

Optimal Investment Strategies for Enhanced Productivity in the Textile Industry

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Goal:

The goal of this research is to identify investment strategies to achieve maximum manufacturing productivity with the ultimate goal of increasing the market share of the US textile industry.

Summary:

US textile firms face challenging decisions; investment decisions are particularly critical since today's investment determines tomorrow's production. Facing competitive pressure from abroad, a firm must often choose between competing investment options. For example, investment in high tech machinery may be desired to minimize payroll expenses but this allocation may reduce the availability of funds for R&D that, if directed at new product development, might open new markets. Furthermore, these investments compete with the investment in information technology (IT) necessary for leaner manufacturing and a long-term reduction in costs due to better supply chain management. In the case of R&D and IT, the *pay-off* to an investment is unknown, further complicating the decision. We analyze the impact of such investments on productivity to mitigate this uncertainty.

Summary of Regression Results:

At the industry level, we determine the sources of productivity growth by regressing total factor productivity on capital-labor ratio, R&D employment, import penetration and IT capital as a share of total capital. The results indicate that higher capital intensity and R&D investment leads to higher productivity. The effect of import competition on productivity is positive, indicating that competition from imports forces domestic firms to be more efficient. The effect of IT investment is small but negative. This result may indicate that the positive effect of IT investment occurs with a lag and that initial costs outweigh initial returns.

We use a panel of data from 1958 to 1994 for the 19 sub-sections of the industry to further estimate the impact of investment options on productivity. The test statistics for the classical model confirm that both group effects and the import variables are significant; the higher the capital-labor ratio, the higher the productivity, and higher productivity leads to more the exports, and these effects vary significantly between industry sub-sectors.

Relevance to the NTC Mission:

Reducing manufacturing costs is imperative to enhance the market share of U.S. firms in the competitive international arena. However, capital budgeting decisions involve significant uncertainties. For example, R&D investment is problematic in that it has an uncertain pay-off; it is difficult to project the profitability of *potential* inventions. We address this difficulty by determining the impact of various investments on productivity gains so that the impact of R&D can then be compared to other investment alternatives such as plant and equipment expenditure. Time series data allows us to ask: Does R&D have an increasing contribution over time? Do learning curve effects cause benefits of such expenditure to increase over time?

Does capital expenditure exhibit diminishing productivity returns over time? Does IT expenditure exhibit increasing productivity returns over time? This study will help to answer these questions.

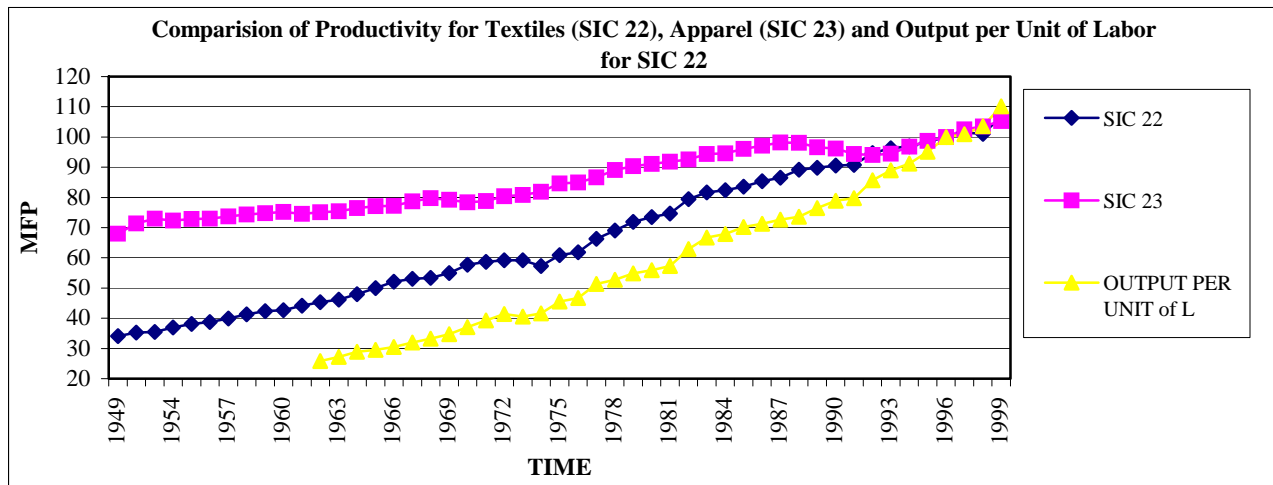
Firms commercializing new products and processes must divert productive resources towards implementation. Such adjustment costs for R&D related projects are estimated to be seven times the adjustment costs of investment in new plant and equipment. This necessarily changes the way we view R&D investment. Analyzing total factor productivity, which includes the interaction between factors, will improve how the industry assesses productivity by including these costs of complexity. According to Cline (1990), productivity gains, not import penetration, have had the largest impact on employment in the textile industry. Productivity *growth* in the textile industry has outpaced the other manufacturing sectors in the U.S. economy. While the gains in labor productivity are great, the overall level of productivity is still below the level of labor productivity of the other manufacturing sectors. This suggests tremendous potential for continued productivity growth. As firm level data become available, other variables can be tested such as the size of the firm, nature of the product (availability of close substitutes), ownership characteristics, vertical integration (supply chain), sources of financing, and offshore plants.

