September 2001

An Economic Analysis of the Cotton Research and Promotion Program

Final Report

Prepared for

William Crawford
Cotton Board
Memphis, TN

Prepared by

Brian C. Murray
Robert H. Beach
William J. White
Catherine Viator
Research Triangle Institute
Health, Social, and Economics Research
Research Triangle Park, NC 27709

Nick Piggott
Michael Wohlgenant
North Carolina State University
Department of Agricultural and Resource Economics
Raleigh, NC

RTI Project Number 8024

RTI
INTERNATIONAL

RTI Project Number
8024

An Economic Analysis of the Cotton Research and Promotion Program

Final Report

September 2001

Prepared for

William Crawford
Cotton Board
Memphis, TN

Prepared by

Brian C. Murray
Robert H. Beach
William J. White
Catherine Viator
Research Triangle Institute
Health, Social, and Economics Research
Research Triangle Park, NC 27709

Nick Piggott
Michael Wohlgenant
North Carolina State University
Department of Agricultural and Resource Economics
Raleigh, NC

Contents

Figures

Tables

Executive Summary

The goal of the Cotton Research and Promotion Program is to expand the demand for upland cotton and to increase profitability for both cotton growers and importers of cotton products. In particular, both the Cotton Research and Promotion Act of 1966 and the Cotton Research and Promotion Amendment Acts of 1990 were designed to enhance the competitive position of U.S. upland cotton relative to man-made fibers. The purpose of this study is to assess how well the Program's goals are being met.

The cotton program is funded by a per-bale assessment on cotton produced in the U.S. and on the equivalent volume of cotton in imported products. The Cotton Board, a quasi-governmental, nonprofit entity that administers the program, collects and manages the revenues. The Cotton Research and Promotion Amendment Acts of 1990 require that the Cotton Board commission a study to be conducted every 5 years. Texas A&M University conducted the first of these studies (Capps et al., 1997), which focused on the program's performance during the 5-year period 1991 through 1995. This study focuses on the period 1996 through 2000.

ES.1 STUDY OBJECTIVES

To assess how successfully the Cotton Research and Promotion Program is achieving its economic goals, this study was designed to meet the following objectives:

- ➤ evaluate the effects of the program on
  - ✓ demand for U.S. upland cotton,

    - ✓ return on investment (ROI) to domestic cotton producers, and
    - ✓ value to importers of cotton products;
- ➤ estimate the overall ROI of the program; and
- ➤ assess nonquantitative program benefits.

ES.2 APPROACH

We describe the study approach used by the team of researchers from RTI and North Carolina State University to accomplish these objectives.

ES.2.1 Background Review

The research team thoroughly reviewed the goals, structure, and features of the Cotton Research and Promotion Program. The team met with representatives of The Cotton Board and Cotton Incorporated (CI) to obtain "between the lines" information not readily apparent in data and other quantitative and qualitative information. The team toured CI's facilities in Cary, NC, and met with several staff members to obtain insights into the Program. The team also visited cotton operations in eastern North Carolina to observe first-hand recent changes in technology available to cotton growers.

Furthermore, the team reviewed the previous program assessment study conducted by Texas A&M (Capps et al., 1997) as well as other studies that evaluate returns to commodity promotion programs.

ES.2.2 Develop Econometric Models

Econometrics is the application of statistical methods to economic questions. The economic questions in this study relate to the degree of influence that the Cotton Research and Promotion Program has on the demand for cotton and the welfare of cotton producers. To quantify these effects, an econometric model was developed, which statistically estimates the relationship between economic variables for four components of the U.S. cotton market. Table ES-1 lists the components and the variables used to estimate the model.

Table ES-1. Econometric Model Components and Variables

Market Component	Dependent Variable	Explanatory Variables[a]
Cotton demand—domestic	Per capita domestic mill use, cotton	Price of cotton Price of substitute fibers Macro variables CI promotion expenditures CI nonagricultural research expenditures
Cotton demand—exports	U.S. exports, cotton	Similar to domestic demand
Cotton supply—domestic	U.S. raw cotton production	Price of cotton (futures) Price of inputs Technology indicators Agricultural research expenditures Yields Time trend
Imports of finished cotton products	Price index for cotton apparel imports	Net import quantities of apparel, cotton equivalent World price of raw cotton Macro variables

[a]Adjustments for time lag effects and seasonality

We estimated the econometric model by specifying a series of equations reflecting the structure of the model defined in Table ES-1 with data on the variables defined therein. An "estimated" model yields values for *parameters* that capture the nature (sign) and magnitude of the economic effects of interest. Of particular interest are the parameters capturing the effects of Program expenditures on the demand for U.S. cotton. These are key determinants of economic welfare for domestic cotton producers. Also of potential importance is the role of the Cotton Research and Promotion Program in expanding the supply of U.S. cotton, although, as we explain below, this effect is more difficult to quantify because of data problems.

ES.2.3 Use Econometric Model Parameters to Estimate ROI

The parameter estimates in the econometric model provide empirical (data-driven) evidence on the size of Program effects on U.S. cotton demand and supply. In this phase of the study, the RTI research team used the econometrically estimated parameters to quantify the ROI of the program. A program that successfully raises the demand for U.S. cotton will, all else equal, increase the amount of cotton consumed in the market and raise the price of cotton above the level that would prevail if there were no demand-enhancing program. These changes in the market will, all else equal, raise the well-being of those domestic producers and importers who obtain a higher price for their product. However, cotton producers and importers must also pay for the Program through a per-unit monetary assessment on the cotton they produce/import. The net return to each party then captures both the benefits and costs of the Program. Net returns were estimated using the economic measure of *producer surplus*. This net return measure was then divided by the cost to estimate the ROI for the program:

ROI = Net return to producers/Program cost

Thus, a program with a positive net return will have a positive ROI. The larger the ROI, the higher the rate of return producers (importers) are receiving on the funds set aside for the Program.

ES.2.4 Supplement Quantitative Analysis with Qualitative Assessment

Econometrics is a powerful tool for testing economic hypotheses (e.g., does the Program have a statistically significant effect on domestic cotton demand?) and for quantifying the magnitude and range of these effects (e.g., how large is the shift in demand?). However, econometrics cannot estimate effects of the Program that are not captured by or are somehow obscured by the data used to parameterize the econometric model. For instance, certain Program efforts run by CI have a very long gestation period, such as agricultural research. Also, certain types of programs in which CI engages are inherently difficult to link with expansion of cotton demand or supply during the period of analysis (e.g., research on the development of nonflammable fabrics in response to federal standards).

To address the potential shortcomings of quantitative analysis in assessing Program benefits, this study supplemented the econometric analysis in a number of ways:

- describes in some detail the types of activities undertaken by CI on behalf of the Cotton Research and Promotion Program;

- identifies changes in technology affecting cotton production and use over time, including the role of CI's efforts in some of these critical areas of technology development; and
- uses data trends and inference to evaluate likely contributions to producer welfare in cases where the econometric models are unable to capture these effects.

ES.2.5 Obtain Technical Peer Review and Revise Analysis

After the initial round of research, model development, and estimation, we prepared a draft report for review by three highly regarded experts in the fields of agricultural economics:

- Dr. Gary Brester, Professor, Montana State University
- Dr. Don Ethridge, Professor, Texas Tech University
- Dr. Henry Kinnucan, Professor, Auburn University

Professors Brester and Ethridge were selected because of their well-known expertise in the area of agricultural marketing in general and generic commodity promotion in particular. Professor Ethridge is a widely respected expert in the economics of the cotton industry.

The team of reviewers reviewed the draft report and provided general feedback on the study's design, validity, and coverage as well as detailed comments on the empirical methods employed and inferences drawn. The research team carefully evaluated the review comments, modified the analysis where appropriate, and revised the report for final distribution.

ES.2.6 Communicate Results to Cotton Board

After revising the analysis in response to review comments, Dr. Brian Murray presented the results of this study to the annual meeting of the Cotton Board in Atlanta on September 8, 2001. Feedback from that meeting is reflected in this final report.

ES.3 RESULTS

Results of the analysis can be reviewed from two perspectives: econometric estimation of the market model and calculation of Program rate of return.

ES.3.1 Econometric Estimation

General Results

In general, the estimated econometric model conforms to expectations based on economic theory. The estimated effects of the cotton price on the quantity demanded (negative) and quantity supplied (positive) are as expected. Export demand and import supply are more *elastic* (responsive) to price than domestic demand and supply, reflecting the wide range of markets globally that can serve foreign demanders and suppliers. Domestic and foreign cotton are seen as substitutes on the world market. There is some evidence on the substitutability of cotton and synthetic fibers as well. The predictive power of the models is generally good, indicating that they are reasonably well suited for simulating the demand effects of altering program expenditures.

Program Effects

The econometric models were rigorously tested to determine the proper time lag structure between the research and promotion expenditures, respectively, and their demand response. The results suggest a statistically significant positive contemporaneous effect of promotion and advertising expenditures on domestic demand. The results also indicate a very strong, time-lag adjusted, positive and significant relationship between nonagricultural research expenditures (fiber quality, fiber management, and textile research) and domestic demand. Taken together, these factors suggest that the Cotton Research and Promotion Program has had a significant positive effect on domestic cotton demand.

The econometric analysis did not find a statistically significant relationship between total Program expenditures and export demand. However, the export model had some data shortcomings that may have undermined the ability to detect the intended effects as described in more detail below. It is possible that more disaggregated data would reveal Program impacts on exports, but for the current model, no Program expenditures are included in the export demand equation.

Taken together, a 1 percent reduction in Program expenditures over the last 5 years would have reduced consumption of U.S. cotton by an estimated 0.14 percent. In addition, the reduced consumption that would have occurred without the Program's effect on demand would have led to an estimated reduction in price of approximately 0.31 percent.

The estimated cotton supply model suggests a significant relationship between various technology indicators (time trend, yields, input cost indices) and supply, but the absence of a long-enough time series impedes our ability to attribute these positive effects directly to CI agricultural research expenditures. Therefore, we address the returns to that program component in a more qualitative way.

ES.3.2 ROI Calculations

The estimated econometric parameters were used to compute Program ROI using the methods described above. Table ES-2 presents results of these calculations. It is worth emphasizing that the calculations are based on a "with-without" comparison, rather than a "before-after" comparison. Specifically, the net returns used in the ROI simulated differences between market outcomes *with* the program and those that would be expected *without* the Program over the period 1996 through 2000. More to the point, a general decline in market conditions may have led to the decline in welfare of producers and importers during this time period, but the relevant question for this analysis is whether the benefits to producers and importers exceeds the costs of the Program, all else equal.

Table ES-2. ROI Calculations

		95 percent Confidence Interval[a]	
Component	**Mean**	**Lower Bound**	**Upper Bound**
Domestic producers			
Promotion	4.6	3.2	6.0
Nonagricultural research	280.3	202.2	360.0
Importers[b]	2.7	1.9	3.4
Total[c]	30.6	22.4	38.9

[a]Indicates a 95 percent statistical probability that the true estimate falls in this range.

[b]Combined effect from promotion and nonagricultural research.

[c]Total net returns to domestic producers + importers divided by total Program costs.

For domestic cotton producers, the ratio of net returns to assessment costs for promotion expenditures is 4.6, with a confidence interval range of 3.2 to 6.0. This is in the general neighborhood of the ROI to promotion found in the Texas A&M study as well as within the range typically found in commodity promotion programs (e.g., Kaiser and Schmit's 2001 study of the egg program).

The ROI of nonagricultural research for domestic producers is extremely high—nearly 70 times higher than the promotion ROI. Although the Texas A&M study found nothing comparable to this magnitude, ROIs this high have been found for other checkoff programs (e.g., California grape study by Alston et al. [1997]). Although great care was exercised in the econometric estimation phases of the study to obtain the best model, the authors nonetheless suggest that great caution be used in interpreting these results. The results suggest that the rather small amount of money CI devotes to nonagricultural research may be greatly leveraged by external funds. The implications of this leveraging are two-fold: CI gets a large "bang for the buck" of every dollar spent in this area and, more cautiously, returns to this expenditure are greatly dependent on the existence of these external funds.

For importers, the price benefits of Program-induced demand expansion are relatively small on a per-unit basis but are spread over enough volume of imported products to more than cover the assessment costs that importers must pay. The estimated rate of return for importers is 2.7, with a range from 1.9 to 3.4. These estimates are somewhat smaller than those found in the Texas A&M study (3.6 to 5.6) and are substantially smaller than the return to domestic cotton producers found in this study.

Total Program ROI is the aggregate return to all domestic producers and importers that directly bear the cost of the program. The mean estimate for total ROI is 30.6, with a range of 22.4 to 38.9. Even though it is a relatively small part of the program (about 15 percent of expenditures), the very high ROI for nonagricultural research exerts great influence on the total ROI. Thus, the caveats surrounding the ROI for that program component discussed above extend to the total ROI measure as well.

Farm Program Interactions

The existence of federal farm programs greatly complicates the calculation of Program effects on price, consumption, and ROI. The measures presented thus far are calculated without specific regard to price subsidies or other such incentives imposed by farm programs. However, although the 1996 FAIR Act was to ostensibly eliminate commodity price subsidies, they remain for cotton producers in the form of loan deficiency payment (LDP) guaranteed prices. Moreover, cotton demanders (mills) receive guarantees in the form of Step 2 payments to cover the gap between the U.S. cotton price and the world cotton price. It is beyond the scope of this study to examine all the complexities of farm program interactions. However, the research team did adjust calculations to capture the nature and approximate magnitude of these interaction effects on the ROI estimates. Table ES-3 presents the results.

Table ES-3. Farm Program Interaction Effects on ROI

	LDP Program	Step 2
Interaction	Minimum price guarantee dampens the price benefit for domestic producers when the market price is below the guarantee price.	Guaranteed price ceiling for domestic mills using U.S. cotton allows any Program-related price increase to bypass the domestic mill and be paid by the government. Enhances the Program price benefit for domestic producers
Effect on Total ROI	–20%	+55%

Although there is some possibility that this ROI may be overstated because of the leverage factors discussed above, the balance of the evidence suggests that the Program returns positive and significant net benefits to domestic producers and importers.

ES.4 LIMITATIONS

No analysis is without shortcomings. Although we made every effort in this study to develop the appropriate models, obtain the correct data, and employ rigorous methods for estimation and simulation, capturing several Program phenomena remained difficult. The following is a list of some particularly important technical issues not entirely resolved in the present analysis.

1. **Agricultural research benefits are not directly estimated.**

   One need only look at the changes in yield, the geographic distribution of supply, and trends in input costs per unit of output to recognize that cotton production has experienced significant technical change in the last several decades. However, it is very difficult to discern the timing of agricultural research effects on supply, especially with the fairly short time series of data available for this study. Therefore, the study was not able to obtain a direct estimate of the ROI for CI agricultural research expenditures. To gain some insights into these benefits, the authors present data on technological developments in cotton production as part of Sections 3 and 7.

2. **The data may obscure the impacts of Program expenditures on export demand.**

   The data used in this analysis could not be separated into domestic and export components of Program expenditures. Therefore, total advertising and nonagricultural research expenditures were included when specifying the export demand function even though the majority of this expenditure is focused on the domestic market. If Program expenditures on domestic and foreign activities changed at the same rate over time, this would not be a problem, but that is not necessarily the case. Unfortunately, we could not divide these total expenditures into their domestic and export components to more directly test whether the export-oriented expenditures were effective in expanding demand.

3. **Returns to nonagricultural research may be biased upward.**

   CI expenditures on nonagricultural research may be correlated with expenditures from other sources that are not tracked by the econometric model of cotton demand (e.g., coordinated research and promotion efforts with private industry or government-funded research). If there is a strong positive correlation with these omitted variables, and if these expenditures exert a positive influence on demand, then the current model may overattribute demand enhancement to CI expenditures in this area, thereby overstating ROI.

4. Importer ROI is difficult to estimate.

Importers of finished cotton goods are assessed a payment on the weight equivalent of cotton contained in the product. The Program benefits importers if it causes the price of imported goods sold in the U.S. to rise more than the price the importers must pay for the good from their sources plus any increase in the marginal cost of supplying the import service. This is difficult to measure with the data available in the study, but we used an econometric method that approximates the corresponding price benefit using an inverse supply function for finished cotton apparel products. A critical question remains about how well that measure separates the welfare effects on the importers from the welfare effects on their suppliers.

ES.5 KEY FINDINGS

Although the analysis had some limitations, we present the following conclusions about the Cotton Research and Promotion Program's success in meeting its goals:

- The Cotton Program has a strong and positive effect on the demand for U.S. upland cotton.
- The returns to producers substantially outweigh the costs.
- Returns for demand-side research may be significantly higher than returns for promotion.
- Returns for domestic producers may be substantially higher than for importers.
- Evidence suggests that CI may be successfully leveraging its research programs with outside parties to the benefit of cotton producers and importers.

Overall, the results of the study indicate that cotton producers benefit from the Program. While care should be taken in using the mean estimate (30.6) as the definitive measure of Program ROI, the confidence interval around that mean suggests that we can say with a great degree of confidence that the Program's benefits outweigh its costs. It is also important to note that even though cotton prices have declined over time, especially in recent years, the econometric models presented in this study suggest prices would have been significantly lower without the Program.

1 Introduction

In the 1960s, as cotton began losing many of its traditional markets to synthetic fibers, U.S. upland cotton producers responded by developing a research and promotion program that could potentially offset the growth of synthetics and reestablish cotton as a dominant fiber. This effort has evolved today into the Cotton Research and Promotion Program. The program is funded by a per-bale assessment on cotton. The revenues are collected and managed by The Cotton Board, a quasi-governmental, nonprofit entity that administers the program.

The goal of the Cotton Research and Promotion Program is to expand the demand for upland cotton and to increase the profitability of both cotton growers and importers of cotton products. The underlying premise is that factors that expand the demand for cotton or reduce the cost of production improve the welfare of the producers and importers paying assessments. Demand expansion can occur through promotional and advertising programs. Such initiatives aim to develop consumer preferences for products made from cotton over those made from other fibers. In addition, textile research can expand the demand for cotton by finding new uses for the fiber and improving quality. Agricultural research can reduce the cost of production by developing new cultivation and processing methods.

The economic value of the Program to producers and importers depends not only on whether promotion and research have been effective in increasing sales or lowering the cost of cotton production, but also on the cost-effectiveness of these activities. It is very unlikely that Program promotion and research activities would not have at least some positive impacts on sales and production costs. The question is whether the costs of the Program are justified by its benefits. To address this question, a team of economists from Research Triangle Institute (RTI) and North Carolina State University (NCSU) performed an economic analysis of the cotton program. The results of that analysis are reported in this document.

1.1 STUDY OBJECTIVES

The purpose of this study is to assess how well the Cotton Research and Promotion Program's goals are being met. Toward that end, the Cotton Board has directed that the study must answer the following key questions:

1. What are the effects of the research and promotion activities on the three key areas of the Program?
   - ➤ demand for upland cotton
   - ➤ return-on-investment (ROI) to cotton producers funding the Program
   - ➤ net value to companies who import cotton products and raw cotton
2. What is the overall rate-of-return associated with the Program?
3. What are the qualitative benefits and returns associated with the Program?

To provide answers to these questions we developed and applied econometric models of the market for U.S. upland cotton. Using these models we can obtain empirical evidence of the Program's effectiveness in enhancing the demand for—and in the case of agricultural research, the supply of—U.S. cotton. For instance, these models can tell us whether the Program has had a statistically significant effect on the demand for cotton, while controlling for factors that are economically important but outside the sphere of the Program's influence (e.g., national income, the price of synthetic substitutes).

Rigorous econometric analysis can be an effective tool for evaluating a program's effectiveness. But some aspects of the Cotton Program are not easy to quantify precisely. Therefore, sole reliance on econometric modeling would likely not provide a complete characterization of the Program's effects. As a result, this report supplements the econometric analysis with a qualitative assessment of program effects. This assessment describes the activities undertaken under the auspices of the Cotton Program, their potential contribution to recognized industry phenomena, and the associated benefits to producers of those activities.

1.2 ORGANIZATION OF THE REPORT

Section 2 presents an overview of the Cotton Research and Promotion Program, including the basis for its funding, the size of its budget, the allocation of program funds across its four major activities, and its stated strategic directions.

Section 3 is a profile of the cotton industry. The profile includes a description of major segments of the industry, historical economic trends for the industry, the role of government farm programs for cotton, and technological developments in cotton production over time.

Section 4 describes the conceptual model and analytical methodology used to develop the econometric model and calculate the Cotton Program's rate of return.

Section 5 presents the results from econometric estimation of the cotton market model. The discussion focuses on the statistical and economic significance of the key policy variables of interest (e.g., program expenditure effects on cotton demand). The section also presents information from sensitivity analyses performed to gauge the robustness of the model to changes in specification. Much of the econometric model detail is described in technical appendices at the end of the report.

Calculations for the rate of return of the cotton program are calculated and discussed in Section 6. Results are presented in aggregate and for the different stakeholder groups involved (e.g., growers and importers).

As indicated above, econometric models cannot capture some aspects of program performance, either because they are difficult to detect in the data or are effectively nonquantifiable. As a result, Section 7 presents a qualitative assessment of potentially important factors not captured in the econometric analysis. Section 7 also concludes the report with a summary of key findings and limitations to the analysis.

2 The Cotton Research and Promotion Program

This section presents an overview of the Cotton Research and Promotion Program, with a focus on the efforts of Cotton Incorporated (CI) to execute the program authorized by Congress and funded by producers and importers. We begin with a brief history of the program, including the enabling legislation and present organization. The second section presents details of the funding and spending history, including the breakdown into the various areas of effort. The third section contains a description of current activities in all of CI's program areas.

2.1 BACKGROUND AND HISTORY

Until the development of petroleum-derived synthetic fibers in the 1950s, cotton was unrivaled as the dominant fiber in clothing and home textiles in the U.S. This situation had existed since before 1800, when the introduction of the cotton gin not only ushered in cotton's use in clothing and other textiles, but also created the nation's largest agricultural export for the next 150 years. The introduction and rapid quality and cost improvement of polyester and nylon fibers led to a sustained decline in the demand for cotton for all uses beginning in about 1960. By 1966, cotton's decline had progressed to the point that Congress felt a need to intervene, eventually passing the Cotton Research and Promotion Act of 1966.

The expressed purpose of the Act was "to enable cotton growers to establish, finance, and carry out a coordinated program of research and promotion to improve the competitive position of, and to expand markets for, cotton" [7 U.S.C. 2101-2118, Public Law 89-502]. In passing the law, Congress reasoned that the inroads in the textile fiber market made by synthetic fibers were largely a result of research and promotion conducted by its makers (primarily large chemical firms). Because individual cotton producers did not have the resources to perform these activities or the legal means to join together to fund such work, Congress provided a coordinating mechanism to enable producers to collectively engage in research and promotion.

2.1.1 Details of the Cotton Research Order

On December 31, 1966, the U.S. Department of Agriculture (USDA) put into effect the Cotton Research and Promotion Order after a successful referendum of growers as required by the Act. It covered all upland cotton grown in the U.S., whether consumed domestically or exported. The Order provided for

- a Cotton Board to oversee the program under the guidance of the USDA;
- a checkoff program to fund the research and promotion activities; and
- authorization for the Board to evaluate, supervise, and pay for these activities.

The Cotton Board was charged to establish and carry out research and promotion projects with respect to production, ginning, processing, distribution, or use of upland cotton and its products, to the end that marketing and use of cotton might be encouraged, expanded, improved, or made more efficient. The Board was to comprise at least one member from each producing state, with additional representation in proportion to the state's production of upland cotton. Each state's representative was to have an alternate, and both of them were to be chosen by the producers of the state. In addition, one member was to be selected by the Secretary of Agriculture to represent the public at large.

The Order required participating producers to pay an assessment on each bale of upland cotton, to be collected by the first handler. These funds were then to be pooled for use in promotion and research activities by the Board. Although the two-thirds vote required by the referendum assured broad support, any producer who did not wish to participate in the checkoff program could apply for a refund of all assessed amounts.

The Board was directed by the Order to contract with another organization to submit research and promotion plans for approval, carry out these plans, and pay for projects with the funds collected. Any such organization was to have a governing body consisting of cotton producers, also chosen in proportion to their state's marketing volumes. The first such organization chosen by the board was the Cotton Producer Institute. In 1970, CI took over these tasks and remains the contractor today.

2.1.2 Changes from the Cotton Research and Promotion Act of 1990

The Cotton Research and Promotion Act was modified significantly in 1990, in an effort to boost its impact on the overall textile market. Most notably, importers of textiles containing upland-type cotton were to be subject to the same assessments as domestic producers. The Board was expanded to include four importer representatives; the Secretary of Agriculture was authorized to change that number over time, as long as at least two importer representatives were named. Interestingly, Congress did not add a requirement to include importers in the governing body of CI.

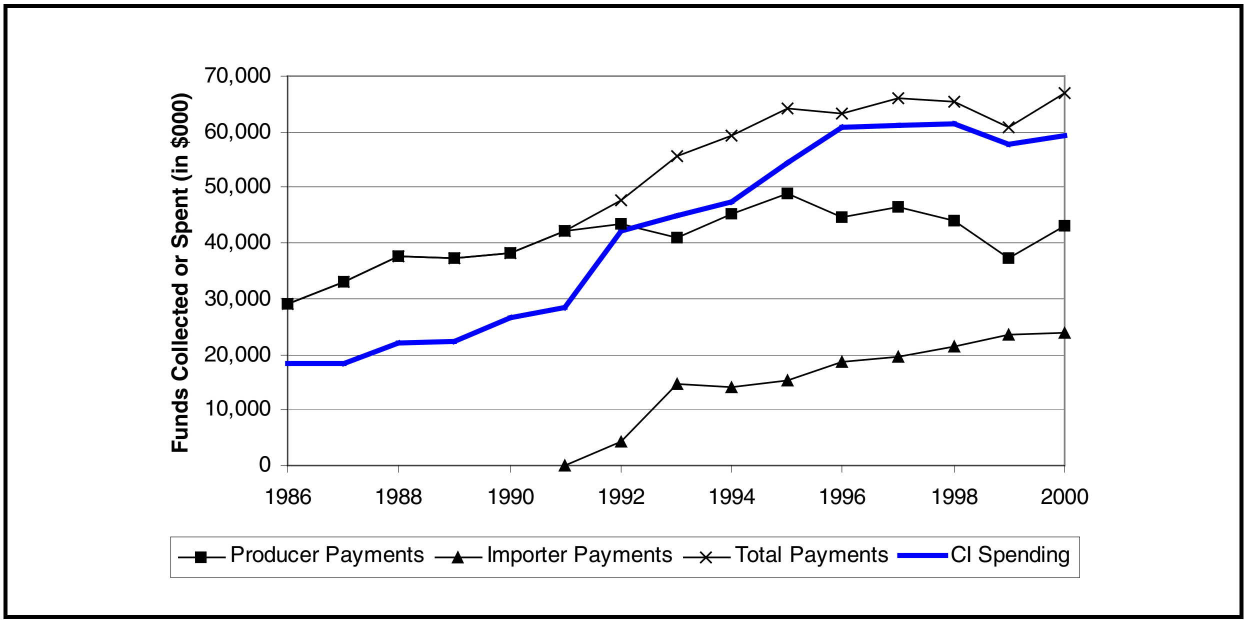
Two other significant changes were made in the 1990 Act. Elimination of the refund provision made the program mandatory for all U.S. growers of upland cotton. The Secretary of Agriculture was required to review the program's effectiveness every 5 years and was authorized to order a referendum if he or she determined it necessary. Producers themselves could demand a referendum upon the request of at least 10 percent of them, as long as no more than 20 percent of the requests came from importers or one state.

2.2 PROGRAM FUNDING AND SPENDING HISTORY

The Cotton Program currently requires producers and importers to pay $1 per bale, plus an additional assessment of one-half of 1 percent of the value. The Secretary of Agriculture may change this latter figure, but it may not exceed 1 percent. The checkoff is collected by the first handler, typically a marketer, merchant, or textile mill. For imports, the U.S. Customs Service handles the payments; the program order allows Customs to recover some of their costs of managing the process. In the case of crops delivered to the Commodity Credit Corporation (CCC) to settle marketing assistance loans, the USDA collects the assessment directly.

Figure 2-1 shows the total amount of program funds collected, broken out by the source of funds. U.S. producers have paid about two-thirds of the total checkoff since 1990, averaging $43 million over the past 5 years. The share paid by importers has grown significantly as imports capture a larger share of total cotton consumption. To avoid double-taxing the import of textiles containing U.S. cotton, importers can apply for exemption from the assessment if they can demonstrate that their products contain U.S. upland cotton. Reimbursement of funds already paid is also provided if satisfactory proof of U.S. origin can be shown.

Figure 2-1. Cotton Program Assessments and Spending, 1986–2000

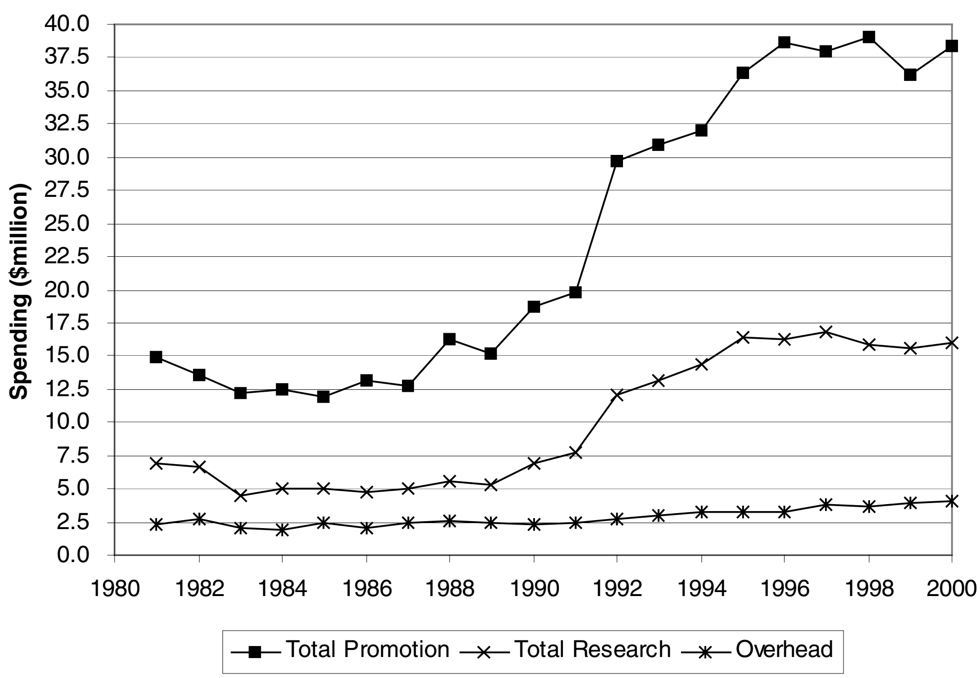


Except as noted, the description of CI's organization and program activities, as well as budget and spending information, was obtained directly from CI during 2 days of on-site meetings at their Cary, North Carolina, headquarters (CI, 2001).

Most of the funds collected are transferred directly to the Cotton Board. USDA retains a small amount to manage its part of the program, including the expenses of up to five full-time employees. The Cotton Board pays for its activities out of the net proceeds of the assessment. It must reimburse any governmental agencies that assist with the import provision, such as the Customs Service. Finally, the Board is obligated to pay $300,000 for any referendum ordered by the Secretary of Agriculture or requested by producers or importers. The balance of the funds is transferred to CI for use in research and promotional activities.

Figure 2-2 illustrates CI's budget over the 20 years for which records were provided. The figure illustrates the large increase in program resources resulting from including importers after 1990. Since inception of the program, promotion has captured about two-thirds of program expenditures, with research accounting for one-third. It is notable that administrative expenses have risen only modestly over this time period and have actually fallen considerably as a percentage of total program funds.

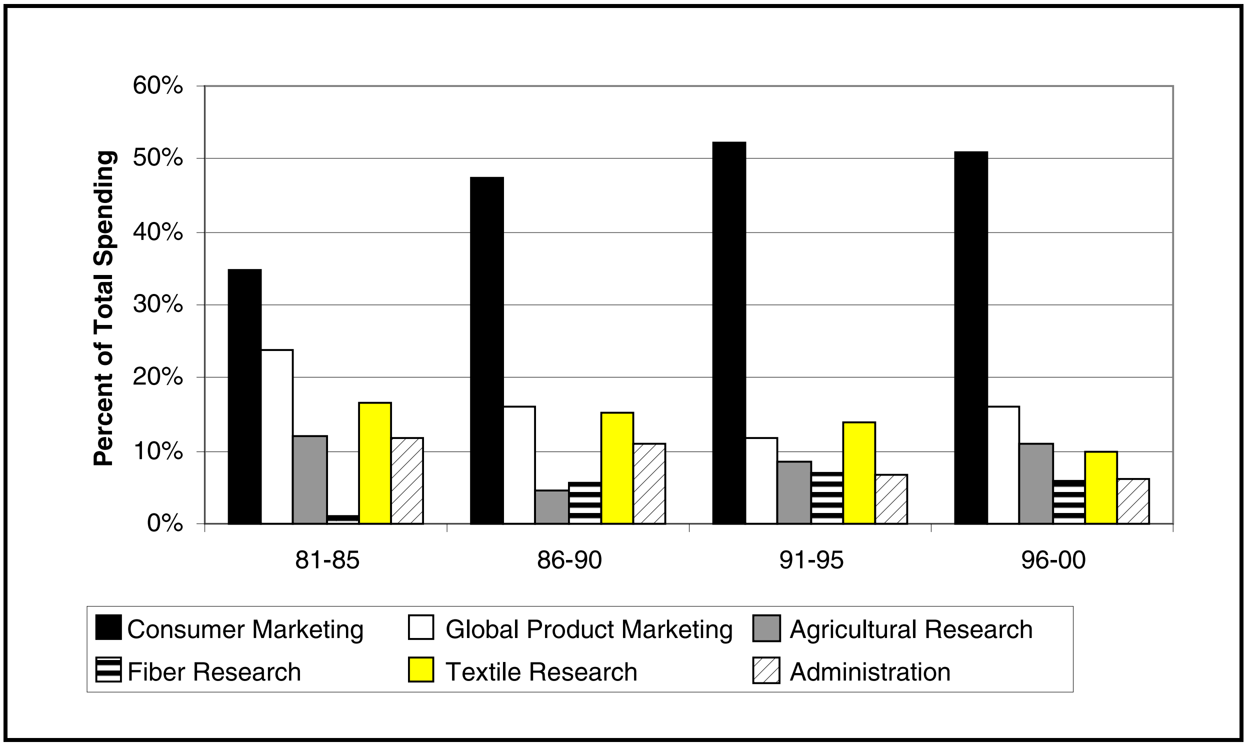
Figure 2-2. CI Program Area Spending



2.3 CI PROGRAM ACTIVITIES

CI engages in a wide variety of research and promotion activities, aimed at fulfilling its mandate from the Cotton Board and the U.S. Congress. For organizational and budgeting purposes, CI divides its efforts into program areas including agricultural research, fiber and textile research, global product marketing (GPM), and consumer marketing. Its support staff includes a strategic planning function as well as executive and administrative personnel. Figure 2-3 illustrates the allocation of spending across these functions over the past 20 years.

Figure 2-3. Spending by Program Area: 5-Year Averages



Although the spending patterns have evolved over the 20-year period for which we have data, the stability of these proportions from year to year is notable. Over the past 5 years, for example, agricultural research has taken a consistent 11 percent of the budget, fiber and textile research 16 percent, consumer marketing (primarily advertising) about 50 percent, and GPM about 16 percent. Spending has been flat in absolute terms over the 1996 to 2000 period, as growth in domestic and export markets has slowed. The most noticeable recent change in CI's spending has been *within* the GPM area, in which an increasing international share matches the gradual move of textile processing offshore.

The primary objectives differ across each of the program areas. Agricultural research is directed at improving the quality of and decreasing production costs for cotton. In the econometric analyses that follow, we view agricultural research as shifting out the supply function for cotton production. Fiber quality research and GPM activities are directed at mills and other primary users of raw cotton and, as such, affect the demand function for cotton. Textile research and consumer marketing are aimed at improving consumers' perceptions and valuation of cotton as a fabric choice. The effects here are on the demand for cotton-containing textile products, providing increases in the derived demand for raw cotton. The next sections discuss recent activities and accomplishments in each of the program areas.

2.3.1 Agricultural Research

Research in the growing, ginning, and processing of cotton has been a critical factor in its continued success as a textile fiber and source of export revenue. The funds allocated to research from the checkoff program are a small, but significant part of total research spending in the U.S., which includes work in corporations, universities, nonprofit organizations, and the federal government. Over the past 5 years, CI has spent about $6.5 million annually in support of agricultural research. For perspective, the USDA spends $45 million per year on cotton, the bulk of it in supporting academic and other nonprofit research (CI, 2001). Section 3.4 offers additional information on the breakdown of USDA spending.

CI does not conduct agricultural research in-house, but like the USDA, sponsors and funds projects proposed by others. CI receives proposals from across the country, evaluates the technical merit and potential of each project, and awards funds to those it deems most promising. Around two-thirds of the budget is committed to projects nominated by the states, in proportion to their cotton production; the remaining funds are for projects evaluated and awarded directly by CI. Regardless of the location of the project, however, CI approves their technical objectives, oversees the research performed, and assesses the completed projects.

Some of the more important results of the nation's cotton research effort are discussed in Section 3, along with contributions made by CI and its sponsored projects. There are at least two reasons to believe that CI's contribution to agricultural research may be larger than its share of funding. First, by focusing on the needs of the producers and processors, the research organization raises the probability that its awards will directly improve the competitiveness of U.S. grown upland cotton. Secondly, frequent interaction with the fabric and textile research and marketing personnel at CI ensures that breakthroughs in cost and quality are communicated rapidly to customers of both raw cotton and cotton textiles.

2.3.2 Fiber Quality and Fiber Management Research

Two other research program areas, Fiber Quality and Fiber Management, provide measurement and data analysis services and engage in technical support related to fiber quality characteristics such as color, staple length, strength, micronaire, and stickiness. In addition, ongoing projects assess fiber performance in finished textiles, including shrinkage, fading, and smoothness. CI's High Volume Instrument/Engineered Fiber Selection (HVI/EFS) system is the standard for measuring cotton fiber quality and is used by merchants and mills to track the performance of each year's crop and to select the optimal mix of cotton bales for their specific needs. These two research units spent $3.5 million in 2000, or about 6 percent of the firm's total.

2.3.3 Textile Research and Implementation

The final research unit is dedicated to textile research, both in processing and fashion fabrics. In effect, this group acts as an R&D organization for U.S. and overseas textile mills, performing many activities that in another industry might be done by individual firms. CI maintains a state-of-the-art pilot plant, with spinning, knitting, and dyeing and finishing operations. The firm rents time on weaving machinery at a Dan River Inc. plant and on nonwovens equipment at a North Carolina State University laboratory.

One of the products of this pilot-scale production facility is a wide array of fabrics of many different weaves and in a multitude of colors. Swatches of these knitted and woven fabrics are compiled into an annual Fabricast product release, which is made available to fashion and designers and clothing manufacturers. Over the past 5 years, more than 20,000 samples have been requested and delivered annually.

The annual budget of the textile research group is about $5 million, or 10 percent of total spending. The *process* R&D performed by CI benefits the textile mills directly and by improving their ability to process cotton and cotton-containing blends encourages them to increase their use of upland cotton. The *product* R&D, in the form of fashion fabrics, increases the desirability of cotton apparel to the final consumer, which then exerts a demand pull similar to advertising and consumer promotion. Although the textile mills might be expected to engage in both types of R&D, their efforts have historically been funded by the chemical firms that produce polyester and other synthetics. CI views their spending on behalf of cotton as a leveling of the textile fiber playing field.

2.3.4 Global Product Marketing

CI's GPM group describes itself as "cotton's sales force." Their mission is to communicate to textile mills and clothing retailers around the globe the CI products and services, make them aware of new products and processes developed by CI and its research partners, and convince them that consumers will demand cotton-containing products. Employees in this group make presentations at trade shows, distribute CI publications, and call on key customers both in the U.S. and abroad.

The GPM organization is, therefore, the primary conduit through which the work of the fiber quality, fiber management, and textile research groups reach cotton customers. In addition, they communicate the most recent consumer preference and awareness data generated by the Consumer Marketing and Strategic Planning groups. An important goal is to present cotton as a superior alternative to synthetic fibers across the spectrum of textile mills production. They attempt to reinforce CI's value proposition to the mills by offering processing support, quality troubleshooting, and other forms of technical service.

The share of CI's budget spent on GPM has varied more over the years than any other category. This area consumed more than 20 percent of total spending in the first few years after 1980, but fell to about 10 percent from 1990 to 1995. Since 1996, outlays have increased again to an average of $10 million per year, or about 16 percent of the total. The split between domestic and international spending within GPM has changed considerably as well. As overseas mills process an ever-greater share of U.S.-produced cotton, the proportion of funds spent on international GPM is increasing appropriately. Over the past 5 years, less than 20 percent of their budget has been spent on domestic GPM, and with U.S. mills still relocating in large numbers, this proportion should be expected to shrink further.

2.3.5 Consumer Marketing

By far the largest program area in terms of expenditure and influence is Consumer Marketing, consisting of advertising and public relations, fashion marketing, and retail merchandising. Approximately $25 million has been spent on advertising alone each year since 1995, and the other two programs each require more than $2 million per year. The most visible element in the consumer marketing effort, the brand image represented by the "Cotton Seal" is maintained and enhanced by these groups, through media promotion, merchandizing events, primary data collection, and strategic partnerships.

As of today, more than 75 percent of all consumers know about the Cotton Seal, and awareness is even higher among the target audience (women 18 to 49 years of age) (CI, 2001). CI's advertising has managed to convey positive images of cotton in apparel and home textiles and should help establish credibility in new product areas, including nonwovens. The fragmenting of media markets has made reaching the consumer more difficult in recent years, but the advertising group has copy reaching consumers in television, magazines, and other print media, and on the Internet.

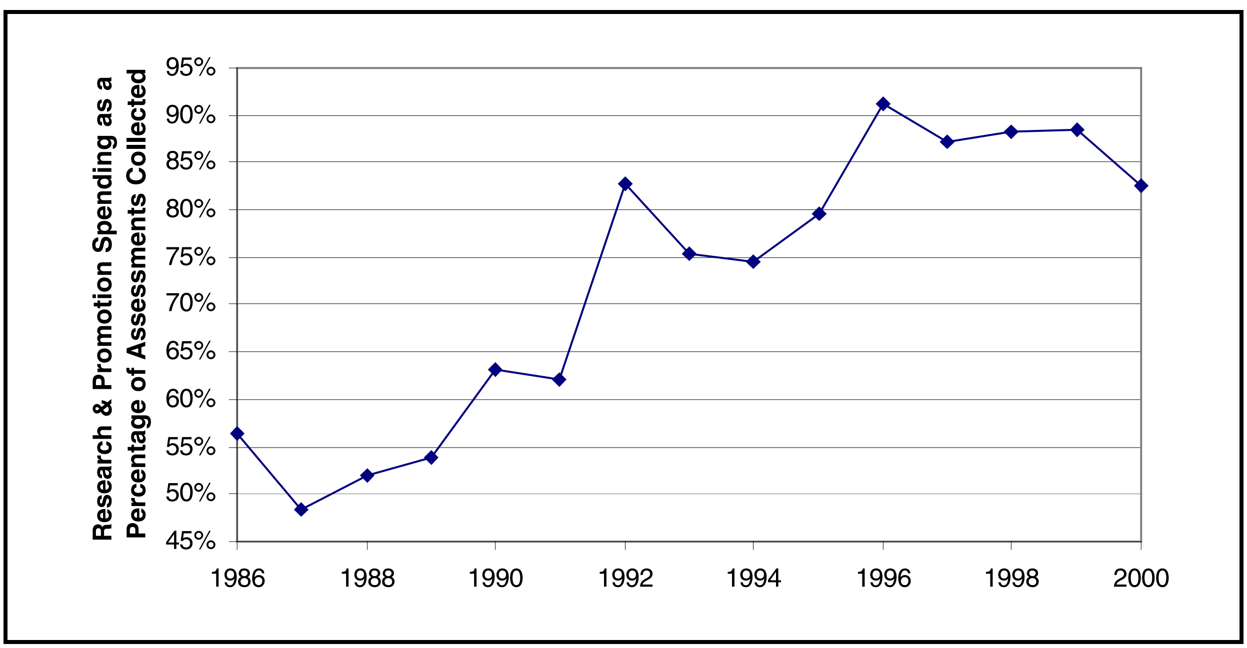
With a limited budget determined by cotton prices and domestic production, CI has increasingly emphasized strategic partnerships with other corporations who have a shared interest in promoting cotton-containing products. Tie-ins with apparel retailers like J.C. Penney have allowed CI to expand its presence in a number of media markets, including prominent display in fashion catalogs. In another innovative link, Procter & Gamble has placed the Cotton Seal on its detergents, which are promoted as being safe for cotton.

2.3.6 Administration

Two final groups are involved in administrative functions within CI: the management staff and a strategic planning organization. The latter group is charged with ensuring that the funds allocated to CI are spent for maximum impact in achieving the Cotton Board's mission. With the rapid pace of change in world fiber markets and the textile supply chain, a forward-looking planning function is vital. It is noteworthy that CI has managed to introduce the strategic planning function and build and operate a new headquarters building without a significant increase in the overhead load. In fact, the share of total expenditures represented by the administration and planning functions has fallen from more than 10 percent in 1981–1985 to about 6.5 percent over the past 5 years.

