This is to certify that the

dissertation entitled

AN ECONOMETRIC ANALYSIS OF THE WORLD COTTON

AND NON-CELLULOSIC FIBERS MARKETS

presented by

JONATHAN R. COLEMAN

has been accepted towards fulfillment
of the requirements for

Ph.D degree in Agricultural Economics

John N. Ferris
Major professor

Date 3/20/1991

AN ECONOMETRIC ANALYSIS OF THE WORLD COTTON AND NON-CELLULOSIC FIBERS MARKETS

Volume I

By

Jonathan R. Coleman

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1991

655-6468

ABSTRACT

AN ECONOMETRIC ANALYSIS OF THE WORLD COTTON AND NON-CELLULOSIC FIBERS MARKETS

By

Jonathan R. Coleman

The main purpose of this study was to specify and estimate an econometric model of the world fiber market, with emphasis on the cotton sector, and to forecast prices, production and consumption for major world fiber market participants. In addition, the model was used to analyze and measure the impacts of recent market developments and policy changes.

The nature of the fiber market is described along with recent trends and market developments, providing the basis for the model specification. The model contains components explaining consumption, production, and pricing of cotton and non-cellulosic fibers for the major world fiber market participants. Estimated equations are combined to form a large simultaneous econometric model. A number of validation statistics are presented that cover various aspects of the model's ability to forecast.

Five sets of simulation results are presented. These are for (i) a forecast of price, production and consumption for the period 1990-2005, (ii) a 10% decrease in cotton production in the USSR, (iii) a 10% increase in cotton production in China, (iv) a 10% decline in the domestic price of cotton in the United States, and (v) an evaluation of the impact of the Multi-Fiber Agreement (MFA) on the cotton and non-cellulosic fibers sectors.

T

fall app

simulat

effect o

in prod

for eve

about

cotton

and to

simula

The model forecasts that between 1990 and 2005 the real world price of cotton will fall approximately 25%, while a 10% price increase is forecast for polyester. Three model simulations involve shocking key variables in major producing regions. In each case, the effect on the world market is significant. For example, given a permanent 10% decrease in production in the USSR, the world price rises by about 9%. Over an 11-year period, for every 1% increase in China's production the world price of cotton falls, on average, about 1% and the price of polyester falls 0.35%. The impact of a 10% decline in the US cotton price during the early 1990s is to reduce US production, on average, less than 3.0%, and to increase world prices an average of 3.7%. The conclusion emerging from the MFA simulation is that the effects on the raw fiber market have not been large.

I woul
course
were
suppo
includ
appre
the W
nume

ACKNOWLEDGEMENTS

I would like to thank Stan Thompson for his guidance and encouragement throughout course-work stage of my program. His comments on an earlier version of this dissertation were useful. I also thank Jake Ferris, who later became my dissertation advisor, for his support and many helpful suggestions. The other members of my dissertation committee included Ken Boyer, Jim Hilker and Bob Myers. Their comments on the dissertation were appreciated. I am also indebted to my colleagues at the International Trade Division of the World Bank. In particular, Taka Akiyama, Ron Duncan and Elton Thigpen provided numerous helpful comments and suggestions throughout the duration of the study.