Overview:

Chart One presents data from the Bureau of Labor Statistics (BLS), on productivity for the industry over a period of fifty years. Fifty years ago the textile industry was 35% as productive as it was in 1996 and between 1996 and 1999, labor productivity increased by 8 percent.

Because modern technologies are substituting away from labor, productivity gains are exaggerated when measured by labor productivity. The preferred measure is multi-factor productivity, that is, output divided by all inputs, not just labor. Chart One illustrates the differences in productivity measures and growth.

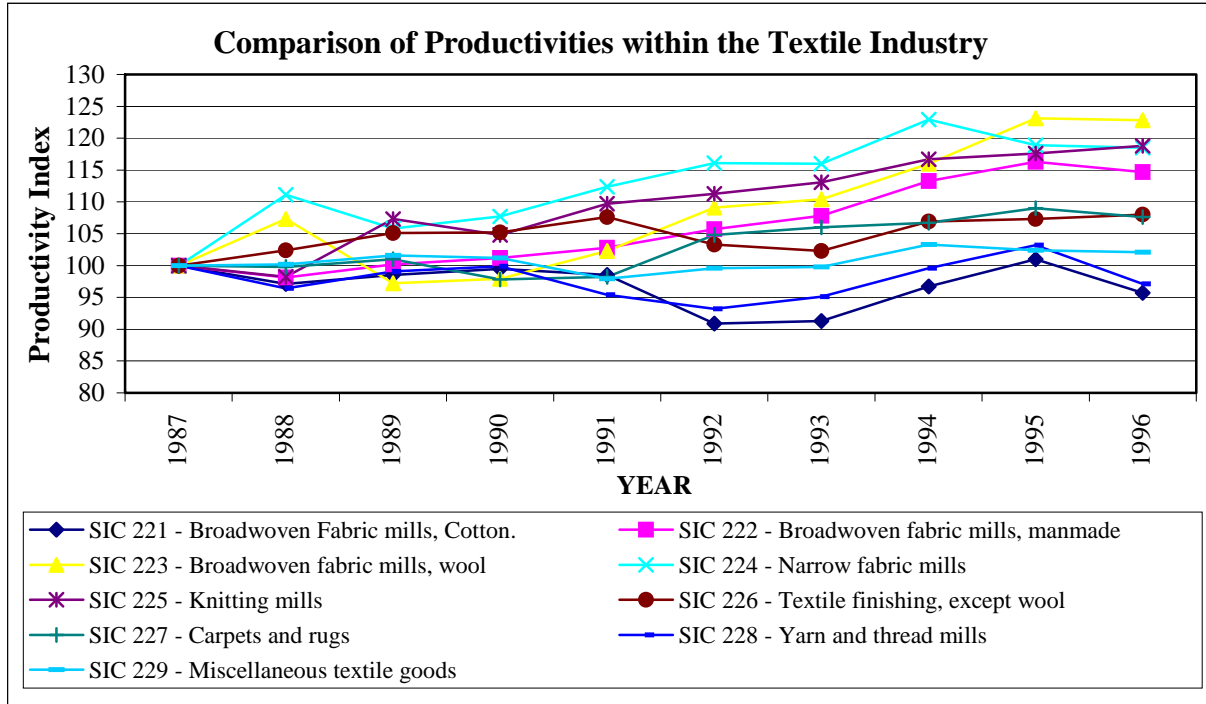
Chart One:



Our study covers three levels of data: the industry overall, sub-sectors of the industry, and firm level data. Trends that are observed for the industry do not necessarily hold true for an individual firm or industry sector. However, firms must operate within the context of the industry, with some effects particular to the sub-sector of the industry, thus each analysis is informative, as demonstrated by the descriptive Charts One and Two, and Table One.

Chart Two presents data from the Annual Survey of Manufacturers, the Bureau of the Census, disaggregated to the four digit SIC code. The SIC code is the Standard Industrial Classification system that categorizes firms according to their business lines, in textiles there are 19 sub-sectors of the industry at the four digit level. Chart Two is disaggregated to the three-digit level and highlights the types of firms that have had the greatest productivity advances. The two sectors that have experienced declining productivity: Broadwoven cotton mills and yarn and thread mills.

Chart Two:



To further our understanding of productivity trends, we present firm level data in Table One: the rates of exit and entry in the textile industry. Historically, firms that exit an industry are generally the more inefficient firms. Those that remain in business and the ones that enter, on the other hand, are typically more productive and technologically advanced. While these numbers are significant and the adjustment costs to the individuals involved is not to be underestimated, the figures are not very different from overall manufacturing norms. Comparison with the apparel rates puts this in some perspective.

Table One: Rates of Plant Entry and Exit

	Gross Rate of Entry	Gross Rate of Exit
Textiles		
1972-77	26%	32%
1977-82	31%	32%
1982-87	20%	38%
1987-92	28%	31%
Apparel		
1972-77	42%	44%
1977-82	48%	43%
1982-87	25%	55%
1987-92	49%	46%

Levinsohn and Petropoulos (2001)

In order to rigorously analyze factors that enhance productivity, we perform regression analysis at both the industry level and the sectoral level. These are each presented in the remainder of the report.

Industry Level Analysis:

Productivity measures the growth in output not explained by the growth in inputs. Following Denny, Fuss and Waverman (1981), a typical production function for a textile firm can be written as:

$$f(q, x) = 0, \quad (1)$$

where q is a vector of outputs, and x is a vector of all inputs (capital, labor and materials and energy), used to produce the output. TFP is measured as the ratio of aggregate real output (Q) divided by aggregate real input (X), as $TFP=Q/X$. The instantaneous rate of growth of TFP is then given by

$$TFP = \dot{Q} - \dot{X} \quad (2)$$

Traditionally, the excess growth in output over the growth in inputs, was attributed to technical change. However, Denny et. al. (1981) have shown that for large, capital-intensive industries, cost savings can result from realization of scale economies and increased competition, in addition to technical change.

The contribution of R&D investment towards increased productivity has been shown to be significant in many industries (see e.g. Griliches (1980), and Scherer (1983)). In addition, recent studies on productivity growth for the U.S. also identify information technology (IT) as a potential source of productivity gains, which can occur through lower transactions cost and improved market information. For the textile industry the potential for IT investment lies in “supply-chain management” and “quick response” which helps lower inventory costs.