In terms of overall delivery of checkoff assessments to research and promotion, the USDA, Cotton Board, and CI have improved their performance continually over time, as Figure 2-4 shows. Spending on all research and promotion areas averaged 87.5 percent of total assessments received during the 1996–2000 period. Of the 12.5 percent in total overhead, slightly less than half was accounted for by CI's administration and strategic planning functions, with the balance going to the Cotton Board, the USDA, and other government agencies supporting the Cotton Research and Promotion Program.

Figure 2-4. Delivery of Checkoff Funds to Research and Promotion: 1986–2000



3 A Profile of the Cotton Industry

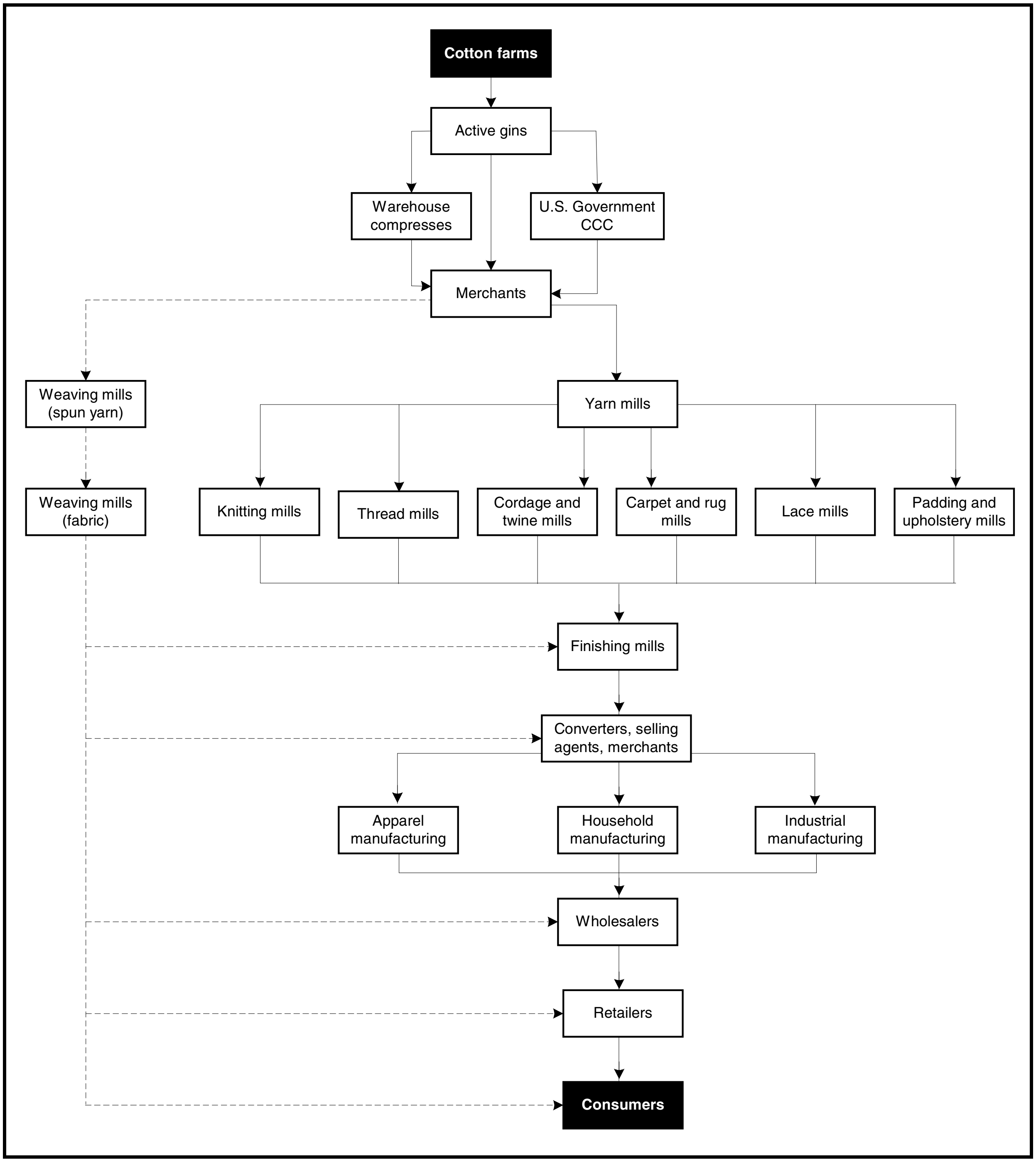
This section describes the cotton industry's role in the economy and how this role has changed over time. Understanding the role of the cotton industry and how other factors may have combined with the Cotton Program to affect the demand for and profitability of U.S. cotton is important for this analysis. Moreover, this industry profile highlights the critical role that technical change has played in the growth, distribution, and use of cotton.

This section describes the cotton industry's basic structure from farm to customer and presents historical data on cotton production, consumption, and prices. Then, we discuss the role of USDA farm programs on cotton producer prices and decisions. The section concludes with a summary discussion of technical change in cotton production and use over time.

3.1 STRUCTURE OF THE U.S. COTTON INDUSTRY

The production and marketing of cotton from farms to final consumers is a complex process that requires coordination among many parties, as shown in Figure 3-1. The cotton industry comprises six sectors: farms, gins, merchants, warehouses, cottonseed oil mills, and textile mills. This industry employs over 440,000 people and generates $40 billion in revenue. As Table 3-1 indicates, roughly half of the employment and revenue are attributed to the textile sector of the industry.

Figure 3-1. Production and Marketing of Cotton



Source: Glade, E., L. Meyer, and H. Stults. 1996. *The Cotton Industry in the United States.* USDA—Economic Research Service, Agricultural Economic Report No. 739.

Table 3-1. Cotton Industry Employment and Revenue, by Sector, 1997

Sector	Number of Jobs	Revenue
Farms	173,446	6,115,526,776
Gins	42,511	802,388,570
Merchants	2,844	8,297,276,000
Warehouses	9,938	277,795,000
Cottonseed oil mills	1,520	1,104,641,145
Textile mills	213,095	23,545,105,000
Total	**443,353**	**$40,142,732,491**

Source: National Cotton Council. 1999. "Sharing a Common Thread: Textiles Thrive on Cotton." <www.cotton.org>. As obtained on May 12, 2001.

For purposes of this report, we have categorized the various sectors of the industry into two broad categories: production and processing. Production consists of growing, harvesting, and ginning the cotton, and processing consists of all activities after the cotton is formed into a bale.

3.1.1 Cotton Production

The planting season for cotton typically occurs from February to June, depending on the region. The seedlings emerge 5 to 15 days after planting, and branches begin to form 3 to 4 weeks later. The cotton plant produces both vegetative and reproductive (fruiting) branches. Squares, or buds, develop on the fruiting branches, representing the first stage in cotton fruit formation. After an average of 23 days (or from late June to mid-August in most of the Cotton Belt), white or cream-colored flowers appear. The petals turn pink and are then shed after fertilization, and the cotton boll begins to develop. The bolls reach full size after 24 days, but need 24 to 40 more days for the fibers to stretch, thicken, and mature and for the boll to open. Although this represents the typical, or ideal, growth pattern, many factors, such as the variety, temperature, length of growing season, soil moisture and fertility, insects, weeds, and disease, can influence the development of a cotton plant (Deterling, 1982).

Each boll of harvested cotton contains between 28 and 45 seeds, which are separated from the fibers at the ginning stage.

When harvested, the cotton crop is composed of lint and cottonseed. Cotton lint is the most valuable portion of the cotton plant (see Table 3-2), but cottonseed is another major component. As shown in Figure 3-2, cottonseed is used in many ways once it is separated from the lint. Approximately 2 percent of the seed is used for re-planting; 38 percent is fed to livestock; and the remaining 60 percent is processed into oil, meal, hulls, and linters (Basra, 1999).[1]

Table 3-2. Retail Value of Cotton Crop, 1993–1994

Product	Pounds Produced	Retail Value
Lint	8,592,000,000	$116,658,587,361
Kernels (for feed)	NR	$1,877,660,322
Kernels (for oil)	2,048,789,000	$1,741,470,650
Hulls	3,387,162,000	$135,486,480
Linters	1,040,252,000	$187,245,360
Total		**$120,600,450,173**

NR = Not reported.

Source: National Cotton Council. 2001. "Weekly Export Report." <www.cotton.org>. As obtained on June 18, 2001.

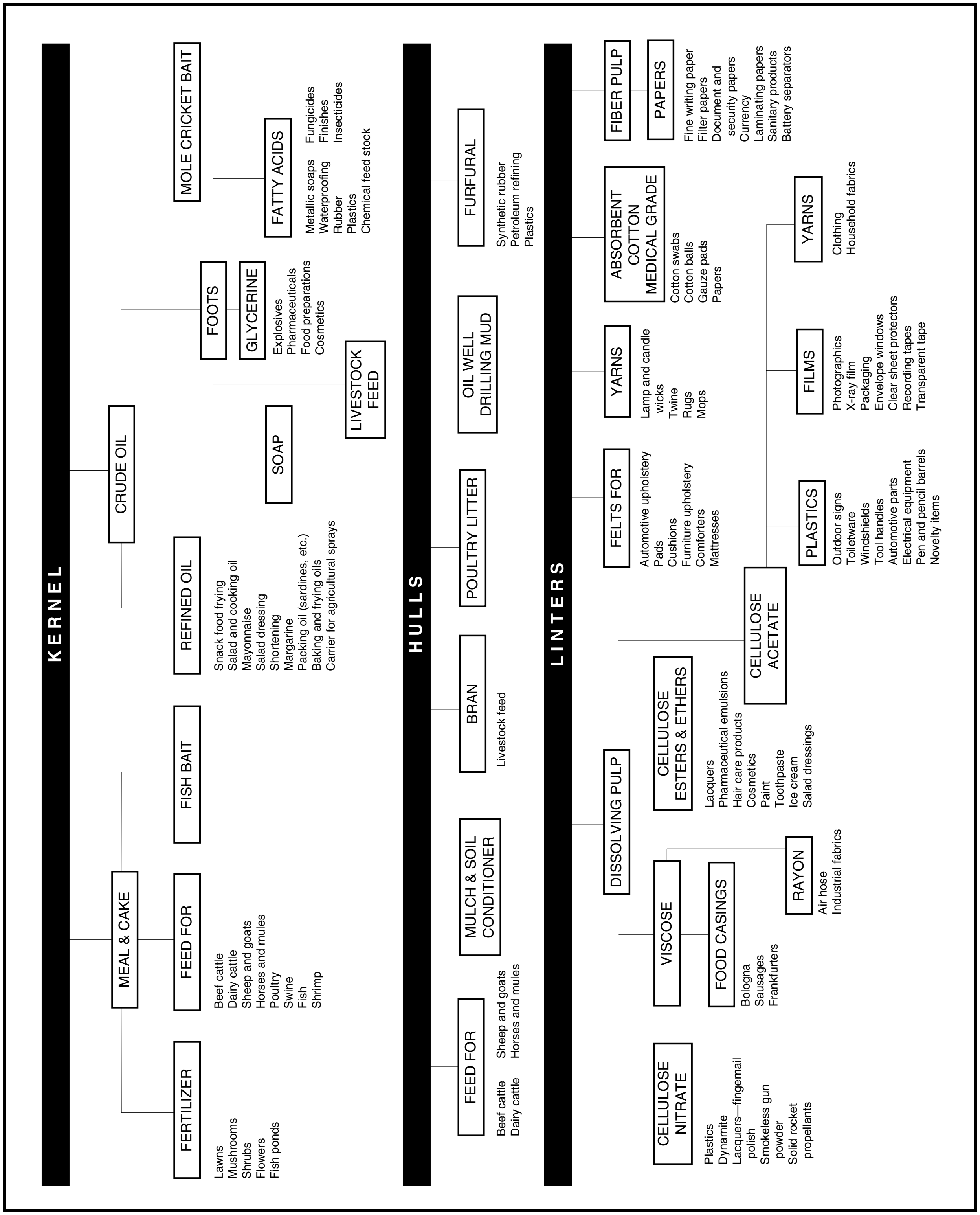
Cotton is grown in the southern part of the U.S., where abundant sunshine and moisture allow for ideal growing conditions. This area of 17 states is commonly called the "Cotton Belt." Texas is the largest producer of upland cotton, producing over 4.4 million bales in 1995. Table 3-3 provides a breakdown of cotton production by region. About 98 percent of the cotton that is produced in the U.S. is upland cotton, the type of cotton this report focuses on. The remainder is extra-long staple (ELS) or American Pima cotton, which is grown in the western part of the Cotton Belt.

As of 1997, cotton farms could be described as having the following characteristics:

- 54 percent of cotton farms had sales valued between $100,000 and $500,000;

[1]Hulls are the outer covering of the cottonseed, and linters are very small fibers that cling to the cottonseed.

Figure 3-2. Cottonseed Products and Their Uses



Source: Gregory, S., E. Hernandez, and B. Savoy. 1999. "Cottonseed Processing." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 793-823. New York: John Wiley & Sons, Inc.

Table 3-3. Production of Cotton by Region, 1999–2000 (1,000 bales)

Region	1999	2000
Southeast (Alabama, Georgia, North Carolina, South Carolina, and Virginia)	3,431.8	4,154.0
Delta (Arkansas, Louisiana, Mississippi, Missouri, and Tennessee)	5,127.0	5,375.0
Southwest (Oklahoma and Texas)	5,194.0	4,275.0
West (Arizona, California, and New Mexico)	2,405.0	3,070.0
Other (Florida and Kansas)	135.9	115.0
Total	16,293.7	16,989.0

Source: U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). <www.usda.gov/nass/pubs/trackrec/track00a.htm#cotton>. As obtained on November 15, 2000.

- 70 percent of cotton farms were individually or family owned, 19 percent were owned by partners, 10 percent were corporate farms, and the remainder were owned by cooperatives or institutions;
- 24 percent of cotton farmers were tenant farmers; the remainder were either full or part owners; and
- 88 percent of cotton farmers were age 35 or older.

The process of ginning is the bridge between cotton production and textile manufacturing. The original cotton gin had one purpose—to separate the fiber from the seed. Today's modern gin is required to dry and clean the seedcotton, separate fibers from seeds, further clean the fibers, and package the fiber into bales. Some modern gins can produce up to 100 bales per hour. The ginning sector has seen massive consolidation over the past 30 years. From 1968 to 1997, the number of gins declined by 73 percent, and average output per gin increased by 13,312 bales (Mayfield et al., 1999).

3.1.2 Cotton Processing

Cotton has more value added to it during processing than any other crop (Basra, 1999).

Cotton has more value added to it during processing than any other crop (Basra, 1999). Once textile mills receive the cotton bales, they are opened, conditioned, mixed, carded, and occasionally combed before spinning. The spun yarns are then knitted or woven to produce fabric, and the fabric is transformed into a multitude of end uses. Dyeing and finishing can occur at any of these phases. The movement of cotton throughout these steps is presented in this section.

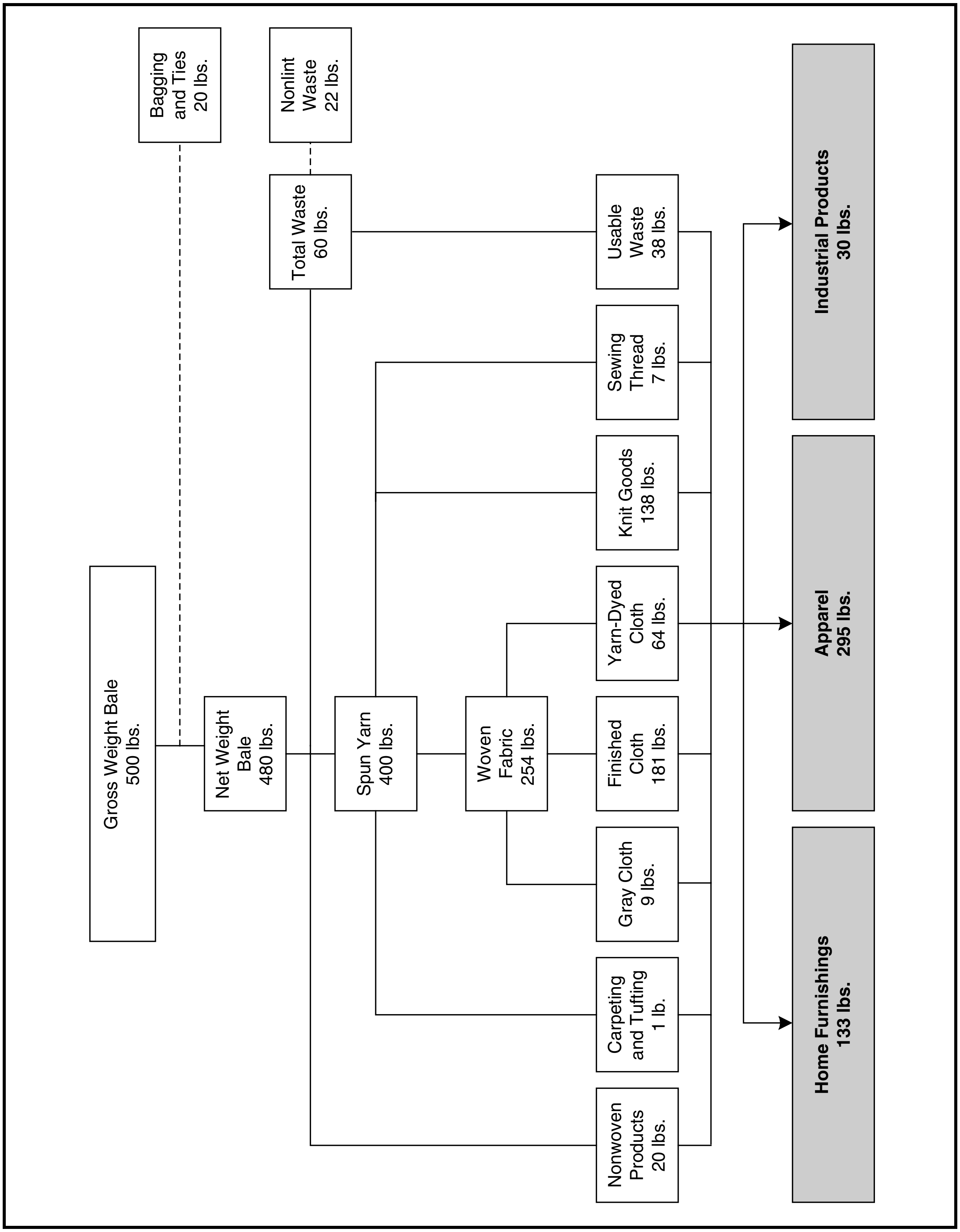
Cotton bales are shipped from gins and warehouses located throughout the Cotton Belt to both foreign and domestic mills. Cotton merchants arrange the transfer of bales between these parties, although they rarely see the actual bale that they merchandise. Cotton merchants are located throughout the Cotton Belt, and typically maintain small offices, with 55 percent having less than five employees. The marketing system has become much more efficient over the past decade with the use of High Volume Instrumentation (HVI) classification system and electronic data exchange.

Cotton is harvested throughout the Cotton Belt in a 6-month time period, beginning in south Texas in mid-July and ending in North Carolina and West Texas in December. However, mills use cotton on a continual basis. To facilitate the movement of cotton along the supply chain, the cotton industry has adopted the Quick Response (QR) and Just In Time (JIT) strategies. These systems, which rely on computer and scanner data, reduce the time between consumer demand and production, and allow for lower inventories to be maintained. These also enable the retailer to communicate with the apparel manufacturer about specific inventory needs. One study cited by the U.S. International Trade Commission (2001) stated that QR resulted in substantial savings at the consumer level due to lower prices and better service.

Domestic textile mills are concentrated in four states: Alabama, Georgia, North Carolina, and South Carolina. As of 1997, the last year in which Economic Census data are available, the number of U.S. textile mills increased by 4.6 percent since 1992. However, according to David Link (2001) of the American Textile Manufacturers Institute, the number of textile mills has decreased since 1997, and the rate of closure is increasing in 2001. To compete, many firms have become vertically integrated, with the largest companies combining spinning, weaving, and finishing (Glade, Meyer, and Stults, 1996).

The National Cotton Council has identified 92 major product classifications as end uses for cotton. They are grouped into three broad categories: home furnishings, apparel, and industrial uses. Apparel is the predominant category, accounting for 295 pounds of an average bale (see Figure 3-3). Men's and boys' apparel is the largest market for cotton, followed by women's and children's

Figure 3-3. Distribution of an Average Bale of U.S. Cotton



Source: Glade, E., L. Meyer, and H. Stults. 1996. *The Cotton Industry in the United States.* USDA—Economic Research Service, Agricultural Economic Report No. 739.

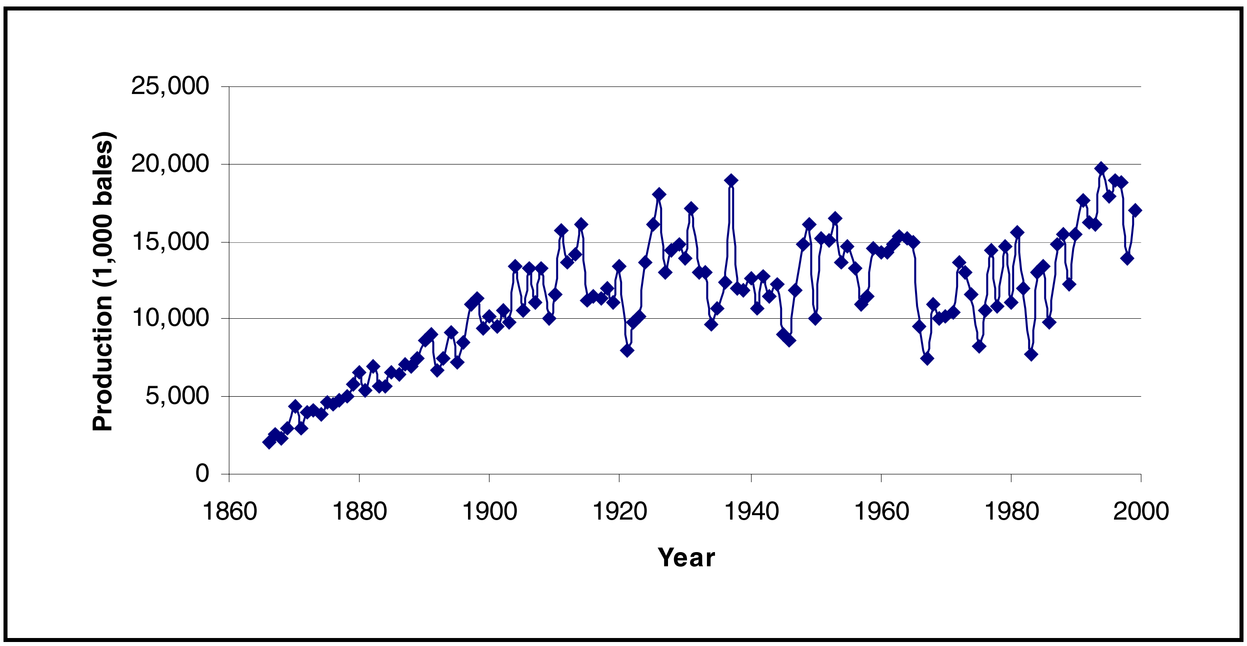
apparel. These markets used 3,705, 2,384, and 771 bales, respectively, in 1997 (National Cotton Council, 1998). Within the apparel category, 52 percent of apparel is constructed of knit fabrics, and 48 percent is of woven fabrics (National Cotton Council, 1998).

3.2 HISTORICAL TRENDS

3.2.1 Raw Cotton

Figure 3-4 shows U.S. production of (farm-level) cotton fiber from 1866 through 1999. The figure depicts a trend of steady expansion from Reconstruction to the mid-twentieth century. This increase was followed by a moderate decline in output, as substitutes for cotton started to take hold in the 1960s and 1970s. Production started to rise again in the late-1970s.

Figure 3-4. U.S. Cotton Production: 1866–1999



Source: U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). <www.usda.gov/nass/pubs/trackrec/track00a.htm#cotton>. As obtained on November 15, 2000.

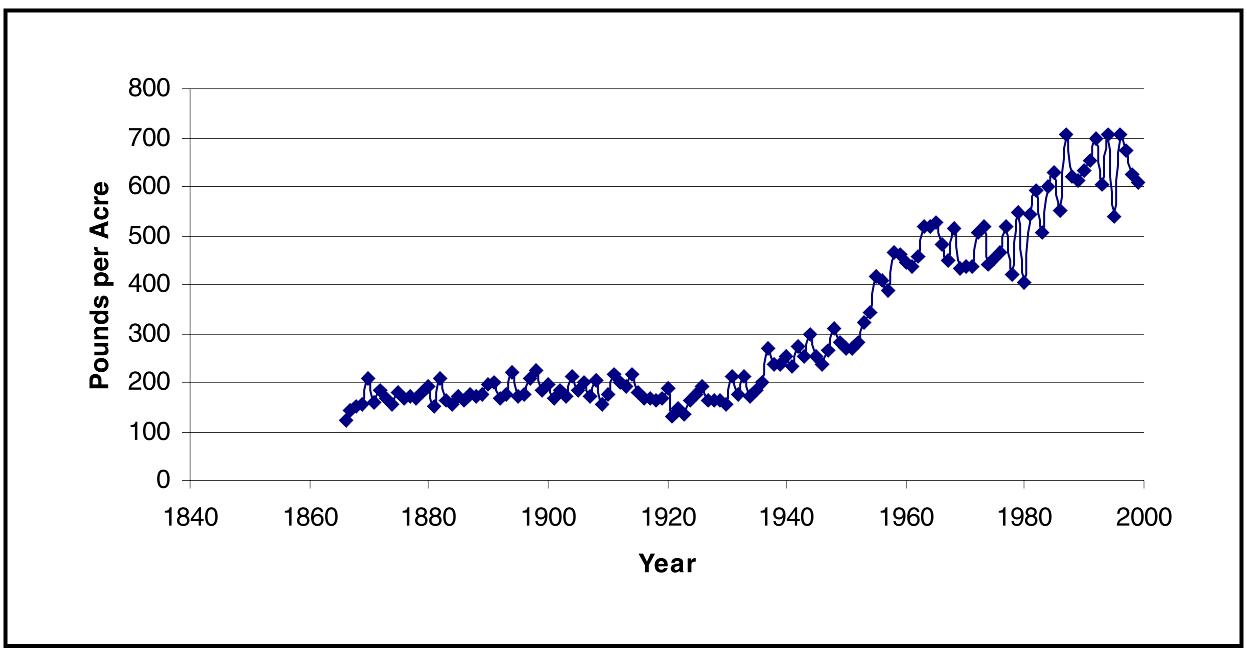
A general trend in agriculture has been a decrease in the number of farms, accompanied by an increase in the average number of acres per farm. This trend has also been evident in cotton. There were 31,493 cotton farms in 1997, compared to 34,812 in 1992 and

43,000 in 1987. Further, the average number of acres per farm has increased from 228 in 1987 to 314 in 1992 to 420 in 1997.

Area planted in cotton peaked at 45 million acres in the mid-1920s and has fallen to about 10 to 15 million acres in recent years. This decline in acreage is attributed to acreage controls, alternative crops, and the presence of the boll weevil (Smith, 1999). The production of cotton has been characterized by regional shifts, with the Southeast region producing 16 percent more cotton in 1997 than in 1986 and the Western region producing 13 percent less. Reasons for the shift from West to East include increased water costs in the West and decreased insect management costs in the Southeast (Anderson, 1999).

Despite acreage decreases, cotton production levels have been maintained as yields per acre have risen considerably over time (see Figure 3-5). These yields reflect the input intensification and genetic improvements in agriculture throughout the twentieth century, in cotton as well as all other commodities, which has been fostered by public and private research and extension expenditures. Some of these improvements are discussed in Section 3.4.

Figure 3-5. U.S. Cotton Yield per Acre: 1866–1999

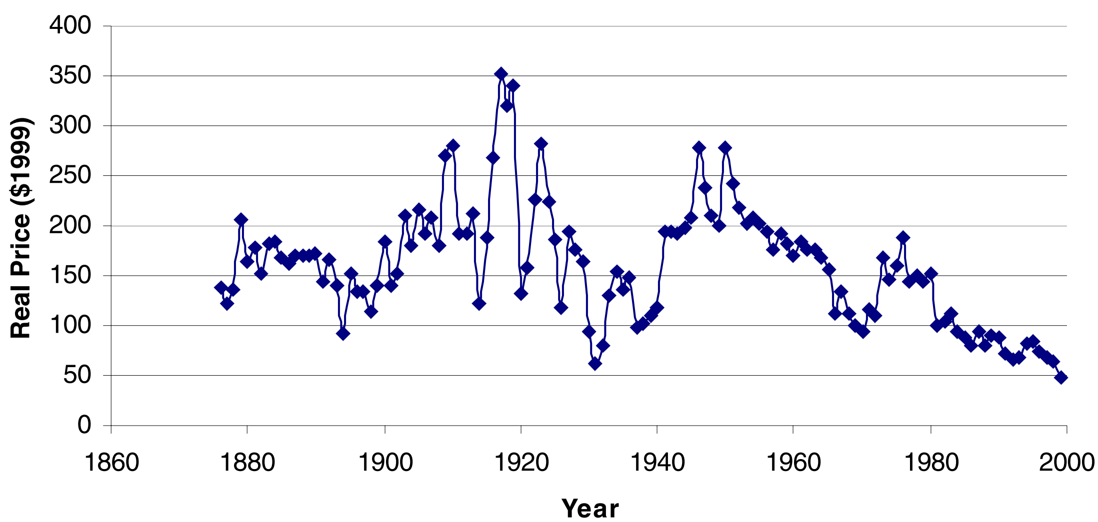


Source: U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). <www.usda.gov/nass/pubs/trackrec/track00a.htm#cotton>. As obtained on November 15, 2000.

Real prices have steadily declined in the last 50 years.

While increased yields benefit cotton producers, other factors also affect their welfare. Market prices for cotton and inputs are key determinants of profitability. Nominal cotton prices have risen over time, of course, but real (inflation-adjusted) prices have varied over the last 125 years (see Figure 3-6). Real prices have steadily declined in the last 50 years. However, the recent decline in real prices does not mean that promotion has not successfully expanded cotton demand. Rather, the factors encouraging lower prices, such as new market entrants and higher yields, have apparently dominated price-enhancing factors such as advertising and promotion. The econometrics section of this report will examine these effects more rigorously.

Figure 3-6. Real Price of Cotton: 1876–1999



Source: U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). <www.usda.gov/nass/pubs/trackrec/track00a.htm#cotton>. As obtained on November 15, 2000.

3.2.2 Textiles and Apparel

Demand for all fibers by the textile, apparel, and home furnishing industries has generally risen over time with population and economic growth. On a per capita basis, U.S. total fiber demand more than doubled between 1962 and 1999, reaching more than 80 pounds per person in 1999. While per capita demand has shown a general upward trend over time, per capita demand also tends to move with economic cycles. Contractions of the economy during recessions in 1974–1975 and 1981–1982 are reflected in falling demand, while recent expansion has moved total per capita fiber demand to its highest level to date. However, changes in demand for specific fibers, such as cotton, are strongly affected by changes in fashion trends, product acceptance, and consumers' lifestyles.

> Raw cotton is the largest investment for a textile mill, representing 64.7 percent of the yarn costs.

As a major raw material of the U.S. textile industry, cotton has seen its popularity decline and rebound over the past 50 years. Although the first of the synthetic fibers, rayon, was introduced in France in 1884, and both nylon and acrylic were introduced commercially in the 1940s, there was little effect on cotton's market share until the early 1950s. Polyester, the chief synthetic competitor to cotton, was introduced commercially in 1953. At the time of polyester's introduction, cotton had a market share near 65 percent, but cotton's share plunged to 30 percent by 1973. From the early 1960s to the early 1980s, cotton's share of the total fiber market was cut in half as synthetic fibers grew in popularity.

Because of the popularity of synthetics, rayon returned to the fashion scene in the 1980s after being largely disregarded in the 1960s and 1970s. Rayon production dropped steadily in the latter part of the decade, due in part to stricter environmental regulations (Tortora, 1997). The environmental movement continued in the 1990s with consumers able to purchase fabrics dyed with natural dyes, organically grown cotton products, and polyester products made from recycled soda bottles. Also, another new synthetic fiber was introduced, lyocell, that had a pollution-free manufacturing process (Tortora, 1997).

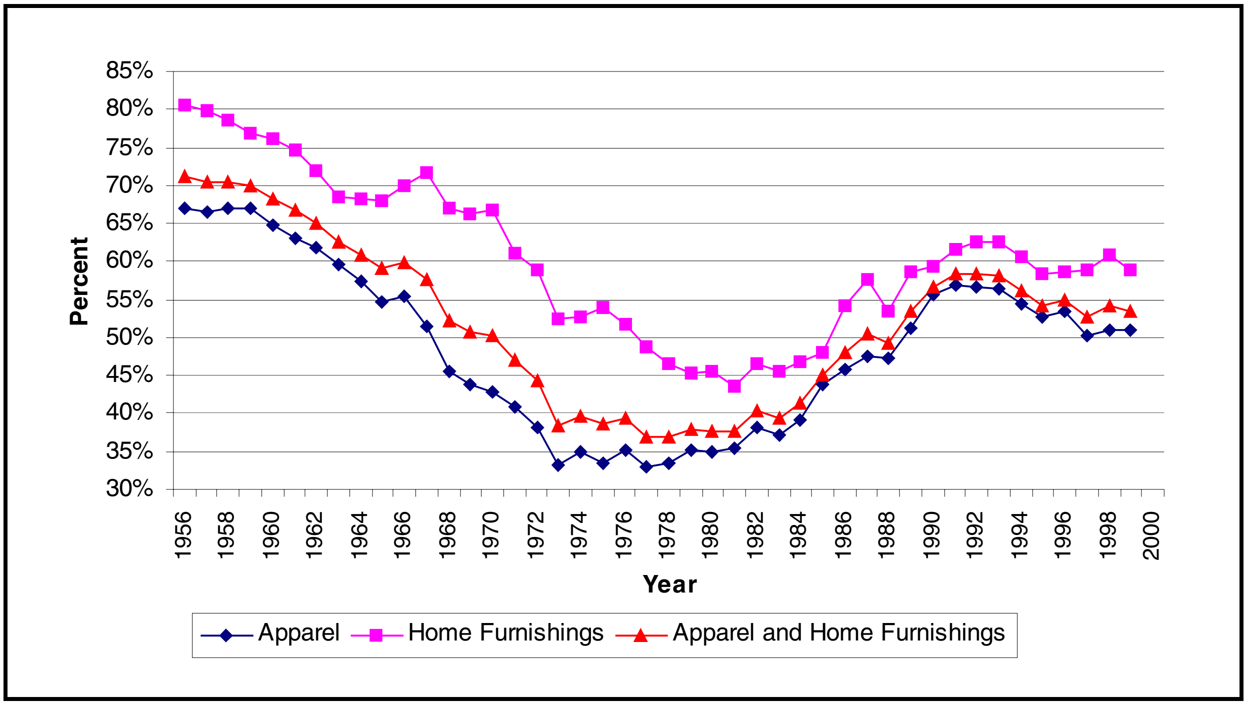
Denim became an increasingly popular fabric among younger generations in the 1980s, as it was used in jeans, jackets, skirts, and entire suits (Clancy, 1996). Subsequently, denim production increased by 75 percent from 1984 to 1994 (National Cotton Council, 1999). Since denim is produced almost entirely from cotton, this trend helped cotton gain 29 percent of the U.S. apparel market share from 1981 to 1993.

Over the past 15 years, U.S. consumer demand for cotton products has risen dramatically as consumer preferences shifted back towards natural fibers (Meyer, 1999).

Over the past 15 years, U.S. consumer demand for cotton products has risen dramatically as consumer preferences shifted back towards natural fibers (Meyer, 1999). Figure 3-7 depicts cotton's share of apparel and home furnishings (excluding carpet) at the mill level from 1956 to 1999. Cotton's share of these items at the retail level increased from 41 percent in 1986 to 64 percent in the third quarter of 2000. Now that cotton market share is back at levels not seen since the 1960s, CI has developed a strategy to "sustain the gain" by maintaining a high market share in denim and towels, building the market share in women's wear, and expanding into new markets such as nonwovens (CI, 2001).

Since the U.S. represents only 10 to 12 percent of worldwide cotton consumption, one must consider global cotton use to have a complete picture. Over the past 10 years, cotton use has increased from 86 to 93 million bales worldwide. However, cotton has lost global market share to polyester every year for a decade (Ethridge, 2001).

Figure 3-7. Cotton Market Share at U.S. Mills



Source: Textile Economics Bureau. Textile Organon (serial). Various issues. New York: Textile Economics Bureau.

3.2.3 International Trade Issues

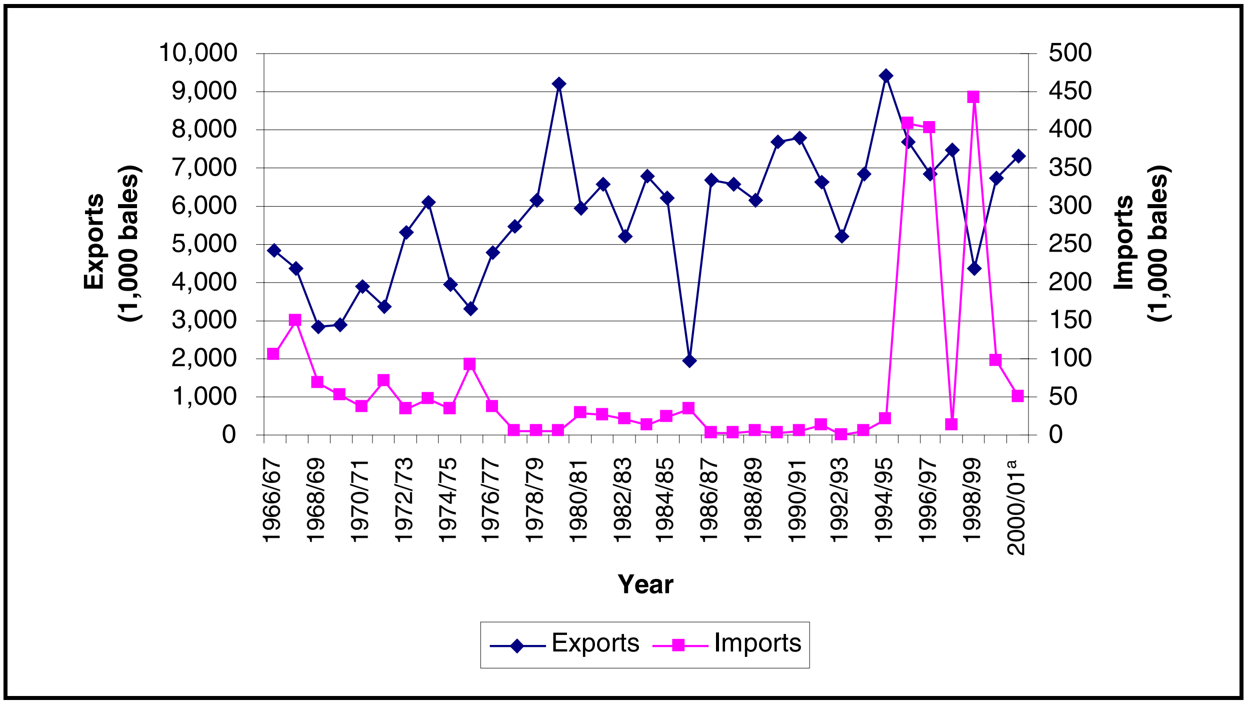
International trade affects all sectors of the cotton industry, but the production and processing sectors experience different effects. For cotton production, trade (specifically exports) has become a substantial source of raw cotton demand for U.S. producers. However, trade (specifically imports) has caused substantial dislocation in the U.S. textile and apparel sectors. Both of these are discussed in greater detail below.

Exports of raw cotton have increased since the1960s, with an average of 5.8 million bales per year (see Figure 3-8). Since 1995, the U.S. exported approximately 40 percent of its domestic production (USITC, 2001). The industry has experienced periods of increased volatility, as in 1998 when exports fell by over 3 million bales. This decline was due to a smaller U.S. crop and larger foreign exportable supplies (USDA, 1998). Unlike domestic mills, which receive bales at fairly constant levels throughout the year, foreign mills exhibit seasonal patterns. Most exports are shipped in the first quarter of the year. Primary markets include Mexico, Turkey, and Indonesia (National Cotton Council, 2001).

There is little competition between domestic and foreign cotton in the U.S. Imports of raw cotton accounted for less than 5 percent of domestic mill consumption during 1995 through 1999, and were less than 1 percent in 1997 and 1999 (USITC, 2001). Imports of raw cotton declined from 1966 to 1994 with an average of 32,000 bales but then increased dramatically to over 400,000 bales in 1995. This sharp increase was primarily due to low stocks in the U.S. at the beginning of the season (Meyer, 2001). Imports in the late 1990s have been extremely volatile, fluctuating from 13,000 bales in 1997 to a 70-year high of 443,000 bales in 1998 and down to 50,000 bales in 2000 (see Figure 3-8). Again, this was due to lower supplies in the U.S. and abundant foreign supplies (USDA, 1998). Primary import sources for the U.S. are Greece, China, and Syria (USITC, 2001).

Exports of cotton textile and apparel were very stable from the 1960s through the 1980s, averaging 300 million pounds per year (see Figure 3-9). The 1990s saw a surge in cotton textile exports, with an average annual growth rate of 15 percent. However, the level of exports has not been able to keep up with the influx of

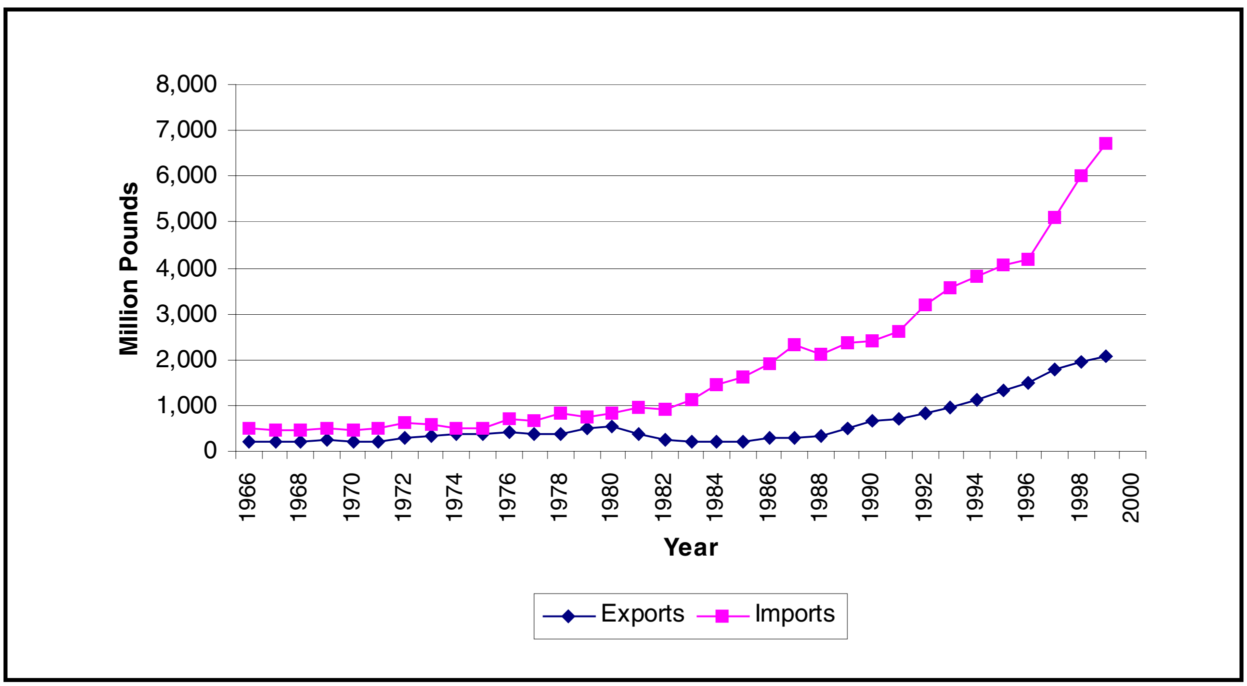
Figure 3-8. Raw Cotton Trade



[a]Forecast.

Source: U.S. Department of Agriculture, Foreign Agricultural Service (USDA/FAS). June 2001. *Cotton: World Markets and Trade*. Circular Series FC 06-01. Washington, DC.

Figure 3-9. Cotton Textiles Trade



Source: U.S. Department of Agriculture, Economic Research Service. Various issues. *Cotton & Wool Yearbook.* November. Washington, DC.

The U.S. has been a net importer of cotton textiles and apparel for the past 30 years.

imports. The U.S. has been a net importer of cotton textiles and apparel for the past 30 years. Import penetration of cotton textiles and apparel continues to rise, increasing from 40.4 percent of consumption to 56.5 percent in only 8 years (1989–1997). Almost three-fourths of the imports consist of apparel, while less than 20 percent are fabric and textile products (the remainder consists of headgear and home furnishings). Apparel manufacturing is more labor intensive than textile processing; thus, this facet is being driven towards low-wage developing countries (Steele, 1995). In many cases, the fabric is constructed in the U.S., cut and assembled in other countries, and then imported back into the U.S. as the final good. This results in a loss to the U.S. of value-added between processing stages. Unfortunately, the industry does not have an estimate of how much apparel made of U.S. grown cotton is imported into the U.S. But when one considers both cotton fiber and cotton content of textile and apparel trade, the U.S. has recently become a net cotton importer. This proves that cotton textile and apparel imports are increasingly made with foreign cotton (Hudson and Ethridge, 2000).