TABLE OF CONTENTS

LIST of TABLES

LIST OF FIGURES

1.1 Background

1.1.1 The Importance o

Cotton is an im

significantly to farm inc

cotton of selected Afri

earned more than $1

agricultural export earn

crop and foreign excha

of Burkina Faso in 198

merchandise trade; whi

of all agricultural expo

generated $3.3 billion i

more than 42% of its a

derived a large propor

many industrialized co

agricultural commodity

earned $ 5.21 billion f

sales amounted to only

6.3% and 2.5% for th

50% of the agricultura

1. Introduction

1.1 Background

1.1.1 The Importance of the Cotton and Manufactured Fibers Markets

Cotton is an important agricultural commodity in many countries, contributing significantly to farm income and export earnings. Table 1.1 shows the export earnings from cotton of selected African, Asian and Industrialized countries. In 1987, cotton exports earned more than $1 billion for African countries, representing about 9.5% of total agricultural export earnings. In some African countries cotton was the principal export crop and foreign exchange earner. For example, 84% of the agricultural export earnings of Burkina Faso in 1987 were derived from cotton sales, amounting to almost 70% of its merchandise trade; while in Sudan and Egypt, cotton sales contributed more than one-half of all agricultural export revenues. In Asia, cotton is relatively less important but still enerated $3.3 billion in export revenues in 1987. For Pakistan, the sales of cotton earned iore than 42% of its agricultural foreign exchange earnings in 1987. China and India also erived a large proportion of their agricultural export earnings from cotton exports. In any industrialized countries and centrally planned economies cotton is also an important ricultural commodity and/or industrial raw material. For example, in 1987 cotton exports rned $ 5.21 billion for the United States and $0.35 billion for Australia, although these es amounted to only a small proportion of total agricultural export earnings, representing % and 2.5% for the United States and Australia, respectively. In contrast, more than of the agricultural export revenues of the USSR were obtained from exporting cotton, valued at over $1.2 billi

Table 1.1 Export Earn

Regions and Countries
Burkina Faso
Chad
Egypt
Mali
Sudan
Tanzania
Togo
AFRICA
China
India
Pakistan
ASIA
Australia
USA
USSR

Source: FAO **Trade Y**

The value of out

major producing regio

in the industrialized a

leading world supplier.

valued almost $5.5 bi

lued at over $1.2 billion.

ble 1.1 Export Earnings from Cotton Production for Selected Countries, 1987

egions nd untries	Cotton Export Earnings ($ million)	Percent of Agric. Export Earnings	Percent of Merchandise Trade
rkina Faso	43.0	84.3	69.6
ad	31.7	24.9	19.8
ypt	388.9	56.2	13.2
li	46.3	30.6	22.3
lan	185.1	59.5	55.5
nzania	43.2	12.6	10.4
go	34.3	33.1	14.5
RICA	1,069.3	9.5	NA
na	756.1	8.9	NA
a	175.0	7.5	NA
istan	445.2	42.3	NA
A	3,319.6	1.9	NA
ralia	353.0	2.5	NA
	5,213.0	6.3	NA
R	1,221.0	51.0	NA

ce: FAO **Trade Yearbook,** 1987.

The value of output and export earnings from the manufactured fiber production of producing regions are shown in Table 1.2. As shown there, production is centered e industrialized and centrally planned countries, although China is emerging as a g world supplier. In 1987, total manufactured fibers production of the United States d almost $5.5 billion. Most of the production was consumed by domestic textile manufacturers, while ea

In the EEC, over one-

was sold externally. Ma

exchange for many dev

<u>Table 1.2 The Value</u>
<u>Production of the Maj</u>

Region
China
E. Europe
EEC-12
Japan
Korea
Taiwan
United States
USSR
World

Source: Fiber Organon
FAO. <u>World</u>

Cotton and man

in a great many count

in the United States

higher-income develo

industries provide a la

as making an importa

anufacturers, while earnings from manufactured fiber exports amounted to $0.44 billion. the EEC, over one-half of the total manufactured fiber output, valued at $4.96 billion, is sold externally. Manufactured fiber sales were also a very important source of foreign change for many developing countries in Asian, especially China, Korea and Taiwan.

ble 1.2 The Value of Output and Export Earnings from the Manufactured Fiber oduction of the Major Producing Regions, 1987.

gion	Value of Output	Value of Exports
	--- $ Billion ---	
ina	1.80	0.72
Europe	2.14	0.26
C-12	4.96	2.54
an	2.63	0.46
ea	1.81	0.91
wan	2.49	0.99
ted States	5.48	0.44
SR	2.35	0.00
ld	27.40	8.28

rce: Fiber Organon. June 1989.
FAO. World Apparel Fiber Consumption Survey, 1989.