In order to determine the sources of productivity growth in the U.S. textile industry we estimate two separate models, one with level values and the other in terms of growth rates. Equation (3) is estimated using level values for the dependent and independent variables:

$$TFP_t = a_0 + a_1 \text{Output}_t + a_2 \text{KLRatio}_t + a_3 \text{R\&D-Intensity}_t + a_4 \text{Import Competition} + a_5 \text{ITKRatio}_t + \varepsilon_t \quad (3)$$

where TFP is the total factor productivity index for the textile industry at the 2-digit level at time t . Output represents real output, measured as nominal sales over price index and is included to measure scale effects. KLRatio, calculated as the ratio of capital input to labor input, measures capital intensity; this is included in order to determine to what extent a more capital-intensive technology improves productivity. R&D-Intensity is the ratio of R&D employment to total employment. Import Competition is measured by the ratio of imports to domestic production, which indicates the extent of import penetration impacts productivity. Finally, ITKRatio measures the real value of Information Technology investment as a share of total capital. The following two graphs give one a sense of how R&D and IT investment have been growing over time.

Chart Three:

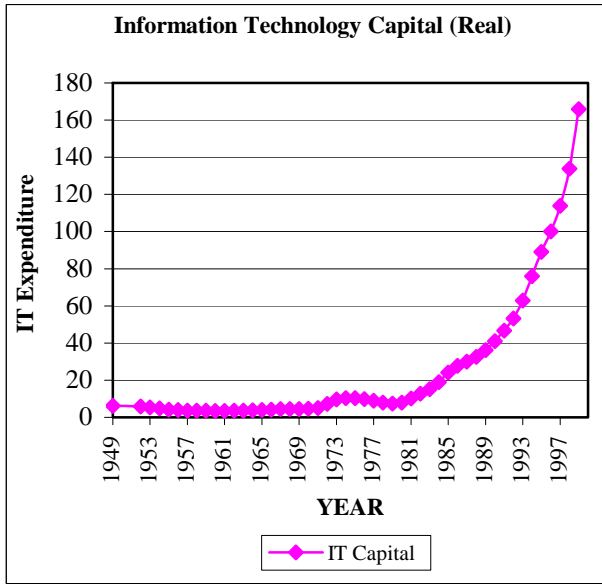


Chart Four:

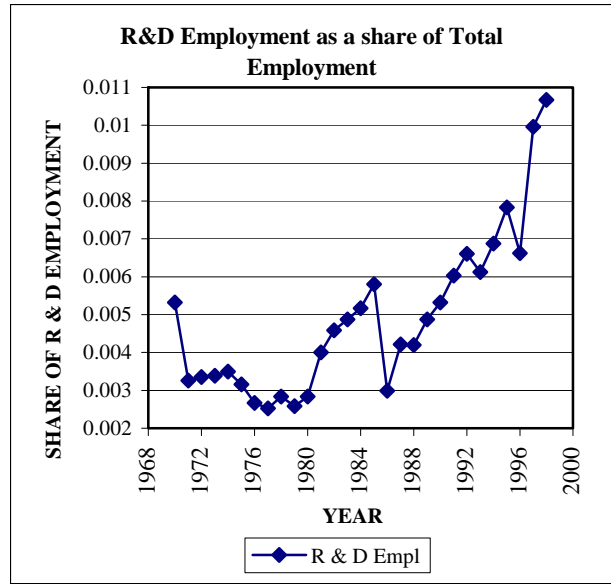


Table Two presents the estimates for the determinants of Total Factor Productivity. Both models (different time periods due to data constraints) have a high overall significance of 0.98. Additionally all coefficients are significant at the 5% and 1% level.

Table Two: *Dependent Variable: LNTFP*

	(1962-1994)	(1970-1994)
	(1)	(2)
<i>Intercept</i>	3.230 (13.67)**	2.176 (5.821)**
<i>LNQ</i>	0.304 (5.88)**	0.596 (6.79)**
<i>LNKLRATIO</i>	0.403 (5.68)**	0.618 (8.69)**
<i>LNMQRATIO</i>	0.189 (3.114)**	0.176 (3.143)**
<i>LNRDEM_RATIO</i>		0.0055 (1.618)
<i>LNITKRATIO</i>	-0.001 (-0.060)	-0.109 (-3.767)**
R² (adj.)	0.98	0.98

Note: R&D data is not available for period before 1970.