Regional trade agreements such as the North American Free Trade Agreement (NAFTA) and the Caribbean Basin Initiative (CBI) have had a major impact on U.S. textile and apparel trade over the past few years (Meyer et al., 2001). These agreements were reached in 1994 and 1983, respectively. Exports of cotton textiles to NAFTA and CBI countries have risen from 65 percent in 1993 to 88 percent in 2000, while those destined for Asian countries have fallen from 14 percent to 3 percent over the same time period. Likewise, cotton textile imports have had a similar pattern. NAFTA and CBI countries are now the source of 41 percent of cotton textile imports, compared to only 18 percent in 1993. Asia, which accounted for 65 percent of cotton textile imports in 1993, now accounts for 46 percent.

3.3 RELEVANT GOVERNMENT PROGRAMS

Since the beginning of the Great Depression, the government has been actively involved in cotton and textile markets, supporting growers, exporters, processors, and textile manufacturers. Over the years, mechanisms used have included tariffs and quotas, output restrictions, price supports, direct payments, and export and use subsidies. In this section, we will discuss the most significant current programs, and identify their impact on the present study.

3.3.1 Farm Programs

Beginning with the Agricultural Adjustment Acts of 1933 and 1938, the government has attempted to support cotton growers' incomes by restricting output and supporting domestic prices. The Federal Agricultural Improvement and Reform (FAIR) Act of 1996, also called the "Freedom to Farm Act," kept several of the long-standing loan and payments provisions but swept away a complicated set of price targets and acreage quotas that had been in place for decades. The FAIR Act covers the period from 1996 to 2002 and includes the following elements: marketing assistance (MA) loans, loan deficiency payments (LDPs), agricultural marketing transition assistance (AMTA) payments, and a three-step competitiveness process (USITC, 2001).

The CCC has been offering nonrecourse MA loans to cotton growers since its founding in 1938. Farmers may request loans on any bales of cotton they have harvested and ginned, as long as they insure them and store them in a USDA-approved warehouse. The loan rate is based on the lower of the adjusted world price (AWP) or 85 percent of the price received over the past 5 years but is guaranteed to be no lower than 50 cents per pound and no higher than 51.92 cents. From this base loan rate, a premium or discount is applied, depending on the region and the quality of the bale being considered. If market prices were to rise during the term of the loan, the grower would be free to sell the cotton and repay the loan, plus fees and charges. If the loan is not paid off within 10 months of the issue date, the grower defaults on the loan and the cotton is forfeited to the CCC.

As an alternative to placing cotton into the CCC loan program, growers can apply for a LDP, which allows them to sell their cotton on the market and receive a payment from the CCC for the difference between the loan rate and the AWP. Growers can also use this provision to pay off their MA loans at the AWP rather than at the loan rate. With cotton prices having fallen below 29 cents per pound this summer, average LDP rates now exceed 23 cents (FSA, 2001).

Prior to the 1996 FAIR Act, farmers could only take part in the MA or LDP programs if they set aside a portion of their acreage to reduce production. This quota system was intended to keep prices up by reducing supply, but yield increases and pressure from textile imports kept downward pressure on prices. In an attempt to restore market forces to the cotton market, the acreage allotments were eliminated, and a schedule of AMTA payments was established. Growers were offered the opportunity to sign up for the 7-year program, which offered payments based on historical production levels. The intent was to gradually reduce these production flexibility contract (PFC) payments as market forces were restored.

Since 1996, however, U.S. and world prices for cotton have fallen significantly, and in 1998, Congress added marketing loss assistance payments to the PFCs. The net result is that cotton growers received double the 7.88 cents per pound initially planned for 1999, and total contract payments for 2000 were 15.21 cents per pound (USITC, 2001, p. 24). The level of cotton support for 2001 and 2002 will depend on the total allocation Congress sets for these programs, but emergency appropriations are likely to emerge again if world cotton prices remain low.

To mitigate potential negative impacts of the price support programs on exports and the domestic textile industry, a three-step competitiveness process was also put in place by the FAIR Act. Step 1 allows the Secretary of Agriculture to lower the AWP if it falls below 115 percent of the loan rate to provide more income to farmers. Step 2 provides for payments to U.S. mills, marketers, and exporters when the U.S. export price as measured by the Cotlook A-Index exceeds the Northern European price by more than 1.25 cents per pound for 4 consecutive weeks. Step 3 protects domestic users by increasing cotton import quotas when the U.S. price exceeds the Cotlook A-Index by more than that same 1.25 cents per pound for 4 consecutive weeks.

Conservation set-asides have been a popular form of supply limitation for more than 50 years, and current farm programs have a number of these initiatives as well. The 1985 farm bill authorized a Conservation Reserve Program (CRP), which makes annual payments based on the rental value of land voluntarily set aside from production. Any such land must be planted in an approved vegetative cover. Land eligible for the CRP include wetlands, designated conservation priority areas, highly erodible land, and cropland surrounded by noncropped wetlands. The 1996 Farm Bill changed the program's focus to emphasize set-asides for wetlands. The 1985 law provided for a maximum of 15 annual payments, but those contracts due to expire in 2000 were extended for a year by the Secretary of Agriculture last summer. The cotton-producing states have actively participated in the CRP since its inception. As of the 1992 Agricultural Census, the 12 principal cotton states had set aside 5 million acres, or about 75 percent of their total cropland. By 1997, the states had increased their set-asides to 7.5 million acres, or more than 10.3 percent of harvested cropland. Nationwide, the 1997 Agricultural Census reported 9.5 percent of cropland entered in the CRP (USDA, 1997).

3.3.2 Textile and Apparel Trade Agreements

Prior to the 1970s, a trade agreement referred to as the Long Term Agreement Regarding International Trade in Cotton Textiles (LTA) was in effect. Thirty-three countries were signatories of this agreement, which was extended twice in 1967 and 1970. This agreement allowed the U.S. to limit volume growth of cotton textile imports at 5 percent per year (Dickerson, 1999).

There were no restrictions on man-made fiber imports during the years 1964 to 1971.

There were no restrictions on man-made fiber imports during the years 1964 to 1971. In this time period, man-made fiber imports increased by 1,200 percent (Nordquist, 1984). Partly because of this influx of imports, the U.S. was one of 38 countries and the European Economic Community to sign the Multi-Fiber Arrangement (MFA) in 1973. Import quotas were established by the participating countries according to product type and country of origin. Products included in the MFA included tops, yarns, piece goods, and apparel made from cotton, wool, and man-made fibers. Most of the arrangements between countries were flexible, allowing "carry-over" of unused quota from a previous year, "carry-forward" of borrowed quota from a succeeding year, and "swing" of unused quota from one category to another in a given year (Yang, 1997).

The MFA was renewed in 1977, 1981, and 1986, with slight changes made each time. The MFA renewal in 1978 was more restrictive than the first arrangement, making quota frauds more frequent. Imports of items not covered under terms of the MFA, such as silk, ramie, and linen, grew significantly in the 1980s

(Glock and Kunz, 1995). For this reason, these fibers were appended to the arrangement terms in 1986 (Yang, 1997).

In 1993 at the GATT Uruguay Round, the Agreement on Textiles and Clothing specified that the MFA was to be phased out by the year 2005. Products will be released from quota at four different time periods, and remaining quotas will be expanded in three phases. The first two stages of the phase-out occurred in 1995 and 1998; the last two are expected to occur in 2002 and 2005. Because importing countries are allowed the decision of what products to liberalize, it is expected that the most sensitive products will not have their quotas removed until the last stage. Tariffs on imported goods will remain, although at a lower rate. Textiles and clothing tariffs of 12 percent will be higher than for all other goods, which is only 4 percent (Majmudar, 1996).

The above-mentioned trade agreements all sought to limit trade through quotas and tariffs. The U.S. has also entered into agreements that promote trade between various countries or regions. These agreements, specifically NAFTA and various Caribbean policies, were encouraged by manufacturers with facilities in these regions. They can take advantage of low labor costs, yet still be in a geographic location that is close to the domestic market (Dickerson, 1999). Canada and Mexico have complete free trade with the U.S., while Caribbean countries pay tariffs only on the value added during the production process. Another important program for the Caribbean region is the Caribbean Basin Textile Access Program (implemented in 1986), which provides a less stringent quota for apparel if the fabric is both made and cut in the U.S.

3.4 TECHNOLOGICAL DEVELOPMENTS

There is concern that some of the benefits to cotton producers and importers provided by the cotton program may prove difficult to quantify using conventional econometric analysis. Although econometrics provides a useful tool for program assessment, it will not capture features of the program that are not reflected in market data such as prices, consumption levels, and trade flows. Thus, the quantitative analysis presented in Sections 4 through 6 is supplemented here with a qualitative evaluation of the types of activities CI conducts. As part of this assessment, we describe key technological developments in cotton since the 1960s and identify, when possible, any ties between these developments and CI funding. Overall improvements in production and processing efficiency, as well as in fiber quality, are presented, followed by specific examples of technological breakthroughs.

Although only CI's contributions to the cotton industry are highlighted in our analysis, it should be noted that other research organizations perform cotton research as well. For example, USDA spent $39.1 million on cotton research in 1999. This funding was committed to both production and processing of upland cotton. The Agriculture Research Service (ARS) division of USDA has at least 10 research units throughout the Cotton Belt that are devoted solely to cotton. Other USDA research units conduct general crop research as well, which includes cotton. Some USDA funding is also directed towards land-grant universities to conduct cotton research. Additionally, the USDA funded over $2.6 million on general clothing and textiles research in 1999, although this is not limited to cotton clothing and textiles.

The International Textile Center (ITC) is another example of a textile research organization. Located in Lubbock, Texas, it is an auxiliary to Texas Tech University. The activities of the ITC revolve around research, testing, and evaluation of textile processing, dyeing, and finishing. While CI only conducts research on upland cotton, the ITC also researches pima cotton, naturally colored cotton, and other natural fibers native to Texas (Alspaugh, 2001). The ITC conducts an average of 75 major projects each year and responds to more that 500 requests for testing, evaluation, specialty processing, and manufacturing (ITC, 2001).

The National Cotton Council (NCC) is an organization representing seven segments of the raw cotton industry—producers, ginners, warehousers, merchants, crushers, cooperatives, and manufacturers. It is supported financially by voluntary contributions from the seven segments on a per-bale or per-ton-of-seed basis. The NCC is involved in activities ranging from cotton program policy, export promotion, trade policy, gin safety, classing issues, pest control, worker protection standards to flammability standards for home furnishings, clothing, and cotton batting. Thus, the NCC is more involved in government and trade issues than scientific research.

In many instances, CI works in conjunction with these other research organizations to solve common problems. For example, the ITC performs some fiber quality research for CI, and the two research organizations often collaborate on projects (Alspaugh, 2001). According to the ITC Communications Director, a mutually beneficial relationship exists between CI and the ITC (Alspaugh, 2001). As another example, CI has established a research partnership with the Hides, Lipids, and Wool Research Unit at the USDA-ARS Eastern Regional Research Center. This partnership has resulted in the development of a dyeing process that enables cotton and wool blends to be dyed in one step, instead of the two-step method used traditionally. Using this process could increase the demand for cotton, especially in upscale markets, because textile mills may be more willing to create cotton/wool blends (Weaver-Missick, 2000).

3.4.1 Technological Improvements

Vast improvements in technology and practices have been made in the cotton industry over the past few decades. Increases in fiber quality and production efficiency, coupled with decreases in growth time, have contributed to these advancements. Research related to fiber quality has primarily focused on maximizing length and strength of cotton fibers. Length, strength, and fineness are the most important cotton fiber qualities related to dry processing (spinning, weaving, and knitting). The focus on fiber strength occurred with the advent of rotor spinning in the 1970s (Smith, 1999). Additionally, cotton production has become much more efficient, resulting in increases in yield and decreases in production time. Likewise, cotton processing facilities have invested in new equipment, which has enabled productivity gains and greater flexibility. The following list provides specific examples of improvements made in cotton production and processing:

- The average staple length of cotton in the U.S. increased from 32.2 thirty-seconds of an inch in 1945 to 35.0 in 1995. This represents an increase in length of 4 to 16 percent, depending on the state (Smith, 1999).
- From 1982 to 1992, fiber length increased at an average rate of 0.0076 cm per year (Benedict, Kohel, and Lewis, 1999).
- In the same time period, cotton fiber gained an average of 0.25 g/tex in strength (Benedict, Kohel, and Lewis, 1999).

- Fiber bundle strength increased by 17 percent between 1985 and 1995 (Smith, 1999).
- The average yield per acre increased from 269 lbs. in 1950 to 537 lbs. in 1995 (Smith, 1999).
- The average productivity gain in producing U.S. cotton between 1939 and 1978 was 5.2 percent per year. Of this, 4.7 percent was due to mechanical technology and 0.5 percent was due to improvements in yield. Annual productivity increased further to 5.6 percent between 1978 and 1982 (Glade, Meyer, and Stults, 1996).
- The 1995 crop (over 18 million bales) was grown on half as much land as was required to produce a similar-sized crop in the 1930s (Smith, 1999).
- Ten years ago, textile mills could spin 200 lbs. of cotton into yarn per spindle each year. They can now spin 600 lbs. per spindle per year (National Cotton Council, 1999).
- From 1984 to 1995, total weaving production in the U.S. has remained the same at about 16.5 billion square yards annually, with a decrease in the number of weaving machines from more than 180,000 to less than 80,000. Productivity of each weaving machine has increased by a factor of almost 2.5 (Isaacs, 1997).

3.4.2 Examples of New Technologies

Cotton farmers have many new technologies that help them to control weeds, insects, plant size, and timing of harvest.

The above-mentioned advances are the results of many technological breakthroughs. Some of these technologies are listed in Table 3-4. However, because of time and space limitations, only those findings that have had a significant impact are included. Thus, this list is not exhaustive of all breakthroughs in the cotton industry. It should also be noted that some of the technologies were not developed specifically for cotton but were later adapted to this crop. Further, adoption rates of new technologies have ranged from less than 1 year to over 15 years. Again, the purpose of this discussion is to identify new technologies that have affected the cotton industry. CI has played both major and minor roles in many of their technologies, as noted in Table 3-4, but it is not our goal to identify their accomplishments.

We believe that one new technology, developed in 1996, has had a significant effect on cotton production and warrants further discussion. This technology, whose effects may not yet be captured in the supply models discussed later in this report, is genetically bioengineered cotton. Cotton is a lead crop in genetic engineering, and production of genetically engineered cotton has been one of

Table 3-4. Selected Technological Breakthroughs in the U.S. Cotton Industry

Technology	Date Invented	Developer	Role of CI[a]	Significant Fact
Bioengineered cotton	1996 Bt and BXN cotton available; 1997 Roundup Ready cotton available; 1998 stacked gene cotton available (combines Bt and RR)	Private firms	CI assisted in scientific evaluation and development of refuge plans that influenced the regulation process for the allowance of Bt varieties, and they have monitored for Bt and applied pesticide resistance in pink bollworm, cotton bollworm, cotton budworm, and in non-Bt targeted pests.	U.S. cotton farmers used 450,000 kg less pesticides on Bt cotton than they would have used on conventional varieties in 1998 (Ferber, 1999).
Boll weevil eradication program	Late 1970s	Concerted effort among cotton growers, USDA, APHIS, and CI. Pilot programs first conducted in North Carolina and Virginia.	CI continues to contribute to the program through monitoring of weevil populations for resistance to malathion, the most efficacious, safe, and cost-effective pesticide for the eradication program.	In those states where the boll weevil had been fully eradicated by 1995 (Virginia, North and South Carolina, Georgia, and Florida), there was an increase in cotton acreage of 2,495,000 acres from 1980 to 1995.
Defoliants and desiccants	1950s	NA	CI completed a 5-year study in 1998 that proved that defoliants and desiccants have no effect on the dying properties of cotton fibers.	The use of one common defoliant, ethephon, more than doubled between 1991 and 1999 to over 5 million pounds (USDA/NASS, 1991, 2000).
Cotton picker	1850 mule drawn; 1948 first mechanical picker available commercially	International Harvester Company first to produce for commercial sale.	CI funded operations-research-type studies that encouraged harvester manufacturers to produce large-capacity baskets. This significantly increased the field capacity of pickers.	A six-row picker is able to pick approximately 75 acres of cotton in a 10-hour day, which is about 65 percent more than a four-row picker (John Deere, 2001).

(continued)

Table 3-4. Selected Technological Breakthroughs in the U.S. Cotton Industry (continued)

Technology	Date Invented	Developer	Role of CI[a]	Significant Fact
Cotton stripper	1871 in principle; mid-1940s widely adopted		CI supported mechanical and economic feasibility studies of using harvester-mounted cleaners on cotton strippers.	Newer models have cleaners that remove up to 500 pounds of trash from every bale and improve turnout by up to 8 percent (John Deere, 2001).
Module system	1972; approximately 15-year total diffusion rate	Texas A&M University	This project had approximately 80 percent financial support from CI.	The module system of handling and storing seed cotton has affected ginning more than any development in several decades… it extended the ginning season, made it easier to handle the larger crop, and reduced the cost of ginning (Mayfield et al., 1999).
EasiFlo cottonseed	1996	CI and USDA Lubbock		Three plants in the U.S. produce EasiFlo, at a cost of $5 per ton. There is a premium for this cottonseed ranging from $15 to $30 per ton.
High-Volume Instrument (HVI)	1968	Created for USDA by Motion Control, Inc., with assistance from Plains Cotton Cooperative Association	CI was involved in demonstrations and pilot runs in the beginning and now assists with calibration checks on an annual basis.	HVI usage spread in the 1980s and was made the official testing instrument by USDA in 1991 (Ramey, 1999).
Engineered Fiber Selection (EFS) Cotton Fiber Management System	1981	CI	Fully developed by CI	According to CI, this software package is the most widely used HVI cotton data management system in the market (CI, EFS brochure, 2000). It influenced the industry to move towards computerization.

(continued)

Table 3-4. Selected Technological Breakthroughs in the U.S. Cotton Industry (continued)

Technology	Date Invented	Developer	Role of CI[a]	Significant Fact
Ring spinning machine	1830	John Thorpe, an American inventor	CI has done numerous research projects to evaluate the effects of cotton fiber properties on ring spinning performance and ring spun yarn quality.	In the 1960s, it appeared that the speed of ring spinners had peaked at 12,000 rpm. By 2000, new advances were made and speeds of 25,000 rpm are now capable.
Rotor (open-end) spinning machine	1960s	N/A	CI has two rotor spinning machines in their laboratories, which allows them to explore the technology as it relates to cotton. Results are communicated to yarn manufacturers and machinery manufacturers for further development.	One of the latest models operates at speeds of 150,000 rpm.
Murata air-jet and Vortex spinning machines	1981 and 1999	Murata, a Japanese equipment manufacturer	A joint project between CI and Murata resulted in a modification of the equipment so that it could run high cotton blends and eventually 100 percent cotton.	The vortex spinning machine can produce 100 percent cotton yarns at 440 meters per minute. This is two times faster than open-end and 20 times faster than ring spinning.
Shuttleless weaving machines	1950s	N/A	While CI does not have a weaving machine in their laboratories, they do sponsor research at various universities to determine how new weaving technologies can be applied to cotton.	There are four types of shutteless weaving machines (projectile, rapier, water-jet, and air-jet) with speeds that range from 1,260 to 2,160 meters of yarn per minute (Tortora and Collier, 1997).
Continuous bleaching for nonwoven purposes	1987	CI patent; licensed to Edward Hall of the United Kingdom		Bleached cotton from this technology has improved properties, including more uniformity, less static build-up, and reduced nep formation (Hollis and Rhodes, 1987).

(continued)

Table 3-4. Selected Technological Breakthroughs in the U.S. Cotton Industry (continued)

Technology	Date Invented	Developer	Role of CI[a]	Significant Fact
Quickwash Plus	1995	Raitech, Inc.	CI worked in collaboration with the developer to improve the initial prototype designs and is working with industry standards organizations to develop recognized testing procedures for this technology.	The Quickwash Plus system uses 2.8 gallons of water, in comparison to 18 gallons used by the current AATCC test method. The total wash/dry time is also reduced from 60 minutes using the current AATCC method to 12 minutes using the Quickwash Plus method.
Garment wrinkle resistant finishing	1987	CI	CI demonstrated this technology to Farah, who was the first apparel manufacturer to use this technology.	Several attempts of wrinkle resistance were made prior to 1987, but these were all done at the fabric level rather than the garment level.

NA = Not available.

[a]All information obtained through personal communication with Dr. Preston Sasser, CI, to Catherine Viator, RTI. March–June 2001.

the most rapidly adopted technologies ever. The first report of genetically engineered cotton was by Umbeck et al. (1987) in 1987, and by 1994 the molecular mapping of the cotton genome had begun. There are two basic categories of genetically engineered cotton: insect resistant and herbicide resistant. The only insect resistant cotton presently available is Bollgard® cotton (commonly called *Bt* cotton), which is resistant to the tobacco budworm and the cotton bollworm. The term *Bt* represents *Bacillus thuringiensis*, a naturally occurring bacteria that is toxic to the above-mentioned lepidopterous insects. Herbicide resistant cottons include BXN® cotton (resistant to Buctril®, or bromoxynil, herbicide) and Roundup Ready® cotton (resistant to glyphosate). Both of these allow for the herbicide to be sprayed over the crop canopy without affecting the cotton plant.

Bollgard® cotton and BXN® cotton were commercially available beginning with the 1996 crop season. The number of acres of Bollgard® cotton jumped from 1.8 million acres in 1996 to 4.2 million acres in 1999. Following the introduction of Bollgard® cotton in 1996, Monsanto Corporation commercialized Roundup Ready® cotton in 1997. This is now the dominant genetically engineered cotton, and it accounted for 37 percent of the U.S. cotton acreage in 1999 (ICAC, 2000). Stacked gene cotton, which combines Bollgard® and Roundup Ready® cotton, has also been available since 1998. Direct benefits of genetically engineered cotton include reduced chemical usage, production costs, and farming risk, and increased yield, profitability, and crop management effectiveness. The International Cotton Advisory Committee (2000) reports spray reductions ranging from 1.0 to 7.7 sprays per crop season. However, recent consumer surveys have shown increased concerns about bioengineered crops and foods, which could negatively affect the amount of bioengineered cotton that is planted in the future.

All of the genetic engineering technologies were introduced by private firms, yet CI has played a part in their development.

All of the genetic engineering technologies were introduced by private firms, yet CI has played a part in their development. In addition to their role that is listed in Table 3-4, CI has also evaluated the efficacy of different *Bt* cotton constructs/varieties and researched the economics of *Bt* cotton systems at various locations (Cotton Incorporated, 2001). It is not possible to separate the contribution of CI from other sources in the development of *Bt* cotton, nor is it our intent to determine the significance of their role.

New technologies are constantly in development for the improvement of cotton production and processing. Biotechnology continues to be a main focus in cotton production research, while cotton processing research is focusing on the combination or elimination of steps in creating, dyeing, and finishing cotton fabric. CI is currently involved in numerous research projects in these areas, as shown in Appendix A.

4 Conceptual Approach to Evaluating the Cotton Program

Measuring the net benefits of the Cotton Program requires

- a theoretical structural model of the cotton market;
- estimates of supply and demand parameters that can be used to parameterize the structural model;
- estimates of the demand response to promotion and nonagricultural research expenditures;
- estimates of the supply response to agricultural research expenditures;
- simulation of the cotton market in the absence of Program expenditures; and
- transformation of the simulated effects of research and promotion and assessments into measures of benefits and costs.

This section discusses the conceptual structural model developed to describe the cotton market. We provide background information on the theory informing the development of our market models and present our model of the cotton market. Estimation of this model provides estimates of the parameters necessary for evaluation of the Program (see Section 5). Finally in Section 6, the estimated parameters are used to simulate the market in the absence of the Program and to calculate the benefits of Program activities to producers.

4.1 THEORETICAL FOUNDATION

Expenditures on generic cotton research and promotion may affect both the demand for cotton and the supply of cotton. Producers may benefit in either case because spending on promotion will increase consumer demand for retail products (and therefore the derived demand for raw cotton), while research on marketing methods (storage, transport, processing, and distribution services) will directly increase the demand for cotton by textile mills, and research on farm production methods will reduce the costs of producing cotton. All of the potential effects of the Program mentioned above have positive benefits to producers, but the important question from a net benefit perspective is whether the gains from Program activities outweigh the costs to producers.

4.1.1 Supply and Demand Curves

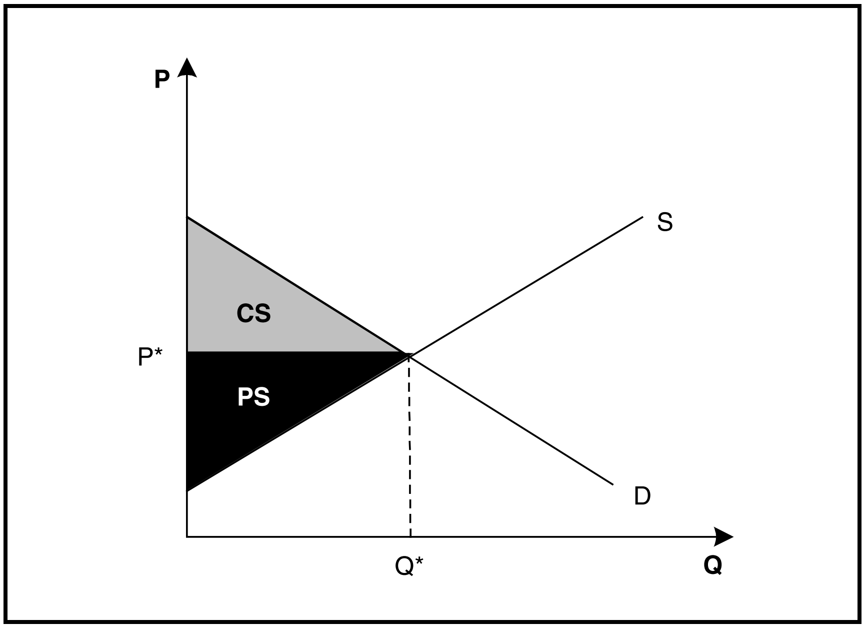
Figure 4-1 displays a simple supply and demand relationship. Demand curves normally slope downward because, everything else being equal, consumers will purchase more of a product as its price declines. Supply curves, on the other hand, generally slope upward because the higher the price of a good, the greater the quantity of that good sellers are willing to make available. Increased cotton prices encourage additional cotton production because of the action of profit-maximizing producers. As the return on cotton production increases relative to the return on alternative activities, producers will choose to produce more cotton.

However, for an agricultural product such as cotton, there are biological lags in changing the quantity produced in response to a price change. This may mean that the quantity harvested in a given year is relatively unresponsive to changes in price that occur after the planting season.[1] Nonetheless, because cotton is a storable commodity, the quantity supplied to domestic and foreign textile mills out of cotton stocks over a given time period (e.g., monthly) is expected to increase immediately as prices rise. Over time, it is likely that there will be an increase in cotton acreage planted in response to an increase in the returns to producing cotton.

---

[1]Some responsiveness of production to price is expected even after the cotton crop has been planted because a higher cotton price is expected to induce more effort on the part of producers to care for the crop. In addition, cotton acreage is more likely to be harvested rather than abandoned when prices are high.

Figure 4-1. Consumer and Producer Surplus



Supply and demand curves show the quantity of a good that will be supplied and demanded, respectively, at each price. The intersection of these two curves determines the market equilibrium price and quantity. The market equilibrium is the only point at which the quantity that buyers want to purchase is equal to the quantity that sellers are willing to make available. If price were not equal to the market equilibrium price, then there would be either a surplus or a shortage in the market, depending on whether price was above or below the equilibrium level. Thus, at any other point, there would be pressure on the price to move towards equilibrium.[2] We assume that all of our observations of price and quantity reflect the market in equilibrium.

For these two-dimensional supply and demand curves, it is assumed that all factors other than price are held constant. If any factor that affects demand or supply (other than price) changes (e.g., the level of Program expenditures), then there will be a shift in the affected curve. In other words, rather than moving along the curve as in the

---

[2] If the price were higher than equilibrium, then sellers would be trying to sell a larger quantity than buyers were willing to purchase, leading to a surplus and putting downward pressure on the price. On the other hand, if price were below equilibrium, then buyers would want to purchase a larger quantity than sellers were willing to make available, leading to a shortage and upward pressure on price.

case of a change in price, there will be a change in the quantity demanded (supplied) at every price following the shift in demand (supply) when one of these other factors changes.

For example, one goal of the Cotton Program is to make consumers aware of the advantages of cotton through promotional expenditures. Assuming these activities are successful, consumers will place a higher value on cotton products than they did previously, and this higher valuation will be reflected in an increase in the quantity of cotton products demanded at every price along the entire retail demand curve. Because the demand for cotton products at retail has increased, there will be an increased demand for the cotton products produced by textile mills, and a corresponding increase in the derived demand for raw cotton facing cotton producers.[3] Another activity performed under the Cotton Program is agricultural research on cotton. Successful agricultural research will typically have effects such as increases in yield and/or lower production costs. Either of these effects would lead to an increase in the supply of raw cotton (possibly with some lag). More cotton would be made available at any given price because of the improvement in returns available to producers.

4.1.2 Consumer Surplus

The shift in demand and/or supply caused by the Program will affect consumer and producer surplus measures, which economists commonly use to estimate changes in the welfare of market participants. Consumer surplus is the maximum amount that consumers would have been willing to pay for the quantity of a good purchased less their expenditures on that good. Thus, consumer surplus is a measure of the gain that consumers get from being able to purchase a good for less than their valuation of that good. The demand curve represents the maximum amount that consumers would be willing to pay for each unit of output. Therefore, consumer surplus is measured as the distance between the demand curve and the equilibrium price summed across all units of the good purchased. When there is an increase in demand for a good (rightward shift of the demand curve), this means consumers' valuation of the good has increased. Although an increase in demand will also increase equilibrium price, other

[3]This market linkage is discussed in more detail later in this section.

things being equal, the increase in valuation typically outweighs the increase in price so that consumer surplus rises.

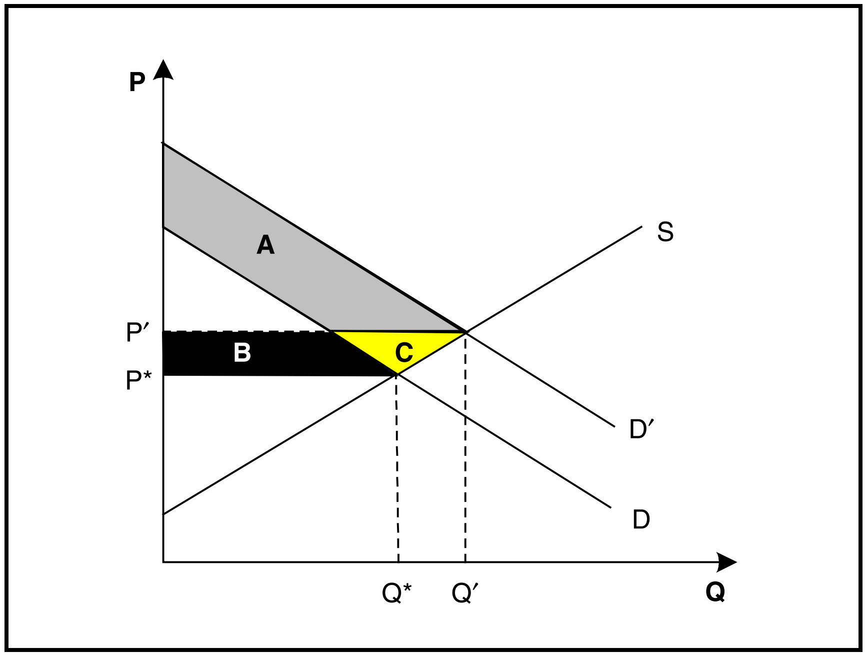
4.1.3 Producer Surplus

Producer surplus, on the other hand, is the total revenue that producers receive for their product less the minimum amount necessary for them to make the product available. The supply curve represents the minimum amount that sellers would be willing to accept for each unit of output, which is equal to their marginal costs. In the case of an outward shift in demand, the price that producers receive will increase for all units sold and they will be able to sell more units. Both of these effects will increase producer surplus. Figure 4-1 graphically illustrates the areas of consumer and producer surplus in a typical competitive market, where Q* is the equilibrium quantity, P* is the equilibrium price, CS is consumer surplus, PS is producer surplus, and S and D denote the supply and demand curves, respectively.

As described above, changes in supply and demand lead to changes in consumer and producer surplus. Figure 4-2 illustrates an example. Here, an increase in demand from D to D′ leads to an increase in equilibrium price from P* to P′ and an increase in equilibrium quantity from Q* to Q′. As a result of these changes, consumer surplus increases by A–B, and producer surplus increases by B+C.[4] Overall, the total surplus to consumers and producers increases by the area A+C following this increase in demand. It will generally be the case that both consumers and producers will benefit from Program activities that increase demand and/or supply. The main factors that determine the share of benefits going to each are the slopes (steepness) of the supply and demand curves. For example, as the demand curve becomes more vertical, price will increase less in response to a given increase in demand (outward shift of the demand curve). This implies that, as the demand curve becomes more vertical, the share of benefits from promotion going to producers will decrease, although their benefits will still be positive.

[4]Consumer surplus increases by the area A–B because consumers gain the area A as a result of their increased willingness to pay for this product but lose area B because the price of each unit has increased. Producer surplus increases by B+C because producers both get a higher price and sell a greater quantity as a result of the increased demand.

Figure 4-2. Change in Consumer and Producer Surplus due to Increase in Demand



4.1.4 Welfare Changes from Program Expenditures

As a measure of the changes in welfare brought about by the Program, we estimated the changes in demand and supply caused by the Program and calculated the resulting changes in consumer and producer surplus. The changes in price and quantity attributable to the Program were used to estimate the rate of return for cotton producers and importers and the overall rate of return associated with the Program.

To estimate the changes in supply and demand that would result if there were no Program, we first estimated the supply and demand curves for the cotton market under the actual conditions that have prevailed in recent years. Our approach recognizes that there is a linkage between the farm-level market for cotton, the textile market (the largest purchaser of raw cotton), and the retail market for final products made from cotton such as apparel and home furnishings. We assumed that each of these markets can be represented by supply and demand functions and that an equilibrium market price and quantity exist at each market level. The effect of cotton research and promotion is revealed by the change in market equilibrium conditions when there is spending on research and promotion relative to the case where this spending is absent.

Figure 4-3 shows the impact of promotion and research on prices, quantities, consumer surplus, and producer surplus for a single commodity in a multistage production system, such as cotton.[5] Derived demand at the farm level (D_f) is equal to retail demand (D_r) less the constant absolute margin (M) at each quantity value.[6] The market is initially in equilibrium where the farm supply curve (S_f) intersects the derived demand curve (D_f). Quantity produced and sold to consumers is given by Q*. Price at the farm level is P_f and price to consumers is P_r.

Suppose promotion causes retail demand to increase from D_r to D_r' and farm-level demand to increase from D_f to D_f'. Farm price increases from P_f to P_f', the retail price increases from P_r to P_r', and quantity produced and consumed increases from Q* to Q′. Consumers gain the area A–B and producers gain the area C in Figure 4-3a.

Figure 4-3b shows a research-induced reduction in production costs where the farm supply shifts down parallel from S_f to S_f'. Farm price falls to P_f'', retail price falls to P_r'', and quantity rises to Q″. Consumer surplus increases by the area D, and producer surplus increases by the area F–E.

As shown in Figure 4-3c, a research-induced reduction in the costs associated with the production of intermediate textile products that leads to a reduction in absolute margin from M to M′ will cause the derived demand for raw cotton to increase from D_f to D_f''. This will increase consumer surplus by the area G and producer surplus by the area H.

4.2 STRUCTURAL MODEL

It is expected that the activities performed under the Cotton Program will simultaneously cause each of the three types of shifts shown in

[5]This figure shows two stages of the production process (retail and farm level) assuming fixed input proportions and a perfectly elastic (flat) supply curve for the intermediate product.

[6]The margin M is the difference between farm prices and the price to consumers, which represents "marketing" costs and include all of the processing, transportation, etc. that take place between the farm and retail levels.

Figure 4-3. Distribution of Returns from Research and Promotion in a Multistage Production System

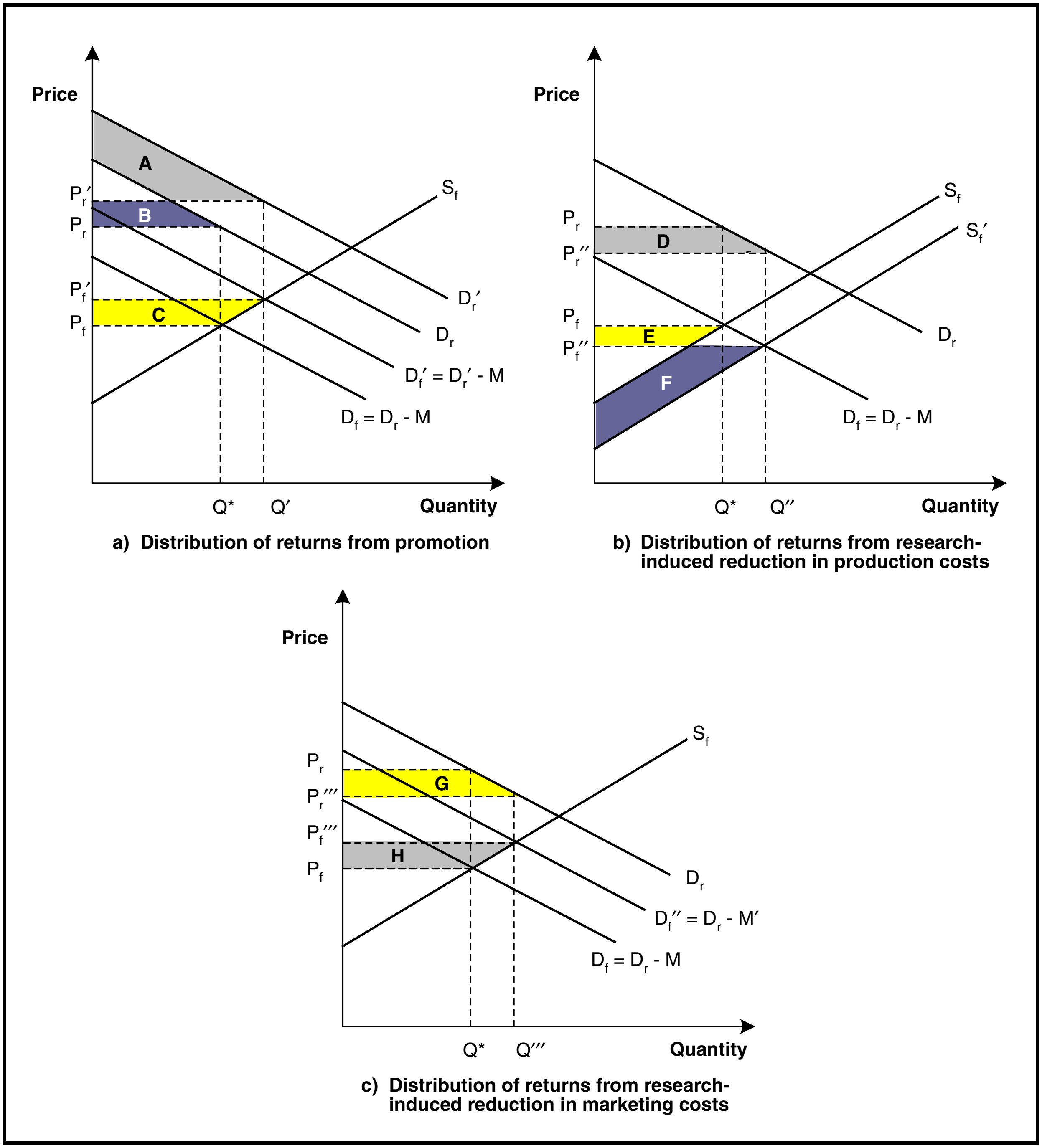


Figure 4-3 to occur in the domestic market for cotton. This is because the Program engages in promotion designed to increase retail demand, research into fiber and textile quality that is aimed at increasing mill-level demand directly (because of reductions in the cost of processing cotton),[7] and agricultural research into methods of reducing production costs or increasing yields. In addition, there is a shift in the supply curve resulting from the assessment itself. The assessment increases the cost of production, resulting in a decrease in supply, all else equal. Because the assessment and the results of agricultural research shift the supply curve in opposite directions, the net shift of the supply curve depends on which effect is larger.

To assess these changes in supply and demand resulting from the Program, we developed a structural model of the domestic cotton industry. The linkages between the relevant market levels must be included to ensure that all of the Program impacts are considered. The framework for such a market linkage model is found in Piggott, Piggott, and Wright (1995); Wohlgenant (1993); and Wohlgenant and Clary (1993), among others. The retail market consists of the apparel market, the home furnishings market, and others. The textile market consists of intermediate textile producers and consumers in the U.S. and is the major demander of raw cotton.[8] To model the impact of Program promotion and research activities on the demand and supply for cotton, we define the structural market model for domestic cotton as follows[9] (see Table 4-1 for a summary of the variables included in each function):

$$Q_{rd}^{d} = D_{rd}(P_{rd}, P_{rm}, A_g, A_b, A_f, Z_r)$$

Retail demand for domestic cotton products (4.1)

---

[7]This research may also increase retail demand if the quality of retail products improves as a result of the research activities.

[8]The term "textiles" as used in this model includes all intermediate products that will be used as inputs into making apparel, home furnishings, or other retail products.

[9]This model assumes a fixed-proportions marketing technology. In other words, a unit of fiber input is combined with a fixed amount of "marketing" inputs to generate a unit of output. We believe that this is a reasonable assumption for cotton product production, at least for the range of production levels being examined. However, it does have somewhat different implications for producers compared with variable proportions technology. Kinnucan, Xiao, and Yu (2000) show that if marketing technology is variable proportions, then research that reduces marketing costs can potentially result in a negative effect on producers.

Table 4-1. Summary of Variables Included in Domestic Raw Cotton Fiber Production Structural Market Model and Where They Enter Supply and Demand Functions

	Retail-Level		Textile Market		Farm Level		Trade	
Variable	Demand	Supply	Derived Demand for Cotton	Supply	Demand	Supply	Imports	Exports
Retail Price of Domestic Products (P_{rd})	x	x	x					
Retail Price of Imported Products (P_{rm})	x	x	x					
Price of Domestic Textiles (P_{td})		x	x	x	x			
Price of Imported Textiles (P_{tm})		x	x	x	x			
Domestic Mill Price of Cotton (P_{cd})			x	x	x	x	x	x
Foreign Cotton Fiber Price (P_{cf})				x	x		x	x
Generic Promotion Expenditure (A_g)	x							
Branded Advertising for Cotton (A_b)	x							
Advertising for Man-made Fibers (A_f)	x							
Nonagricultural Research Expenditure (R_t)			x	x				
Demand Factors in Retail Market (Z_r)	x							
Supply Factors in Retail Market (W_r)		x	x					
Supply Factors in Textile Market (W_t)				x				
Demand Factors for Export Markets (Z_x)								x
Agricultural Research Expenditure (R_a)						x		
Supply Factors at Farm Level (W_f)						x		
Supply Factors for Foreign Cotton Textiles (W_m)							x	x
Supply Factors for Foreign Raw Cotton (T_f)								x

$$Q^s_{rd} = S_{rd}(P_{rd}, P_{td}, P_{tm}, W_r)$$

Retail supply of domestic cotton products (4.2)

$$Q^d_{td} = D_{td}(P_{rd}, P_{td}, P_{tm}, W_r)$$

Derived demand for intermediate cotton textiles (4.3)

$Q^s_{td} = S_{td}(P_{td}, P_{tm}, P_{cd}, P_{cf}, R_t, W_t)$

Supply of intermediate cotton textiles (4.4)

$Q^d_{fd} = D_{fd}(P_{td}, P_{tm}, P_{cd}, P_{cf}, R_t, W_t)$

U.S. demand for domestic raw cotton fiber (4.5)

$Q^s_{fd} = S_{fd}(P_{cd}, R_a, W_f)$

U.S. supply of raw cotton fiber (4.6)

$Q^d_{fx} = D_{fx}(P_{cd}, P_{cf}, Z_x, W_m, T_f)$

Export demand for raw U.S. cotton fiber (4.7)

$P_{tm} = MC_{tm}(P_{cd}, P_{cf}, W_m)$

Price of imported textile products (4.8)

$P_{td} = MC_{td}(P_{cd}, P_{cf}, W_t)$

Price of domestic textile products (4.9)

$Q^d_{rd} = Q^s_{rd}$

Retail market clearance (4.10)

$Q^d_{td} = Q^s_{td}$

Textile market clearance (4.11)

$Q^d_{fd} + Q^d_{fx} = Q^s_{fd}$

Farm-level market clearance (4.12)

where Q^k_{ij} represents quantities for which k denotes quantity supplied (s) or demanded (d); i denotes market level (retail [r], textile [t], or farm [f]); and j denotes domestic (d), export (x), or foreign (f). In addition, P_{rd} is the retail price for domestic cotton products, P_{rm} is the retail price for imported cotton products, A_g is generic promotion expenditures for cotton, A_b is branded advertising expenditures for cotton, A_f is advertising expenditures for man-made fibers,[10] Z_r is a vector of demand factors in the retail market other than advertising (e.g., income), P_{td} is the price of domestic intermediate cotton textiles, P_{tm} is the price of imported intermediate cotton textiles, W_r is a vector of supply factors in the retail market (e.g., retail wages, energy costs), P_{cd} is the domestic price of cotton at the mill level, P_{cf} is the price of foreign cotton fiber, R_a is agricultural cotton research expenditures (made by both CI and public institutions funding cotton research), R_t is nonagricultural research expenditures made by CI, W_t is a vector of supply shifters for the cotton textile market (e.g., textile wages, energy costs), W_f is a vector of supply factors for cotton producers (e.g., input costs, prices of alternative crops), Z_x is a vector of demand factors for export markets, W_m is a vector of supply factors for foreign cotton textiles, and T_f represents shifters of the supply of raw foreign cotton.

