*

Adj.  $R^2$  = 0.99

The results are comparable with those previously cited except that the coefficient for Import penetration is no longer significant. There are theoretical considerations for why this coefficient may be ambiguous or difficult to estimate, meriting further investigation. While the effect of R&D capital on productivity growth may be more direct than R&D employment, data on R&D expenditures is fraught with missing data: the small number of firms reporting such expenditures does not meet the disclosure requirements at the Census Bureau. We estimated the missing values through bootstrapping, fitting a non-linear regression line through the available data. I have written a proposal to work with the confidential files at the Census Bureau that will eliminate data problems.

The consistency of the various regression models gives us confidence in the robustness of these findings; however, we must ascertain that the results are not spurious. That is,  $R^2$  and t-values may be high simply because of common trends in the dependent and independent variables. Thus we estimate equation (2), which uses rates of growth rather than the actual levels of the variables under consideration.

$$\dot{MFP}_t = 0.001 + 0.321 \dot{Q}_t + 0.343 \dot{KLR} + 0.003 \dot{RD}_t + 0.002 \dot{IM} - \dot{Ex} + -0.0086 \dot{ITKR} + e_t \quad (2)$$

(1.79) (2.17)\*\* (2.39)\*\* (1.23) (1.28) (-2.4)\*\*

$R^2$  = 0.65

These growth rate estimates reconfirm that the results from the level effects are robust. The coefficients have the same signs and are significant. When measured in growth terms the coefficient of output measures scale effects; this value is positive but less than 1. This indicates that scale economies are not very high, suggesting thereby that a larger firm size is not necessary to achieve higher productivity.

**Sector Level Estimation:** We use panel data in the sector analysis, regressing the productivity index for each sector, over time, on the same variables reported by sector rather than aggregated over the industry. This allows us to control for unobserved individual and/or time specific effects (heterogeneity), which may be correlated with the explanatory variables in the model. This is a fixed effects model and measures the impact of the variables on productivity, separating out idiosyncrasies attributable to sector differences. Thus the regression results do not return one constant but rather a constant for each of the 19 sectors of the industry. The signs of the coefficients are as expected, consistent with the industry study, and the variables are significant.

MFP = constants + .001269 K/L + .000033 IMPORTS + .000143 EXPORTS + .000045VALUE OF SHIPM\*T +  $e_t$   
Very significant t's (2.039) (1.703) (1.662) (7.182) Adj. R<sup>2</sup> = .46

The size of the constant terms ranges from a low of 0.59 for broad woven fabrics, man-made fiber and silk to a high of 0.96 for cordage. The low constant sectors have lower productivity growth and include circular knit fabrics, yarn, spun, of cotton, man-made fibers, or silk, and tire cord and fabric.

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#### **Next Year's Goals:**

Refining the statistical models, adding variables of interest (patent data and supply chain integration data), and interpreting the results to clarify policy prescriptions. Advance the plant level analysis using Census (LRD) data.

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#### **Approach:**

The industry level analysis was extended to examine rates of growth (eq.2) to ascertain that we are not attributing causation where there is only correlation due to similar trends. This merits further statistical analysis, specifically co-integration analysis to determine the unit root and remove any trend effects. On the sector analysis, the anomalies of each sector are being identified as well as correlations between variables. Preliminary analysis of the correlations indicates there may be multi-colinearity, which will be corrected with either co-integration or a growth rate model, not a trivial procedure using panel data. Another concern is auto-correlation, that factors are correlated across periods. This can be corrected by the AR(1) model that incorporates the residual from the past observation into the regression model for the current observation. The plant level analysis is proceeding with the data on publicly held companies that we obtained from Compustat but this is a limited sample, thus further work is pending the outcome of Christoffersen's proposal to the Census Bureau to access the Longitudinal Research Database (LRD) that covers plant level data on both publicly held and private companies.

Once the models are refined, we will analyze the coefficients returned and interpret them with respect to firms' strategies. At the same time, work can commence with additional variables, once the dominant impacts have been identified and controlled for. We will introduce measures of supply chain integration if data on the degree on vertical integration can be obtained. Concentration ratios can be introduced to show the importance of market power. As an indication of innovative activity we would like to use patent data in lieu of R&D measures. Many interesting areas can be explored in the coming year but the fundamental model must be determined as robustly as possible to properly assess the additional variables. This will lead to further insight and policy prescriptions.

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#### **Outreach to Industry:**

Industrial interactions: 5 [Burlington, UNIFI, Pillowtex, Toyobo Inc., Dow Chemicals]

Paper Presentations: the Annual Conferences of the *North American Productivity Workshop* and *The Eastern Economics Association*

Publications under review

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**New Resources Required:** Software: Frontier Analysis \$1,600