Figures in parentheses represent t-statistics.

**Indicates significance at 1% level, and * indicates significance at 5% level.

- The positive correlation between KL Ratio (capital-labor ratio) and TFP indicates increased capitalization and downsizing have a positive impact on TFP.
- The coefficient of Import Competition, measured as the ratio of imports to domestic output – suggests that increased competition forces domestic firms to become more efficient and therefore positively affects productivity.
- The positive coefficient of RDEmp shows investment in human capital improves productivity.
- ITCapital measures the extent to which investment in computers and software improves productivity. The coefficient value is small but significantly negative. This result seems to be in keeping with other studies in textiles, which find no significant relationship between investment in information technology and growth based on early data. It is likely that in the initial years cost of IT investment may outweigh returns from it.

Growth Effects:

One of the issues with using level values is that the R^2 and t-values may be high simply because of common trends in the dependent and independent variables. In order to ascertain that the results from the above model are not spurious we estimate equation (4) in terms of growth rates.

$$TFP_t = b_{10} + b_{11} \dot{Q} + b_{12} \dot{KLR} + b_{13t} \dot{RD}_t + b_{14} \dot{IMPEN} + b_{15} \dot{ITKR} + \varepsilon_{1t} \quad (4)$$

Estimation results are reported in Table Three:

Table Three: *Dependent Variable: TFP Growth*

	1962-1994 (1)	1970-1994 (2)
<i>Intercept</i>	0.001 (1.97)*	0.001 (1.59)
<i>Q Growth</i>	0.286 (2.49)**	0.352 (2.33)**
<i>KLR Growth</i>	0.257 (2.31)**	0.350 (2.31)**
$\Delta IMPEN$	-0.0025 (-0.80)	-0.0028 (-0.64)
$\Delta RDR (Empl)$		0.003 (1.24)
$\Delta ITKR$	0.0046 (-1.64)	-0.0074 (-1.98)**
R^2	0.56	0.65

Note: R&D data is not available for period before 1970.

Figures in parentheses represent t-statistics.

** Indicates significance at 1% level and * indicates significance at 5% level.

Results from the growth rates analysis follows; these estimates are consistent with the results from the level effect estimates, indicating that the analysis is robust.

- The coefficient for output (Q) growth remains positive and significant. When measured in growth terms the coefficient of output measures scale effects (Kwoka, 1993). The 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.
- The coefficient for the growth rate of capital intensity (KLR) remains positive and significant. A positive coefficient for KLR indicates that an increase in capital intensity is associated with an increase in productivity in the textile industry.
- The effect of the growth in R&D employment is positive but not significant.
- The effect of the growth in IT-capital investment on productivity remains negative. This might indicate that the cost of investment in computers etc. may outweigh the returns in the initial stages.
- The coefficient for import penetration (Im/Q) is negative but insignificant. As this measurement lacks statistical significance, we can make no conclusions regarding the impact of imports on productivity. This may reflect the ambiguous impact of imports. While import competition challenges our industry to attain increased productivity, it also hampers the industry, and its ability to remain productive.

To complement our industry level analysis, we proceed with analysis by sector in order to further inform our understanding of factors that enhance productivity. The panel data covers 19 sectors over time. The time series aspect will allow us to analyze how these parameters change over time and the cross-sectional data will show how the parameters differ across industry sectors.

Industry Sector Analysis:

Since our data set combines time series and cross section, modeling in this setting calls for the utilization of panel data analysis models. The analysis of panel data is the subject of one of the most active and innovative bodies of literature in econometrics, partly because panel data provide such a rich environment for the development of estimation techniques and theoretical results. In more practical terms, however, researchers have been able to use time-series cross-sectional data to examine issues that could not be studied in either cross-sectional or time-series settings alone.

A main reason for the strongly increasing utilization of panel data in the last two decades is due to the opportunity which such data give for controlling for unobserved individual and/or time specific effects (heterogeneity), which may be correlated with the explanatory variables in the model. The effect of individual heterogeneity in a panel data set relative to a specific linear model can, for instance, be eliminated by measuring all variables from their individual means or by using suitably differenced data.