Although research and promotion are specific types of supply and demand shifters and could be included under the more general vectors of factors affecting supply and demand, they are listed separately because evaluating their effects is the primary aim of this study. Therefore, it is useful to note where these expenditures enter the model. Among promotion and research activities, there exist both “generic” expenditures and “branded” expenditures. The distinction between generic and branded promotion and research expenditures is that generic expenditures are designed to increase demand for a given commodity, while branded expenditures are designed primarily to increase the demand for a particular company’s product. To accurately estimate the impact of the generic research and promotion activities funded by the Program on the cotton market, we need to separate the effects of this Program

[10]Both branded promotional expenditures for cotton-containing products and promotional expenditures for substitute products such as man-made fibers are important to consider and were part of our theoretical model. However, in the final model estimated empirically, these variables are not included. Promotional expenditures for man-made fibers were not included because no data were available. Branded promotional expenditures were proxied using Levi Strauss expenditures, but their inclusion revealed no significant impact on the coefficient for CI promotion. Because the available data series for these expenditures was shorter than for the other demand variables (and was available only quarterly rather than monthly for part of the series) and did not reveal significant interaction effects with CI promotion, they were dropped from the final model.

from the effects generated by other sources, if those effects are significant.

Branded advertising expenditures, while directed at promoting the specific product of a particular firm, could also increase market demand and therefore producer returns. This is especially true if the advertising message emphasizes product attributes common to the product class (e.g., cotton). This point is discussed in Clary (1993). If the impact of branded advertising is not considered, then the results of the estimation may be biased. The direction of the bias is not clear, however, because branded and generic promotion could be either substitutes or complements for one another.[11]

Additional important determinants of the demand for domestic cotton are the prices of substitute fibers such as foreign cotton, polyester, and rayon. However, Shui, Behgin, and Wohlgenant (1993) find that factors other than relative fiber prices accounted for the majority of the shift away from natural fibers and towards man-made fibers that occurred between 1950 and 1987. In all four specifications that they tested, they found that nonprice effects accounted for about 70 percent of the predicted decline in natural fiber market share. The effects of nonfiber inputs (especially energy and labor) have contributed as much or more to changes in cotton market share as have relative fiber prices. Technical change over this period increased the use of man-made fibers and reduced the use of natural fibers as the fiber industry increased its share of capital inputs used in production (natural fibers are generally more labor-intensive to process). This work provides additional support for the notion that the relationship between cotton and man-made fibers needs to be carefully specified and must include variables in addition to fiber prices to accurately capture the complex interactions between these products.

Because our emphasis is on cotton producers and that is the market level for which data are available, we estimated partially reduced-form supply and demand equations at the farm level. To estimate these equations while incorporating effects from the other levels of

[11]As mentioned earlier, our results did not reveal significant effects of including branded promotional expenditures (proxied by Levi Strauss) on the coefficient for CI promotion. It is possible that with more complete data on branded promotional expenditures related to cotton-containing products we would have found a significant interaction effect.

the market, we substituted the determinants of retail and intermediate textile demand into the farm-level demand equation. We obtained reduced-form equations for prices, which have the following form:

$$P_{rd} = P_{rd}(P_{td}, P_{tm}, A_g, A_b, A_f, W_r, Z_r), \text{ and} \quad (4.13)$$

$$P_{rm} = P_{rm}(P_{td}, P_{tm}, A_g, A_b, A_f, W_r, Z_r). \quad (4.14)$$

Substituting Eqs. (4.8) and (4.9) into these equations for P_{tm} and P_{td} and substituting Eqs. (4.13) and (4.14) into Eq. (4.5) gives us a partially reduced-form equation for domestic demand for domestically produced cotton (i.e., the domestic industry derived demand for domestic cotton):

$$Q_{fd}^{d} = D_{fd}(P_{cd}, P_{cf}, A_g, A_b, A_f, R_t, W_r, W_t, Z_r). \quad (4.15)$$

This is our representation of mill-level demand for domestic cotton. In addition, we modeled the export demand for raw U.S. cotton as

$$Q_{fx}^{d} = D_{fx}(P_{cd}, P_{cf}, W_m, Z_x, T_f). \quad (4.16)$$

Domestic demand plus export demand gives us total demand for domestically produced cotton.

In addition to a model of the demand for domestically produced cotton, we needed a model of the domestic supply of cotton to estimate the equilibrium price and quantity of cotton produced domestically. Domestic producers' decisions regarding the amount of cotton they will supply to the market can be thought of as a two-stage process. First, they decide how much acreage to plant in cotton and what varieties to plant. Annual production of cotton depends on the expected effective price of cotton (i.e., the price producers expect to receive when they sell their output adjusting for government programs) and other factors that shift the supply function (e.g., input costs) because these factors affect the planting decision. Once the planting decision has been made, additional factors such as the level of insect damage and weather conditions affect the annual production level. The second stage is determining how much cotton to sell out of stocks each month.[12] Monthly

[12] However, it is not necessarily the cotton producers that are holding the cotton stocks. Often, middlemen, such as the cotton merchants, purchase the cotton from producers and hold it in inventory until sale to textile mills.

supply of cotton depends on such factors as annual production, the level of cotton stocks, storage costs, cotton spot prices, and cotton futures prices.

Although a monthly supply equation could be estimated, we relied on an annual supply function to estimate changes in producer surplus resulting from the Program.[13] This is because we are interested in the returns to domestic cotton producers and use of a monthly supply function will not necessarily provide us with an accurate picture of the effects on the domestic producers. Use of the monthly supply function in estimating the benefits to producers may capture benefits that do not accrue to cotton producers. Instead, some of these benefits may be flowing to merchants, speculators, etc. Thus, the domestic supply of cotton was modeled as

$$Q_{fd}^{s} = S_{fd}(EP_{cd}, R_a, W_f) \tag{4.17}$$

where EP_{cd} is the expected effective price of cotton. This is an expected price because of the lag between planting, harvesting, and selling cotton. It includes not only the market price expected by producers, but also the expected effects of government payments. The higher the expected price (which we estimated empirically using the average futures price during the cotton planting season), the more producers are expected to supply, everything else being equal. However, in addition to the effects of the market price, U.S. government price support programs for cotton may also influence cotton producers' decisions. When producers are anticipating government payments, the relevant supply price they face is the expected market price plus the expected government payment.

Eqs. (4.15), (4.16), and (4.17) can be implemented empirically and estimated econometrically, which provides us with estimates of the statistical relationship between the respective quantities and all of the variables included in the model affecting that quantity. The parameter estimates obtained from this model will provide us with measures of the responsiveness of quantity demanded and supplied to price, promotion, and research (as well as other relevant variables). The responsiveness of one economic variable to another

[13]This implies that we need to aggregate our estimated monthly demand equation to an annual level for use in determining net effects of the Program in conjunction with the supply function.

is typically reported as an elasticity, which measures the percentage change in one variable resulting from a given percentage change in another variable. For example, the price elasticity of demand is a measure of how responsive quantity demanded is to price. If the price elasticity of demand is –0.3, this means that a 1 percent increase in the price of the product will lead to a decline in quantity demanded of 0.3 percent.[14] Using our parameter estimates, we calculated elasticities for the relevant variables.

The price elasticities of supply and demand are especially important for this analysis because they play a large role in determining the distribution of net benefits from promotion and research between producers and consumers. In general, as the supply elasticity becomes larger, implying that producers will increase production by a larger percentage in response to a given change in price, producers benefit less from Program activities and consumers benefit more. In addition, as the demand elasticity becomes larger (in absolute value), implying consumers are more responsive to price changes, the benefits to producers will be reduced, other things being equal.

In addition to the model of the domestic cotton market described above, a second model was developed to examine the effects of the Program on cotton importers. Measuring the returns to importers is a more difficult problem than measuring the returns to domestic producers because "importers" are quite heterogeneous. They may be either retailers or wholesalers, for example, and there are extreme differences in size of operations. Conceptually, cotton importers can be viewed as firms that obtain cotton (or cotton products) from foreign suppliers and market products containing cotton in the U.S.

In the simplest case, cotton importers could be viewed as merchants marketing a given product produced outside the U.S. In that case, we could think of each firm as receiving a margin M (price received less price paid) that goes to pay for expenses of marketing (i.e., labor, packaging, transport costs) and any profit (quasi-rents)

[14]The price elasticity of demand will almost always be negative because an increase in price normally leads to a decrease in quantity and vice versa. However, other elasticity measures may be positive or negative depending on whether the variables being compared tend to change in the same direction or not.

accruing to the importers' fixed factors of production in the short run. However, no data are available that would allow us to construct a margin variable for cotton imports.

Therefore, the approach taken here is based on the idea that importers, like any producer, can be viewed as having a supply curve for the products they sell. Under very general conditions, we can then view any profit obtained by importers as the area above the supply curve and between the two prices (the price with the Program less the price without the Program). The critical empirical matter for calculating returns is to find the relevant import supply elasticity. Appropriate import supply elasticity is the one calculated from the supply equation holding constant the price of inputs (e.g., the price of cotton and cotton products purchased from foreign suppliers). Otherwise, if we allowed the price of cotton inputs to change in response to the checkoff program, the estimate of the supply elasticity would include profits earned by foreign cotton producers (the suppliers to the importers). By holding the price of cotton and foreign cotton products constant, we are able to net out the effect of the checkoff program on foreign cotton producers.

In essence, the approach taken to estimate the import supply function can be viewed as a generalization of the approach that would be used if we had data on importers' margins. Let $M = P_{rm} - P_{tm}$, where P_{rm} is the retail price of imported cotton products in the U.S. and P_{tm} is the price of the products purchased in foreign countries by cotton importers.[15] If the margin relationship is $M = c + dQ$, where c represents the effect of marketing costs, Q represents the volume marketed, and d is a parameter to be estimated, then upon substituting for M, we obtain the (inverse) importer's supply function:

$$P_{rm} = P_{tm} + c + dQ. \qquad (4.18)$$

We have taken the margin relationship and expressed it in terms of the price of imported products as a function of the prices of all inputs (the price of intermediate products, P_{tm}, other marketing costs, c, and the quantity marketed).

---

[15] They are referred to here as intermediate textile products to distinguish them from products available at retail. However, they may in fact be in a variety of forms when imported, including finished products.

However, in addition to the fact that we do not have comprehensive data on retail prices of imported cotton products, we also do not have data on the prices of intermediate products imported into the U.S. Thus, we need to use a proxy for P_{tm} in Eq. (4.18). We have used the foreign price of raw cotton, P_{cf}, and the prices of other marketing and processing inputs used to produce intermediate cotton products, c′, as proxies for P_{tm}. That is, if we assume that $P_{tm} = c' + eP_{cf}$, where e is the transformation coefficient from raw cotton to intermediate cotton products, then after substituting it into Eq. (4.18), we obtain the equation

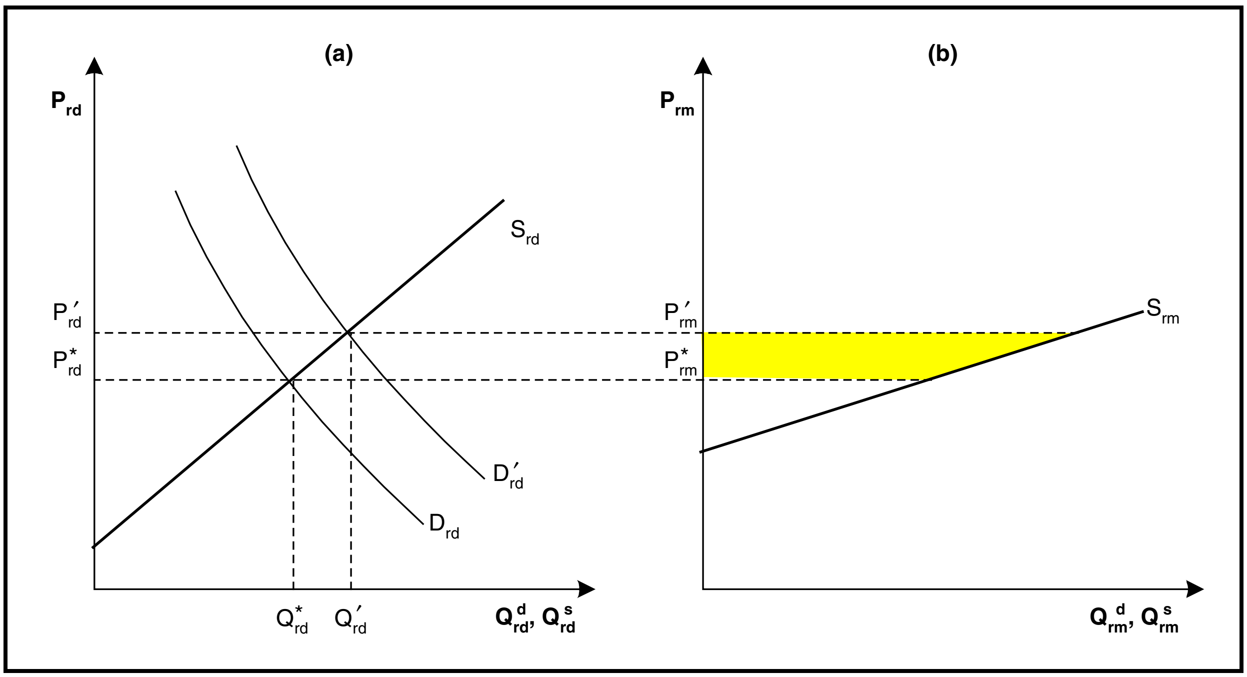
$$P_{rm} = eP_{cf} + c + c' + dQ. \qquad (4.19)$$

Thus, holding the prices of all inputs (including P_{cf}) constant, we would be able to measure an impact of the quantity of imports on the price of imported cotton textiles at retail that would have the same marginal effect as the original Eq. (4.18).

Although this approach is reasonable given the data available, it is not without its limitations. The primary limitation is that this supply curve corresponds to the supply of imports at retail, but not all importers are retailers. In addition, there could be other input suppliers (e.g., owners of capital, equipment, buildings) who would capture some of the profits resulting from the Cotton Program. Indeed, for those importers who are simply merchants moving cotton-containing products from one location to another, there likely would be little gain (or loss) from the Cotton Program. The effect would simply be to pass along all the costs of the assessment to consumers. However, no data are available that would permit separation of the firms that actually import the cotton products from the rest of the import supply chain. Thus, the producer surplus attributed to importers may be somewhat overstated using this equation but will still provide useful information on the Program's impacts on importers. To estimate producer surplus to importers, Eq. (4.19) must be estimated and the producer surplus with and without the Program estimated based on the price importers would receive with and without the Program. The version of Eq. (4.19) implemented empirically and the results of the estimation are provided in Section 5.

Producers' surplus to importers can be measured by the area above the supply curve and between the prices with and without the checkoff program. Figure 4-4 shows the change in producer surplus received by importers when their price is increased by Cotton Program activities. Figure 4-4a shows the effects on equilibrium price and quantity of an increase in retail demand caused by Cotton Program promotion and research. Equilibrium price increases from P^*_{rd} to P'_{rd} and equilibrium quantity increases from Q^*_{rd} to Q'_{rd}. This shift leads to an increase in the demand for raw cotton. The impacts of this increase on domestic cotton producers can be measured using the structural model of the U.S. cotton market derived earlier and is not shown here. Figure 4-4b shows the impact on importers. As a result of the increase in price received for imported cotton products at retail, from P^*_{rm} to P'_{rm}, importers experience a gain in producer surplus equal to the shaded areas of the graph. Provided the right variables are included in the supply equation, this area will measure quasi-rents (profits) to cotton importers.

Figure 4-4. Change in Importer Producer Surplus due to Cotton Program



Unfortunately, we do not have data on prices of intermediate cotton-containing products shipped into the U.S., which is what we ideally would want to measure the price of inputs to importers.

However, we can use the world price of cotton (the "A" index) and other input prices (e.g., foreign textile wages, energy costs) as proxies for the cost of imported cotton. If the technology producing these intermediate products from cotton fiber approximates constant returns to scale, then using these input prices as proxies for the price of intermediate textile products will allow us still to make valid inferences about the profitability of market middlemen downstream from producers of intermediate goods. On the one hand, if we find the supply is upward-sloping, then we can conclude that importers likely benefit from the Program, because if that is the case then there will be positive producer surplus associated with the Program. On the other hand, if the supply function is perfectly flat, then importers will not gain (or lose) from the Program.

5 Econometric Estimation and Results

This section presents our estimated models of U.S. raw cotton supply, domestic mill demand for raw cotton, and export demand for raw cotton as well as imported cotton products' supply. It provides a discussion of alternative model specifications considered and an explanation of the reasons for choosing the final models presented. The results obtained from these econometric models were used in simulation models, described in Section 6, to evaluate the benefits and costs of the Program.

5.1 DATA

Prior to presenting our chosen models and estimation results, we provide an overview of data and data sources used in our models.[1] We used monthly, quarterly, and annual data for different parts of the analysis depending on the relevant period and the data available. We estimated U.S. raw cotton supply using annual data from the period 1975 through 2000. For estimation of the domestic demand and export demand for U.S. raw cotton, we used monthly data for the period from January 1986 through December 2000. Finally, import supply was estimated using quarterly data from the first quarter of 1990 through the second quarter of 2000.

[1]Tables containing all data used in this analysis are provided in Appendix B.

5.1.1 Quantities

Monthly data on the quantity of raw cotton consumed by domestic mills and the quantity exported were obtained from various issues of the USDA's *Cotton and Wool Outlook*, which is published ten times per year (and includes data for all 12 months within those ten issues). Quarterly data on net imports of textiles in terms of raw fiber equivalents were generated by aggregating across monthly data on textile imports and exports from the *Cotton and Wool Outlook* for the relevant months in each quarter and subtracting total exports from total imports. Annual production levels were collected from various issues of the annual USDA publication, *Cotton and Wool Yearbook*.

5.1.2 Prices

The important prices used for analyzing the domestic raw cotton market are both the price of U.S. raw cotton at the mill level and the price received by producers,[2] the foreign price of cotton, and rayon and polyester prices. Each of these prices except the price received by producers was obtained from the National Cotton Council (2001) web site. The mill price was adjusted for government subsidies by subtracting the average user certificate subsidy value for each month from the reported price. Data on the monthly value of this subsidy for the use of domestic cotton were obtained from CI. All prices obtained from the National Cotton Council were converted into raw fiber equivalent form[3] and deflated using the consumer price index (CPI).

For the annual supply function, the relevant price is the price that producers expect to receive when they make their planting decision. This price determines the quantity that producers will choose to supply (subject to random variation due to weather or other factors). After the planting decision has been made, the

[2]These prices differ because of transportation and other costs incurred between the farm and mill delivery as well as government programs. In addition, the cotton assessment itself creates a gap between the price purchasers pay and producers receive.

[3]More waste is associated with cotton fiber than with polyester or rayon. Thus, more raw cotton is required to generate a pound of usable fiber than for either polyester or rayon. From the mills' perspective, the relevant price is the price per unit of useable fiber. This is taken into account by adjusting prices so that the price per unit of useable fiber is being compared instead of the price of fiber (cotton price is divided by 0.9, while polyester and rayon prices are divided by 0.96).

quantity that will be produced is fairly unresponsive to price because biological factors (e.g., optimal planting season) largely prevent supply response in the short run. For commodities such as cotton that have government support programs in place, the price that producers expect to receive is not necessarily equal to the market price. Thus, we adjusted the supply price to reflect both expectations of the market price and the influence of government programs.

To capture producers' expectations of the market price, we used the average of the nearby December futures prices over the months when most cotton is planted each year, calculated based on information from CI's monthly database.[4] These futures prices should reflect all information available to growers when they make their planting decision. An increase in the futures price implies that growers expect to receive a higher market price for their crop at harvest. Other things being equal, a higher expected price at planting time should induce growers to plant more cotton, either on land that was formerly idle or previously had other crops grown on it.

However, another important influence on their supply decision is the level of government support payment expected, if that payment varies with output.[5] Prior to 1996, eligible cotton production was guaranteed to receive at least that year's target price established by the USDA. Thus, the relevant supply price for eligible cotton was the greater of the target price and the expected market price. Approximately 85 percent of production received payments under this program (USDA, 1995b). Therefore, in years from 1975 through 1995 when the target price was binding (i.e., target price > market price), the supply price used in the economic model was calculated as the weighted average of the target price and the expected market price. In years when the target price was not binding (i.e., target price < market price), the supply price was simply set equal to the expected market price. The FAIR Act of

---

[4]The available data on cotton futures prices were monthly based on the value at the end of each month. To represent expectations during the planting season, we averaged the futures prices reported for the end of February, the end of March, and the end of April.

[5]A government program paying a lump sum regardless of output, such as the current AMTA program, should not influence planting decisions because it does not change growers' incentives.

1996 eliminated price supports under the target price program, but kept the LDP program (discussed in Section 3.3). The availability of LDP payments also influences the supply decisions, but these payments differ from price supports under the target price program because they are based on the difference between the loan rate and the AWP and all cotton production is eligible. Thus, in the economic model, the supply price for each year from 1996 through 2000 was calculated as the expected market price plus the expected LDP payment for that year. The expected LDP payment was assumed to equal the loan rate minus the average AWP at planting if the loan rate was above the AWP and zero otherwise. The time series of supply prices was then deflated by the CPI prior to use in the annual supply model.

To estimate the impacts of the Program on importers, it is necessary to identify the Program's effect on retail prices. CI provided quarterly data on the average retail prices of a variety of men's and women's apparel (11 categories of men's apparel and 12 categories of women's apparel) from the first quarter of 1990 through the second quarter of 2000. We used these data to create a Fisher Ideal price index[6] for retail apparel in each quarter.

5.1.3 Promotion and Research

CI provided monthly data on Program expenditures for several categories of expenditures for the period 1986 through 2000. The data used in the domestic and export demand models were monthly data categorized into advertising and nonagricultural research expenditures. Because of the high level of seasonal variability in these expenditures, the data were deseasonalized prior to use in the model. In addition, the supply model used annual data on total agricultural research expenditures devoted to cotton (including USDA, State Agricultural Experiment Station, and Other Institutions [a category that includes CI] expenditures) obtained

---

[6]The Fisher Ideal price index (F) is defined as the geometric mean of the Laspeyres and Paasche price indices, which are two of the most commonly used measures of the proportionate changes in the prices of a specified set of goods and services over time. It is calculated as

$$F = \sqrt{\left(\frac{p_t q_0}{p_0 q_0}\right) \times \left(\frac{p_t q_t}{p_0 q_t}\right)}$$

where the reference period is designated as period 0 and the period with which it is compared is designated as period t. The variables p and q represent vectors of prices and quantities of retail apparel products, respectively.

from the USDA Current Research Information System (CRIS) for fiscal years 1993 through 1999 (USDA CRIS, 2001) and from personal communication with a CRIS staff member who provided unpublished data from fiscal years 1970 through 1992 (Unglesbee, 2001). Annual data on CI agricultural research expenditures from 1981 through 2000 was provided by CI and was used to measure the impacts of changing that subset of total expenditures on cotton agricultural research. The Cotton Board provided data on the dollar value of assessments collected from domestic producers and importers over the period 1986 through 2000. All promotion and research expenditure data were deflated by the CPI.[7]

5.1.4 Other Variables

In addition to the variables mentioned above, we collected data for several other variables included in the models. The domestic demand model is estimated using per capita quantities. To calculate these quantities and convert other variables to per capita terms, we collected monthly population data for the U.S. from the U.S. Census Bureau (2001). For the domestic demand model, data on income were derived from monthly data on total personal disposable income for the U.S. taken from the St. Louis Federal Reserve Bank's FRED database on their web site (FRED, 2001). We deflated these income data by the CPI and divided the data by population to obtain monthly per capita disposable income.

We obtained the wage in the domestic textile industry and a monthly index of energy costs from the U.S. Bureau of Labor Statistics (BLS, 2001). Foreign gross domestic product (GDP) was proxied by GDP for Organisation for Economic Cooperation and

[7] Another option for deflating the promotional expenditures would be to use a media cost index to reflect the changes in price level that have taken place specifically for promotion rather than for the general price level. However, using a media cost index implies that the question of interest is the effectiveness of a given quantity of promotion, whereas the question we are interested in for this study is the effectiveness of a real dollar of promotion. The opportunity cost of using a dollar for promotion is that it cannot be used for other activities (e.g., nonagricultural research) or returned to those paying assessments, so that is the relevant comparison. Unless the rapid increase in the costs of promotion relative to the general price level in recent years has been accompanied by an equal or greater increase in its effectiveness relative to other CI activities, the rapid media cost increases may suggest that promotion is becoming relatively less attractive over time as the real price of a unit of promotion becomes more expensive. This point is not captured by the use of a media cost index to deflate expenditures.

Development (OECD) countries after subtracting U.S. GDP from the total.[8] Data for OECD countries were used because those were the only consistent data series on foreign GDP available. These data were available at a quarterly frequency from various issues of *Quarterly National Accounts* and *National Accounts of OECD Countries*. They were converted into monthly estimates using PROC EXPAND in the SAS statistical software package. This procedure fits a cubic spline to the input series and the output is computed from this interpolating curve.

Another variable for which PROC EXPAND was used to estimate monthly values is the level of foreign cotton stocks because this variable is only available at the annual level. These data were obtained from USDA's Foreign Agricultural Service (FAS). Changes in farm input prices were estimated using the index of prices paid by farmers for the series production, interest, taxes, and wage rates obtained from various issues of *Agricultural Statistics*, an annual USDA publication.

We deflated all data series denominated in dollars prior to use in estimation. The CPI is the only price index used as a deflator in this report. CPI data are available online from the U.S. Bureau of Labor Statistics (2001). For all of the models, we used the series for all U.S. urban consumers, including monthly and annual data as appropriate, with 1982–84 = 100. For the purposes of presenting the results in Section 6, all dollar-denominated variables presented were converted into year 2000 dollars to provide a more recent frame of reference.

5.2 DOMESTIC MILL CONSUMPTION OF COTTON

We modeled mill-level demand for cotton as a partially reduced-form equation described by Eq. (4.15). In this specification, per capita mill consumption of cotton is modeled as a function of the price of cotton, prices of substitute fibers, demand and supply shifters of domestically produced textile products, and demand and supply shifters of foreign-produced textile products. The demand and supply shifters of foreign-produced textile products represent

[8]In addition, the Czech Republic, Korea, Hungary, and Poland were not included in the series for consistency because their data were not included in OECD GDP estimates for the entire period from 1986 through 2000.

the impact of the price of imported textile products on mill-level demand for cotton. It would have been preferable to use a variable to represent the price of imported textiles directly, but lack of data for the monthly demand model precluded using these data in the present model.

The demand for mill use of cotton was estimated with monthly time series data covering the period January 1986 through December 2000, a total of 180 observations. The model was estimated in linear form and the following variables were included (the corresponding variable name from Eq. (4.15) is included in parentheses):

$MILLUSE_t$ (Q_{fd}^{d})	=	U.S. per capita raw cotton used by mills (pounds per person)
$M_{i,t}$	=	monthly dummy variables (M_i =1 for ith month, 0 otherwise) for i = 1,...,11 where December is the reference month with its effect represented by the intercept
$PCOTTON_t$ (P_{cd})	=	real U.S. raw fiber equivalent price of cotton (cents/lb)
$PPOLY_t$ (Z_r)	=	real U.S. raw fiber equivalent price of polyester (cents/lb)
$PRAYON_t$ (Z_r)	=	real U.S. raw fiber equivalent price of rayon (cents/lb)
$DTEXW_t$ (W_t)	=	real domestic wage in U.S. textile manufacturing industry ($/hour)
$WPCOT_t$ (P_{cf})	=	real A Index of world cotton price (cents/lb)
$DECI_t$ (W_t, W_r)	=	U.S. real energy cost index (1982-84=100)
DPI_t (Z_r)	=	U.S. per capita real disposable income ($1,000/person)
$FGDP_t$ (Z_r)	=	real GDP of OECD countries, excluding U.S. (billions of $)
$SAGPROM_t$ (A_g)	=	seasonally adjusted CI real promotional expenditures ($)
$SAGNARES_t$ (R_t)	=	seasonally adjusted CI real nonagricultural research expenditures ($)

All "real" variables above were obtained by deflation using the CPI for all items. In addition to promotional and nonagricultural research expenditures, other domestic demand and supply shifters in the model include prices of competing fibers ($PPOLY_t$, $PRAYON_t$), prices of other factors in textile manufacturing ($DTEXW_t$, $DECI_t$), and per capita real disposable income (DPI_t).

Proxies for the impact of the price of imports on domestic mill demand include foreign income ($FGDP_t$) and the world price of cotton ($WPCOT_t$).

Our study focused on quantifying the impact of generic promotion and research on demand for cotton. One complication we had to address is the timing of these explanatory variables. It is important to allow for the possibility that their impact on consumption may be more complicated than simply affecting consumption contemporaneously (i.e., in the same period that they occur). That is, the effects of promotion and research on demand may be distributed over a number of months or longer. Generally, models that allow for explanatory variables to affect the dependent variable over several periods are referred to as distributed lag models because the influence of the explanatory variable is distributed over a number of lagged values of that variable. The number of periods that these effects influence the independent variable, m, can be either finite or infinite.

Unfortunately, economic theory does not offer much guidance in determining the appropriate value for m; however, we do need to assume that the sum of the coefficients on the explanatory variables is finite to avoid the possibility of the expected value of the dependent variable being explosive. Thus, it is necessary to consider alternative lag lengths for both advertising and research to determine the "best" lag structure. With the correct lag length m* unknown, the number of regressors that must be included in the model is also unknown. If the researcher chooses an m other than m* ($m \neq m^*$) the parameter estimates of the model will either be biased or inefficient (imprecise). It will be biased if $m < m^*$ because there are omitted variables, but it is inefficient if $m > m^*$ due to overspecification of the model.

Our selection of the best model was in the context of viewing the model as either a finite or infinite distributed lag model between mill consumption and promotion and research. Concerning the possibility of a finite distributed lag model and the potentially large number of lags involved, we considered different possible distributed lag models and decided that the Almon distributed lag would probably provide the greatest flexibility. We then embarked on grid search procedures in an attempt to find the best model (see Appendix C for details on the grid search). Concerning the possibility of an infinite distributed lag model, we employed a geometric lag model. In all cases of model selection across alternative specifications, we relied on the Akaike Information Criteria (AIC), the Schwartz-Bayesian Criteria (SBC), the adjusted R^2 value (see Appendix C for details on calculating these three statistical measures), and the implied estimated economic effects (elasticities) to compare competing models and arrive at a preferred model.

As described in Appendix C, the ranking of models differed considerably across the various criteria. Under some conditions, the highest ranking model had long lags on advertising and research, while under others, the implied lag lengths were quite short or zero. In addition, the results for some of these models implied theoretically implausible results, such as upward-sloping demand curves. Given the economic and statistical considerations as a whole, our preference is for a relatively simple model with a 3-month lag on research, no lags on promotion, and no lags on cotton price. The long-run impacts of promotion and research are not too different in this model than in models with longer lag lengths, and this model has superior performance from a theoretical standpoint (it displays the expected negative sign for the elasticity of demand).

The statistical results for this preferred model are shown in Table 5-1. The model was estimated by ordinary least-squares (OLS), OLS with correction for first-order autocorrelation in the error term, and two-stage least squares (2SLS) with correction for autocorrelation in the error term. With the exception of the effect of a change in the price of cotton, the results are very similar across the three models. It is especially encouraging that the three models show remarkable stability with respect to the relationship between mill consumption and promotion and research. In particular, the elasticity of promotion is estimated to be approximately 0.02 across all three models, and the long-run elasticity estimates of mill consumption with respect to research (the sum of current and lagged effects) range from 0.31 (model 2) to 0.35 (model 3). These elasticities imply that a 10 percent increase in promotion expenditure would lead to a 0.2 percent increase in cotton demand, while a 10 percent increase in nonagricultural research

Table 5-1. Regression Results for the Monthly Per Capita Mill Demand for U.S. Cotton, 1986-2000

Independent Variable	OLS			First-Order Autocorrelation			2SLS & First-Order Autocorrelation		
	Para-meters	t-values	Elasticity	Para-meters	t-values	Elasticity	Para-meters	t-values	Elasticity
$CONSTANT_t$	1.97714	2.27		2.26220	2.17		1.75181	2.07	
$M1_t$	0.24005	7.19		0.23910	8.23		0.23720	7.57	
$M2_t$	0.15837	4.74		0.15725	4.83		0.15811	4.64	
$M3_t$	0.32105	9.60		0.32054	9.59		0.32788	9.43	
$M4_t$	0.22697	6.86		0.22504	6.72		0.22650	6.49	
$M5_t$	0.30343	9.06		0.29989	8.81		0.32037	8.99	
$M6_t$	0.25450	7.54		0.25163	7.32		0.27420	7.59	
$M7_t$	0.10311	3.10		0.09812	2.91		0.11965	3.38	
$M8_t$	0.36200	11.05		0.35981	10.89		0.36604	10.74	
$M9_t$	0.28302	8.54		0.28263	8.47		0.28398	8.23	
$M10_t$	0.34242	10.41		0.34239	10.69		0.33890	10.10	
$M11_t$	0.19263	5.88		0.19252	6.78		0.18853	6.15	
$PCOTTON_t$	–0.00434	–2.52	–0.165	–0.00265	–1.35	–0.101	–0.01089	–3.21	–0.413
$PPOLY_t$	–0.00434	–2.43	–0.156	–0.00371	–1.64	–0.133	–0.00361	–1.65	–0.129
$PRAYON_t$	0.00284	1.99	0.149	0.00205	1.15	0.107	0.00261	1.50	0.137
$DTEXWAGE_t$	–0.19959	–1.67	–0.687	–0.24807	–1.70	–0.859	–0.13169	–0.87	–0.453
$WPCOTTON_t$	0.00710	4.17	0.240	0.00548	2.71	0.186	0.01264	4.08	0.427
$DECI_t$	–0.00683	–2.43	–0.243	–0.00713	–2.16	–0.255	–0.00723	–2.14	–0.256
DPI_t	–15866.9	–0.23	–0.144	–27662.2	–0.37	–0.253	–67879.7	–0.87	–0.616
$FGDP_t$	3.20E-05	0.47	0.164	5.80E-05	0.76	0.295	0.000061	0.79	0.309
$SAGPROM_t$	2.04E-08	1.93	0.022	1.57E-08	1.58	0.017	2.12E-08	2.00	0.023
$SAGNARES_t$	4.90E-07	4.55	0.145	4.68E-07	4.61	0.139	5.12E-07	4.72	0.152
$SAGNARES_{t-1}$	4.29E-08	0.42	0.013	2.91E-08	0.28	0.009	7.30E-08	0.68	0.022
$SAGNARES_{t-2}$	2.64E-07	2.67	0.078	2.52E-07	2.62	0.075	2.79E-07	2.75	0.083
$SAGNARES_{t-3}$	3.21E-07	3.10	0.095	2.97E-07	3.06	0.088	3.16E-07	3.06	0.094
rho				0.26845	3.32		0.19303	2.62	
N	177			177			176		
R^2	0.8453			0.8550			0.7990		
R^2-bar	0.8208			0.8310			0.7671		
DW	1.5199			2.1243			2.0318		
SSE	1.2064			1.3020			1.2413		
AIC	–4.7060			–4.7600			–4.67023		
SBC	–4.2574			–4.2935			–4.21988		

expenditures would lead to a 3.5 percent increase in cotton demand.

Of the three versions of the preferred model estimated, the third version (2SLS) is the preferred model overall because of the endogeneity of the price of cotton. Because first-order autocorrelation in the residuals was found in the model estimated by OLS, 2SLS was applied with correction for first-order autocorrelation in the residuals. We used the two-step procedure developed by Hatanaka (1976). The procedure, which is more simply explained by Harvey (1991), consists of the following steps.

- Obtain a consistent estimate of rho by regressing the endogenous variables (which appear on the right-hand side of the equation) on all the predetermined and lagged predetermined models of the system.
- Use the quasi-differencing operator, (1-rho*L) (L lagged operator), to transform the model into a form where the error term is uncorrelated.
- Regress each one of the quasi-differenced endogenous variables (i.e., $w_{it} = z_{it}\text{-rho*}z_{it-1}$) on all the predetermined and lagged predetermined variables of the model and use the predicted values of w_{it} as instruments for the quasi-differenced endogenous variables.
- Use these predicted values and quasi-differenced predetermined variables appearing on the right-hand side of the equation as instruments in instrumental variable estimation of the parameters (i.e., apply the GIVE estimator).

The estimates from applying the two-step 2SLS procedure are shown in the third model in Table 5-1. Overall, the results seem quite reasonable and suggest a strong and significant impact of promotion and research on mill consumption of cotton. There is significant seasonality in mill consumption as indicated by the statistically significant monthly dummy variables. The own-price elasticity of demand for cotton is –0.4, which is close to estimates of about –0.3 by Lowenstein (1952), Wohlgenant (1986), and Waugh (1964). It is somewhat smaller than the estimate of –0.6 by Shui, Behgin, and Wohlgenant (1993). However, the estimate of own-price elasticity of demand is larger than Capps et al. (1997), where researchers estimated an elasticity of demand of –0.16. One significant difference between this study and the Capps et al. (1997) study is the assumption in their study that price affects consumption only after a 13-month lag. When we included the 13-month lagged price variable in our model (in addition to current price), we found no statistically significant impact of lagged price. We take these results to strongly suggest that mill consumption and the raw fiber price are contemporaneously determined.

Consistent with the Capps et al. (1997) study, we find that the empirical results suggest that polyester is a complement to cotton and that rayon is a substitute in the U.S. market. We find cross-price elasticities of –0.13 and 0.14 for polyester and rayon, respectively. These results imply that the responsiveness of cotton demand to changes in the prices of polyester or rayon is much smaller than the responsiveness to a change in the price of cotton. Thus, these elasticities are much more in accordance with theory than the cross-price elasticities reported in the Capps et al. analysis. That study found cross-price elasticities of –0.55 and 0.27 for polyester and rayon, respectively, whereas the elasticity of demand for cotton was only –0.16.

As expected, textile wages and energy costs exert a negative influence on mill consumption. Although the impact of foreign GDP on consumption is positive as expected, the impact of U.S. disposable income on consumption is negative. However, U.S. disposable income is statistically insignificant, suggesting it is highly correlated with the wage variable.

The world price of cotton variable (WPCOTTON), represented by the A Index, also has a large and significant effect on cotton mill use. This variable is a strong indicator of the cost of imported cotton textile products. Higher world cotton prices raise the cost of producing cotton in foreign countries, which translates into higher prices of cotton products imported and higher U.S. mill consumption of cotton. It is important also to recognize that, because the U.S. is not a small country in international trade of cotton, feedback effects may exist from changes in the U.S. cotton price on the world cotton price. Therefore, in the simulations of the impact of promotion and research on returns to cotton producers this feedback effect needs to be considered.

Other variables were entertained and initially included in the model (e.g., foreign textile wages, real exchange rate), but inclusion of these variables led to little change and/or improvement in the model. Also, there was some evidence to indicate that including these additional variables substantially increased the level of multicollinearity, which would have led to imprecise estimates. This is not too surprising considering that wages are a high proportion of income. A regression of $FGDP_t$ on real foreign textile wages and the real exchange rate shows an R-squared above 80 percent, confirming that $FGDP_t$ is highly collinear with foreign textile wages and the exchange rate.

To examine the effects of including branded advertising, the model was also estimated including monthly promotional expenditures made by Levi Strauss. Levi Strauss was chosen to represent branded advertising on cotton products because it is a very well known brand with a large advertising budget that focuses on selling products high in cotton content, such as jeans. Including this proxy for branded advertising actually made the estimated returns to Cotton Program promotion slightly higher. However, including this variable did not significantly improve the fit of the model so it was dropped from the final version of the model estimated. This result suggests that the effectiveness of Cotton Program promotional expenditures is not substantially influenced by branded promotional expenditures, at least not the type of expenditure made by Levi Strauss. It is possible that branded expenditures that more directly emphasize the cotton content of the products being promoted may have a more substantial influence on the effectiveness of Cotton Program expenditures. However, there were insufficient promotional data for other companies to include them in the model.

Another interesting question is whether promotion of cotton substitutes such as polyester and rayon has a significant influence on the effectiveness of the Cotton Program. There is very little consumer promotion of the synthetic fibers that are the primary competitors to cotton, though. Instead, the majority of synthetics promotion is aimed at textile mills. We did not have sufficient data on these cross-promotional expenditures to include them in the cotton market model, so we could not test for the effect of these expenditures on the demand for cotton.

Several diagnostic tests were performed on the final version of the model. The model was re-estimated using just the last 5 years of data (1996 through 2000) because the cotton checkoff program is being evaluated over this time period. A change in the structure from the previous years to the most recent years might indicate concern about the validity of the statistical model over the entire sample (1986 through 2000) used to evaluate the impact of the checkoff program over the past 5 years. The results for the most recent 5 years show changes in some of the coefficients, but by the Chow test we fail to reject the null hypothesis that the structure in the last 5 years is any different than over the previous 10 years. We also examined the recursive residuals to see if there was any strong indication that the structure was changing over time. Again, although we observe changes in the coefficients over time, there seems little evidence that the structure has changed in significant ways over time.

The model was also re-estimated to include the square roots of promotion and research as explanatory variables to test to see if the linear model adequately models the relationship between mill consumption and promotion and research. Again, the results indicate failure to reject the simple linear model with zero linear lags on promotion and three linear lags on research.

5.3 EXPORT DEMAND FOR U.S. COTTON

The export demand for U.S. cotton is specified as a partially reduced-form equation given by Eq. (4.16) in which exports of U.S. cotton are modeled as a function of the price of domestic cotton, prices of substitute fibers, and demand and supply shifters of foreign-produced textile products. These demand and supply shifters will influence the amount of U.S. cotton that foreign mills will choose to purchase. In addition, we estimated a variety of export specifications including promotion and nonagricultural research. However, neither promotion nor research seems to have a significant effect on export demand in our preferred model. This result may be because data specifically related to foreign promotion and transfer of research results were not available at a monthly level. Thus, total monthly advertising and nonagricultural research were included in these specifications even though the majority of this expenditure is focused on the domestic market. If Program expenditures on domestic and foreign activities changed at the same rate over time, this would not be a problem, but that is not necessarily the case. It is possible that more disaggregated data would reveal Program impacts on exports, but for the current model, no Program expenditures are included in the export demand equation. Thus, the relevant information provided by the export demand equation is limited to the price elasticities of export demand with respect to the price of U.S. cotton and the world cotton price.

This demand equation was estimated using monthly data over the period from January 1986 through December 2000, which provides a total of 180 observations. The model was estimated in linear form[9] using the following variables (the corresponding variable names from Eq. (4.16) is included in parentheses):

$M_{i,t}$	=	monthly dummy variables (M_i=1 for ith month, 0 otherwise) for i=1,...,11 where December is the reference month
$EXPORTS_t$ (Q^d_{fx})	=	U.S. exports of raw cotton (thousands of bales)
$PCOTTON_t$ (P_{cd})	=	U.S. real raw fiber equivalent price of cotton (cents/lb)
$PPOLY_t$ (Z_r)	=	U.S. real raw fiber equivalent price of polyester (cents/lb)
$FTEXWAGE_t$ (W_m)	=	real foreign manufacturing wage ($/hour)
$WPCOTTON_t$ (P_{cf})	=	real A Index of the world cotton price (cents/lb)
$DECI_t$ (W_m)	=	U.S. real energy cost index, used as a proxy for foreign energy costs
$FGDP_t$ (Z_x)	=	foreign real GDP for OECD countries other than U.S. (billions of $)
$ROWSTK_t$ (Z_x)	=	foreign cotton stocks (pounds)
$EXPORTS_{t-1}$ (Q^d_{fx})	=	lagged U.S. exports of raw cotton (thousands of bales)
rho	=	first-order autocorrelation parameter value

All of the variables denominated in dollar terms (PCOTTON, PPOLY, FTEXWAGE, WPCOTTON, DECI, and FGDP) were deflated using the CPI for all items.

The foreign supply and demand shifters included in the model include prices of competing fibers in the foreign fiber market (PPOLY, WPCOTTON), prices of other factors affecting foreign

---

[9]Other specifications were also estimated, including double-log and semi-log models, but the linear model cannot be rejected based on the results from any of the models that we estimated. In other words, the linear model is at least as good as any alternative models that we tried. Therefore, we chose to use the linear model because it is relatively simple.

textile manufacturing demand for U.S. cotton (FTEXWAGE, DECI, ROWSTK), and foreign income (FGDP). The real exchange rate, promotion, and nonagricultural research were initially included as well, but inclusion of these variables did not lead to significant improvement in the model. It appears that WPCOTTON is a much better indicator of export demand for cotton than a more general exchange rate.