Cotton and manufactured fibers are consumed by textile and apparel manufacturers great many countries throughout the world. Traditionally consumption was centered e United States and Western Europe, but recently this has moved to many of the r-income developing countries in Asia. In these countries, textile and clothing tries provide a large proportion of total manufactured output and employment, as well king an important contribution to merchandise trade. As reported in Table 1.3., 57%

of the value of merchan

was provided by its t

contributed more than

of the employment for

States and Western Eu

still make an import

employment.

Table 1.3 Percent of
Trade and Manufact

Region
Bangladesh
China
India
Japan
Korea
Hong Kong
Singapore
Philippines
United States
W. Europe

Source: Industrial Sta
World Devel

1.1.2 Market Instabil

The world cotto

since the early 1960s.

of the value of merchandise trade and 64% of employment in manufacturing in Bangladesh was provided by its textile sector in 1987. In Korea and Hong Kong textile sales contributed more than one-quarter of the value of manufacturing output and over one-third of the employment for its manufacturing work force. The textile industries of the United States and Western Europe are relatively less important in their respective economies, but still make an important contribution to the balance of trade and as a source of employment.

Table 1.3 Percent of Textiles Market in Value of Manufacturing Output, Merchandise Trade and Manufacturing Employment for Major Textile Producing Countries, 1987.

Region	Value of Manufacturing Output	Merchandise Trade	Manufacturing Employment
	---- Percent ----		
3angladesh	NA	57	64
China	18	24	13
ndia	12	18	23
apan	7	0	14
orea	25	23	35
Iong Kong	35	39	44
ngapore	4	6	4
hilippines	8	6	26
nited States	5	2	10
. Europe	3	4	7

urce: Industrial Statistics Yearbook, United Nations, 1987.
World Development Report, 1988. World Bank.

2 Market Instability

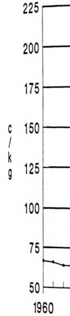
The world cotton and manufactured fibers markets have undergone substantial change the early 1960s. These changes have led to substantial price volatility (Figures 1.1

and 1.2). Cotton price
in 1973, 1976, 1980, 19
associated with the acc
in production and cons
1960 and 1970 the co
maintained a floor on
from higher rates of g
growth in the United
throughout the period
harvest in that year, w
1980, resulted from t
United States and in m
in China had a major
in 1984 sent prices to
can be associated with
countries.

The polyester p
from increased prod
manufactured fibers t
a result of the first o
with the general rates
be implemented withi
manufactured fibers.

and 1.2). Cotton prices tend to be cyclical with peaks every three or four years (such as in 1973, 1976, 1980, 1983 and 1990). In general, the peaks and troughs in prices can be associated with the accumulation and run-down of cotton stocks, which result from changes in production and consumption decisions by market participants. For example, between 1960 and 1970 the cotton price remained stable as a result of US cotton policy which maintained a floor on the world price. The 1970-74 period of increasing prices resulted from higher rates of general inflation, as well as a simultaneous expansion in economic growth in the United States, Japan and the EEC, which led to declining stock levels throughout the period. The drop in price in 1974 was the result of an extremely good harvest in that year, while the rise in price between 1974 and 1976, and between 1977 and 1980, resulted from the acreage diversion from cotton to grains which occurred in the United States and in many other major cotton growing areas. During the 1980s, production in China had a major effect on the world price. For example, the record production level in 1984 sent prices to very low levels in 1985, while the price increases in the late 1980s can be associated with persistent strong demand for cotton, especially by the industrialized countries.