The panel data model that we use in this study is the fixed effect model as given in equation 5.

$$y_{it} = \alpha_i + \beta'x_{it} + u_{it} \quad (5)$$

where $i = 1, 2, \dots, 19$ and $t = 1, 2, \dots, T$

y_{it} is the output and x_{it} is the vector of inputs for the i th textile sector in the t th period. α_i captures specific four-digit standard industrial classification (SIC) effect.

Regression Results of the Panel Data Analysis:Table Four: *Dependent variable: TFP4*

Variables	Coefficients (t-statistics)	
	WITH GROUP DUMMY	WITHOUT GROUP DUMMY
Capital-Labor Ratio	.001269 (2.039)	.00057 (1.147)
Imports	.000033 (1.703)	.000096 (5.070)
Exports	.000143 (1.662)	.000305 (3.521)
Value of Shipments	.000045 (7.182)	.000006 (1.271)
Constant		.823877 (63.072)

Analysis:

Using equation 5 above, we run panel data regression without group dummy variables and with group dummy variables. We model total factor productivity as a function of capital-labor ratio, imports, exports, and value of shipment. Capital-labor ratio is defined as the dollar amount of capital per unit of labor hour.

- With group dummy variables, we find that the total factor productivity is positively related to capital-labor ratio, which means that higher the capital per unit of labor production hour, more is the productivity in the textile industry.
- The coefficient on imports is also positive and statistically significant. Thus, as imports increase, the U.S. textile industry has responded historically through more productivity to stay competitive in the global market place.
- Exports also are positively related to the total factor productivity. This complements our initial finding of imports being positively related to the total factor productivity. With increased productivity, cost declines and this makes the U.S. textile products more competitive; that increases exports.
- Value of shipment is also positively related to the total factor productivity. As value of shipment rises, total factor productivity also rises pointing to economies of scale in the U.S. textile industry.
- To analyze the group effect, we examine the estimated fixed effects. We find that for each of the 19 groups, the constants are positive and highly statistically significant. The size of the fixed effect for each of the 19 four-digit industrial classifications differs. The size of the coefficient ranges from a low of 0.59 for broad woven fabrics, man-made fiber and silk to a high of 0.96 for cordage. These low coefficient sectors also include circular knit fabrics, yarn, spun, of cotton, man-made fibers, or silk, and tire cord and fabric, and have lower productivity growth in comparison to sectors such as cordage.

Conclusions and Future Direction:

Due to intensified international competition and dynamic technological growth, the textile industry faces the need for greater productivity. This study has identified factors that contribute to productivity but we need to explore these relationships further. The relationship between productivity and technological growth is understood to be positive, with a diminishing horizon, however “this one of the most complex yet vital issues in today’s business world” (Griliches, 1998).

Using regression analysis, we estimate the impact of technological efforts on productivity through the investment in information technology and the employment of scientists conducting R&D, as well as capital deepening and economies of scale. Having identified the important factors, obtained the data sets and estimated the impacts of these factors, we are poised to analyze the coefficients. These represent the elasticities of productivity relative to capital, labor and R&D investment. For example, the elasticity of capital indicates the percentage increase in production to expect from increased investment in new plant and equipment. Similarly, the R&D elasticity will indicate the impact on production due to investment in R&D. Comparison of these measures reveals the relative importance of various investments such as the impact of investment in R&D relative to capital investment on production. As the work progresses, we will better understand how to increase the productivity and competitiveness of the textile industry. This will lead to policy prescriptions, in particular, with regard to competing investment strategies to increase market share.

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Industrial interactions: 5 [Burlington, UNIFI, Pillowtex, Toyobo Inc., Dow Chemicals]
 Paper Presentation at the annual conference of the *North American Productivity Workshop*
 Publications under review

URL: <http://faculty.philau.edu/christoffersens/NTCGrant/index.htm>

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