Also, we performed a grid search over lags and degrees of polynomial distributed lags on promotion and nonagricultural research similar to the one performed for the domestic demand model. As in the domestic demand model, the preferred models using AIC and SBC criteria generally suggested very short lags. Before inclusion of a lagged dependent variable or correction for autocorrelation, research is marginally significant, but promotion is not. Promotion was generally found to have a negative, but not significant, effect on export demand across the models ranking highest in the grid search. It is possible that this results from high levels of advertising increasing domestic demand (where the majority of advertising is taking place) such that less cotton is available for exports, although this effect should be captured by the export demand response to a change in U.S. cotton price.

When either lagged exports or a correction for autocorrelation in the error term is added, then the significance of research disappears. When promotion is dropped from the equation, the model preferred by a grid search over research lags and polynomial degrees is a first order polynomial with one lag. However, the parameters on nonagricultural research in this preferred specification are not significant. As mentioned above, the lack of significance for advertising and research on export demand may result from using total promotion and nonagricultural research expenditures rather than expenditures specific to the export markets. Nonetheless, given the results derived from available data, both advertising and research were dropped from the preferred export demand model.

Table 5-2 provides results of the estimation of the preferred model. The model was estimated by OLS and 2SLS. The results are generally quite similar across the models. The results agree fairly well with other studies of the cotton market. There is significant

Table 5-2. Regression Results for Monthly Export Demand for U.S. Cotton, 1986-2000

Independent Variable	OLS			2SLS and First-Order Autocorrelation		
	Parameters	t-values	Elasticity	Parameters	t-values	Elasticity
CONSTANTt	361.930	0.84		338.440	0.77	
$M1_t$	–149.761	–2.70		–153.243	–2.70	
$M2_t$	–124.293	–2.30		–120.853	–2.20	
$M3_t$	–71.837	–1.32		–74.392	–1.36	
$M4_t$	–260.092	–4.71		–263.555	–4.74	
$M5_t$	–274.309	–5.10		–275.322	–5.07	
$M6_t$	–286.276	–5.31		–285.608	–5.25	
$M7_t$	–279.346	–5.19		–277.163	–5.12	
$M8_t$	–307.754	–5.74		–306.221	–5.68	
$M9_t$	–360.646	–6.65		–358.869	–6.58	
$M10_t$	–256.853	–4.63		–253.844	–4.55	
$M11_t$	–83.386	–1.53		–81.071	–1.46	
$EXPORTS_{t-1}$	0.583	8.93	0.583	0.601	9.27	0.601
$PCOTTON_t$	–6.008	–2.27	–0.618	–6.757	–1.98	–0.692
$PPOLY_t$	0.670	0.27	0.065	0.748	0.31	0.072
$WPCOTTON_t$	6.711	2.48	0.678	7.266	2.23	0.732
$DECI_t$	–1.270	–0.43	–0.122	–0.389	–0.13	–0.037
$FGDP_t$	0.021	0.68	0.285	0.016	0.52	0.211
$ROWSTK_t$	–5.640E-0	–0.86	–0.154	–3.790E-0	–0.57	–0.103
rho				0.07600	–0.53	
N	179			178		
R^2	0.7415			0.7540		
R^2-bar	0.7154			0.7290		
DW	1.9500			1.8939		
SSE	3331071.4			3332785.1		
AIC	10.0437			10.0510		
SBC	10.3820			10.3906		

seasonality to U.S. cotton exports as indicated by the highly significant monthly dummy variables. The seasonal pattern of exports is quite different from that of mill consumption and it is also much more variable. Although domestic mill consumption is fairly smooth over time and typically hits its lowest point in December, exports display far more volatility over the course of a year and usually are close to their peak in December. The export demand elasticity for cotton is about –0.7, which is just below the lower end of the range estimated for the export demand elasticity by Duffy, Wohlgenant, and Richardson (1990) and is more elastic than domestic demand, as we would expect. The price of polyester has a positive coefficient, as expected, but it is not significant. The effect of lagged exports is highly significant. It seems that the major factors contributing to export demand are the domestic cotton price, the world cotton price, seasonality, and partial adjustment of exports over time to these and other unobserved trade shocks, with none of the other variables having a very important role. The price elasticity for the world price of cotton is around 0.7, suggesting that foreign cotton and U.S. cotton are substitutes for one another, and that U.S. export demand is fairly sensitive to the world cotton price. As mentioned in the previous section, because the U.S. cannot be considered a small country in terms of cotton production, changes in the U.S. cotton price are likely to influence the world cotton price. It is important to consider this effect when simulating the impact of changes in U.S. cotton price on export demand.

The energy cost index, foreign GDP, and foreign cotton stock variables all have the expected signs but are not significantly different from zero. The foreign manufacturing wage (used as a proxy for the foreign textile wage) was included in alternative model specifications, but it was not significant and seems to be highly correlated with foreign GDP, so it was dropped to avoid problems with multicollinearity.

To check for stability of the parameter estimates over time, the model was reestimated for 1996 through 2000, which is the period of emphasis for this study. The estimated parameters over this time period are very similar to those obtained using the data from 1986 through 2000, and the Chow test fails to reject the null hypothesis of no structural change in export demand over the last 5 years.

Although the DW statistic is reported, it is not relevant for this model because of inclusion of a lagged dependent variable. The Durbin-h statistic is often suggested in this case, but as Harvey (1991) points out, this statistic is not very reliable in small samples. Instead, what is recommended is the LM test, which is a test of rho = 0 by estimating an auxiliary regression in which the estimated residuals are regressed on the lagged residuals and all the explanatory variables appearing on the right-hand side of the regression equation. A simple t-test on the lagged residual variable is then performed to determine if autocorrelation in the residuals is present. An LM test on the model residuals reveals the presence of autocorrelation, so a first-order autocorrelation correction was added to the model. When the model was estimated using 2SLS and a first order autocorrelation correction, the rho parameter was not significant, but we kept it because it reduces the significance of the autocorrelation. Including this term does not greatly affect the parameter estimates, but it does imply a bit more responsiveness of exports to U.S. and world cotton prices.

5.4 DOMESTIC SUPPLY OF RAW U.S. COTTON

The domestic supply of raw U.S. cotton was modeled at the annual level because the planting decision is made on an annual basis. Although there may be some response of production to changes in price after planting (e.g., higher abandonment at low price), it is likely to be relatively small. The supply function is based on a relatively simplified version of Eq. (4.17). It is modeled as a function of expected cotton price, an index of farm input prices lagged one year, and a trend variable (to capture technical change). The supply function was estimated using data from 1975 through 2000, a total of 26 observations. A linear model was estimated incorporating the following variables (the corresponding variable name from Eq. (4.17) is included in parentheses):

$PROD_t$ (Q^s_{fd}) = annual U.S. cotton production (thousands of bales)

$FPCOTTON_t$ (EP_{cd}) = cotton futures price averaged over planting months (cents/lb)

$PINPUT_{t-1}$ (W_f) = index of prices paid by farmers for inputs

$TREND_t$ (R_a) = trend variable that indexes years, increasing from 1 in 1975 to 26 in 2000[10]

All variables denominated in dollars were deflated by the CPI for all items.

More complex specifications were considered,[11] but the data currently available are inadequate to allow much complexity beyond the current model. The more complex models generally were not very stable in terms of parameter estimates with respect to changes in lag lengths on research or model specification. At least part of this problem is probably due to increases in farm labor productivity and cotton input cost reductions that are attributable to causes other than cotton research. Weather also plays a significant role in determining cotton production from year to year. However, we did not have enough data on these effects to include them in the model. In addition, the data series is not long enough to permit inclusion of many additional variables while maintaining sufficient degrees of freedom, especially given the long lags expected on agricultural research. This omission probably is contributing to the difficulty experienced in estimating a supply equation.

The results of this relatively simple model do appear reasonable, however, in terms of the estimated supply elasticity and the signs of the parameters. Table 5-3 provides the results of the estimation for the model estimated with OLS both with and without the input price index. The trend term is very significant when the farm input price index is not included in the model. Once the input price is added to the specification, the trend variable becomes much smaller in magnitude and is no longer significant. This suggests that an important part of the outward supply shifts over time being

---

[10]A trend variable was included as a proxy for the effects of agricultural research due to the difficulty in estimating a robust specification as a function of agricultural research directly. The trend variable will provide an upper bound on the supply shift caused by agricultural research because it also captures other factors that may increase supply over time.

[11]For example, we estimated models that included CI agricultural research expenditures; total cotton agricultural expenditures (including USDA, the State Agricultural Experiment Stations [SAES], and other nongovernmental organizations such as CI); cumulative research at a variety of depreciation rates; and other variants on research expenditures. In addition, we attempted to estimate production functions and to relate yield and production costs to cotton agricultural research independently.

Table 5-3. Regression Results for Annual Supply of U.S. Cotton, 1975-2000

Independent Variable	OLS without Input Price Index			OLS with Input Price Index		
	Parameters	t-values	Elasticity	Parameters	t-values	Elasticity
$CONSTANT_t$	432.3066	0.10		18,957.7	1.49	
$FPCOTTON_t$	94.7157	2.31	0.454	103.8293	2.21	0.498
$TREND_t$	546.6276	4.66	0.038	301.9883	1.43	0.021
$PINDEX_{t-1}$				-190.0750	-1.61	-1.099
N	26			25		
R^2	0.6092			0.5952		
R^2-bar	0.5752			0.5374		
DW	2.2059			2.3368		
SSE	1.04×10^8			9.31×10^7		

captured by the trend variable is due to reductions in input costs.

The problem arises in determining the extent to which the reduction in input costs and the rate of technical change are due to agricultural research expenditures by CI. Even if it is assumed that expenditures by CI have exactly the same effectiveness as all other agricultural research expenditures on cotton, a similar problem remains. Determining what proportion of the changes in input costs and cotton production technology are due to agricultural research into cotton when so many other factors potentially influence cotton supply is quite difficult. Given our data limitations, we were unable to develop defensible estimates of those proportions. Thus, the primary use of the supply model is to obtain econometric estimates of the supply elasticity and to provide some sense of the shifts in the cotton supply function that have occurred over time. Section 7 provides additional qualitative discussion of the impacts of agricultural research on cotton supply.

There was no evidence of significant autocorrelation for either model. The price elasticity of supply is about 0.45 for the model without the input price index and 0.49 in the model including that index, which is in the range of supply elasticities in the literature. Duffy and Wohlgenant (1991) use a short-run supply elasticity for cotton of 0.3, and Duffy, Shalishali, and Kinnucan (1994) report a value of 0.92 for the cotton supply elasticity.

As expected, the price index of farm inputs has a negative impact on cotton production. This index is included in the model with one lag to reflect expectations of prices at planting time based on the previous year's production costs. The elasticity of supply with respect to this price index is –1.1, suggesting a fairly large responsiveness of cotton supply to increases in input prices. The elasticity of supply with respect to the trend variable implies that the long-run trend has supply shifting out by about 3.8 percent per year when input prices are not included. When the input price index is included in the model, the model implies supply is shifting out by 2.1 percent annually after accounting for the portion of the outward shift being caused by input price reductions. Some portion of this outward supply shift is presumably due to agricultural research focusing on cotton. However, given data restrictions, we have not been able to develop defensible estimates of the share of the supply shift that has been caused by agricultural research.

5.5 IMPORT SUPPLY OF COTTON PRODUCTS

During the period 1996 through 2000, the Cotton Research and Promotion Program collected an average of $21.4 million per year from importers. This accounts for approximately one-third of the total funding for the Program over this time. Because importers began paying assessments in 1992, their share of total assessments has been trending slightly upward, rising from about a quarter to a third of total assessments over this time. This trend is primarily due to the rapid growth in the quantity of imported textiles containing cotton coming into the U.S. during the 1990s. Although domestic producers and importers both pay assessments to fund the same Program, the benefits that importers receive are quite different from those domestic cotton producers receive. Therefore, it is important to conduct a separate analysis of Program effects on importers to find out whether this group receives net benefits from the checkoff program.

Conceptually, demand for textiles (containing cotton) can be viewed as demand for both domestically produced and imported textiles. Because the U.S. exports as well as imports textiles, it is important to develop a model that does not double-count quantities sold. Most of the cotton coming into the U.S. from other countries is apparel or intermediate products that will be made into apparel. However, many of the cotton products exported to other countries are relatively unprocessed and may return to the U.S. in a more finished form. Therefore, it is reasonable to view net imports of textiles containing cotton as the relevant quantity variable to evaluate.

Cotton importers' supply behavior was estimated with quarterly time series data over the time period 1990 through the second quarter of 2000, a total of 42 observations. The model was estimated with all continuous variables transformed into natural logarithms so that the estimated coefficients are elasticities. The following variables (in logarithms) were used in the model:

$PIMPORTS_t$ (P_{rm})	=	real Fisher index of 100 percent cotton apparel products (deflated by CPI for all items),
$QIMPORTS_t$ (Q^d_{fm})	=	net imports of products containing cotton (pounds of raw-cotton equivalent),
$DECI_t$ (W_m)	=	U.S. real energy cost index (1982-84=100),
$FTEXWAGE_t$ (W_m)	=	real foreign textile wages ($/hours),
$WPCOTTON_t$ (P_{cf})	=	real A Index of world cotton price (cents/lb).

The model was estimated in price-dependent, rather than quantity-dependent, form as described by Eq. (4.19). Also, some experimentation occurred with selecting explanatory variables. Quarterly dummies were not found to be singly or jointly significant and were therefore not included in the final estimated models. Different lag structures on quantity and price were evaluated as well, and it appears that both lagged price of imports and lagged quantity of net imports should be included as explanatory variables. Finally, the restriction that the sum of the price elasticities of input prices equal unity was imposed on the model. This restriction comes from the property that the cost function is homogenous of degree one in input prices. Therefore, we would expect the marginal cost function, which is the inverse supply function, also to be homogeneous of degree one in input prices. The restriction was tested and was not rejected statistically.

The results are shown in Table 5-4 for two models, one estimated by OLS and the other estimated by 2SLS. The results are very similar and indicate significant impacts of current and lagged net imports on the price of imports. Although the current quantity variable is negative, the sum of the current and lagged quantity are positive and are consistent in indicating that the supply curve of importers is upward sloping in the long run. Indeed, an estimate of the long-run flexibility[12] can be derived by summing the two quantity variables and dividing by 1 minus the coefficient on $PIMPORTS_{t-1}$. For the OLS results, the estimated long-run flexibility of price with respect to quantity is 0.24. For the 2SLS results, the estimated long-run flexibility of price with respect to quantity is 0.14. Long-run supply elasticities are obtained by taking the inverses of these flexibilities of prices with respect to quantities. For the OLS model, the long-run elasticity of importers is estimated to be 4.2; for the 2SLS model, the long-run elasticity of importers is estimated to be 7.1. While the exact magnitude of the elasticity is hard to determine, the statistical results clearly indicate that the supply curve of importers is upward sloping, suggesting that importers have benefited from the checkoff program.

Application of the LM test to the OLS model yielded a t-statistic of –0.66, which is well below the cut-off point for either a 5 percent or 10 percent significance level. Therefore, there does not appear to be any evidence of autocorrelation in the residuals.

5.6 CONCLUSIONS

The models of domestic mill demand, export demand, domestic supply, and import supply all provide fairly good fits to the data and generate theoretically reasonable parameter estimates. In general, the parameter estimates either have the expected signs or have “wrong” signs that are not significant. Based on our models, it appears that both promotion and nonagricultural research increase

[12]Flexibilities are analogous to elasticities in quantity-dependent models. They measure the change in price resulting from a marginal change in quantity.

Table 5-4. Econometric Results for Aggregate Quarterly Supply of Cotton Textile Importers, 1990-2000

Independent Variable	OLS		2SLS	
	Parameters	t-values	Parameters	t-values
$Constant_t$	–6.6249	–4.816	–4.3479	–3.224
$PIMPORTS_{t-1}$	0.4550	3.138	0.4503	3.512
$QIMPORTS_t$	–0.1591	–2.073	–0.1853	–2.143
$QIMPORTS_{t-1}$	0.2908	3.721	0.2634	3.186
$WPCOTTON_t$	-0.3955×10^{-1}	–0.4362	-0.8119×10^{-2}	-0.939×10^{-1}
$DECI_t$	0.8986	4.906	0.7756	3.988
$FTEXWAGE_t$	0.1406	0.644	0.2325	—
R^2	0.5977		0.6345	
R^2-bar	0.5402		0.5851	
DW	1.9450		1.9799	
SSE	0.23182		0.25676	

domestic mill demand for cotton. However, there was no evidence for effects of promotion or research on the export demand equation. In addition, the supply of cotton has generally increased over time, but we were unable to determine what portion of that shift is due to CI agricultural research expenditures. It appears that agricultural research likely has a positive effect on cotton supply, but the exact relationship between research expenditures and cotton supply is not clear.

These parameter estimates are used in the following section to generate estimates of the net change in producer surplus and return on investment associated with Program expenditures. The parameters that allow us to make these calculations are the advertising and research parameters and corresponding elasticities as well as the supply and demand price elasticities. Although we have found strong evidence for significant demand shifts resulting from Program expenditures, it still remains to examine the benefits to producers relative to Program costs to ensure that producers are benefiting overall as a result of the Cotton Program.

6 Returns to the Cotton Program

In this section, we use the estimated parameters from the previous section to estimate the benefits of Program expenditures. Estimating the net benefits (and average return on investment [ROI]) involves changing Cotton Program expenditures and simulating market conditions under alternative levels of Program activity. The change in producer surplus was calculated for promotion, nonagricultural research, and the combination of the two by increasing the relevant Program expenditures by 1 percent and simulating market conditions. Because each of the equations used in our model of the market for raw U.S. cotton is linear, the total ROI and the marginal ROI will be similar as long as the shift due to Program expenditures is not so large as to significantly change the relevant elasticities.

The econometric results presented in the previous section allow us to estimate the change in the quantity of cotton sold that has resulted from Program expenditures, holding prices (and all other variables) constant. The estimated coefficients on promotion and nonagricultural research reveal the increase in farm-level demand expected for each dollar in Program expenditure on those activities. Multiplying these coefficients by the actual Program expenditures in each month reveals the extent to which the supply and demand curves were shifted in that month as a result of promotion or research. In addition, the coefficient for agricultural research is a measure of the shift in the supply curve that results from a dollar of expenditure on agricultural research activities. To simulate the market with a marginal increase in Program expenditures, we simply need to increase those expenditures by 1 percent (the change we assumed for calculation purposes) and observe what the supply and demand curves would look like. The simulated equilibrium provides the information necessary to calculate the ROI for producers.

6.1 RATE OF RETURN CALCULATIONS

The returns to the groups served by the Cotton Program, domestic producers and importers, were estimated using two separate sets of models. Using our econometrically estimated equations from Section 5, we can simulate the prices and quantities that would have prevailed without the Program and calculate the change in producer surplus resulting from the Program. While the econometric results indicated that generic advertising and research have each had positive effects on the quantity demanded and agricultural research has had a positive effect on the quantity supplied, the important result to cotton producers is the impact on producer surplus.

To measure the effect of the Program on domestic producers, we simulated the proportionate change in price expected to result from a marginal change in Program expenditures using

$$EP_{cd}^{s} = \frac{s_1\beta_1 EA + s_1\beta_2 ENAR}{e - s_1(\eta + \eta_{fd}\eta_f) - (1-s_1)(\eta_x + \eta_{fd}\eta_f)} \qquad (6.1)$$

where E in front of a variable denotes a proportional change in that variable; s_1 is the share of domestic cotton production sold domestically; e is the estimated supply elasticity; η is the estimated domestic demand elasticity; η_x is the estimated export demand elasticity; η_{fd} is the estimated elasticity of price transmission between U.S. and foreign cotton prices; η_f is the estimated elasticity of U.S. mill consumption with respect to the foreign cotton price; η_{xf} is the estimated elasticity of export demand with respect to the foreign cotton price; P^S is the effective price received by domestic producers;[1] A is promotional expenditures; NR is nonagricultural research expenditures; and β_1 and β_2 are the domestic promotion and nonagricultural research elasticities, respectively.

[1] Note that this price is generally not the same as the price paid by demanders because of gaps created by the assessment, by U.S. government subsidies to buyers of U.S. cotton, and by government support payments to producers.

For more details on the derivation of this equation, see Appendix D. Eq. (6.1) is a modified version of Eq. (D.5) that does not include export demand or supply shifts resulting from the Cotton Program. As discussed earlier in Section 5, although such shifts may be taking place, they could not be identified given the available data. Thus, the returns calculated in this section include only the benefits of domestic promotion and domestic nonagricultural research. The model was simulated for marginal changes in promotion only, nonagricultural research only, and total demand-side effects (combination of promotion and nonagricultural research).

Price transmission between domestic and foreign cotton prices was included in the calculation because the U.S. is a large cotton producer. Thus, we expect that changes in the U.S. cotton price will affect cotton prices around the world. Because the world price (proxied by the A Index) was found to have a significant positive effect on both U.S. mill demand and export demand, an increase in the A Index caused by promotion or research is expected to shift the demand for U.S. cotton out further. The elasticity of price transmission was estimated using a regression of the world price on the domestic cotton price. The equation was estimated in differenced form with a first-order correction for autocorrelation. We experimented with including other variables in the equation besides the two cotton prices, but they did not have a significant effect. The estimated elasticity of price transmission between U.S. and world cotton prices was 0.34, implying that a 1 percent increase in U.S. cotton prices would result in a 0.34 percent increase in world cotton prices.

Given the change in price estimated using Eq. (6.1), the change in producer surplus can be calculated by the following equation:

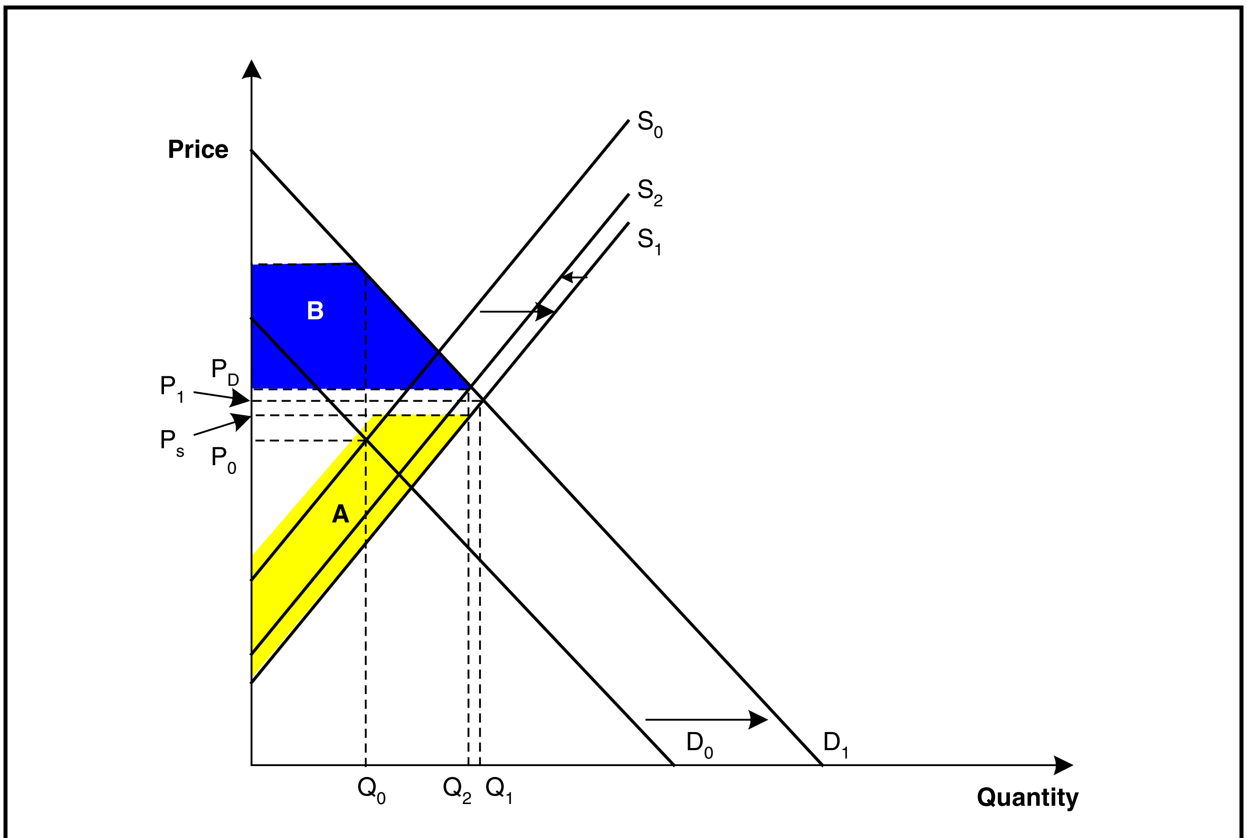
$$\Delta PS = P_{cd}^{s0}\, Q_{fd}^{s0}\, EP_{cd}^{s}\,(1 + 0.5\, EQ_{fd}^{s}) - \frac{1}{1 - \dfrac{e}{s_1(\eta + \eta_{fd}\eta_f) + (1 - s_1)(\eta_x + \eta_{fd}\eta_f)}} \bullet T \qquad (6.2)$$

where a subscript of 0 denotes baseline conditions, E denotes a proportionate change in a variable, and T is the assessment collected from domestic producers. This formula will generate estimates of the change in producer surplus experienced by producers when Program expenditures are marginally increased.

6.1.1 Cotton Producers

Figure 6-1 shows the hypothesized impact of the Program on the domestic cotton industry modeled at the farm level. Both supply and demand are shifted by Program activities. In addition, there is a supply shift resulting from the assessment collected from producers. It is expected that the net effects of Program activities have been to shift the demand curve outward from D_0 to D_1 and the supply curve outward from S_0 to S_1. The collection of the assessment, which is assumed for simplicity to operate like a per-unit excise tax, causes a shift in supply from S_1 to S_2. It is important to recognize that both producers and consumers pay a portion of the tax in this case. The portion that each pays is known as their tax incidence. The reason that producers' incidence is less than the full amount of the tax is that they are able to pass on part of the cost to consumers through higher prices for cotton. This graph shows that the assessment causes a gap between the price paid by buyers, P_D, and the price received by sellers, P_S. Note that

Figure 6-1. Program Impacts on Domestic Cotton Industry



relative to P_1 (the price after demand and supply shifts, but before inclusion of the assessment), buyers pay a higher price and sellers receive a lower price when the assessment is added.

Assuming that the horizontal shift in demand is larger than the horizontal shift in supply, both price and quantity would be expected to increase as a result of the Program. Assuming the same absolute increase in demand and supply at all quantities, Figure 6-1 can also be used to indicate changes in welfare resulting from the Cotton Program. Area A represents gains in producer surplus, while Area B represents gains in consumer surplus. The distribution of total net gains among producers and consumers depends on the relative price elasticities of supply and demand.

One of the effects of the Cotton Program is expected to be an increase in supply due to agricultural research (and we found evidence that agricultural research is increasing supply over time). However, we were not able to obtain reliable estimates of the portion of the supply shift due specifically to CI agricultural research as discussed in Section 5. As mentioned earlier, the relatively short data series available and the complexity involved in modeling all of the factors influencing the supply decision prevented us from obtaining robust, defensible estimates of the supply shift due to CI activities. Thus, the ROI measures reported include only the benefits of shifts in the domestic demand for raw cotton.

Based on the expression in Eq. (6.1), our estimated parameters from Section 5, and the average supply price and quantity from 1996 through 2000, a 1 percent increase in annual promotional expenditures would have resulted in an average price increase of 0.02 percent under free market conditions.[2] A 1 percent increase in annual nonagricultural research expenditures, on the other hand, is estimated to raise cotton prices by 0.30 percent. Taken together, these results imply that a 1 percent increase in expenditures on

---

[2]In fact, during the period 1996 through 2000, government programs were in effect either on the supply side or the demand side for few months. However, a measure of the return under free market conditions may be the most useful for setting Cotton Program policy because of the uncertainty associated with future government support programs. Because of this uncertainty, it may not be prudent to base Cotton Program decisions on their interaction with government support programs that are subject to change. We do present historical results incorporating government programs later in this section, however.

both promotion and research would increase cotton prices by 0.32 percent. The increase in quantity given an estimated increase in price is calculated by multiplying the proportionate increase in price found using Eq. (6.1) by the estimated supply elasticity. The proportionate changes in quantity implied by a 1 percent increase in annual promotional expenditures, annual nonagricultural research expenditures, and total demand-side expenditures are 0.01 percent, 0.14 percent, and 0.15 percent, respectively.

Using the estimated changes in price and quantity resulting from Cotton Program activities, parameters estimated in Section 5, and the average values of price and quantity from 1996 through 2000, we calculated net changes in producer surplus over that period using Eq. (6.2). This net change in producer surplus was then divided by the change in assessment paid by domestic producers for calculating the overall return and by the share of the change in expenditures on promotion or research paid by domestic producers to find the ROI for those shifts individually. The equation used to calculate ROI for domestic producers is given by:

$$ROI_i = \frac{\Delta PS_i}{assess_i \bullet s_D} \qquad (6.3)$$

where i is either promotion, nonagricultural research, or total demand-side expenditures; assess refers to the change in either total assessment paid or change in total expenditures for promotion or research; and s_D is the average share of assessments paid by domestic producers.

Table 6-1 summarizes the estimated impacts on domestic producers that would result from a marginal increase in expenditures on Program activities over the period 1996 through 2000 assuming a free cotton market (i.e., no government programs). The results of the simulation indicate that the net increase in producer surplus resulting from a 1 percent increase in demand-side expenditures would be $20.2 million, while a 1 percent increase in assessments paid by domestic producers would equal about $453,400. Thus, net producer surplus was increased by an average of $44.50 for each dollar of assessments paid. These calculations suggest that the benefits to producers were more than sufficient to cover Program expenditures for the period analyzed.

Table 6-1. Marginal Benefits and Costs of the Cotton Research and Promotion Program for Domestic Producers, 1996-2000 (constant 2000$)

Marginal Benefits, Costs[a]	
Net Producer Benefits, Promotion	$1,339,915
Net Producer Benefits, Non Ag Research	$18,871,694
Net Producer Benefits, Combined	$20,166,529
Domestic Producer Costs, Promotion	$290,084
Domestic Producer Costs, Non Ag Research	$67,334
Domestic Producer Assessment, Combined	$453,447
Producer Benefits/Producer Costs, Promotion	**4.6**
Producer Benefits/Producer Costs, Non Ag Research	**280.3**
Producer Benefits/Producer Assessments, Combined	**44.5**

[a]These values correspond to a 1 percent increase in expenditures and costs/assessments. For promotion and research the costs to domestic producers of a marginal increase in Program expenditures are calculated as 1 percent of the expenditures on those activities multiplied by the share of total Program assessments paid by domestic producers (about 67 percent). For the combined measure, the costs are calculated as a 1 percent increase in the total assessments paid by domestic producers.

In addition to the overall ROI measures, Table 6-1 provides estimates of the marginal return to each promotion and nonagricultural research separately. These results reveal that while increasing expenditures on either of these program activities seems to have benefits greater than the costs, nonagricultural research has a far higher return.

Although the results assuming a free market may provide the most relevant information regarding the effects of the Cotton Program given uncertainty surrounding future government farm programs, we also examined the effects on the returns to the Cotton Program under several variations of government cotton support programs. The effects of these different programs are explained in more detail in Section 6.3. Table 6-2 shows the estimated ROI under different government programs as well as a weighted ROI measure based on the number of months each was in effect during 1996 through 2000. These results show that when the Step 2 program is in effect, there is a significantly larger benefit of promotion and research to producers. This is because the effective price faced by consumers of raw cotton (primarily foreign and domestic textile mills) does not increase as much as it would in a free market. When demand shifts

Table 6-2. Effects of Interaction with Government Cotton Programs on Domestic Producer ROI, 1996-2000 (constant 2000$)

Marginal Benefits, Costs[a]	Free Market	LDP	Step 2	LDP and Step 2	Weighted Average[b]
Net Producer Benefits, Promotion	$1,339,915	$1,065,155	$2,081,637	$1,473,021	$1,611,416
Net Producer Benefits, Non Ag Research	$18,871,694	$15,365,473	$28,341,000	$20,570,558	$22,337,780
Net Producer Benefits, Combined	$20,166,529	$16,384,866	$30,380,092	$21,998,879	$23,905,031
Domestic Producer Costs, Promotion	$290,084	$290,084	$290,084	$290,084	$290,084
Domestic Producer Costs, Non Ag Research	$67,334	$67,334	$67,334	$67,334	$67,334
Domestic Producer Assessment, Combined	$453,447	$453,447	$453,447	$453,447	$453,447
Producer Benefits/Producer Costs, Promotion	**4.6**	**3.7**	**7.2**	**5.1**	**5.6**
Producer Benefits/Producer Costs, Non Ag Research	**280.3**	**228.2**	**420.9**	**305.5**	**331.7**
Producer Benefits/Producer Assessments, Combined	**44.5**	**36.1**	**67.0**	**48.5**	**52.7**

[a]These values correspond to a 1 percent increase in expenditures and costs/assessments. For promotion and research the costs to domestic producers of a marginal increase in Program expenditures are calculated as 1 percent of the expenditures on those activities multiplied by the share of total Program assessments paid by domestic producers (about 67 percent). For the combined measure, the costs are calculated as a 1 percent increase in the total assessments paid by domestic producers.

[b]Weights for the four policy regimes are based on the number of months each was in effect during 1996-2000.

out, the market price will rise. However, this will trigger larger government subsidies per pound of cotton. The net price after subsidy will rise much less than the price received by producers as a result of these payments. Thus, the quantity purchased and the price received by producers both increase more than they would under free market conditions. The LDP program, on the other hand, acts to reduce the ROI of promotion and nonagricultural research activities when binding. This is because part of the increase in market price is offset by reductions in government LDP payments. A weighted average of the returns under different government programs in existence from 1996 through 2000 yields a return that is a bit higher than the free market return presented in

Table 6-1. Here, the ROI for domestic producers is estimated to be 52.7 when the effects of government programs are taken into account.

6.1.2 Cotton Importers

The primary emphasis for the cotton importers is whether they are receiving positive benefits or not, rather than the level of benefits. This is because of the difficulty in separating out the producer surplus gains that are flowing to the cotton importers as opposed to other groups in the marketing chain. What we are calculating is technically the returns to suppliers of imported cotton products rather than the returns to importers. Included in the "suppliers of imported products" are retailers, etc., that may not be importing the products directly and may not be paying the cotton assessment themselves. Nonetheless, our approach will enable us to determine whether importers are receiving positive net benefits from the Cotton Program.

As discussed earlier in Sections 4.2 and 5.5, the method used to calculate the import supply function is to estimate the price of imported cotton products as a function of marketing and processing input prices and net import quantity, holding input prices constant. Then, to measure the impact of the Cotton Program on cotton importers, the idea is to use the supply elasticity calculated in Section 5.5. Because this elasticity was calculated holding the world price of cotton constant, the area above the supply curve and between apparel prices with and without a marginal increase in Program expenditures should give an indication of the amount gained by importers from the Program. There was no evidence to suggest that the supply curve had shifted in response to the Program expenditures (other than from the assessment on importers) so that knowing the change in price due to the Program and the elasticity of supply is sufficient to calculate the change in producer surplus. The formula used to calculate the change in producer surplus is

$$\Delta PS = P_{rm}^{0}\, Q_{rm}^{0}\, EP_{rm}\,(1 + 0.5\ EQ_{rm}) - \left(\frac{1}{1 - \frac{e_m}{\eta_m}}\right) \bullet T_m \qquad (6.4)$$

where P_{rm}^{0} and Q_{rm}^{0} are the initial price and net quantity of imported cotton products, ΔP_{rm} and ΔQ_{rm} are the change in price and quantity resulting from the cotton Program, e_m is the input supply elasticity, η_m is the import demand elasticity (assumed to be –0.5), and T_m is the change in assessment paid by importers.

In Eq. (6.4), the price and quantity changes refer to changes that are equilibrium changes. By the results of standard welfare analysis, we know that these changes can be calculated from the observed total equilibrium change in price resulting from the Program and by how much quantity changes as a result of moving along the importers' supply curve. As indicated above, the elasticity of supply estimated in Section 5.5 is what we used to calculate the quantity effect. Conceptually, the price effect could be calculated from a reduced form equation in which the price of imported products would be regressed on all the determinants of supply and demand for imports, including the research and promotion expenditures on cotton. Unfortunately, this approach was unsuccessful, so an alternative method of estimating the equilibrium change in the price of imported cotton products was used.

This alternative method is to estimate the cost share of raw cotton in final imported products. The USDA FAS reports that 1998 U.S. cotton textile imports were 12.49 million bales and the value of cotton textile imports was $30.7 billion (USDA FAS, 1999). This was the only data concerning the value and quantity of imports that was located for the 1996 through 2000 period. It was assumed to be representative of this period. Assuming a 480-pound cotton bale implies a unit imported cotton products value of $5.12 per pound of cotton equivalent. In 1998, the average A Index value for cotton was $0.59 per pound, which implies that the cost share of raw cotton in imported cotton products is about 0.12, or 12 percent. As reported in Section 6.1, the elasticity of price transmission from U.S. cotton to the world cotton price was estimated to be 0.34. Thus, the overall elasticity of the price of imported cotton products with respect to the price of U.S. cotton is 0.04 (0.12 x 0.34). This implies that, for each 1 percent change in the price of U.S. cotton, we would expect the price of cotton imports to change by 0.04 percent.

In summary, given the change in price of U.S. domestic cotton from the Cotton Program, the change in import price can be calculated using the elasticity of price transmission of 0.04. The change in quantity of imports then can be calculated using the supply elasticity of 7.1 and the welfare effects on importers can be calculated using Eq. (6.4). Given the above caveats with respect to what the welfare effect is actually measuring, this approach gives insight into the range of likely net returns importers in the aggregate have received from the Cotton Program over the past 5 years.

Based on the estimated price increase for domestic cotton resulting from a 1 percent increase in Program expenditures, the expected increase in the price of imported cotton products that would result is 0.0018 percent, and the expected increase in quantity is 0.0128 percent. These numbers are based on the assumption of free markets. Although these percentages appear very small, the initial quantity of net imports is so large and the importers are able to pass such a large percentage of the assessment cost to consumers (based on the supply and demand elasticities) that even a very tiny increase in net price may result in net benefits to producers. Table 6-3 presents the estimated ROI for importers using the technique described above. As for domestic producers, the ROI for importers varies depending on the government cotton policies in place. Table 6-4 displays the estimated impacts on cotton importer ROI under different government policies. As for domestic producers, the Step 2 program increases the benefits associated with the Cotton Program, while the LDP program, when binding, dampens the effects of the Cotton Program.

Table 6-3. Marginal Benefits and Costs of the Cotton Research and Promotion Program for Importers, 1996-2000 (constant 2000$)

Marginal Benefits, Costs[a]	
Net Producer Benefits, Combined	$570,661
Domestic Producer Assessment, Combined	$213,176
Producer Benefits/Producer Assessments, Combined	**2.7**

[a]These values correspond to a 1 percent increase in expenditures and costs/assessments. For promotion and research the costs to importers of a marginal increase in Program expenditures are calculated as 1 percent of the expenditures on those activities multiplied by the share of total Program assessments paid by importers (about 33 percent). For the combined measure, the costs are calculated as a 1 percent increase in the total assessments paid by importers.

Table 6-4. Effects of Interaction with Government Cotton Programs on Importer ROI, 1996-2000 (constant 2000$)

Marginal Benefits, Costs[a]	Free Market	LDP	Step 2	LDP and Step 2	Weighted Average[b]
Net Producer Benefits, Combined	$570,661	$460,096	$868,790	$624,145	$679,781
Domestic Producer Assessment, Combined	$213,176	$213,176	$213,176	$213,176	$213,176
Producer Benefits/Producer Assessments, Combined	**2.7**	**2.2**	**4.1**	**2.9**	**3.2**

[a]These values correspond to a 1 percent increase in expenditures and costs/assessments. For promotion and research the costs to importers of a marginal increase in Program expenditures are calculated as 1 percent of the expenditures on those activities multiplied by the share of total Program assessments paid by importers (about 33 percent). For the combined measure, the costs are calculated as a 1 percent increase in the total assessments paid by importers.

[b]Weights for the four policy regimes are based on the number of months each was in effect during 1996-2000.

6.1.3 Sensitivity Analysis

The estimates of rates of return included in Sections 6.1.1 and 6.1.2 are based on point estimates of the parameters. Because these estimates are unlikely to be exactly correct, the measures of net benefits should also be thought of as estimates rather than exact measurements. Generally, studies that measure the demand response to advertising calculate and report point estimates of benefits to producers and do not report the precision with which this point estimate is measured. For example, a researcher may report that the ROI for a particular advertising effort is 10 to 1. It would also be informative to report how precisely this ROI was measured. That is, a researcher could also calculate and report a confidence interval around this ROI, allowing lower and upper bounds to accompany this estimate, thus providing important additional information. For example, it would be helpful to know whether these lower and upper bounds include zero, indicating whether this estimate of the ROI is statistically significantly different from zero. Moreover, testing whether a particular welfare estimate is statistically significant may not be as informative as taking an additional step of calculating the probability that a particular welfare measure change is greater than zero. For example, reporting “the best estimate of the ROI is 10 to 1, but we cannot be confident that this estimate is statistically significantly different from zero,” is not as informative as “the precision with which the ROI can be measured indicates that we can be 75 percent certain that the ROI ratio is greater than 1, and the best estimate of this ROI is 10 to 1."

If we generate estimates of the welfare measures at each draw from the probability distribution of the estimated parameters, we can generate an empirical approximation of the underlying probability distribution for the welfare measures. This empirical version of the distribution can then be used to assign measures of precision to the point estimates of changes in welfare. Estimates of welfare impacts resulting from the Program can then be reported with accompanying confidence intervals. The width of these intervals then provides a measure of confidence about whether the returns are positive. Although point estimates of welfare measures are useful, they are much more informative when accompanied by measures of precision. More detail on the sensitivity analysis employed is provided in Appendix D.

Measures of precision for each of the welfare measure were generated by drawing values at random from the estimated distribution of the parameters. The resulting drawn parameters were then used to conduct the simulations of the cotton market and to evaluate accompanying welfare impacts. This process was repeated for 10,000 random draws of parameter estimates. Table 6-5 presents the results of these calculations for both domestic producers and importers. Even at the lower 5 percent boundary, the ROI is still very large, providing additional evidence that the Cotton Program was quite successful in increasing producer returns during 1996 through 2000.

6.2 CONCLUSIONS FROM RATE OF RETURN ESTIMATES

To determine the average rate of return (and total net benefits) associated with the Program, we simulated what the market for cotton would look like with a marginal increase in Program expenditures. This was done by increasing Program expenditures (and assessments) by 1 percent and using our model results to simulate supply and demand under this condition. We perform this simulation for both the domestic raw cotton market and the import market to measure producer surplus to both domestic producers

Table 6-5. Sensitivity Analysis of Cotton Program ROI, 1996-2000

Marginal Benefits, Costs[a]	Free Market 95 Percent Confidence Interval[c] Lower Bound	Free Market 95 Percent Confidence Interval[c] Upper Bound	Weighted Average[b] 95 Percent Confidence Interval[c] Lower Bound	Weighted Average[b] 95 Percent Confidence Interval[c] Upper Bound
Domestic Producers				
Net Producer Benefits, Promotion	$934,449	$1,740,764	$1,131,675	$2,085,695
Net Producer Benefits, Non Ag Research	$13,613,398	$24,243,406	$16,114,637	$28,695,494
Net Producer Benefits, Combined	$14,782,552	$25,634,025	$17,532,997	$30,376,270
Domestic Producer Costs, Promotion	$290,084	$290,084	$290,084	$290,084
Domestic Producer Costs, Non Ag Research	$67,334	$67,334	$67,334	$67,334
Domestic Producer Assessment, Combined	$453,447	$453,447	$453,447	$453,447
Producer Benefits/Producer Costs, Promotion	**3.2**	**6.0**	**3.9**	**7.2**
Producer Benefits/Producer Costs, Non Ag Research	**202.2**	**360.0**	**239.3**	**426.2**
Producer Benefits/Producer Assessments, Combined	**32.6**	**56.5**	**38.7**	**67.0**
Importers[d]				
Net Producer Benefits, Combined	$413,329	$730,156	$493,697	$868,534
Domestic Producer Assessment, Combined	$213,176	$213,176	$213,176	$213,176
Producer Benefits/Producer Assessments, Combined	**1.9**	**3.4**	**2.3**	**4.1**

[a]These values correspond to a 1 percent increase in expenditures and costs/assessments. For promotion and research the costs to domestic producers or importers of a marginal increase in Program expenditures are calculated as 1 percent of the expenditures on those activities multiplied by their share of total Program assessments. For the combined measure, the costs are calculated as a 1 percent increase in the total assessments they pay.

[b]Weights for the four policy regimes are based on the number of months each was in effect during 1996-2000. Results for individual government policy regimes are not presented here, but show similar results. The lower bounds on ROI are positive under every government policy examined.

[c]Indicates a 95 percent statistical probability that the true estimate falls in this range.

[d]Combined effect from promotion and nonagricultural research.

and importers. Producer surplus is then compared with and without the Program. Table 6-6 summarizes the overall findings concerning the ROI for domestic producers, importers, and for these two groups combined assuming a free market for cotton.