The polyester price (fob US plants) declined between 1960 and 1973. This resulted from increased productive capacity and improvements in technology which allowed manufactured fibers to compete with cotton. The price reversal that started in 1973 was a result of the first oil shock, while the rise in price throughout the 1980s was consistent with the general rates of inflation. Given that production and consumption decisions can be implemented within a relatively short period, there is very little stockholding of manufactured fibers. As a result, there is an absence of the inter-year fluctuations that are



1/ Middling 1-3/32",

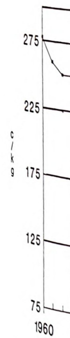
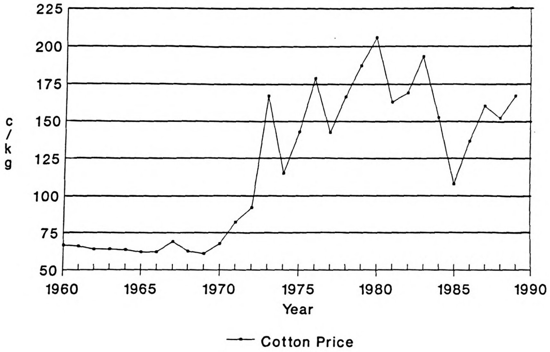


Fig. 1.1 World Cotton Price, 1960-1989

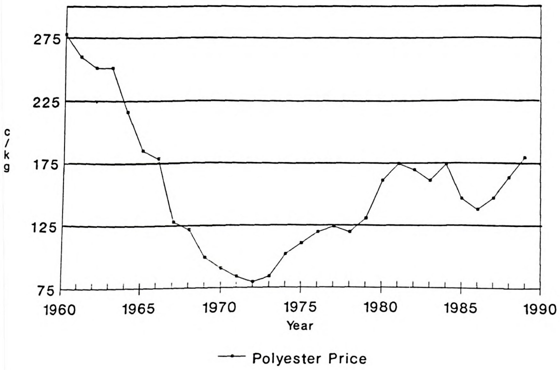
Cotton Outlook "A" Index 1/



Middling 1-3/32", c.i.f North Europe

Fig. 1.2 World Polyester Price, 1960-89

FOB US Plants



seen in the cotton pric
fiber and cotton in the
both price series declin

1.1.3 Recent Market I

There are a numb
World Bank, USDA, F
history and future per
effects of changes in d

The agricultural
structural changes. In
has introduced price a
decentralizing decision
links between agricult
produces about 15% o
carefully and are seen

The recent polic
The introduction of
production between 1
cotton. During this p
be highly responsive t
to them. Given the i
a generator of foreign

en in the cotton price series. However, the strong competition between manufactured ›er and cotton in the 1980s caused the prices of these to move fairly consistently, with th price series declining in the mid-1980s and rising during the 1986-89 period.

.3 Recent Market Developments

There are a number of developments which some market commentators (e.g., ICAC, orld Bank, USDA, Fiber Organon) have argued are of great significance to the recent :ory and future performance of the fiber market. These developments center on the ects of changes in domestic cotton policy in the major producing countries.

The agricultural sector in the USSR is currently undergoing major policy-induced ctural changes. In an effort to improve production and productivity, the government introduced price and property-right incentives, encouraged greater accountability by entralizing decision-making, improved input access and quality, and strengthened the between agricultural research centers and the farming sector. Since the USSR uces about 15% of the world cotton supplies, these developments are being monitored fully and are seen as a major determinant of fiber market prospects in the early 1990s.

The recent policy changes which occurred in China are also being watched closely. introduction of price incentives in the late 1970s led to a three-fold increase in uction between 1977 and 1984, with China emerging as the leading world supplier of n. During this period and continuing throughout the 1980s, producers were found to ghly responsive to changes in the profitability of the various crop enterprises available em. Given the importance of the cotton and textile sectors for employment and as erator of foreign exchange, the government is expected to continue its support for the cotton sector during th

been reported at 3% p

have great significance

In the United St

determine cotton polic

introduced in the Food

US crops more com

determining acreage r

The target price for th

This means that real t

an effort to reduce c

Rudman deficit reduct

world cotton prices t

significance now than

will have an importan

international fibers ma

Another import

the outcome of the ne

of the on-going discu

restrictions on the im

(mainly the United St

---

[1] During the 1960s and 1970s the U
the policy too expensive and led to the
cotton policy is presented in section 8.4.

ton sector during the early 1990s. An unofficial target growth rate in production has en reported at 3% per year between 1990 and 1995. If this growth is achieved it will e great significance for cotton prices during this period and beyond.