Table 6-6. Summary of ROI Calculations, 1996-2000

Component	Mean	95 Percent Confidence Interval[a]	
		Lower Bound	Upper Bound
Domestic producers			
Promotion	4.6	3.2	6.0
Nonagricultural research	280.3	202.2	360.0
Importers[b]	2.7	1.9	3.4
Total[c]	30.6	22.4	38.9

[a]Indicates a 95 percent statistical probability that the true estimate falls in this range.

[b]Combined effect from promotion and nonagricultural research.

[c]Total net returns to domestic producers + importers divided by total Program costs.

We find that the producer returns to this Program have been quite large. For this Program to be beneficial to producers, it is only necessary to have the ROI be above the opportunity cost of using the assessment funds for other purposes. Given that an ROI measure of 1 implies a 100 percent return on investment in the Cotton Program and our measures are far greater, the ROI measures calculated are clearly greatly above any reasonable estimate of the opportunity cost of those funds (i.e., the return expected in alternative investments). Although domestic producers seem to have a much higher ROI from the Cotton Program than importers, the estimated return to the importers still far exceeds their opportunity costs. This follows from the relatively high estimated elasticities of demand response to promotion and nonagricultural research.

Another interesting question is whether the rate of return on advertising and research differ. If so, this implies that a reallocation of expenditures towards the area with a relatively higher return would improve net returns to producers. Thus, rates of return are calculated separately for promotion and nonagricultural research to address this issue. Our results indicate that, although it would pay to increase both activities, it appears that reallocation towards nonagricultural research would provide a larger return.

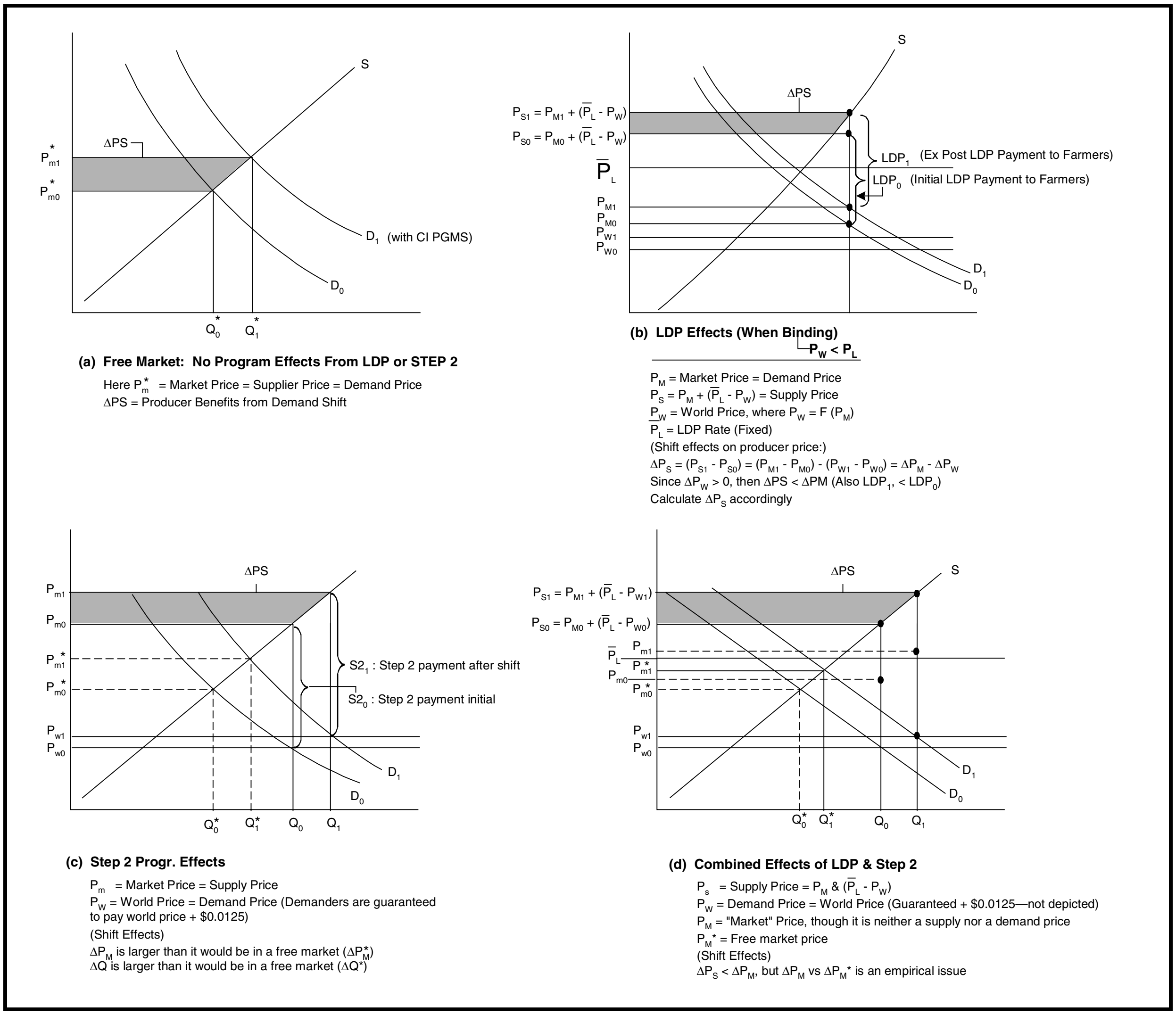
6.3 FARM PROGRAM INTERACTIONS

The existence of federal farm programs greatly complicates the calculation of Program effects on price, consumption, and ROI. The measures presented throughout the text to this point are calculated without specific regard to price subsidies or other such incentives imposed by farm programs. However, although the 1996 FAIR Act was to ostensibly eliminate commodity price subsidies, they remain for cotton producers in the form of LDP guaranteed prices. Moreover, cotton demanders (mills) receive guarantees in the form of Step 2 payments to cover the gap between the U.S. cotton price and the world cotton price. It is beyond the scope of this study to examine all the complexities of farm program interactions. However, Figure 6-2 provides a diagram of these interactions.

Panel (a) in Figure 6-2 represents the undistorted market solution. Here supply and demand intercept without subsidies on either the demand side or the supply side. A shift in the market demand induced by the Cotton Research and Promotion Program is simulated to cause a rise in the market price from P^*_{m0} to P^*_{m1}. The shaded area (producer surplus) represents the return to producers of the Program.

Panel (b) introduces the effects of the LDP system. If the adjusted world price (AWP) of cotton falls below the LDP target rate of 51.92 cents per pound, cotton growers are eligible for a supplemental payment equal to the difference between the LDP target rate and AWP. The total price received by the grower is equal to the price they receive in the market (P_M) plus the supplemental payment ($\bar{P}_L - P_W$), where $\bar{P}_L$ is the LDP rate and P_W is the AWP. The demand shift raises the U.S. market price from P_{M0} to P_{M1}. However, the total price to suppliers will decline if the rise in the U.S. market price causes a corresponding rise in the AWP (thereby diminishing the supplemental payment to farmers). If the relationship between the U.S. price and the world price is 1:1, then the rise in the world price causes a decline in the supplemental payment that, from the producer's perspective, completely offsets the rise in the market price. In this case, there

Figure 6-2. Farm Program Interactions
The influence of U.S. farm programs such as the loan deficiency payment (LDP) system and Step 2 program greatly complicates the calculation of ROI.



would be no net benefit of the demand shift to producers.[3] However, there are a number of reasons to expect that the U.S. market price and the AWP do not move in parallel fashion. First of all, U.S. cotton is widely regarded to be of a superior quality and not perfectly substitutable with cotton from elsewhere in the world (thus they are not exactly the same commodity and may not receive the same price in the market). There are also transportation costs to consider, which also keeps U.S. prices from directly tracking the

[3]We thank Dr. Henry Kinnucan for pointing this out in his review of the first draft of this report.

AWP. To test for this empirically, we ran a price transmission regression of the AWP on the U.S. price and estimated a statistically significant price transmission parameter of 0.3. This means that a $1 change in the U.S. price is generally matched by a 30 cent change in the world price. This feedback diminishes the benefit to producers somewhat—the LDP price supplement shrinks some, but not nearly enough to wipe out the Program benefits to producers.

Panel (c) illustrates the effects of the Step 2 program. When the U.S. price is above the A Index world price by a certain amount (1.25 cents per pound for 4 weeks), U.S. mills, marketers, and exporters receive a supplemental payment to use U.S. cotton that is equal to the difference between the U.S. price and the A Index basis. In this case, a Program-induced shift in U.S. demand raises the market price here. If Step 2 conditions are in effect, then demanders do not effectively pay the higher U.S. price; rather, they receive a higher supplemental Step 2 payment from the government. By foregoing a negative demand response, U.S. prices rise more than they would without Step 2. Therefore, this enhances the price benefits of the cotton program to U.S. producers. The price transmission issue applies here as well. The size of the Step 2 supplement is diminished in part by the corresponding rise in the world price. We adjust for that using the price transmission parameter of 0.3 referenced above.

It is possible for both the LDP and Step 2 programs to be in effect simultaneously. The world price may be low enough to trigger LDP payments in the U.S., but the U.S. price may still be more than high enough above the world price to trigger the Step 2 payments. This has, in fact, been the case for much of the time during 1999 through 2000. Panel (d) demonstrates how prices are determined when both programs are in effect. Because the LDP tends to diminish the price benefits of the Program-induced demand shift and the Step 2 tends to enhance this effect, it is not possible to determine a priori, whether the net interactive effects of the programs are positive or negative. It is an empirical issue.

The analysis throughout this report focuses on the undistorted market situation described by Panel (a). Although the ROI are retrospective measures and the period 1996 through 2000 brought periods where none, one, or both of the farm program subsidies were in effect, we thought it more useful for *future planning* purposes to evaluate the ROI under the undistorted case. Our rationale is that there is no guarantee what form these farm programs will take in the foreseeable future, especially in light of the Farm Bill reauthorization slated for 2001. However, to determine the sensitivity of the ROI results to these farm program features, the research team did adjust calculations to capture the nature and approximate magnitude of these interaction effects on the ROI estimates. Table 6-7 summarizes the results of that effort.

Table 6-7. Farm Program Interaction Effects on ROI

	LDP Program	Step 2
Interaction	Minimum price guarantee dampens the price benefit for domestic producers when the market price is below the guarantee price.	Guaranteed price ceiling for domestic mills using U.S. cotton allows any Program-related price increase to bypass the domestic mill and be paid by the government. Enhances the Program price benefit for domestic producers
Effect on Total ROI	–20%	+55%

7 Limitations, Supplemental Analysis, and Conclusions

This section concludes the study with a characterization of the limits of the analysis, an assessment of their importance, supplemental information to address some of the limitations, and a summary statement of key findings.

7.1 LIMITATIONS AND SUPPLEMENTAL ANALYSIS

No analysis is without shortcomings. Although every effort has been made in this study to develop the appropriate models, obtain the correct data, and employ rigorous methods for estimation and simulation, several Program phenomena remained difficult to capture. This section addresses some particularly important technical issues not resolved in the present analysis. Future analyses of the Cotton Research and Promotion Program should try to address these issues.

7.1.1 Agricultural Research Benefits

As described in Section 3 of this report, there has been a profound change in the geographic distribution of supply and increased mechanization in U.S. cotton production. These are indicators of substantive technical change in the last several decades. However, it is very difficult to discern the timing of agricultural research effects on supply, especially with the fairly short time series of data available for this study.[1] Therefore, the study was not able to obtain a direct estimate of the ROI for CI agricultural research expenditures.

Although we were unable to directly estimate the effects of agricultural research on the cotton supply function, we do include a time trend variable as a proxy for a constant degree of technical change over the time period in the analysis (see Section 5). This trend variable coefficient is positive and significant, indicating that technical change has shifted out supply over time. Section 4 shows how a technology-induced outward shift in the supply for cotton can benefit producers if the reduction in costs per unit of output is larger than any decline in price that results from the adoption of these cost-reducing (yield-enhancing) technologies.

Before turning to other issues, it is instructive to look at the data on agricultural research and view it in the context of other trends in cotton growing technology, costs, and prices to get some sense of how these factors may be related. Figure 7-1 shows separate indices of real cotton-related agricultural research expenditures from 1981 through 1999 by CI and by all sources tracked by the USDA.[2] Real CI agricultural research expenditures declined substantially in the 1980s and rebounded in the 1990s, reflecting the evolving priorities of CI over the last two decades. Total cotton-related research expenditures were more stable over time than CI expenditures, showing a modest decline in the 1980s and a slight increase in the 1990s.

Figure 7-2 presents the trend in cotton yields and production costs per acre over the last 25 years. Since the mid-1970s there has been a downward trend in real production costs and an increase in yields. The yield effects, however, are both volatile and fairly flat

---

[1]The short time series is more problematic in supply estimation than demand estimation. Demand effects can be estimated using the monthly data available for this study, but supply decisions are annual and therefore must be modeled with annual data. Moreover, lag effects of agricultural research may be quite long, requiring several years of lagged expenditure to capture. With a limited number of observations of annual data (post-1981), this leaves few degrees of freedom for statistical estimation of the supply function.

[2]1981 is the first year of available data for CI agricultural research. USDA tracks all cotton-related research funded by the federal government, state experiment stations, and nonfederal sources (including CI).

Figure 7-1. Index of Agricultural Research Expenditures: Cotton Incorporated vs. All Sources

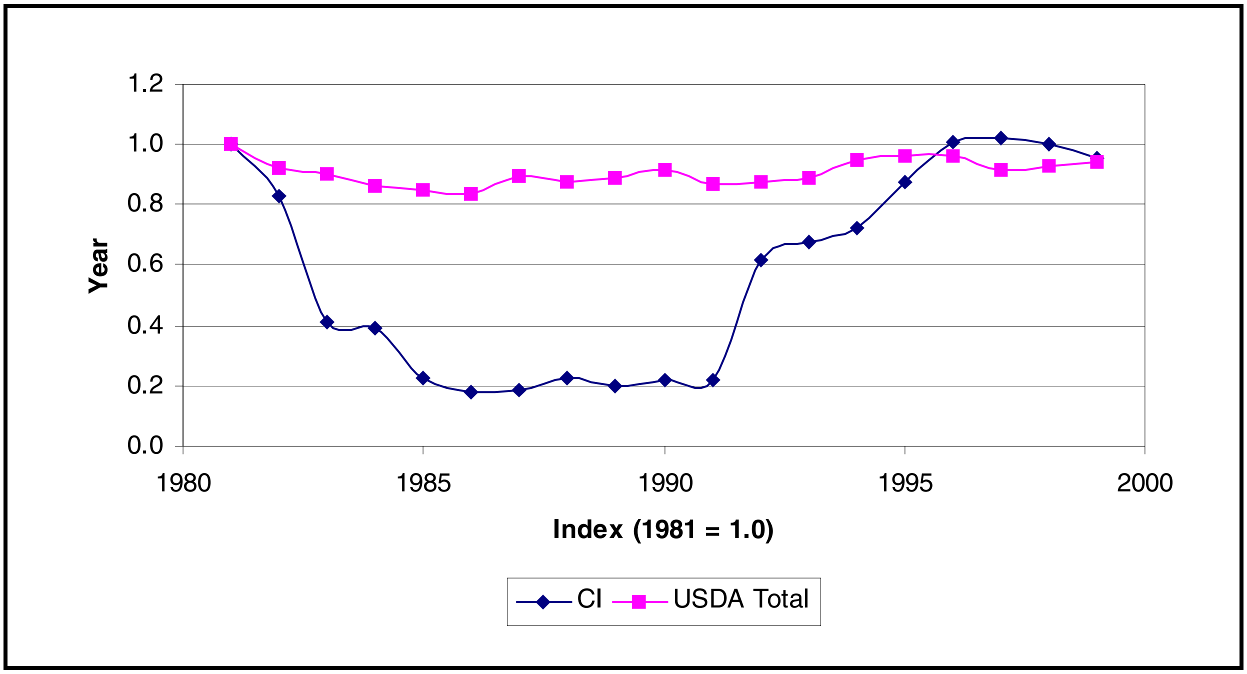
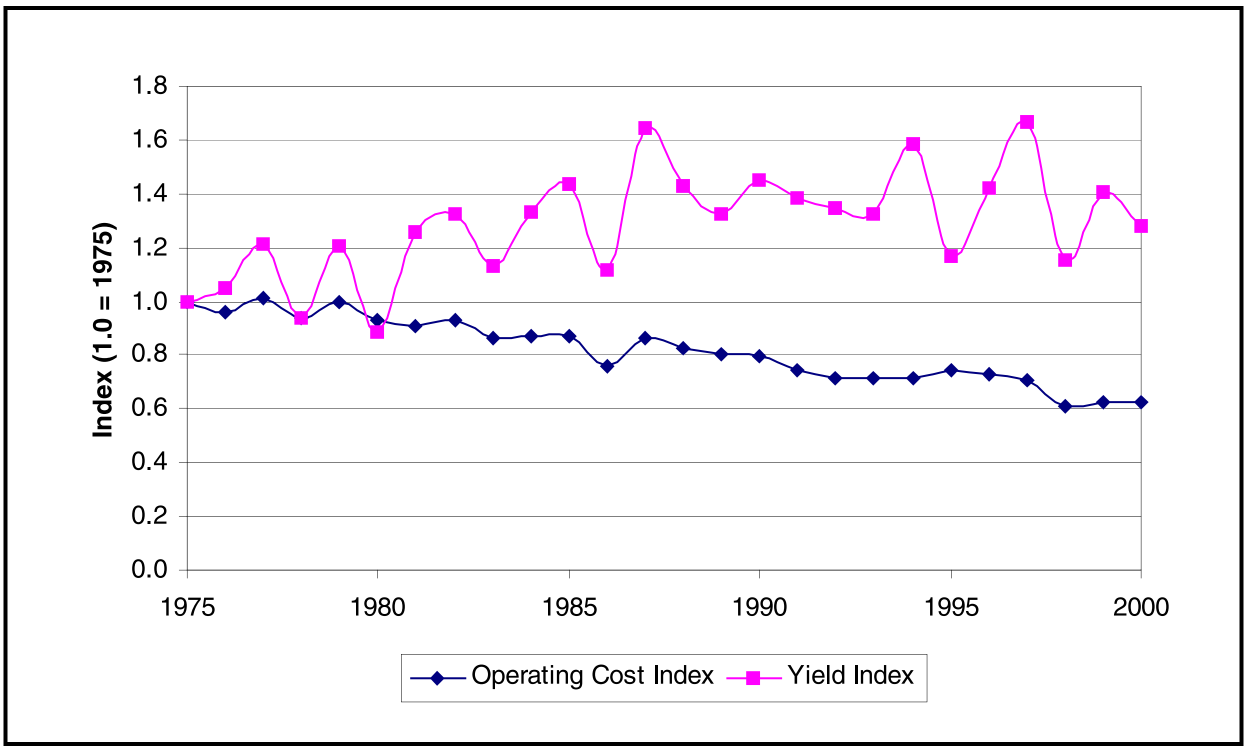
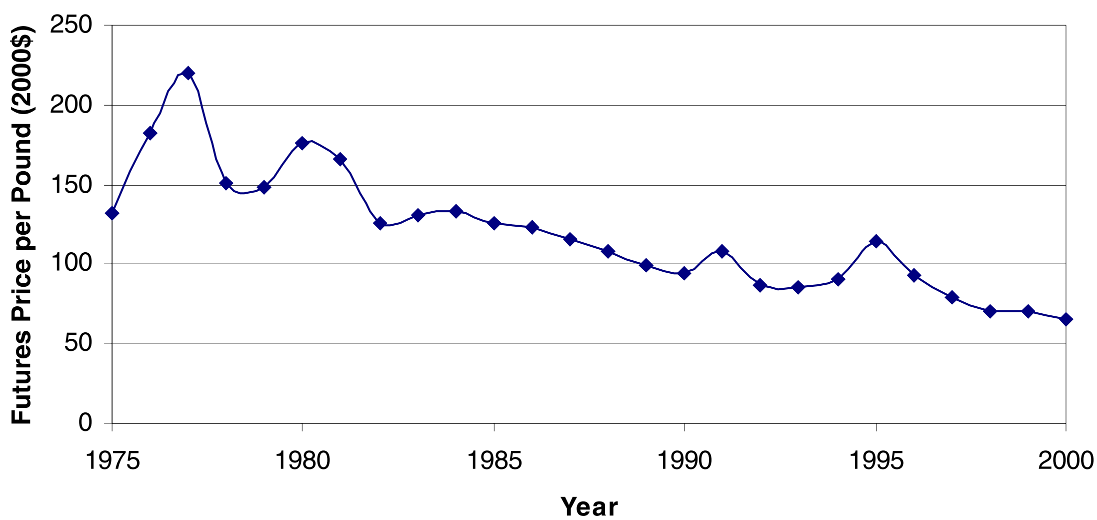


Figure 7-2. Cotton Yield and Production Cost Indices: 1975-2000



between the mid-1980s and 2000.[3] Both the decline in costs and rise in yields are indicative of positive technical change; however, real prices have also fallen sharply during the time period as illustrated in Figure 7-3. It is not possible to determine how much of the decline in price is due to the adoption of lower-cost/higher yield technologies and how much is due to other factors such as global supply increases, lower price of substitute fibers, and general macroeconomic and trade conditions. However, it seems clear that many of the technology benefits to cotton growers have been offset by the decline in price, whatever their cause. This does not imply that cotton growers are not, on balance, better off with these technical changes than without. Rather, there are a myriad of factors depressing prices in the sector that have apparently offset much of the gain from lower costs.

Figure 7-3. Real Price of Cotton: 1975-2000



[3]One hypothesis for the flattening yields is that the cotton that has been genetically engineered to resist certain pesticides and insects—and has been widely adopted since the mid-1990s—evolved from the lower-yielding seed varieties. Thus, lower costs and less variable yield may have come at the cost of lower yields. However, we were not able to test that hypothesis in this study.

Adequate data may be available to directly estimate returns to CI agricultural research when the Cotton Board next assesses the returns to the program in 2006.

7.1.2 Effect of Program Expenditures on Export Demand

The data used in this analysis could not be separated into domestic and export components of program expenditures. Therefore, total advertising and nonagricultural research expenditures were included when specifying the export demand function even though the majority of this expenditure is focused on the domestic market. If Program expenditures on domestic and foreign activities changed at the same rate over time, this would not be a problem, but that is not necessarily the case. Unfortunately, it was not possible to divide these total expenditures into their domestic and export components to more directly test whether the export-oriented expenditures were effective in expanding export demand. Econometric analysis indicated that these variables did not add significant explanatory power and thus were dropped from the estimated model.

Further global integration of the cotton industry is likely to make it even more difficult for CI to separate export-oriented expenditures from domestically focused efforts. Therefore, future analyses may face the same difficulty in evaluating export program effects.

7.1.3 Potential Upward Bias in ROI Estimate for Nonagricultural Research

The estimated ROI of nonagricultural research for domestic producers is quite high—nearly 70 times as high as the promotion ROI. Although the Texas A&M study found nothing comparable to this magnitude, ROIs this high have been found for other checkoff programs (e.g., California table grape study by Alston et al. [1997]). The results, as they stand, are indicative of the possibility that the rather small amount of money that CI devotes to nonagricultural research may be greatly leveraged by external funds. The implications of this leveraging are two-fold: CI gets a large “bang for the buck” of every dollar spent in this area and, more cautiously, returns to this expenditure are greatly dependent on the existence of these external funds.

Although we exercised great care in the econometric estimation phases of the study to obtain the best model, the authors nonetheless suggest that the results be interpreted with caution. CI expenditures on nonagricultural research may be correlated with expenditures from other sources that are not tracked by the econometric model of cotton demand (e.g., coordinated research and promotion efforts with private industry or government-funded research). If there is a strong correlation with these omitted variables, and if these expenditures exert a positive influence on demand, then the current model may overattribute demand enhancement to CI expenditures in this area, thereby overstating ROI. This problem could be remedied in the future if data from partner programs could be obtained.

7.1.4 Difficulties in Estimating Importer ROI

Importers of finished cotton goods are assessed a payment on the weight equivalent of cotton contained in the product. The Program benefits importers if it causes the price of imported goods sold in the U.S. to rise more than the price the importers pay for the goods plus any increase in the marginal cost of supplying the importing service. This benefit is difficult to measure with the data available in the study, because a price series on final and intermediate imported cotton products and data on the cost of importing are lacking.

To approximate the returns to importers, we estimated an import supply function for finished goods containing cotton. We used this estimated function to measure the benefits to suppliers of imported products of a Program-induced demand shift in the U.S. This is an appropriate measure for the returns to all suppliers of imports, but the measure potentially includes benefits to parties that supply the importer firms themselves. Therefore, the ROI for importers may overstate the true ROI. Unfortunately, we cannot separate the benefits for importers from the benefits for their suppliers. Thus, the ROI might be viewed as an upper-end estimate of the return to importers. However, the lower bound of the 95 percent confidence interval for importer ROI is 1.9. Therefore, the evidence still suggests that importers gain from the Program, just not to the extent that domestic producers do.

Although the returns to importers are difficult to quantify, we are confident that importers do not lose from the Program because of their ability to pass along the assessment to consumers.[4]

7.2 KEY FINDINGS

Although the analysis had some limitations, we present the following conclusions about the Cotton Research and Promotion Program's success in meeting its goals:

- ➤ The Cotton Program has a strong and positive effect on the demand for U.S. upland cotton.
- ➤ The returns to producers substantially outweigh the costs.
- ➤ Returns for demand-side research may be significantly higher than returns for promotion.
- ➤ Returns for domestic producers may be substantially higher than for importers.
- ➤ There is evidence that CI may be successfully leveraging its research programs with outside parties to the benefit of cotton producers and importers.

Thus, the balance of the evidence suggests the returns to domestic cotton producers and importers exceed the costs of the Cotton Research and Promotion Program.

[4]When the supply function for a market is fairly elastic, as is the case with imported cotton goods, more of a per-unit assessment is passed on to consumers through higher prices. That is because suppliers have wide latitude to serve other markets that are not subject to the assessment and thus are less inclined to serve the "taxed" market unless prices adjust accordingly.

References

Alspaugh, Pamela, International Textile Center. May 7, 2001. Personal communication with Catherine Viator, Research Triangle Institute.

Alston, J.M., J.A. Chalfant, J.E. Christian, E. Meng, and N.E. Piggott. 1997. "The California Table Grape Commission's Promotion Program: An Evaluation." Giannini Foundation Monograph 43, Giannini Foundation of Agricultural Economics, University of California, Oakland.

Anderson, C.G. 1999. "Cotton Marketing." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 659-679. New York: John Wiley & Sons, Inc.

Basra, Amarjit. 1999. *Cotton Fibers: Developmental Biology, Quality Improvement, and Textile Processing*. New York: Food Products Press.

Benedict, C., R. Kohel, and H. Lewis. 1999. "Cotton Fiber Quality." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 269-288. New York: John Wiley & Sons, Inc.

Capps, O., D.A. Bessler, G.C. Davis, J.P. Nichols, C.G. Anderson, and E.G. Smith. 1997. *Economic Evaluation of the Cotton Checkoff Program*. Departmental Technical Report 97-2. College Station: Department of Agricultural Economics, Texas A&M University.

Clancy, D. 1996. *Costume Since 1945: Couture, Street Style, and Anti-Fashion*. New York: Drama Publishers.

Clary, C. 1993. "The Effects of Generic and Brand Advertising on Farm Level Prices." Unpublished Ph.D. dissertation, North Carolina State University.

Cotton Incorporated (CI). No date. Database.

Cotton Incorporated (CI). 2000. Engineered Fiber Selection System brochure.

Cotton Incorporated (CI). 2001. Presentation to Research Triangle Institute, March 5 and 9, 2001.

Deterling, D. 1982. "How a Cotton Plant Grows: The Miracle of Fiber Development." *Progressive Farmer*.

Dickerson, K. 1999. *Textiles and Apparel in the Global Economy*, 3rd Edition. New Jersey: Prentice-Hall, Inc.

Dorfman, J.H., C.L. Kling, and R.J. Sexton. 1990. "Confidence Intervals for Elasticities and Flexibilities: Re-Evaluating the Ratio of Normals Case." *American Journal of Agricultural Economics* 72(4):1006-1017.

Duffy, P.A., and M.K. Wohlgenant. 1991. "Effects of an Export Subsidy on the U.S. Cotton Industry." *Southern Journal of Agricultural Economics* 23:1-7.

Duffy, Patricia A., Kasazi Shalishali, and Henry W. Kinnucan. 1994. "Acreage Response Under Farm Programs for Major Southeastern Field Crops." *Journal of Agricultural and Applied Economics* 26(2): 1-7.

Duffy, P.A., M.K. Wohlgenant, and J.W. Richardson. 1990. "The Elasticity of Export Demand for U.S. Cotton." *American Journal of Agricultural Economics* 72:468-474.

Ethridge, Don, Texas Tech University. 2001. Personal communication with Brian Murray, RTI.

Ferber, D. 1999. "Risks and Benefits: GM Crops in the Cross Hairs." *Science* 286:1662-1666.

The Federal Reserve Bank of St. Louis. 2001. FRED. <http://www.stls.frb.org/fred>.

Fieller, E.C. 1954. "Some Problems in Interval Estimation." *Journal of the Royal Statistical Society* Series B 16:175-185.

Geweke, J. and R. Meese. 1981. "Estimating Regression Models of Finite but Unknown Order." *International Economic Review* 22:55-70.

Glade, E., L. Meyer, and H. Stults. 1996. *The Cotton Industry in the United States*. USDA—Economic Research Service, Agricultural Economic Report No. 739.

Glock, R.E., and G.I. Kunz. 1995. *Apparel Manufacturing: Sewn Product Analysis*, 2nd Edition. New Jersey: Prentice-Hall, Inc.

Green, Richard, David M. Rocke, and William Hahn. 1987. "Standard Errors for Elasticities: A Comparison of Bootstrap and Asymptotic Standard Errors." *Journal of Business and Economic Statistics* 5:145-149.

Greene, William H. *Econometric Analysis.* New York: MacMillan Publishing Company, 1990.

Gregory, S., E. Hernandez, and B. Savoy. 1999. "Cottonseed Processing." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 793-823. New York: John Wiley & Sons, Inc.

Griffin, J.M., and P.R. Gregory. 1976. "Intercountry Translog Model of Energy Substitution Responses." *American Eocnomic Review* 66:845-857.

Harvey, A.C., The Econometric Analysis of Time Series, The MIT Press: Cambridge, Mass., 1991.

Hatanaka, M. 1976. "Several Efficient Two-Step Estimators for the Dynamic Simultaneous Equations Model with Autoregressive Disturbances." *Journal of Econometrics* 4:189-204.

Hollis, I., and D. Rhodes. 1987. "Cotton Discards Its Forgotten Image." *Nonwovens Report International* 197:24-25.

Hudson, D., and D. Ethridge. 2000. "Competitiveness of Agricultural Commodities in the United States: Expanding Our View." *American Journal of Agricultural Economics* 82(5):1219-1223.

International Cotton Advisory Committee (ICAC). 2000. Report of an expert panel on biotechnology in cotton.

International Textile Center (ITC). 2001. <http://www.itc.ttu.edu/itc.htm>. As obtained on April 17, 2001.

Isaacs, M., III. 1997. "Weaving Strides Into 21st Century." *Textile World* 147(2):53-54.

John Deere. <www.deere.com>. As obtained on April 9, 2001.

Judge, G., Hill, R., Griths, W., Lütkepohl, H. & Lee, T. C. (1988), *Introduction to the Theory and Practice of Econometrics*, New York: Wiley.

Kaiser, H.M., and T.M. Schmit. 2001. "An Economic Evaluation of Generic Egg Advertising by the American Egg Board." Working paper. Cornell University, Department of Applied Economics and Management.

Kinnucan, H., H. Xiao, and S. Yu. 2000. "Relative Effectiveness of USDA's Nonprice Export Promotion Instruments." *Journal of Agricultural and Resource Economics* 25:559-577.

Klein, L.R. 1953. *A Textbook of Econometrics*. Evanston: Row Peterson and Co.

Krinsky, I., and A. Robb. 1986. "On Approximating the Statistical Properties of Elasticities." *Review of Economics and Statistics* 68:715-719.

Krinsky, I., and A. Robb. 1990. "On Approximating the Statistical Properties of Elasticities: A Correction." *Review of Economics and Statistics* 72:189-190.

Krinsky, I., and A. Robb. 1991. "Three Methods for Calculating Statisitcal Properties for Elasticities." *Empirical Economics* 16:1-11.

Lemieux, C.M., and M.K. Wohlgenant. 1989. "Ex Ante Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." *American Journal of Agricultural Economics* 71:903-904.

Link, David, American Textile Manufacturers Institute. June 28, 2001. Personal communication with Catherine Viator, Research Triangle Institute.

Lowenstein, F. 1952. "Factors Affecting the Domestic Mill Consumption of Cotton." Agricultural Economics Research 4:44-51.

Majmudar, M. 1996. "The MFA Phase-Out and EU Clothing Sourcing: Forecasts to 2005." *Textile Outlook International* (March):31-61.

Mayfield, W., W.S. Anthony, S. Hughs, R. Baker, and W. Lalor. 1999. "Ginning." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 683-707. New York: John Wiley & Sons, Inc.

Meyer, L., S. MacDonald, C. Skelly, and J. Johnson. February 23, 2001. "USDA Perspective on the Outlook for Cotton." *Agricultural Outlook Forum*.

Meyer, L.A. 1999. "An Economic Analysis of U.S. Total Fiber Demand and Cotton Mill Demand." Cotton and Wool Yearbook (November) <http://www.ers.usda.gov/Prodsrvs/rept-fc.htm#cottonup>. As obtained on November 19, 2000.

Meyer, Leslie, USDA Economic Research Service. June 27, 2001. Personal communication with Catherine Viator, Research Triangle Institute.

National Accounts of OECD Countries. 2001. Main Aggregates Volume 1, 1988-1999.

National Cotton Council. 1998. *Cotton Counts Its Customers*.

National Cotton Council. 1999. "Sharing a Common Thread: Textiles Thrive on Cotton." <www.cotton.org>. As obtained on May 12, 2001.

National Cotton Council. 2001. "Weekly Export Report." <www.cotton.org>. Obtained on June 18, 2001.

National Cotton Council. EconCentral webpage <http://risk.cotton.org/prices/>. Obtained on September 27, 2001.

Nordquist, B.K. 1984. "International Trade in Textiles and Clothing: Implications for the Future." *Clothing and Textiles Research Journal* 3(2):35-39.

OECD. Quarterly National Accounts. Number 4, 1993; Number 4, 1998; Number 3, 1999; Number 2, 1999; Number 4, 2000; Number 3, 2000; Number 2, 2000; Number 1, 2000.

Sasser, Dr. Preston, Cotton Incorporated. March–June 2001. Personal communication with Catherine Viator, Research Triangle Institute.

Piggott, N.E. 1997. "The Benefits and Costs of Generic Advertising of Agricultural Commodities." Unpublished Ph.D. dissertation, University of California, Davis.

Piggott, N.E., R.R. Piggott, and V.E. Wright. 1995. "Approximating Returns to Incremental Advertising Expenditures: Methods and an Application to the Australian Meat Industry." *American Journal of Agricultural Economics* 77(August):497-511.

Ramey, Jr., H.H. 1999. "Classing of Fiber." In *Cotton: Origin, History, Technology, and Production*, C.W. Smith and J.T. Cothren, eds., pp. 709-727. New York: John Wiley & Sons, Inc.

Scheffe, H. 1970. "Multiple Testing versus Multiple Estimation in Proper Confidence Sets, Estimation of Directions and Ratios." *Analytical Mathematical Statistics* 41:1-29.

Shui, S., J.C. Behgin, and M.K. Wohlgenant. 1993. "The Impact of Technical Change, Scale Effects, and Forward Ordering on U.S. Fiber Demands." *American Journal of Agricultural Economics* 75(August):632-641.

Smith, C.W., ed. 1999. "Production Statistics." In *Cotton: Origin, History, Technology, and Production*, pp. 435-449. New York: John Wiley & Sons, Inc.

Steele, P. 1995. "Textile and Garment Sourcing and the Single European Market." *Textile Outlook International* 1995:114-131.

Textile Economics Bureau. Textile Organon (serial). Various issues. New York: Textile Economics Bureau.

Tortora, P. 1997. "75 Years of Change in Consumer Textiles (1921-1996)." *Textile Chemists and Colorists* 29(5):19.

Tortora, P., and B.J. Collier. 1997. *Understanding Textiles, 5th edition*. New Jersey: Prentice-Hall, Inc.

Umbeck, P., G. Johnson, K. Barton, and W. Swain. 1987. "Genetically Transformed Cotton (*Gossypium hirsutum* L.) Plants." *Biotechnology* 5:263-265.

Unglesbee, Dennis, USDA. April 19 and July 23, 2001. Personal communication with Robert Beach, RTI. Data for 1970-1976, 1977-1985, 1986-1992.

U.S. Bureau of Labor Statistics. 2001. Producer Price Index-Commodities (Series ID: WPUSOP3510 and eeu32230006) and Consumer Price Index-All Urban Consumers (Series ID: CUSR000SA0).

U.S. Census Bureau. "National Population Estimates." Obtained on March 1, 2001. <http://www.census.gov/population/www/estiamtes/uspop.html>.

U.S. Department of Agriculture. 1998. "U.S. and World Cotton Markets Diverge in 1998." *Agricultural Outlook* (September):14-17.

U.S. Department of Agriculture. 2001. Current Research Information System (CRIS). Data for 1993-1999. <http://cris.csrees.usda.gov>.

U.S. Department of Agriculture. 1986-2001. *Cotton and Wool Outlook*. Washington, DC.

U.S. Department of Agriculture, Economic Research Service. 1986-2000. *Cotton & Wool Yearbook*. November. Washington, DC.

U.S. Department of Agriculture, Economic Research Service (USDA/ERS). April 1995a. *Agricultural Outlook*. Publication No. AO-217. Washington, DC: Government Printing Office.

U.S. Department of Agriculture, Economic Research Service (USDA/ERS). 1995b. "A History of American Agriculture: 1776-1990." <http://www.usda.gov/history2/text4.htm>.

U.S. Department of Agriculture, Foreign Agricultural Service (USDA/FAS). June 2001. *Cotton: World Markets and Trade*. Circular Series FC 06-01. Washington, DC.

U.S. Department of Agriculture, Foreign Agricultural Service (USDA/FAS). 2001. "Cotton and Rice Weekly Prices." Obtained on September 5, 2001. <ftp://ftp.fas.usda.gov/public/cotton/COTN0830.TXT>.

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). 1991. Agricultural Chemical Usage, Field Crop Summary.

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). 1997. *1997 Census of Agriculture*—State Data, Table 6, pp. 250-58.

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). <www.usda.gov/nass/pubs/trackrec/track00a.htm#cotton>. As obtained on November 15, 2000.

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). 2001. *Agricultural Statistics 2001*. GPO: Washington, DC.

U.S. International Trade Commission (USITC). 2001. Industry and Trade Summary: Cotton. USITC Publication 3391 (January).

Waugh, F.L. 1964. Demand and Price Analysis: Some Examples from Agriculture, Economic and Statistical Analysis Division/ Economic Research Service, U.S. Department of Agriculture, Technical Bulletin Vol. 1316.

Weaver-Missick, T. 2000. "Fabric to Dye for." *Agricultural Research* (November). <www.ars.usda.gov/is/AR/archive/nov00>.

Wohlgenant, M.K. 1986. "Impact of an Export Subsidy on the Domestic Cotton Industry." Texas Agricultural Experiment Station Report. Texas A&M University, College Station, Texas.

Wohlgenant, M.K. 1993. "Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: The Case of the U.S. Beef and Pork Industries." *American Journal of Agricultural Economics* 75(August):642-651.

Wohlgenant, Michael K., and Cynda R. Clary. 1993. "Development and Measurement of Farm-to-Retail Price Linkage for Evaluating Dairy Advertising Effectiveness." *The Journal of Agricultural Economics Research* 44(4):18-27.

Yang, S. 1997. "Modeling Structural Change in the U.S. Textile Industry." Ph.D. dissertation, North Carolina State University.

Appendix A: Examples of Work in Progress at Cotton Incorporated for the Development of New Technologies (CI, 2001)

- **Production**
  - ✓ Research on COTMAN™ (a computer-based decision aid) is ongoing. In 2001, there will be four multistate projects looking at refining insecticide-termination rules under high yield situations, irrigation termination, UNR application, in addition to refining the heat unit accumulation procedure used by COTMAN.
  - ✓ A practical assay kit for detection of *N. fresenii* in aphids (Agdia), which will reduce cost and pesticide use.
  - ✓ A more efficient attractant system (bait) for boll weevil traps used in the eradication program (McKibben).
  - ✓ Development of an assay system to rapidly screen germplasm for resistance to feeding by lygus bugs (Teuber).
  - ✓ Development of transgenic insects (autocidial gene) for management of pink bollworm (Miller).
  - ✓ Identify proteins with modes of action similar to *Bt* against aphids and lygus, primarily for use in developing transgenic varieties.
  - ✓ Economic evaluation of UNRC, precision farming, *Bt*, *Bt-II*, and other new technologies.
  - ✓ Through support of improved software for cotton farm record-keeping, we are establishing a package that will meet business and regulatory needs on farms.
  - ✓ Use of oligomer synthesis to track fiber development—research to understand the biochemical pathway of cellulose synthesis in cotton fiber—fundamental science, huge upside potential—essential for efficient use of biotechnology for fiber improvement.
  - ✓ Breeding to improve transgenic varieties—weed and insect control.
  - ✓ Methods of comparative evaluation of transgenic varieties under field-production conditions because Official Variety Tests are inapplicable.
  - ✓ Economic evaluation of herbicide-resistant, transgenic systems—the 1997-1999 Regional Project, report in preparation.
  - ✓ Evaluation of new lay-by herbicides so producers encounter fewest possible problems with new compounds—several products, chiefly from Valent and DowAgro Sciences.
  - ✓ Nematology—research to find ways to manage the reniform nematode, an increasing pest of cotton.
  - ✓ Host-plant-resistance breeding against reniform nematodes by using sources outside of *Gossypium hirsutum*—*G. bardadense* and *G. longicalyx*, for example.

- ✓ Seed and fiber promoters—produced and now testing a number of gene-expression promoters at Texas Tech University.
- ✓ Defoliation—study of genes involved in leaf drop in cotton—two genes in the pathway are described at Auburn University, with continuing work needed.
- ✓ Single Sequence Repeat (SSR) development and fiber-gene discovery—multiple SSRs and subsequent gene retrieval—ongoing at Alabama State University.
- ✓ Fiber specific promoters and genes—discovery of fiber expansion genes ongoing at University of California.
- ✓ SSRs for use as genetic markers—produced over 200 SSRs, over 3,000 ESTs (DNA sequences that produce useful traits), and multiple, associated genes—Texas A&M.
- ✓ Development of a new method to measure lint density and production on seeds—Brookhaven National Laboratory.
- ✓ Cotton stickiness (caused by constituent plant sugars, insect honeydew, seed fragments or fiber waxes) is a sporadic problem with U.S. cotton, particularly cottons grown in dry climates that have late season populations of whiteflies and aphids. CI continues to sponsor research.

➤ **Processing**

- ✓ Projects are under way to use scanning and image capture techniques to eliminate technician measurement of samples used in shrinkage and appearance evaluations.
- ✓ A new version of MILLNet EFS® software has been undertaken. This version is designed to take full advantage of PC-based Windows Client/Server architecture and uses Microsoft's SQL database. This version, named MILLNet32, is needed because computer networks used by the industry have matured in recent years and tasks have become dispersed, and many users, in diverse locations, need access to the same data files. MILLNet32 is also designed to be a complete corporate-wide mill cotton management system that has the potential to help mills acquire exactly the cotton they need for a specific end product and processing machinery at the lowest possible cost and yet produce product that consistently meets their customers' specifications. This project is now in beta evaluation at Avondale Mills and the general release is scheduled for the end of August 2001.
- ✓ The development of functional finishes offers the chance for cotton to compete in an area where synthetics have become the majority. These chemistries include water repellant, soil release, odor absorbing finishes, UV protection, antimicrobial finishes, and scents.
- ✓ The development of 100 percent cotton recreational performance apparel has begun to allow cotton to compete

in areas where moisture management is critical. These products should be breathable, fast drying, and, in some cases, water repellent.

- ✓ New technology for reducing flammability includes developing new molecules that make cotton fabrics less flammable; using existing chemistry with new application techniques; and applying technology from the plastics industry to cotton.
- ✓ Comfort assessment technology is critical for CI to continue to differentiate cotton from synthetics that claim to be "cotton-like" and more comfortable than cotton. Instruments and technology systems are being evaluated in-house and outside CI that can accurately show the comfort of cotton fabrics relative to synthetic fabrics.
- ✓ Murata MVS (vortex) air jet spinning. CI's process and end product developments are playing a central role in the decision of textile manufacturers to install these machines.
- ✓ CI is playing an important role in demonstrating to the textile industry the economics and yarn potential of compact spinning systems.
- ✓ Continuing demonstration to the yarn spinning industry of the importance of fiber quality on the processing efficiency and quality of yarn product.
- ✓ Seamless knitting has become a fast mover in the underwear business. The ability to eliminate seams in the garments and to reduce the cut-and-sew steps is critical. CI will pursue this technology for outerwear items such as golf and tennis shirts.
- ✓ CI is developing the Engineered Wovens Program, which is a modeling system for woven fabrics. This technology will allow a manufacturer of woven fabrics to predict the performance of a new weaving set-up without having to weave the fabric. This process will shorten the development costs and time by reducing the number of samples required to process from weaving through dyeing and finishing to meet specifications.
- ✓ CI will continue to work on bio-polishing and dyeing as well as bio-preparation and dyeing. The goal is to combine bio-polishing, bio-preparation, and dyeing in the same bath, which will offer great cost savings and better fabric hand performance.
- ✓ Low temperature bleaching is being investigated with the supplier of the technology. This system will offer savings in energy and time. Work is also beginning on a system with another textile chemistry supplier, which will result in less rinsing after preparation offering savings in water and energy costs.
- ✓ CI has purchased a digital printing system with CAD/CAM properties to develop the ability to apply different colorants

and the necessary delivery systems. The gain will be greater flexibility, unlimited pattern and color combinations, and cost savings.

✓ CI is investigating minimum application methods (foam and sprays) to apply conventional chemistries or dyes. These systems use less water and therefore less energy and offer the ability to apply different chemistries on both sides of a fabric.

✓ In-house development is continuing of an economical cotton and wood pulp blend for airlaid nonwovens fabrics implementation.

✓ Barnhardt Manufacturing has installed a continuous bleaching line that CI developed. This process will deliver a cleaner and more open fiber for use in spunlace fabrics. Barnhardt is currently the largest supplier of kier-bleached staple fiber in the U.S. The addition of this continuous line will allow Barnhardt to compete at a higher fiber quality. CI will assist them in this endeavor.

✓ Work is continuing on patented airlaid technology from M&J Fibretech in Denmark with specific interest in the production of cotton airlaid, absorbent cores, disposable wipes, and components for hygiene products.

✓ Ongoing work is targeted to the expanded development of cotton spunlace (hydro-entanglement) for multiple wiping applications including short- and long-life end uses.

Appendix B: Data Appendix

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1986.01	583	186	64.9	0	64.9	72.1
1986.02	523	193	66.0	0	66.0	73.4
1986.03	542	188	68.1	0	68.1	75.6
1986.04	572	173	68.8	0	68.8	76.4
1986.05	579	81	70.3	0	70.3	78.1
1986.06	538	69	71.2	0	71.2	79.2
1986.07	499	14	73.6	0	73.6	81.8
1986.08	581	393	35.3	0	35.3	39.2
1986.09	603	387	44.1	0	44.1	49.0
1986.10	660	648	52.7	0	52.7	58.5
1986.11	554	552	55.0	0	55.0	61.1
1986.12	556	570	61.9	0	61.9	68.7
1987.01	621	747	65.4	0	65.4	72.7
1987.02	587	544	62.4	0	62.4	69.3
1987.03	676	653	62.7	0	62.7	69.7
1987.04	661	660	66.3	0	66.3	73.7
1987.05	642	488	74.7	0	74.7	83.0
1987.06	655	468	80.6	0	80.6	89.5
1987.07	655	574	81.1	0	81.1	90.1
1987.08	666	420	84.2	0	84.2	93.6
1987.09	694	315	80.0	0	80.0	88.9
1987.10	713	367	72.7	0	72.7	80.7
1987.11	666	615	71.7	0	71.7	79.6
1987.12	582	721	70.7	0	70.7	78.6
1988.01	621	663	69.0	0	69.0	76.7
1988.02	649	740	66.1	0	66.1	73.5
1988.03	706	779	67.3	0	67.3	74.8
1988.04	610	571	67.6	0	67.6	75.1
1988.05	630	517	69.4	0	69.4	77.1
1988.06	603	554	71.2	0	71.2	79.1
1988.07	477	320	65.6	0	65.6	72.9
1988.08	692	265	60.4	0	60.4	67.1

(continued)

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000 (continued)

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1988.09	634	265	58.3	0	58.3	64.8
1988.10	603	235	59.5	0	59.5	66.1
1988.11	597	398	61.0	0	61.0	67.8
1988.12	512	670	63.2	0	63.2	70.2
1989.01	648	483	64.0	0	64.0	71.1
1989.02	609	738	63.3	0	63.3	70.3
1989.03	722	629	65.6	0	65.6	72.8
1989.04	650	627	68.5	0	68.5	76.1
1989.05	771	682	71.9	0	71.9	79.9
1989.06	731	254	72.7	0	72.7	80.7
1989.07	613	902	76.4	0	76.4	84.8
1989.08	831	507	79.0	0	79.0	87.8
1989.09	753	492	76.5	0	76.5	85.0
1989.10	792	522	77.6	0	77.6	86.2
1989.11	731	520	76.4	0	76.4	84.9
1989.12	579	682	72.1	0	72.1	80.1
1990.01	754	875	69.9	0	69.9	77.7
1990.02	690	797	72.0	0	72.0	80.0
1990.03	757	997	75.6	0	75.6	84.0
1990.04	711	734	78.4	0	78.4	87.2
1990.05	800	590	82.3	0	82.3	91.4
1990.06	721	538	87.1	0	87.1	96.7
1990.07	641	440	86.7	0	86.7	96.3
1990.08	829	544	83.7	0	83.7	92.9
1990.09	692	412	79.2	0	79.2	88.0
1990.10	802	377	78.3	0	78.3	87.0
1990.11	687	718	78.5	0	78.5	87.2
1990.12	490	769	79.8	0	79.8	88.7
1991.01	672	991	80.4	0	80.4	89.4
1991.02	661	1016	86.8	0	86.8	96.4
1991.03	819	1,109	90.1	0	90.1	100.1
1991.04	723	661	89.5	0	89.5	99.5

(continued)

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000 (continued)

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1991.05	721	537	93.6	0	93.6	104.0
1991.06	868	452	88.9	0	88.9	98.8
1991.07	694	209	79.9	0	79.9	88.8
1991.08	876	184	74.7	0	74.7	83.0
1991.09	739	167	71.8	1.6	70.2	78.0
1991.10	913	261	67.6	1.6	66.0	73.3
1991.11	743	581	62.9	1.0	61.9	68.8
1991.12	629	788	62.3	1.2	61.2	68.0
1992.01	850	875	60.3	0.8	59.5	66.1
1992.02	761	754	57.3	1.7	55.6	61.8
1992.03	825	837	58.8	3.0	55.8	62.0
1992.04	824	710	63.1	3.5	59.6	66.2
1992.05	820	567	63.4	2.5	61.0	67.7
1992.06	811	576	65.3	0	65.3	72.5
1992.07	822	347	68.8	4.5	64.3	71.4
1992.08	849	301	65.4	3.1	62.3	69.2
1992.09	871	267	61.5	2.5	59.0	65.5
1992.10	911	272	57.6	3.5	54.1	60.1
1992.11	825	403	59.9	3.8	56.1	62.3
1992.12	752	581	61.7	3.9	57.7	64.2
1993.01	853	545	64.2	4.3	59.9	66.6
1993.02	828	491	64.8	3.2	61.7	68.5
1993.03	934	633	65.4	2.4	63.0	70.0
1993.04	890	537	65.1	1.5	63.6	70.7
1993.05	865	423	65.0	1.8	63.2	70.2
1993.06	870	377	62.7	1.2	61.6	68.4
1993.07	803	373	62.8	0.6	62.2	69.1
1993.08	919	287	57.8	1.2	56.6	62.9
1993.09	881	248	58.0	0	58.0	64.5
1993.10	864	346	58.8	1.2	57.6	64.0
1993.11	836	405	59.5	0.8	58.7	65.2
1993.12	744	571	65.0	2.2	62.8	69.8

(continued)

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000 (continued)

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1994.01	811	738	71.5	2.0	69.5	77.2
1994.02	818	512	79.6	1.0	78.6	87.4
1994.03	955	743	79.4	0.1	79.3	88.1
1994.04	880	761	81.4	0	81.4	90.4
1994.05	949	854	85.4	0	85.4	94.9
1994.06	945	770	82.6	0	82.6	91.7
1994.07	817	626	75.9	0	75.9	84.4
1994.08	1,042	531	75.5	0	75.5	83.8
1994.09	978	333	75.7	0	75.7	84.1
1994.10	952	341	73.0	1.2	71.8	79.8
1994.11	954	710	76.9	2.4	74.6	82.8
1994.12	798	1,099	87.5	0.5	87.1	96.7
1995.01	978	1,115	95.2	0	95.2	105.7
1995.02	912	1,383	100.1	0	100.1	111.2
1995.03	1,048	1,392	111.9	0	111.9	124.3
1995.04	879	1,104	113.2	0	113.2	125.7
1995.05	1,006	684	113.9	0	113.9	126.6
1995.06	909	410	117.7	0	117.7	130.7
1995.07	743	300	100.0	0	100.0	111.2
1995.08	1,000	315	89.7	0	89.7	99.7
1995.09	887	246	96.3	0	96.3	107.0
1995.10	908	452	90.8	0	90.8	100.9
1995.11	861	733	90.6	0	90.6	100.6
1995.12	669	1,230	89.7	0	89.7	99.7
1996.01	894	1,262	88.9	0	88.9	98.7
1996.02	869	1,295	89.8	0	89.8	99.7
1996.03	911	777	88.8	0	88.8	98.6
1996.04	931	577	92.1	0	92.1	102.3
1996.05	991	343	90.2	0	90.2	100.2
1996.06	860	263	86.0	0	86.0	95.5
1996.07	867	183	82.2	0	82.2	91.3
1996.08	998	257	82.6	0	82.6	91.8

(continued)

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000 (continued)

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1996.09	900	171	83.0	0	83.0	92.2
1996.10	1,002	277	79.0	0	79.0	87.7
1996.11	901	573	76.9	0	76.9	85.4
1996.12	766	899	79.1	0	79.1	87.9
1997.01	996	666	78.0	0	78.0	86.6
1997.02	867	728	77.7	0	77.7	86.3
1997.03	907	848	78.0	0	78.0	86.6
1997.04	975	711	75.2	0	75.2	83.5
1997.05	979	631	75.5	0	75.5	83.9
1997.06	905	604	77.1	0	77.1	85.7
1997.07	931	501	78.5	0.4	78.1	86.7
1997.08	966	458	77.6	1.6	76.0	84.4
1997.09	1,008	299	76.6	1.2	75.4	83.7
1997.10	1,040	400	75.0	1.7	73.2	81.4
1997.11	881	581	75.0	1.8	73.2	81.3
1997.12	882	774	71.6	1.1	70.5	78.3
1998.01	979	781	69.5	1.9	67.5	75.0
1998.02	897	826	69.5	4.3	65.2	72.4
1998.03	973	944	73.0	5.5	67.5	75.0
1998.04	956	712	69.5	5.1	64.4	71.6
1998.05	934	507	71.8	7.0	64.7	71.9
1998.06	919	610	80.9	10.0	70.9	78.7
1998.07	915	607	83.6	11.8	71.8	79.8
1998.08	929	402	79.8	7.2	72.6	80.6
1998.09	919	280	79.0	9.3	69.8	77.5
1998.10	957	265	75.4	10.5	64.9	72.1
1998.11	806	795	71.5	12.7	58.8	65.3
1998.12	722	1,027	67.2	7.7	59.5	66.1
1999.01	882	156	64.5	0	64.5	71.6
1999.02	824	182	63.4	0	63.4	70.4
1999.03	940	221	66.3	0	66.3	73.7
1999.04	888	169	64.7	0	64.7	71.9

(continued)

Table B-1. Monthly Cotton Price and Quantity Variables, 1986-2000 (continued)

Month	U.S. Domestic Mill Use (1,000 480-lb bales)	Exports of Raw U.S. Cotton (1,000 480-lb bales)	Mill Delivered Price (cents/lb)	User Certificate Value (cents/lb)	Effective Mill Price[a] (cents/lb)	Fiber Equivalent Effective Mill Price[b] (cents/lb)
1999.05	864	256	63.2	0	63.2	70.2
1999.06	885	261	60.9	0	60.9	67.6
1999.07	785	330	56.2	0	56.2	62.5
1999.08	883	263	57.1	0	57.1	63.5
1999.09	878	152	56.0	0	56.0	62.2
1999.10	872	173	57.8	7.8	50.0	55.6
1999.11	873	471	55.9	7.4	48.5	53.9
1999.12	762	680	53.9	6.8	47.1	52.3
2000.01	810	698	58.5	9.0	49.5	55.0
2000.02	849	794	61.7	6.8	54.9	61.0
2000.03	935	1,062	64.8	6.5	58.3	64.8
2000.04	811	749	61.0	4.1	56.9	63.3
2000.05	931	684	64.1	5.9	58.2	64.6
2000.06	907	527	62.1	5.3	56.8	63.1
2000.07	730	497	60.7	3.2	57.5	63.9
2000.08	920	430	64.6	5.1	59.5	66.1
2000.09	804	336	66.8	5.5	61.3	68.1
2000.10	846	382	66.0	4.1	61.9	68.8
2000.11	749	435	68.3	4.2	64.1	71.2
2000.12	640	541	70.1	2.9	67.2	74.6

[a]Calculated as mill delivered price minus user certification value.

[b]Fiber equivalent prices take fiber waste associated with processing into account. This price is calculated by dividing the effective mill price by 0.90.

Sources: U.S. Department of Agriculture. 1986-2001. *Cotton and Wool Outlook*. Washington, DC.
U.S. Department of Agriculture, Economic Research Service. 1986-2000. *Cotton & Wool Yearbook*. November. Washington, DC.
Cotton Incorporated (CI). No date. Database.

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1986.01	$502,663	$1,348,345	$225,486	$359,254
1986.02	$379,914	$686,137	$235,478	$315,667
1986.03	$508,991	$505,453	$263,356	$308,087
1986.04	$951,636	$1,031,919	$306,673	$371,230
1986.05	$762,407	$840,396	$271,920	$287,445
1986.06	$1,097,510	$1,085,998	$292,211	$324,060
1986.07	$1,805,310	$2,280,296	$407,938	$417,824
1986.08	$913,372	$1,108,461	$255,006	$274,241
1986.09	$766,094	$930,516	$264,444	$311,133
1986.10	$659,474	$554,040	$284,260	$319,221
1986.11	$670,512	$694,184	$294,601	$306,841
1986.12	$3,140,041	$1,191,169	$822,643	$328,880
1987.01	$380,387	$1,020,351	$217,846	$347,082
1987.02	$418,279	$755,425	$277,002	$371,331
1987.03	$1,001,884	$994,920	$306,123	$358,118
1987.04	$1,111,102	$1,204,838	$325,840	$394,432
1987.05	$977,722	$1,077,736	$296,734	$313,676
1987.06	$891,763	$882,409	$268,397	$297,650
1987.07	$1,204,564	$1,521,490	$350,183	$358,669
1987.08	$639,789	$776,443	$294,333	$316,535
1987.09	$629,462	$764,560	$296,524	$348,876
1987.10	$901,081	$757,020	$347,934	$390,726
1987.11	$631,995	$654,307	$341,846	$356,049
1987.12	$2,822,106	$1,070,561	$843,602	$337,259
1988.01	$397,519	$1,066,306	$198,184	$315,756
1988.02	$856,670	$1,547,174	$333,150	$446,600
1988.03	$1,097,775	$1,090,144	$304,740	$356,500
1988.04	$1,667,441	$1,808,112	$336,865	$407,778
1988.05	$1,194,845	$1,317,069	$471,802	$498,739
1988.06	$836,536	$827,762	$287,262	$318,571

(continued)

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000 (continued)

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1988.07	$1,193,180	$1,507,111	$331,201	$339,227
1988.08	$563,975	$684,436	$358,708	$385,766
1988.09	$644,523	$782,853	$362,114	$426,047
1988.10	$3,216,496	$2,702,257	$324,014	$363,864
1988.11	$778,099	$805,569	$370,561	$385,957
1988.12	$2,337,186	$886,607	$828,560	$331,245
1989.01	$346,132	$928,466	$222,924	$355,172
1989.02	$669,486	$1,209,113	$330,173	$442,609
1989.03	$1,425,389	$1,415,481	$310,249	$362,945
1989.04	$1,061,353	$1,150,892	$202,478	$245,101
1989.05	$1,314,340	$1,448,787	$409,305	$432,674
1989.06	$2,161,416	$2,138,745	$390,493	$433,053
1989.07	$1,324,081	$1,672,453	$274,596	$281,250
1989.08	$1,440,760	$1,748,495	$283,983	$305,404
1989.09	$826,152	$1,003,464	$354,809	$417,452
1989.10	$1,324,237	$1,112,524	$301,857	$338,982
1989.11	$792,287	$820,258	$321,973	$335,350
1989.12	$2,789,058	$1,058,024	$802,848	$320,966
1990.01	$416,871	$1,118,216	$286,078	$455,792
1990.02	$2,006,212	$3,623,283	$341,384	$457,638
1990.03	$1,911,077	$1,897,792	$365,167	$427,191
1990.04	$973,752	$1,055,901	$381,986	$462,397
1990.05	$1,554,550	$1,713,569	$429,911	$454,456
1990.06	$1,033,779	$1,022,936	$443,001	$491,284
1990.07	$488,871	$617,495	$449,347	$460,236
1990.08	$1,248,043	$1,514,615	$476,029	$511,936
1990.09	$1,205,112	$1,463,758	$357,353	$420,445
1990.10	$1,959,758	$1,646,440	$452,778	$508,465
1990.11	$1,606,439	$1,663,153	$416,746	$434,061
1990.12	$3,484,004	$1,321,651	$1,309,089	$523,353

(continued)

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000 (continued)

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1991.01	$432,408	$1,159,893	$310,968	$495,448
1991.02	$669,678	$1,209,460	$398,830	$534,646
1991.03	$1,543,599	$1,532,869	$466,683	$545,949
1991.04	$1,246,031	$1,351,151	$485,604	$587,827
1991.05	$2,506,477	$2,762,871	$471,014	$497,906
1991.06	$1,355,328	$1,341,112	$517,364	$573,752
1991.07	$890,456	$1,124,739	$569,538	$583,340
1991.08	$1,174,912	$1,425,864	$503,506	$541,486
1991.09	$881,059	$1,070,155	$416,155	$489,629
1991.10	$1,544,270	$1,297,379	$611,041	$686,193
1991.11	$2,356,541	$2,439,736	$522,947	$544,674
1991.12	$4,286,732	$1,626,164	$1,300,464	$519,905
1992.01	$710,647	$1,906,242	$400,461	$638,032
1992.02	$905,886	$1,636,059	$549,799	$737,026
1992.03	$2,148,653	$2,133,717	$496,545	$580,883
1992.04	$3,410,481	$3,698,201	$563,223	$681,785
1992.05	$1,525,908	$1,681,997	$552,793	$584,354
1992.06	$1,761,734	$1,743,255	$522,187	$579,101
1992.07	$1,477,613	$1,866,380	$781,640	$800,582
1992.08	$1,403,471	$1,703,242	$550,583	$592,114
1992.09	$4,762,882	$5,785,111	$661,673	$778,494
1992.10	$2,143,487	$1,800,796	$678,738	$762,216
1992.11	$2,363,518	$2,446,959	$673,710	$701,701
1992.12	$5,417,698	$2,055,194	$2,105,344	$841,683
1993.01	$751,777	$2,016,569	$511,533	$814,997
1993.02	$957,069	$1,728,497	$438,934	$588,407
1993.03	$2,475,064	$2,457,859	$541,644	$633,643
1993.04	$2,877,455	$3,120,207	$781,545	$946,066
1993.05	$2,189,444	$2,413,408	$558,339	$590,217
1993.06	$3,541,759	$3,504,610	$886,442	$983,057

(continued)

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000 (continued)

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1993.07	$1,064,136	$1,344,115	$618,921	$633,920
1993.08	$1,102,757	$1,338,297	$624,946	$672,086
1993.09	$2,232,282	$2,711,383	$619,233	$728,561
1993.10	$2,349,826	$1,974,146	$691,248	$776,264
1993.11	$2,487,445	$2,575,261	$711,586	$741,150
1993.12	$7,452,140	$2,826,956	$2,195,443	$877,703
1994.01	$700,875	$1,880,030	$459,804	$732,580
1994.02	$1,489,361	$2,689,834	$618,076	$828,553
1994.03	$5,392,717	$5,355,230	$639,567	$748,198
1994.04	$1,898,714	$2,058,896	$694,191	$840,323
1994.05	$1,875,754	$2,067,630	$802,702	$848,531
1994.06	$2,411,865	$2,386,567	$856,294	$949,623
1994.07	$1,271,598	$1,606,161	$647,096	$662,777
1994.08	$1,420,120	$1,723,447	$1,033,968	$1,111,961
1994.09	$2,712,176	$3,294,274	$735,205	$865,008
1994.10	$2,288,155	$1,922,335	$594,126	$667,197
1994.11	$2,972,503	$3,077,444	$1,148,419	$1,196,133
1994.12	$6,276,109	$2,380,831	$1,748,527	$699,033
1995.01	$1,634,083	$4,383,270	$617,287	$983,489
1995.02	$1,514,133	$2,734,573	$591,821	$793,358
1995.03	$2,826,960	$2,807,309	$861,938	$1,008,339
1995.04	$2,676,922	$2,902,756	$663,204	$802,813
1995.05	$2,534,956	$2,794,264	$1,005,685	$1,063,103
1995.06	$2,303,910	$2,279,745	$737,316	$817,677
1995.07	$1,907,830	$2,409,789	$783,976	$802,974
1995.08	$2,298,155	$2,789,023	$912,842	$981,698
1995.09	$1,751,098	$2,126,926	$696,019	$818,904
1995.10	$2,794,071	$2,347,367	$650,742	$730,777
1995.11	$3,691,052	$3,821,360	$854,814	$890,329
1995.12	$9,824,189	$3,726,789	$2,490,960	$995,846

(continued)

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000 (continued)

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1996.01	$1,248,131	$3,347,991	$568,636	$905,976
1996.02	$1,590,223	$2,871,994	$518,833	$695,515
1996.03	$2,849,136	$2,829,331	$873,659	$1,022,051
1996.04	$2,310,364	$2,505,274	$619,620	$750,054
1996.05	$2,601,019	$2,867,084	$747,636	$790,321
1996.06	$4,160,244	$4,116,608	$642,255	$712,255
1996.07	$2,302,941	$2,908,856	$899,109	$920,897
1996.08	$9,234,676	$11,207,131	$737,673	$793,316
1996.09	$1,887,996	$2,293,205	$677,995	$797,697
1996.10	$2,742,663	$2,304,178	$683,874	$767,984
1996.11	$3,176,406	$3,288,545	$915,625	$953,667
1996.12	$8,256,892	$3,132,238	$1,861,220	$744,086
1997.01	$1,610,426	$4,319,812	$448,103	$713,938
1997.02	$1,334,110	$2,409,446	$579,679	$777,081
1997.03	$3,018,202	$2,997,221	$760,117	$889,223
1997.04	$2,534,844	$2,748,692	$749,653	$907,460
1997.05	$2,700,945	$2,977,232	$885,038	$935,568
1997.06	$4,744,353	$4,694,590	$695,554	$771,364
1997.07	$2,353,700	$2,972,970	$973,036	$996,616
1997.08	$1,872,399	$2,272,329	$734,440	$789,839
1997.09	$3,578,867	$4,346,978	$737,106	$867,245
1997.10	$4,385,681	$3,684,517	$730,262	$820,077
1997.11	$2,849,187	$2,949,774	$726,048	$756,213
1997.12	$10,701,235	$4,059,495	$2,067,679	$826,625
1998.01	$1,380,914	$3,704,168	$619,709	$987,348
1998.02	$2,146,758	$3,877,114	$614,595	$823,887
1998.03	$2,285,271	$2,269,385	$681,477	$797,226
1998.04	$2,298,237	$2,492,124	$753,190	$911,742
1998.05	$3,087,145	$3,402,938	$613,805	$648,849
1998.06	$2,746,365	$2,717,559	$692,820	$768,332

(continued)

Table B-2. Monthly Cotton Incorporated (CI) Promotion and Nonagricultural Research Expenditures, 1986-2000 (continued)

Month	CI Promotional Expenditures	CI Seasonally Adjusted Promotional Expenditures	CI Nonagricultural Research Expenditures	CI Seasonally Adjusted Nonagricultural Research Expenditures
1998.07	$2,764,004	$3,491,226	$748,174	$766,305
1998.08	$2,018,257	$2,449,341	$738,820	$794,550
1998.09	$2,313,399	$2,809,910	$556,969	$655,304
1998.10	$7,920,522	$6,654,223	$706,910	$793,853
1998.11	$4,550,962	$4,711,629	$666,361	$694,047
1998.12	$9,129,145	$3,463,125	$1,739,110	$695,269
1999.01	$1,773,146	$4,756,293	$515,246	$820,913
1999.02	$2,117,424	$3,824,136	$599,508	$803,662
1999.03	$3,239,700	$3,217,180	$706,177	$826,122
1999.04	$2,917,152	$3,163,253	$543,904	$658,400
1999.05	$2,602,558	$2,868,781	$601,966	$636,334
1999.06	$3,262,287	$3,228,069	$601,376	$666,921
1999.07	$2,782,637	$3,514,762	$953,449	$976,554
1999.08	$2,321,296	$2,817,107	$659,774	$709,541
1999.09	$2,515,627	$3,055,541	$658,578	$774,852
1999.10	$3,809,959	$3,200,839	$640,347	$719,103
1999.11	$3,120,962	$3,231,144	$518,726	$540,278
1999.12	$8,691,388	$3,297,063	$2,063,808	$825,078
2000.01	$1,118,913	$3,001,376	$469,646	$748,261
2000.02	$937,089	$1,692,413	$700,185	$938,624
2000.03	$5,125,882	$5,090,250	$827,274	$967,787
2000.04	$2,081,914	$2,257,552	$726,345	$879,246
2000.05	$3,068,673	$3,382,576	$696,896	$736,684
2000.06	$4,427,060	$4,380,625	$749,007	$830,643
2000.07	$2,559,098	$3,232,409	$867,069	$888,081
2000.08	$2,822,401	$3,425,244	$770,443	$828,558
2000.09	$2,864,756	$3,479,602	$507,128	$596,663
2000.10	$2,331,499	$1,958,749	$675,337	$758,397
2000.11	$4,063,694	$4,207,158	$754,839	$786,201
2000.12	$8,876,336	$3,367,223	$1,506,851	$602,415

Source: Cotton Incorporated. No date. Database.

Table B-3. Prices of Substitute Fibers, 1986-2000

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1986.01	63	65.6	78	81.3	52.0	57.8
1986.02	63	65.6	78	81.3	54.6	60.7
1986.03	63	65.6	78	81.3	52.6	58.5
1986.04	63	65.6	75	78.1	48.4	53.8
1986.05	62	64.6	75	78.1	45.4	50.4
1986.06	62	64.6	75	78.1	41.3	45.9
1986.07	62	64.6	75	78.1	37.6	41.7
1986.08	62	64.6	75	78.1	37.0	41.2
1986.09	62	64.6	75	78.1	43.6	48.5
1986.10	62	64.6	75	78.1	51.3	57.0
1986.11	62	64.6	75	78.1	52.6	58.5
1986.12	62	64.6	75	78.1	59.8	66.5
1987.01	62	64.6	80	83.3	65.7	73.0
1987.02	62	64.6	80	83.3	65.9	73.3
1987.03	62	64.6	80	83.3	63.2	70.3
1987.04	62	64.6	80	83.3	65.9	73.2
1987.05	62	64.6	80	83.3	76.0	84.5
1987.06	64	66.7	80	83.3	80.1	89.0
1987.07	69	71.9	80	83.3	83.3	92.6
1987.08	69	71.9	80	83.3	86.5	96.1
1987.09	69	71.9	83	86.5	83.4	92.7
1987.10	70	72.9	83	86.5	75.8	84.2
1987.11	69	71.9	83	86.5	75.9	84.4
1987.12	69	71.9	83	86.5	75.2	83.5
1988.01	69	71.9	83	86.5	72.5	80.6
1988.02	69	71.9	83	86.5	67.6	75.1
1988.03	72	75.0	87	90.6	66.4	73.8
1988.04	72	75.0	87	90.6	65.8	73.1
1988.05	74	77.1	89	92.7	65.6	72.9
1988.06	74	77.1	89	92.7	69.0	76.7

(continued)

Table B-3. Prices of Substitute Fibers, 1986-2000 (continued)

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1988.07	76	79.2	91	94.8	64.0	71.1
1988.08	76	79.2	91	94.8	57.8	64.2
1988.09	76	79.2	91	94.8	56.6	62.9
1988.10	76	79.2	96	100.0	57.9	64.3
1988.11	76	79.2	96	100.0	58.7	65.2
1988.12	76	79.2	105	109.4	61.5	68.3
1989.01	81	84.4	100	104.2	63.5	70.6
1989.02	81	84.4	100	104.2	62.8	69.8
1989.03	81	84.4	100	104.2	65.9	73.2
1989.04	81	84.4	110	114.6	73.5	81.6
1989.05	81	84.4	110	114.6	77.3	85.9
1989.06	89	92.7	110	114.6	78.8	87.6
1989.07	89	92.7	110	114.6	82.7	91.9
1989.08	89	92.7	110	114.6	82.9	92.1
1989.09	89	92.7	110	114.6	81.6	90.7
1989.10	89	92.7	119	124.0	82.2	91.3
1989.11	89	92.7	119	124.0	82.2	91.3
1989.12	89	92.7	119	124.0	77.6	86.2
1990.01	89	92.7	119	124.0	74.8	83.1
1990.02	89	92.7	119	124.0	77.0	85.6
1990.03	89	92.7	119	124.0	79.4	88.2
1990.04	89	92.7	119	124.0	83.0	92.3
1990.05	85	88.5	119	124.0	86.5	96.1
1990.06	82	85.4	119	124.0	90.2	100.2
1990.07	78	81.3	119	124.0	91.0	101.1
1990.08	78	81.3	119	124.0	81.1	90.1
1990.09	78	81.3	119	124.0	81.3	90.3
1990.10	78	81.3	122	127.1	81.6	90.7
1990.11	78	81.3	122	127.1	82.5	91.7
1990.12	78	81.3	124	129.2	83.9	93.3

(continued)

Table B-3. Prices of Substitute Fibers, 1986-2000 (continued)

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1991.01	78	81.3	124	129.2	83.6	92.9
1991.02	78	81.3	124	129.2	85.2	94.6
1991.03	78	81.3	124	129.2	84.0	93.3
1991.04	72	75.0	124	129.2	83.4	92.7
1991.05	72	75.0	124	129.2	84.4	93.7
1991.06	72	75.0	124	129.2	83.8	93.1
1991.07	72	75.0	124	129.2	80.7	89.7
1991.08	72	75.0	124	129.2	73.0	81.1
1991.09	72	75.0	124	129.2	70.1	77.9
1991.10	72	75.0	116	120.8	67.8	75.4
1991.11	72	75.0	116	120.8	63.3	70.3
1991.12	72	75.0	116	120.8	61.7	68.5
1992.01	72	75.0	116	120.8	59.2	65.8
1992.02	72	75.0	116	120.8	56.3	62.5
1992.03	73	76.0	116	120.8	55.5	61.6
1992.04	74	77.1	116	120.8	58.5	65.0
1992.05	74	77.1	114	118.8	60.7	67.4
1992.06	74	77.1	114	118.8	64.3	71.4
1992.07	74	77.1	113	117.7	65.2	72.4
1992.08	74	77.1	113	117.7	59.6	66.2
1992.09	74	77.1	113	117.7	56.2	62.5
1992.10	74	77.1	113	117.7	52.9	58.8
1992.11	74	77.1	113	117.7	52.8	58.6
1992.12	73	76.0	112	116.7	54.3	60.3
1993.01	73	76.0	112	116.7	57.3	63.7
1993.02	73	76.0	112	116.7	60.6	67.3
1993.03	73	76.0	112	116.7	61.5	68.3
1993.04	73	76.0	112	116.7	61.1	67.8
1993.05	73	76.0	112	116.7	60.1	66.8
1993.06	73	76.0	112	116.7	58.5	65.0

(continued)

Table B-3. Prices of Substitute Fibers, 1986-2000 (continued)

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1993.07	72	75.0	112	116.7	57.9	64.3
1993.08	72	75.0	112	116.7	55.4	61.6
1993.09	72	75.0	112	116.7	55.2	61.3
1993.10	72	75.0	112	116.7	54.8	60.9
1993.11	72	75.0	112	116.7	55.1	61.3
1993.12	72	75.0	105	109.4	59.5	66.1
1994.01	72	75.0	104	108.3	69.2	76.9
1994.02	71	74.0	104	108.3	80.7	89.6
1994.03	71	74.0	103	107.3	81.8	90.9
1994.04	72	75.0	103	107.3	83.9	93.3
1994.05	76	79.2	102	106.3	86.1	95.7
1994.06	76	79.2	102	106.3	85.5	95.0
1994.07	76	79.2	102	106.3	81.9	91.0
1994.08	76	79.2	102	106.3	76.6	85.1
1994.09	76	79.2	102	106.3	75.1	83.4
1994.10	78	81.3	104	108.3	74.1	82.3
1994.11	78	81.3	104	108.3	77.6	86.2
1994.12	78	81.3	104	108.3	87.2	96.9
1995.01	82	85.4	104	108.3	95.6	106.2
1995.02	86	89.6	104	108.3	100.9	112.2
1995.03	86	89.6	104	108.3	110.5	122.8
1995.04	86	89.6	104	108.3	113.8	126.4
1995.05	86	89.6	104	108.3	115.7	128.6
1995.06	92	95.8	119	124.0	119.0	132.2
1995.07	92	95.8	125	130.2	100.0	111.1
1995.08	92	95.8	125	130.2	85.1	94.5
1995.09	92	95.8	125	130.2	91.2	101.3
1995.10	92	95.8	125	130.2	91.4	101.6
1995.11	92	95.8	125	130.2	89.2	99.1
1995.12	88	91.7	125	130.2	87.9	97.7

(continued)

Table B-3. Prices of Substitute Fibers, 1986-2000 (continued)

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1996.01	88	91.7	125	130.2	86.2	95.8
1996.02	88	91.7	125	130.2	85.0	94.5
1996.03	88	91.7	125	130.2	83.2	92.5
1996.04	84	87.5	120	125.0	82.8	92.0
1996.05	80	83.3	115	119.8	83.0	92.2
1996.06	78	81.3	115	119.8	83.0	92.2
1996.07	78	81.3	115	119.8	79.7	88.6
1996.08	78	81.3	115	119.8	76.3	84.8
1996.09	76	79.2	115	119.8	75.4	83.7
1996.10	73	76.0	115	119.8	75.5	83.9
1996.11	72	75.0	115	119.8	76.0	84.5
1996.12	72	75.0	115	119.8	79.2	88.0
1997.01	70	72.9	115	119.8	79.9	88.8
1997.02	70	72.9	115	119.8	80.4	89.4
1997.03	70	72.9	115	119.8	80.6	89.6
1997.04	68	70.8	115	119.8	78.9	87.6
1997.05	68	70.8	115	119.8	79.3	88.2
1997.06	68	70.8	115	119.8	80.6	89.5
1997.07	68	70.8	115	119.8	81.4	90.4
1997.08	68	70.8	115	119.8	81.2	90.2
1997.09	69	71.9	115	119.8	79.6	88.4
1997.10	68	70.8	115	119.8	77.5	86.2
1997.11	68	70.8	115	119.8	77.2	85.8
1997.12	68	70.8	115	119.8	74.4	82.7
1998.01	67	69.8	115	119.8	71.2	79.2
1998.02	65	67.7	115	119.8	68.8	76.4
1998.03	65	67.7	115	119.8	68.4	76.1
1998.04	65	67.7	115	119.8	65.0	72.3
1998.05	65	67.7	115	119.8	64.5	71.6
1998.06	64	66.7	115	119.8	67.0	74.4

(continued)

Table B-3. Prices of Substitute Fibers, 1986-2000 (continued)

Month	Polyester Price (cents/lb)	Fiber Equivalent Polyester Price[a] (cents/lb)	Rayon Price (cents/lb)	Fiber Equivalent Rayon Price[a] (cents/lb)	A Index (cents/lb)	Fiber Equivalent A Index[a] (cents/lb)
1998.07	62	64.6	115	119.8	69.4	77.1
1998.08	58	60.4	110	114.6	68.1	75.6
1998.09	58	60.4	105	109.4	65.9	73.2
1998.10	53	55.2	101	105.2	60.8	67.6
1998.11	53	55.2	101	105.2	56.7	63.0
1998.12	53	55.2	101	105.2	56.0	62.3
1999.01	51	53.1	101	105.2	55.8	62.0
1999.02	51	53.1	101	105.2	56.2	62.4
1999.03	51	53.1	101	105.2	56.7	63.0
1999.04	50	52.1	101	105.2	57.9	64.3
1999.05	50	52.1	100	104.2	59.9	66.5
1999.06	51	53.1	101	105.2	58.6	65.1
1999.07	52	54.2	95	99.0	54.4	60.5
1999.08	52	54.2	98	102.1	51.0	56.6
1999.09	53	55.2	97	101.0	49.3	54.8
1999.10	53	55.2	97	101.0	47.4	52.7
1999.11	53	55.2	97	101.0	46.1	51.3
1999.12	53	55.2	97	101.0	44.2	49.1
2000.01	53	55.2	97	101.0	47.6	52.9
2000.02	55	57.3	97	101.0	53.7	59.7
2000.03	55	57.3	97	101.0	57.5	63.8
2000.04	55	57.3	97	101.0	58.7	65.3
2000.05	58	60.4	97	101.0	60.4	67.2
2000.06	58	60.4	98	102.1	59.5	66.1
2000.07	58	60.4	98	102.1	58.4	64.9
2000.08	58	60.4	98	102.1	60.9	67.6
2000.09	58	60.4	98	102.1	61.6	68.5
2000.10	59	61.5	98	102.1	60.9	67.7
2000.11	59	61.5	98	102.1	64.0	71.1
2000.12	59	61.5	98	102.1	65.9	73.2

[a]Fiber equivalent prices take into account fiber waste that occurs during processing. To calculate these prices, we divided polyester and rayon prices by 0.96 and divided the A Index price by 0.9.

Source: National Cotton Council's EconCentral webpage <http://risk.cotton.org/prices/>.

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1986.01	$3,193.2	239,638	$5.83	85.2	$6,734.44	44,075	109.9
1986.02	$3,209.7	239,788	$5.80	76.5	$6,769.32	42,927	109.7
1986.03	$3,236.1	239,928	$5.82	67.3	$6,766.88	41,837	109.1
1986.04	$3,236.3	240,094	$5.83	62.9	$6,766.62	40,786	108.7
1986.05	$3,246.5	240,271	$5.81	64.9	$6,801.10	39,792	109.0
1986.06	$3,257.7	240,459	$5.83	65.2	$6,835.08	38,851	109.4
1986.07	$3,273.7	240,651	$5.79	56.1	$6,845.36	37,962	109.5
1986.08	$3,282.4	240,854	$5.83	55.4	$6,852.62	37,109	109.6
1986.09	$3,296.7	241,068	$5.90	57.3	$6,877.51	36,319	110.0
1986.10	$3,295.6	241,274	$5.86	54.9	$6,890.73	35,574	110.2
1986.11	$3,303.1	241,467	$5.87	55.1	$6,906.72	34,873	110.4
1986.12	$3,319.1	241,620	$5.90	55.2	$6,940.00	34,215	110.8
1987.01	$3,360.4	241,784	$5.94	58.0	$6,999.18	33,586	111.5
1987.02	$3,393.8	241,930	$5.93	59.5	$7,047.18	33,023	111.9
1987.03	$3,411.4	242,079	$5.93	60.2	$7,103.94	32,495	112.3
1987.04	$3,290.2	242,252	$5.93	61.7	$7,172.62	31,981	112.8
1987.05	$3,434.5	242,423	$5.87	61.6	$7,226.92	31,500	113.1
1987.06	$3,446.7	242,608	$5.89	62.5	$7,288.09	31,049	113.6
1987.07	$3,465.6	242,804	$5.87	63.4	$7,332.72	30,625	113.9
1987.08	$3,495.1	243,012	$5.88	64.9	$7,391.41	30,221	114.4
1987.09	$3,508.3	243,223	$6.00	63.4	$7,447.09	29,848	114.8
1987.10	$3,544.7	243,446	$5.98	62.4	$7,498.90	29,496	115.1
1987.11	$3,564.1	243,639	$5.99	62.5	$7,557.19	29,164	115.5
1987.12	$3,598.9	243,809	$6.01	61.4	$7,599.82	28,850	115.7
1988.01	$3,617.0	243,981	$6.02	59.2	$7,651.39	28,548	116.1
1988.02	$3,641.0	244,131	$6.03	58.5	$7,675.87	28,273	116.2
1988.03	$3,668.9	244,279	$6.05	58.2	$7,714.10	28,009	116.6
1988.04	$3,688.6	244,445	$6.06	60.9	$7,765.53	27,746	117.2
1988.05	$3,707.3	244,610	$6.07	61.6	$7,811.06	27,491	117.6
1988.06	$3,737.4	244,806	$6.10	60.3	$7,875.25	27,241	118.1
1988.07	$3,770.0	245,021	$6.03	61.3	$7,946.25	26,996	118.6
1988.08	$3,787.4	245,240	$6.08	61.1	$8,009.12	26,750	119.0

(continued)

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000 (continued)

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1988.09	$3,811.7	245,464	$6.21	58.8	$8,077.02	26,510	119.6
1988.10	$3,841.9	245,693	$6.22	58.7	$8,126.77	26,272	120.0
1988.11	$3,858.2	245,884	$6.26	60.0	$8,177.94	26,037	120.4
1988.12	$3,899.6	246,056	$6.29	59.2	$8,234.24	25,803	120.8
1989.01	$3,930.2	246,224	$6.32	60.8	$8,298.82	25,567	121.3
1989.02	$3,947.3	246,378	$6.32	61.8	$8,349.78	25,345	121.7
1989.03	$3,979.2	246,530	$6.34	62.3	$8,405.51	25,123	122.3
1989.04	$3,987.5	246,721	$6.32	68.4	$8,478.49	24,895	123.2
1989.05	$3,987.1	246,906	$6.32	71.8	$8,535.30	24,668	123.8
1989.06	$4,009.0	247,114	$6.33	70.2	$8,581.33	24,442	124.1
1989.07	$4,021.3	247,342	$6.28	68.4	$8,647.13	24,217	124.6
1989.08	$4,029.1	247,573	$6.32	63.6	$8,677.20	23,989	124.6
1989.09	$4,036.7	247,816	$6.40	65.9	$8,721.49	23,768	124.9
1989.10	$4,060.4	248,067	$6.39	65.8	$8,784.36	23,552	125.5
1989.11	$4,095.2	248,281	$6.42	64.6	$8,837.20	23,343	125.9
1989.12	$4,112.6	248,479	$6.44	64.8	$8,905.26	23,143	126.4
1990.01	$4,176.2	248,659	$6.39	72.7	$9,028.98	22,951	127.6
1990.02	$4,210.5	248,827	$6.44	69.2	$9,102.60	22,777	128.1
1990.03	$4,228.8	249,012	$6.51	67.0	$9,172.35	22,617	128.6
1990.04	$4,261.6	249,306	$6.55	68.0	$9,229.28	22,471	129.0
1990.05	$4,263.1	249,513	$6.58	68.5	$9,263.75	22,342	129.2
1990.06	$4,290.5	249,743	$6.60	67.6	$9,332.46	22,234	130.0
1990.07	$4,318.9	249,973	$6.57	68.1	$9,379.97	22,148	130.6
1990.08	$4,328.1	250,226	$6.61	74.2	$9,459.49	22,088	131.7
1990.09	$4,355.3	250,484	$6.68	82.0	$9,523.93	22,062	132.6
1990.10	$4,351.1	250,737	$6.66	88.1	$9,591.54	22,079	133.5
1990.11	$4,360.4	250,969	$6.64	89.5	$9,623.14	22,143	133.8
1990.12	$4,378.9	251,194	$6.66	84.7	$9,678.34	22,265	134.3
1991.01	$4,386.1	251,399	$6.65	82.6	$9,738.95	22,453	134.8
1991.02	$4,399.8	251,588	$6.62	78.4	$9,768.35	22,700	134.9
1991.03	$4,411.5	251,772	$6.65	75.5	$9,784.78	23,021	134.9
1991.04	$4,434.2	251,986	$6.73	75.7	$9,817.70	23,437	135.2

(continued)

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000 (continued)

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1991.05	$4,453.8	252,200	$6.75	78.0	$9,860.63	23,946	135.7
1991.06	$4,484.6	252,436	$6.78	78.4	$9,893.53	24,555	136.1
1991.07	$4,481.8	252,665	$6.80	77.5	$9,911.21	25,271	136.3
1991.08	$4,495.4	252,921	$6.82	78.8	$9,945.15	26,100	136.7
1991.09	$4,518.3	253,181	$6.88	79.1	$9,983.31	26,993	137.1
1991.10	$4,516.6	253,433	$6.83	78.3	$10,014.74	27,940	137.3
1991.11	$4,534.3	253,662	$6.82	78.1	$10,086.94	28,915	137.9
1991.12	$4,581.5	253,856	$6.88	76.6	$10,156.08	29,895	138.3
1992.01	$4,633.3	254,051	$6.84	74.3	$10,202.62	30,872	138.4
1992.02	$4,668.5	254,231	$6.85	74.3	$10,245.39	31,761	138.7
1992.03	$4,684.3	254,435	$6.88	74.4	$10,276.94	32,588	139.2
1992.04	$4,705.6	254,670	$6.98	75.4	$10,277.17	33,355	139.5
1992.05	$4,727.7	254,909	$6.95	77.8	$10,277.91	34,009	139.8
1992.06	$4,741.4	255,158	$6.97	81.0	$10,299.11	34,527	140.2
1992.07	$4,750.2	255,410	$6.94	80.4	$10,330.71	34,884	140.6
1992.08	$4,733.9	255,692	$6.97	80.2	$10,357.37	35,078	140.9
1992.09	$4,774.1	255,952	$7.00	80.8	$10,380.21	35,113	141.2
1992.10	$4,817.8	256,211	$6.98	80.0	$10,421.49	35,006	141.8
1992.11	$4,831.9	256,443	$6.98	78.4	$10,446.61	34,769	142.2
1992.12	$4,986.5	256,655	$7.04	76.4	$10,457.46	34,416	142.4
1993.01	$4,820.2	256,866	$7.05	76.6	$10,484.43	33,951	142.8
1993.02	$4,826.0	257,051	$7.04	76.9	$10,513.56	33,423	143.2
1993.03	$4,819.1	257,235	$7.05	77.5	$10,530.83	32,819	143.4
1993.04	$4,908.8	257,441	$7.06	78.3	$10,574.16	32,132	143.9
1993.05	$4,933.8	257,654	$7.05	79.6	$10,615.40	31,391	144.3
1993.06	$4,930.1	257,882	$7.07	80.5	$10,639.73	30,610	144.4
1993.07	$4,931.6	258,119	$7.01	79.6	$10,672.91	29,801	144.6
1993.08	$4,956.7	258,374	$7.07	79.1	$10,710.27	28,964	144.9
1993.09	$4,957.4	258,619	$7.15	79.5	$10,733.71	28,138	145.1
1993.10	$4,980.7	258,861	$7.14	78.8	$10,784.00	27,322	145.7
1993.11	$5,002.6	259,067	$7.18	76.2	$10,814.86	26,528	146.0
1993.12	$5,157.1	259,261	$7.25	73.3	$10,859.84	25,771	146.4

(continued)

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000 (continued)

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1994.01	$4,961.1	259,450	$7.22	73.6	$10,880.86	25,049	146.4
1994.02	$5,032.1	259,598	$7.22	74.9	$10,933.26	24,409	146.8
1994.03	$5,061.6	259,777	$7.25	74.7	$10,985.88	23,841	147.2
1994.04	$5,070.8	259,998	$7.28	75.5	$11,016.85	23,346	147.3
1994.05	$5,153.1	260,190	$7.28	76.2	$11,064.19	22,950	147.6
1994.06	$5,162.0	260,408	$7.33	78.3	$11,120.93	22,662	148.0
1994.07	$5,183.5	260,637	$7.31	79.6	$11,185.85	22,496	148.5
1994.08	$5,209.0	260,868	$7.36	81.4	$11,257.54	22,454	149.1
1994.09	$5,240.6	261,104	$7.45	79.6	$11,303.09	22,528	149.4
1994.10	$5,290.4	261,332	$7.44	77.1	$11,328.84	22,707	149.5
1994.11	$5,298.0	261,533	$7.46	77.7	$11,371.26	22,982	149.9
1994.12	$5,323.2	261,722	$7.48	75.9	$11,399.70	23,343	150.2
1995.01	$5,346.8	261,906	$7.55	76.6	$11,432.61	23,789	150.6
1995.02	$5,357.4	262,075	$7.49	76.6	$11,466.53	24,277	151.0
1995.03	$5,370.1	262,247	$7.53	76.8	$11,497.41	24,821	151.3
1995.04	$5,339.0	262,450	$7.62	78.2	$11,557.19	25,430	151.9
1995.05	$5,395.6	262,637	$7.57	80.4	$11,600.59	26,079	152.2
1995.06	$5,413.8	262,852	$7.62	81.4	$11,649.15	26,758	152.5
1995.07	$5,427.7	263,082	$7.64	79.9	$11,689.37	27,458	152.7
1995.08	$5,442.3	263,310	$7.68	79.4	$11,729.28	28,182	153.0
1995.09	$5,463.1	263,559	$7.72	79.0	$11,750.58	28,898	153.2
1995.10	$5,484.5	263,807	$7.73	77.2	$11,797.04	29,610	153.7
1995.11	$5,504.7	264,008	$7.77	75.2	$11,832.29	30,310	153.8
1995.12	$5,526.0	264,180	$7.83	76.7	$11,911.51	30,990	154.1
1996.01	$5,533.1	264,331	$7.87	78.5	$12,033.57	31,653	154.8
1996.02	$5,580.6	264,486	$7.82	77.8	$12,106.68	32,250	155.1
1996.03	$5,609.5	264,662	$7.86	80.1	$12,164.46	32,807	155.6
1996.04	$5,575.6	264,861	$7.95	83.3	$12,211.36	33,332	156.2
1996.05	$5,651.5	265,059	$7.94	84.6	$12,237.28	33,799	156.5
1996.06	$5,683.8	265,278	$7.99	84.7	$12,281.72	34,200	156.8
1996.07	$5,694.8	265,502	$7.95	84.2	$12,339.81	34,526	157.1
1996.08	$5,718.5	265,750	$7.94	84.6	$12,392.15	34,784	157.3

(continued)

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000 (continued)

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1996.09	$5,746.1	265,998	$7.99	85.3	$12,460.84	34,975	157.8
1996.10	$5,753.3	266,237	$8.02	84.8	$12,526.57	35,115	158.3
1996.11	$5,778.4	266,475	$8.01	84.9	$12,596.78	35,216	158.8
1996.12	$5,807.5	266,664	$8.14	85.7	$12,667.13	35,288	159.2
1997.01	$5,828.7	266,840	$8.12	86.5	$12,729.40	35,344	159.5
1997.02	$5,856.0	267,007	$8.18	85.2	$12,785.22	35,391	159.9
1997.03	$5,887.3	267,190	$8.23	83.0	$12,790.25	35,444	159.9
1997.04	$5,903.4	267,396	$8.21	81.8	$12,796.44	35,514	160.0
1997.05	$5,922.7	267,599	$8.22	82.2	$12,814.25	35,611	160.1
1997.06	$5,946.5	267,818	$8.25	83.6	$12,863.49	35,747	160.3
1997.07	$5,967.8	268,048	$8.19	83.1	$12,926.62	35,932	160.5
1997.08	$6,002.3	268,311	$8.23	84.2	$12,995.30	36,173	160.8
1997.09	$6,029.0	268,563	$8.33	85.3	$13,064.10	36,455	161.3
1997.10	$6,062.0	268,799	$8.33	83.2	$13,104.03	36,774	161.6
1997.11	$6,094.9	269,009	$8.33	81.9	$13,130.70	37,124	161.8
1997.12	$6,117.9	269,189	$8.42	80.2	$13,149.07	37,497	161.9
1998.01	$6,158.2	269,379	$8.42	77.5	$13,172.60	37,891	162.1
1998.02	$6,195.3	269,536	$8.38	75.9	$13,179.58	38,280	162.2
1998.03	$6,231.1	269,699	$8.43	74.2	$13,169.38	38,670	162.2
1998.04	$6,254.5	269,886	$8.48	74.7	$13,178.75	39,060	162.4
1998.05	$6,286.3	270,078	$8.47	76.3	$13,217.17	39,435	162.7
1998.06	$6,308.5	270,287	$8.50	77.2	$13,274.68	39,789	162.9
1998.07	$6,337.2	270,509	$8.48	76.9	$13,340.82	40,115	163.2
1998.08	$6,364.6	270,763	$8.54	75.4	$13,369.19	40,411	163.5
1998.09	$6,381.5	271,007	$8.63	75.4	$13,320.77	40,669	163.5
1998.10	$6,410.0	271,240	$8.65	74.6	$13,309.32	40,891	163.9
1998.11	$6,466.7	271,459	$8.64	72.8	$13,372.21	41,076	164.2
1998.12	$6,446.7	271,644	$8.71	70.8	$13,562.11	41,224	164.5
1999.01	$6,488.4	271,841	$8.68	71.3	$13,816.43	41,334	164.8
1999.02	$6,515.6	271,987	$8.64	70.1	$13,996.74	41,402	164.8
1999.03	$6,540.8	272,142	$8.78	71.2	$14,091.15	41,430	165.0
1999.04	$6,569.0	272,317	$8.83	75.9	$14,184.11	41,419	166.0

(continued)

Table B-4. Monthly Income, Population, Input Prices, World Cotton Stocks, and CPI, 1986-2000 (continued)

Month	Disposable Income Annual Rate (billions)	U.S. Population (thousands)	Domestic Textile Wages	Energy Price Index	OECD GDP Annual Rate[a] (billions)	Rest of World Cotton Stock[b] (1,000 bales)	Consumer Price Index (CPI) (1982-84=100)
1999.05	$6,583.1	272,508	$8.81	77.5	$14,183.64	41,365	166.0
1999.06	$6,636.9	272,718	$8.89	78.6	$14,231.69	41,267	166.1
1999.07	$6,638.3	272,945	$8.83	80.7	$14,349.49	41,125	166.7
1999.08	$6,686.8	273,197	$8.88	83.5	$14,443.68	40,935	167.1
1999.09	$6,668.3	273,439	$9.01	85.8	$14,532.76	40,708	167.8
1999.10	$6,760.0	273,672	$8.99	83.5	$14,578.48	40,444	168.2
1999.11	$6,781.6	273,891	$8.98	83.6	$14,622.24	40,148	168.5
1999.12	$6,783.4	274,076	$9.04	83.6	$14,698.05	39,822	168.9
2000.01	$6,830.6	274,271	$9.03	83.8	$14,799.41	39,465	169.4
2000.02	$6,858.5	274,423	$9.03	87.5	$14,925.01	39,104	170.2
2000.03	$6,910.4	274,583	$9.05	90.9	$15,058.49	38,726	171.2
2000.04	$6,939.7	274,765	$9.05	89.2	$15,088.79	38,321	171.1
2000.05	$6,963.5	274,952	$9.05	90.9	$15,143.76	37,905	171.3
2000.06	$6,991.5	275,155	$9.07	97.7	$15,264.07	37,481	172.2
2000.07	$7,006.4	275,372	$9.06	97.3	$15,351.89	37,053	172.7
2000.08	$7,017.8	275,619	$9.09	95.9	$15,405.10	36,619	172.8
2000.09	$7,098.6	275,857	$9.16	100.6	$15,517.80	36,194	173.6
2000.10	$7,071.8	276,083	$9.16	99.7	$15,581.04	35,778	173.9
2000.11	$7,079.2	276,298	$9.16	99.3	$15,645.89	35,372	174.3
2000.12	$7,109.8	276,513	$9.21	97.9	$15,691.72	34,980	174.6

[a]Excluding the United States, Czech Republic, Hungary, Korea, and Poland. Monthly estimates were generated by applying PROC EXPAND in the SAS statistical software package to quarterly data.

[b]Monthly estimates were generated by applying PROC EXPAND in the SAS statistical software package to annual data.

Sources: The Federal Reserve Bank of St. Louis. 2001. FRED. <http://www.stls.frb.org/fred>.
U.S. Bureau of Labor Statistics. 2001. Producer Price Index-Commodities (Series ID: WPUSOP3510 and eeu32230006) and Consumer Price Index-All Urban Consumers (Series ID: CUSR000SA0).
U.S. Census Bureau. "National Population Estimates." Obtained on March 1, 2001. <http://www.census.gov/population/www/estiamtes/uspop.html>.
OECD. Quarterly National Accounts. Number 4, 1993; Number 4, 1998; Number 3, 1999; Number 2, 1999; Number 4, 2000; Number 3, 2000; Number 2, 2000; Number 1, 2000.
National Accounts of OECD Countries. 2001. Main Aggregates Volume 1, 1988-1999.

Table B-5. Annual Cotton Supply Data, 1975-2000

Year	Crop Year Production (1,000 bales)	Expected Market Cotton Price[a] (cents/lb)	Target Price	Loan Rate	Expected Effective Cotton Price[b] (cents/lb)	Prices Paid by Farmers	Cotton Incorporated Agricultural Research	Total U.S. Agricultural Research on Cotton	CPI
1975	8,302	41.2	38.0	36.12	41.2	51.4	Unavailable	$34,680,000	53.8
1976	10,581	60.4	43.2	38.92	60.4	54.9	Unavailable	$34,894,000	56.9
1977	14,389	77.4	47.8	44.63	77.4	57.8	Unavailable	$38,456,000	60.6
1978	10,856	57.0	52.0	48.00	57.0	63.0	Unavailable	$38,621,000	65.2
1979	14,629	62.4	57.7	50.23	62.4	72.3	Unavailable	$38,873,000	72.6
1980	11,122	83.9	58.4	48.00	83.9	80.3	Unavailable	$40,451,000	82.4
1981	15,646	87.9	70.9	52.46	87.9	87.3	$3,749,000	$47,337,000	90.9
1982	11,963	65.8	71.0	57.08	70.2	91.3	$3,300,000	$46,214,000	96.5
1983	7,771	70.8	76.0	55.00	75.2	91.9	$1,692,000	$46,853,000	99.6
1984	12,982	79.0	81.0	55.00	80.7	93.1	$1,688,000	$46,587,000	103.9
1985	13,432	66.0	81.0	57.30	78.8	90.2	$999,000	$47,527,000	107.6
1986	9,731	63.2	81.0	55.00	78.3	86.7	$807,938	$47,860,000	109.6
1987	14,760	57.3	79.4	52.25	76.1	87.3	$855,385	$52,860,000	113.6
1988	15,411	62.0	75.9	51.80	73.8	92.0	$1,091,429	$54,090,000	118.3
1989	12,196	61.7	73.4	50.00	71.6	97.0	$1,026,656	$57,258,000	124.0
1990	15,505	71.4	72.9	50.27	71.4	99.0	$1,174,591	$62,134,000	130.7
1991	17,614	85.0	72.9	50.77	85.0	100.0	$1,219,089	$61,424,000	136.2
1992	16,218	56.9	72.9	52.35	70.5	101.0	$3,559,076	$64,105,000	140.3
1993	16,134	62.1	72.9	52.35	71.3	102.0	$4,037,752	$66,623,000	144.5
1994	19,662	77.9	72.9	50.00	77.9	107.0	$4,399,945	$72,958,000	148.2

(continued)

Table B-5. Annual Cotton Supply Data, 1975-2000 (continued)

Year	Crop Year Production (1,000 bales)	Expected Market Cotton Price[a] (cents/lb)	Target Price	Loan Rate	Expected Effective Cotton Price[b] (cents/lb)	Prices Paid by Farmers	Cotton Incorporated Agricultural Research	Total U.S. Agricultural Research on Cotton	CPI
1995	17,900	101.2	72.9	51.92	101.2	108.0	$5,503,535	$76,240,000	152.4
1996	18,942	84.7	NA	51.92	84.7	115.0	$6,501,893	$78,408,000	156.8
1997	18,793	74.0	NA	51.92	74.0	118.0	$6,777,091	$76,665,000	160.5
1998	13,918	66.6	NA	51.92	66.6	114.0	$6,750,132	$78,748,000	163.0
1999	16,968	59.8	NA	51.92	67.5	113.0	$6,538,030	$81,622,000	166.6
2000	16,822	58.7	NA	51.92	65.7	118.0	$6,682,440	Unavailable	172.2

NA = not applicable.

[a]This price is calculated for 1975-1995 by using a weighted average of target price and expected market price in years when the target price is binding. Based on historical data, it was assumed that 85 percent of production would be eligible for target price payments. For 1996-2000, it was assumed that all production was eligible for payments and the expected level of payment was calculated based on the difference between the loan rate and the adjusted world price during the cotton planting season.

Sources: U.S. Department of Agriculture, Economic Research Service. 1986-2000. *Cotton & Wool Yearbook*. November. Washington, DC.
Cotton Incorporated. No date. Database.
Unglesbee, Dennis, USDA. April 19 and July 23, 2001. Personal communication with Robert Beach, RTI. Data for 1970-1976, 1977-1985, 1986-1992.
U.S. Department of Agriculture, National Agricultural Statistics Service (USDA/NASS). 2001. *Agricultural Statistics 2001*. GPO: Washington, DC.
U.S. Bureau of Labor Statistics. 2001. Consumer Price Index-All Urban Consumers (Series ID: CUSR000SA0).
U.S. Department of Agriculture. 2001. Current Research Information System (CRIS). Data for 1993-1999. <http://cris.csrees.usda.gov>.

Table B-6. Quarterly Import Supply Data, 1990-2000

Quarter	Fisher Ideal Price Index of Retail Cotton Products[a]	Net Imports (Cotton Equivalents)[b] (1,000 bales)
1990.01	1.000	965.0
1990.02	0.991	838.7
1990.03	0.960	1,060.6
1990.04	1.064	801.7
1991.01	0.992	869.0
1991.02	0.991	827.7
1991.03	0.971	1,125.5
1991.04	1.067	1,079.7
1992.01	0.993	1,148.9
1992.02	1.001	1,147.7
1992.03	0.959	1,444.2
1992.04	1.091	1,151.3
1993.01	1.000	1,240.3
1993.02	0.996	1,312.1
1993.03	0.954	1,611.6
1993.04	1.093	1,254.5
1994.01	0.989	1,285.8
1994.02	0.975	1,242.7
1994.03	0.946	1,705.4
1994.04	1.049	1,359.9
1995.01	0.953	1,410.0
1995.02	0.977	1,379.7
1995.03	0.915	1,702.8
1995.04	1.051	1,188.7
1996.01	0.969	1,215.7
1996.02	0.990	1,190.3
1996.03	0.956	1,703.5
1996.04	1.074	1,442.4
1997.01	0.993	1,454.8
1997.02	0.998	1,559.3
1997.03	0.969	2,161.0

(continued)

Table B-6. Quarterly Import Supply Data, 1990-2000 (continued)

Quarter	Fisher Ideal Price Index of Retail Cotton Products[a]	Net Imports (Cotton Equivalents) (1,000 bales)[b]
1997.04	1.080	1,740.9
1998.01	1.005	1,812.4
1998.02	1.017	2,004.0
1998.03	0.994	2,593.7
1998.04	1.079	2,055.6
1999.01	0.985	2,168.7
1999.02	1.000	1,976.1
1999.03	0.966	2,863.2
1999.04	1.074	2,445.6
2000.01	0.971	2,500.9
2000.02	0.981	2,577.3

[a]Calculated from data provided by CI on retail apparel prices and quantities sold.

[b]Calculated from USDA Cotton *and Wool Outlook*, various issues, by subtracting exports of cotton from imports.

Sources: U.S. Department of Agriculture. 1986-2001. *Cotton and Wool Outlook*. Washington, DC.
Cotton Incorporated. No date. Database.

Appendix C: Details of Grid Search

The impacts of promotion and research on cotton consumption may be distributed over a number of months or even longer. Models that allow for such effects over time are generally referred to as distributed lag models. Thus, an extremely important aspect of this study involved carefully and accurately modeling the timing of promotion and research on the demand for cotton using distributed lag models. However, there is no consensus in the economics literature on the appropriate criteria to use in selecting the best model. Possible candidates are the Akaike Information Criteria (AIC), Schwartz Bayesian Criteria (SBC), and the adjusted R-square.

The AIC, SBC, and adjusted R-square are computed as follows:

$$AIC = -2\ln L + 2k$$

$$SBC = -2\ln L + \ln T\, k$$

$$Adj\, R^2 = 1 - \left[\frac{(T-1)}{(T-K)} \left(1 - R^2\right) \right]$$

where L is the value of the likelihood function evaluated at the parameter estimates, T is the number of observations, K is the number of estimated parameters, and R^2 is the standard R-square. However, assuming a Gaussian process (as we have done here) the AIC and SBC criteria reduce to

$$AIC = \ln\sigma^2 + \frac{2k}{T}$$

$$SBC = \ln\sigma^2 + \frac{k\ln T}{T}$$

where σ^2 is the estimated variance of the error term.

Each of these criteria takes different forms and as a result does not necessarily imply the same ordering of preferred models. These alternative forms place different weights on factors such as number of observations used, number of parameters estimated, and how they take into account the in-sample fit of the model. No single criterion stands alone as the "preferred criterion," and each has known advantages and disadvantages under different scenarios. For instance, the AIC criterion can lead to selecting too long of a lag length (Judge et al., 1988), whereas the SBC criterion is known to produce consistent estimates of the lag length under certain conditions. Geweke and Meese (1981) investigated the properties of the AIC and SBC and discovered that, as sample size becomes large, the probability that the lag length chosen will be less than the optimal lag length (i.e., $m < m^*$) vanishes. That is, the probability of underestimating the true lag length, thereby resulting in biased estimates, becomes zero as sample size becomes large. Furthermore, they also established that the probability that the lag length would be overestimated ($m > m^*$) as sample size becomes large, thereby making estimates inefficient, does not vanish for the AIC criterion but does for the SBC criterion. These large sample properties are useful to understand but are tempered by the fact that researchers are rarely fortunate enough to have large samples in practice.

Monte Carlo experiments by Geweke and Meese (1981) to investigate the small sample behavior of these different estimators revealed that, for samples greater than 100 observations, these estimators provide small sample results close to the theoretical asymptotic results (Judge et al., 1988). This is encouraging for the case at hand. With a sample size of 180, some confidence can be placed in the results provided by the above-mentioned criteria. They should be able to identify the appropriate m for explanatory variables that we suspect may have distributed lag effects. Thus, in selecting an optimal lag length, we examined all three criteria.

C.1 MODEL SELECTION AMONG DISTRIBUTED LAG MODELS

Various challenges and trade-offs arise in selecting distributed lag models. As mentioned previously, sample size is critically important in the confidence one can place in the parameter estimates and the criteria used for selecting lag length. If m is large and only a limited sample of observed data is available, then we may not have enough observations to estimate all of the parameters. Furthermore, even if a large sample of observed data is available, as additional lags of explanatory variables are included in the model a high degree of multicollinearity can occur, which is detrimental to standard errors of the estimated coefficients. Typically, applied researchers address this problem by imposing restrictions on estimated parameters, thereby reducing the number of estimated coefficients. By imposing restrictions that fail to be rejected (i.e., are found to be consistent with the data) the in-sample fit of the model is not greatly adversely affected, but problems with degrees of freedom and multicollinearity are reduced. A final complicating facet of selecting the model is that arriving at a preferred model based on one criterion, or some combination of the criteria described above (i.e., AIC, SBC, or adjusted R-square), does not guarantee that the implied estimated economic effects (elasticities) in the preferred model make sense. That is, the researcher must combine both the statistical evidence about which model appears to fit the data best and accurately capture the distributed lag effects with prior beliefs from economic theory in arriving at the "preferred model."

Our selection of the best model was in the context of viewing the model as either a finite or infinite distributed lag model between mill consumption and promotion and research. Concerning the possibility of a finite distributed lag model and the potentially large number of lags involved, we considered different possible distributed lag models and decided that the Almon distributed lag model (without end-point restrictions imposed) would probably provide the greatest flexibility. We then embarked on grid search procedures in an attempt to find the best model. Concerning the possibility of an infinite distributed lag model, we employed a geometric lag model but found its performance to be inferior to the Almon model based both on economic theory and on statistical properties. In all cases of model selection across alternative specifications, we relied on statistical measures of AIC, SBC, and adjusted R-square and the implied estimated economic effects (elasticities) to compare competing models and arrive at a preferred model.

C.2 GRID SEARCH

The approach that most researchers recommend in a situation like this is to first search for the best lag length using unrestricted lags. Then once the maximum lag is determined, researchers use a sequential testing procedure to determine the lowest-order polynomial to impose on the maximum lag length (Greene, 1990). An alternative procedure, but one that is computationally expensive, is to search over different lag lengths and degrees of polynomial simultaneously. Both procedures were employed in this study.

C.2.1 Results of Grid Search across Lag Lengths

For the first search we entertained the possibility that the explanatory variables for the price of cotton ($PCOTTON_t$), promotion ($SAGPROM_t$), and nonagricultural research ($SAGNARES_t$) may have distributed lag effects.[1] Using unrestricted lags, we conducted a search by estimating all combinations of lag lengths for price up to 13 lags (i.e., $PCOTTON_{t-m}$, where m = 0, 1, 2, …., 13), promotion up to 13 lags (i.e., ., $SAGPROM_{t-m}$, where m = 0, 1, 2, …, 13), and research up to 60 lags (i.e.., $SAGNARES_{t-m}$, where m = 0, 1, 2, ….., 60). This search involved estimating a total of 11,956 alternative models (14x14x61=11,956). The maximum lag lengths were chosen based on the assumption that the impact of cotton price and promotion would probably not last longer than a year and that the impact of research might have lags as long as 5 years. For each model the AIC, SBC, and adjusted R-square were calculated, and then models were sorted from best to worst for each of these criteria. A subset of the results of this grid search are shown in Table C-1 where the top 25 models according to each criterion are displayed. The results of this grid search indicated lag lengths of 13 for price and promotion and 59 for research by the AIC criterion, but lag lengths of zero for price and promotion and three for research by the SBC criterion. The rankings according to the criterion of adjusted R-square favor lag lengths of 8 for price and promotion and 59 for research.

We note two striking features with respect to the results of this grid search: first, the stark contrast of preferred models depending on which criterion is used, with results spanning the range of possibilities, and second, regardless of criterion the lag lengths for price and promotion are found to be the same for the models that are ranked best for each criterion. Recall that the AIC criterion has the potential to overestimate lag length whereas this probability vanishes as the sample size gets large for the SBC criterion. First impressions of these results lead us to suspect that the AIC results may have overestimated the lag lengths. Similarly the large

[1] A similar search was performed for estimation of the export demand equation, but those results are not reported here in the interest of brevity.

Table C-1. Grid Search Using Unrestricted Lag Length Search

Rank	Model	AIC	Model	SBC	Model	Adj. R^2
1	p13a13r59	–6.3819	p00a00r03	–4.2574	p08a08r59	0.9271
2	p13a12r59	–6.3806	p01a00r03	–4.2427	p08a09r59	0.9243
3	p13a11r59	–6.3502	p00a00r02	–4.2330	p09a08r59	0.9242
4	p13a13r60	–6.3440	p00a00r04	–4.2305	p10a08r59	0.9238
5	p13a12r60	–6.3432	p00a01r03	–4.2285	p08a10r59	0.9219
6	p13a11r60	–6.3168	p00a06r00	–4.2260	p11a08r59	0.9217
7	p13a10r59	–6.2782	p00a00r01	–4.2218	p08a11r59	0.9212
8	p12a13r59	–6.2707	p00a07r00	–4.2197	p10a09r59	0.9212
9	p10a13r59	–6.2707	p00a00r00	–4.2192	p09a09r59	0.9211
10	p10a12r59	–6.2685	p01a00r04	–4.2168	p10a10r59	0.9203
11	p13a10r60	–6.2668	p01a00r02	–4.2145	p08a07r59	0.9194
12	p13a09r60	–6.2665	p02a00r03	–4.2138	p12a08r59	0.9191
13	p13a09r59	–6.2614	p01a01r03	–4.2136	p11a09r59	0.9188
14	p12a12r59	–6.2611	p01a00r00	–4.2120	p10a11r59	0.9188
15	p10a11r59	–6.2558	p00a00r05	–4.2112	p09a10r59	0.9186
16	p13a08r60	–6.2553	p00a02r03	–4.2104	p08a12r59	0.9180
17	p11a12r59	–6.2551	p00a05r00	–4.2091	p09a11r59	0.9174
18	p11a13r59	–6.2547	p00a08r00	–4.2086	p09a07r59	0.9172
19	p12a11r59	–6.2504	p01a06r00	–4.2085	p13a08r59	0.9171
20	p11a11r59	–6.2435	p00a01r00	–4.2073	p10a12r59	0.9167
21	p12a13r60	–6.2429	p00a02r00	–4.2061	p11a10r59	0.9165
22	p10a10r59	–6.2400	p01a07r00	–4.2044	p13a11r59	0.9165
23	p13a08r59	–6.2360	p00a01r02	–4.2044	p10a07r59	0.9164
24	p10a13r60	–6.2347	p00a06r01	–4.2017	p13a09r59	0.9161
25	p10a12r60	–6.2327	p00a01r04	–4.2014	p12a09r59	0.9160

Notes: Each model is denoted by a nine letter-digit name where p denotes $PCOTTON_t$, a denotes $SAGPROM_t$, and r denotes $SAGNARES_t$. The two-digit number following each of these letters (either p, a, or r) denotes the choice of m (the lag length) of the corresponding explanatory variable. For example, p00a01r02 would represent a model that includes current price ($PCOTTON_t$), current and one period lagged of promotion ($SAGPROM_t$ and $SAGPROM_{t-k}$) and current and two periods lagged of research ($SAGNARES_t$, $SAGNARES_{t-1}$, and $SAGNARES_{t-2}$).

differences between the lag lengths estimated using the SBC and adjusted R-square also hints that the adjusted R-square criterion may have also overestimated the lag lengths. Closer inspection of the results from the models "p13a13r59" (price and promotion 13 months and research 59 months) and "p08a08r59" (price and promotion 8 months and research 59 months) reveals that this seems to be the case. Either none or only a few of the price lags are individually statistically significantly different from zero, and the sum of these lags is positive, implying an upward-sloping demand curve. In addition, the sum of the lags on promotion is negative.

For the model that was ranked best by the SBC criterion, the "p00a00r03" (no lags on price and promotion and three lags on research), the results are much more promising with estimated coefficients on price and promotion and three of the four estimated coefficients on research being individually statistically significantly different from zero. In addition, the signs of these estimated effects are consistent with theory, including a downward-sloping demand curve and positive effects on demand from promotion and nonagricultural research. On the basis of the economics of the three models and by the consistency properties of the SBC criterion, our preference would be for the model with zero lags for price and promotion and three lags for research.

C.2.2 Results of Grid Search across both Lag Lengths and Polynomial Degree

Next we entertained a more complex grid search where we allowed the lag lengths of promotion ($SAGPROM_t$) and nonagricultural research ($SAGNARES_t$) to vary simultaneously with different polynomial degrees. Based on the previous grid search and some further investigation we decided not to allow the lag length and polynomial degree on price to vary further because it would complicate this search and we were content that including current price in the model adequately represented this relationship.

The grid search over different combinations of lags and polynomial degrees for promotion and research was done by searching over lag lengths (m) up to 13 months for promotion and up to 48 months for research and polynomial degrees (d) from 1st up to 6th order. This search resulted in a total of 17,204 models being estimated. Again, for each model the AIC, SBC, and adjusted R-square were calculated and then sorted, and we ranked the preferred models. The top 25 models according to each criterion appear in Table C-2. According to both models that ranked best according to the AIC and SBC criteria, the appropriate lag length for promotion is 6 months and for research, 40 months. Despite both criteria agreeing on lag length, they do not agree on the degree of polynomial for promotion—the AIC finds in favor of a 6th order whereas the SBC finds in favor of a 1st order. The 6th order polynomial in promotion is ranked 15th according to the AIC. An F-test reveals that these two competing models are not statistically significantly different from each other. Based on this result we took a closer look at models with a 6-month, 1st order lag for promotion and a 40-month, 4th order lag for research (denoted by "a1-06r4-40" in Table C-2). Although this model seems reasonable from the standpoint of lag length for research relative to promotion, it is inferior to the simpler model (zero lags on cotton price and promotion and a 3-month lag on research) when statistical and economic considerations are factored into the equation. First, the polynomial restrictions are statistically rejected with a p-value of 0.01. Second, the results produce a positive, although statistically insignificant, effect of cotton price on mill consumption.

Given the economic and statistical considerations as a whole, our preference is for the simpler model. The long-run impacts of promotion and research are not all that different in the model with long lags than in the model with shorter lags while the own-price effect in the simple model implies a downward-sloping demand curve and the own-price effect in the more complex model does not. In particular, the model with 13 lags on promotion and 40 lags on research indicates long-run promotion and research elasticities of 0.07 and 0.53, respectively. The model with zero lags on promotion and three lags on research suggests long-run promotion and research elasticities of 0.02 and 0.33.

Table C-2. Grid Search Using Almon Distributed Lag Models for Promotion and Research

Rank	Model	AIC	Model	SBC	Model	Adj. R^2
1	a6-06r4-40	–4.9991	a1-06r4-40	–4.4107	a6-08r4-05	0.8288
2	a6-06r5-40	–4.9954	a1-10r3-36	–4.3933	a5-06r5-07	0.8286
3	a5-06r4-40	–4.9920	a1-12r3-36	–4.3899	a5-06r4-08	0.8285
4	a4-05r4-40	–4.9909	a1-06r3-43	–4.3895	a6-08r3-04	0.8285
5	a4-05r5-40	–4.9908	a1-06r3-40	–4.3868	a4-05r3-04	0.8284
6	a6-06r4-47	–4.9884	a1-06r5-40	–4.3856	a4-05r4-05	0.8283
7	a5-05r5-40	–4.9871	a1-05r4-40	–4.3853	a6-08r3-03	0.8283
8	a5-06r4-47	–4.9854	a1-06r3-44	–4.3789	a5-06r3-04	0.8282
9	a4-05r4-44	–4.9852	a1-11r3-36	–4.3783	a6-08r5-07	0.8281
10	a5-06r5-40	–4.9852	a2-06r4-40	–4.3776	a5-06r6-08	0.8280
11	a5-05r4-40	–4.9845	a1-12r3-39	–4.3772	a5-06r4-05	0.8279
12	a4-05r4-47	–4.9836	a1-10r4-36	–4.3772	a6-08r4-04	0.8279
13	a6-06r6-40	–4.9815	a1-01r4-40	–4.3770	a5-06r3-03	0.8279
14	a6-06r4-44	–4.9809	a1-12r4-36	–4.3761	a5-06r4-07	0.8277
15	a1-06r4-40	–4.9781	a1-01r3-36	–4.3752	a5-06r5-08	0.8277
16	a4-05r6-40	–4.9771	a1-08r4-40	–4.3735	a6-06r4-08	0.8277
17	a5-05r4-44	–4.9756	a1-06r4-43	–4.3717	a6-08r5-06	0.8276
18	a5-06r4-44	–4.9748	a1-10r3-39	–4.3714	a4-05r3-03	0.8276
19	a6-08r4-47	–4.9742	a1-12r4-40	–4.3709	a6-06r5-07	0.8275
20	a1-06r5-40	–4.9739	a1-05r3-43	–4.3706	a6-08r5-05	0.8275
21	a6-06r5-47	–4.9737	a2-10r4-40	–4.3704	a5-06r6-07	0.8275
22	a5-05r6-40	–4.9733	a1-10r4-40	–4.3692	a4-05r4-04	0.8275
23	a5-05r4-47	–4.9730	a1-06r3-45	–4.3679	a5-06r5-09	0.8275
24	a4-05r5-44	–4.9715	a1-12r3-40	–4.3665	a6-08r6-08	0.8273
25	a5-06r6-40	–4.9714	a1-10r3-43	–4.3664	a5-06r4-04	0.8273

Notes: Each model is denoted by a nine letter-digit name where a denotes $SAGPROM_t$ and r denotes $SAGNARES_t$. The first digit number following each of these letters denotes the choice polynomial degree (d) and the second two-digit number after the - denotes the lag length (m) for the corresponding explanatory variable. For example, a1-06r4-40 denotes a model that includes a first-order degree polynomial that includes six lags of promotion ($SAGPROM_{t-k}$ where k=0,1, …6) and a fourth-order polynomial that includes 40 lags of research ($SAGNARES_{t-k}$ where k=0,1,…40).

Appendix D: Calculating Program Returns

This appendix provides more detailed information on the methods used to calculate the returns to the Cotton Program. It describes the methods used to estimate the increase in price and quantity that result from Program activities. In addition, it describes how these changes in price and quantity are used to estimate the resulting change in producer surplus. Finally, we discuss the methods used to conduct a sensitivity analysis for the ROI measures.

D.1 ESTIMATING CHANGES IN PRODUCER SURPLUS

To estimate the change in cotton price taking place as a result of the Cotton Program, the cotton market was modeled using a series of equations representing supply, demand, and market-clearing relationships. The effects of a marginal change in Program expenditures can be simulated using an equilibrium displacement model. The endogenous variables of the model are proportional changes in quantities of cotton sold domestically (EQ_{fd}^{d}), cotton sold on the export market (EQ_{fx}^{d}), cotton supplied by producers (EQ_{fd}^{s}), farm-level cotton prices (EP_{cf}), and foreign cotton prices (EP_{cf}). Fixed values are assumed for all input costs, for domestic and export market shares, and for elasticities of supply and demand for this marginal change.

$$EQ_{fd}^{d} = \eta EP_{cd} + \eta_f EP_{cf} + \beta_1 EA + \beta_2 ENAR \qquad (D.1)$$

$$EQ_{fx}^{d} = \eta_x EP_{cd} + \eta_{fx} EP_{cf} + + \beta_3 EA + \beta_4 ENAR \qquad (D.2)$$

$$EQ_{fd}^{s} = eEP_{cd} + \beta_5 EAR \qquad (D.3)$$

where EA, ENAR, and EAR denote proportional changes in promotion, nonagricultural research, and agricultural research expenditures, respectively; η is the price elasticity for domestic demand; η_x is the price elasticity for export demand; η_f is the cross-price elasticity of domestic mill demand for cotton with respect to the world price of cotton; η_{fx} is the cross-price elasticity of export demand for cotton with respect to the world price of cotton; e is the price elasticity for domestic supply; β_1 through β_4 are domestic and export demand elasticities with respect to promotion or nonagricultural research; and β_5 is the supply elasticity with respect to agricultural research.

The proportionate change in quantity supplied equals the weighted change in quantity demanded:

$$EQ^{s}_{fd} \quad = \quad s_1 EQ^{d}_{fd} + (1 - s_1)EQ^{d}_{fx} \qquad (D.4)$$

where s_1 is the share of domestic production used by domestic mills. Substituting for the change in quantities yields

$$\begin{aligned} eEP_{cd} + \beta_5 EAR = \; & s_1(\eta EP_{cd} + \eta_f EP_{cf} + \beta_1 EA + \beta_2 ENAR) + \\ & (1 - s_1)(\eta_x EP_{cd} + \eta_{xf} EP_{cf} + \beta_3 EA + \beta_4 ENAR). \end{aligned}$$

Rearranging this expression and substituting $\eta_{fd}EP_{cd}$ for EP_{cf}, where η_{fd} is the elasticity of price transmission between U.S. and foreign cotton prices, gives us an equation for the proportionate change in price:

$$EP_{cd} = \frac{s_1\beta_1 EA + s_1\beta_2 ENAR + (1-s_1)\beta_3 EA + (1-s_1)\beta_4 ENAR - \beta_5 EAR}{e - s_1(\eta + \eta_{fd}\,\eta_f) - (1 - s_1)(\eta_x + \eta_{fd}\,\eta_{xf})} \qquad (D.5)$$

Now, Eq. (D.5) can be used to calculate the changes in price and quantity necessary to generate estimates of changes in producer surplus. Following Lemieux and Wohlgenant (1989), the change in producer surplus (PS) can be calculated using

$$\Delta PS = P^{0}_{cd}\, Q^{s0}_{fd}(EP_{cd} - K)\,(1 + 0.5\, EQ^{s}_{fd}) \qquad (D.6)$$

where K is the proportionate downward shift in the supply curve resulting from agricultural research expenditures, P^{0}_{cd} is the equilibrium price in the baseline, Q^{s0}_{fd} is the quantity supplied in the baseline, and EQ^{s}_{fd} is calculated using Eq. (D.3). For scenarios where there is no supply shift, K is simply set equal to zero.

Augmenting Eq. (D.6) to include the effects of the assessment on producer surplus yields:

$$\begin{aligned} \Delta PS = \; & P^{0}_{cd}\, Q^{s0}_{fd}(EP_{cd} - K)\,(1 + 0.5\, EQ^{s}_{fd}) - \\ & \frac{1}{1 - \dfrac{e}{s_1(\eta + \eta_{fd}\,\eta_f) + (1-s_1)(\eta_x + \eta_{fd}\,\eta_{xf})}} \bullet T \end{aligned} \qquad (D.7)$$

where T is the assessment collected from domestic producers.[1] Only a portion of the assessment falls on producers; the rest is passed on to consumers through higher prices. The proportion paid by consumers and producers depends on their relative price elasticities. Eqs. (D.5) and (D.7) are used in Section 6 to generate estimates of the changes in producer surplus resulting from changes in Program expenditures.

D.2 SENSITIVITY ANALYSIS

To measure the demand response to promotion, researchers estimate the "true" underlying demand function by choosing a demand model and incorporating promotion into the model, which hopefully does a decent job of measuring the impact promotion has had on the "true" underlying demand function. Let the vector of estimated coefficients for the demand model be denoted by $\hat{\beta}$. Accompanying these estimated coefficients are measures of their precision. Let the variance-covariance matrix that characterizes the underlying probability distribution of these point estimates be denoted by $\hat{\Sigma}$. Hypothesis tests concerning the statistical significance of the promotion on demand can be performed using the information contained in $\hat{\beta}$ and $\hat{\Sigma}$. That is, we can test whether promotion has had a statistically significant effect on demand. If there has indeed been a statistically significant effect on demand, then it is informative to calculate the magnitude of this impact. Magnitude of impact can be determined by calculating promotion elasticities of demand ($\hat{\omega}$), which are functions (sometimes nonlinear depending on the choice of functional form) of the estimated coefficients $\hat{\beta}$ and the observed data X (i.e., $\omega = \omega[\hat{\beta}, X]$). The question that remains is how we can calculate measures of precision for the $\hat{\omega}$ using the information contained in $\hat{\Sigma}$. Similarly, the precision of simulated producer welfare measures from promotion (ΔZ) obtained using the estimated promotion elasticities ($\hat{\omega}$) will also depend on information contained in $\hat{\Sigma}$.

[1]Theoretically, it would have been preferred to include a tax term in the supply function (Eq. [D.3]) such that an increase in the assessment would shift supply. However, given the added complexity of doing so and the assessment's small proportion of price, producer incidence was estimated as shown in Eq. (D.7).

Because these relationships can be nonlinear, deriving a measure of precision for estimated values of $\hat{\omega}$ and ΔZ from information contained in $\hat{\Sigma}$ is not necessarily straightforward. One approach to addressing this problem is to linearize the functions. This approach was proposed by Klein (1953) and adopted by Griffin and Gregory (1976), for example. Krinsky and Robb (1991) raised questions about the appropriateness of the linear approximation and compared this approach with two alternative techniques. One alternative technique uses bootstrapping (see Green, Hahn, and Rocke [1987] for an illustration), and the other uses a simulation technique, with many random draws taken from the multivariate normal distribution with mean $\hat{\beta}$ and variance-covariance matrix $\hat{\Sigma}$ (see Krinsky and Robb [1986, 1990]). Both techniques generate empirical distributions for the elasticities and, based on the Krinsky and Robb (1991) comparison, produce results that are similar to those from the linear approximation. Similar findings were reported by Dorfman, Kling, and Sexton (1990), who compared six alternative techniques for constructing confidence intervals for elasticities: three bootstrap-based approaches, a linear approximation approach, and approaches proposed by Fieller (1954) and Scheffé (1970). In their application, with very simple forms for single-equation demand models, five of these techniques worked reasonably well, producing comparable results, while the method suggested by Scheffé did not. Concerning implementation, however, Krinsky and Robb (1991) make some persuasive arguments for preferring the simulation approach, pointing out that the linearization approach may be inappropriate when elasticity formulas are complex, and that the bootstrap is very computer-intensive, requiring models to be re-estimated repeatedly.

The problem of how to evaluate precision of estimates also arises for the estimates of promotion welfare measures (ΔZ). The issues are essentially the same, because the welfare changes are also nonlinear functions of the estimated $\hat{\beta}$ and the observed data X (i.e., $\Delta Z = \Delta Z[\hat{\beta},\mathbf{X}]$). Although the functional relationship between ΔZ and $\hat{\beta}$ is complicated, to obtain measures of precision for ΔZ from what we know about the precision of $\hat{\beta}$ is no different, in principle, from obtaining measures of precision for elasticities. Piggott (1997) showed how this can be done using a simulation technique similar to Krinsky and Robb (1991) where a large number of draws, say N, would be taken from $\hat{\beta} = N(\hat{\beta}, \hat{\Sigma})$. Each draw would then be used to calculate the implied price elasticities of demand and promotion elasticities, which would be used to solve an equilibrium displacement model of a simulated change in promotion and to calculate the implied changes in welfare. In carrying out this approach, restrictions from theory may also be imposed (such as curvature) by checking the feasibility of the estimated price and promotion elasticities at each iteration. If N were sufficiently large, stable estimates would be obtained of the mean and standard deviation of the implied changes in welfare (ΔZ), and a confidence interval could be placed around each element of the estimated ΔZ. If the confidence interval does not include the value zero, then the hypothesis that the particular estimate of ΔZ is not different from zero can be rejected. Furthermore, if N is sufficiently large, then the sample of estimates of the implied changes in welfare can be used to calculate the probability that the welfare measures will be greater than a particular value of interest.

To evaluate the precision of our benefit and cost measures, we conducted random draws taken from the multivariate normal distribution with mean $\hat{\beta}$ and variance-covariance matrix $\hat{\Sigma}$, as mentioned above. This type of simulation is commonly known as Monte Carlo simulation. Using what we know about the joint probability distribution of estimation errors for the estimated parameters, we can generate random draws of parameter values and calculate the welfare measure associated with each draw. This sampling process mimics the variability present in the estimated coefficients and can be interpreted as repeating the process of generating our data with new draws on the error terms in the estimated equations, and re-estimating the parameters.