In the United States, the 1990 Food, Agriculture, Conservation, and Trade Act will ermine cotton policy until 1995. The Act continues the market-orientated provisions oduced in the Food Security Act of 1985. The major changes are provisions to make crops more competitive internationally, and to increase flexibility in the rules rmining acreage reductions, in order to allow farmers to respond to market signals. target price for the entire 1991-1995 period will be fixed at the 1990 level of 72.9c/lb. means that real target prices will fall significantly over the next five years. This is in effort to reduce overall agricultural expenditures in accordance with the Gramm-man deficit reduction requirements, as well as in response to the expectation of lower d cotton prices throughout the early 1990s. While the United States has less ficance now than in the past[1], United States policy provisions in the 1990 Farm Act ave an important impact on the United States cotton sector in particular, as well as national fibers markets in general.

Another important development being monitored closely by many commentators is tcome of the negotiations over the Multi-Fiber Agreements (MFA) which are part on-going discussions in the Uruguay Round of the GATT. The MFA places tions on the imports of textile and clothing items into some industrialized countries y the United States and the EEC) from many developing countries. These evolved

---

960s and 1970s the US support price acted as a floor on the world price. The emergence of China in the 1980s made nsive and led to the policy changes which were contained in the Food Security Act 1985. A brief discussion of US sented in section 8.4.1.

in the 1960s and have

domestically produced

It is hard to predict th

stance of the United S

of free access to inte

powerful political inte

1.2 Research Needs

Accurate cotton

such as producers and

guesses about future

countries where earni

and provide an impo

addition, forecasts of

countries and regions

example, the identific

depend on accurate f

Research is ne

and consumption. W

Monetary Fund, the I

time to time, these

regression models, c

author is aware, the

in the 1960s and have been increasingly strengthened since then, as the market share of domestically produced textile and clothing products in the industrialized countries declined. It is hard to predict the outcome of these negotiations. This will depend mainly on the stance of the United States, which has to balance its overall accordance with the principle of free access to international commodity and manufactured goods markets, with the powerful political interests of the textile and clothing manufacturers at home.

.2 Research Needs

Accurate cotton and manufactured fiber price forecasts are useful to many groups, ıch as producers and consumers of fibers, governments and lending institutions. Informed ıesses about future fiber prices are especially important to decision makers in those ıuntries where earnings from fiber sales represent a large proportion of export earnings d provide an important source of employment in manufacturing (Tables 1.1-1.3). In dition, forecasts of world levels of production and consumption trends for different untries and regions are valuable to producers and consumers of fiber products. For ımple, the identification and development of potential export markets for many countries pend on accurate forecasts of where demand will be strong in the future.

Research is needed to provide accurate forecasts of future fiber prices, production l consumption. While a number of institutions (e.g., the World Bank, the International netary Fund, the International Cotton Advisory Committee) publish price forecasts from e to time, these are based on a fairly simple analyses, such as using single-equation ression models, or are based on observations of recent price trends. As far as the ıor is aware, there exists no price and quantity forecasts based on a more complete framework in which p

there appears to be co

sophisticated method

In addition to de

to investigate other iss

on the effects that som

have on future price l

For example, a

producer and stock-h

analyses have been u

world fiber market an

the 1990s. Such anal

in China's cotton po

countries. There are

on the world fiber m

Another impor

(such as those in the

prices. A quantitati

participants for mon

Finally, while s

agreement (MFA) c

(Goto et al, 1989),

Measuring the impa

ramework in which price and quantity forecasts are derived simultaneously. Therefore here appears to be considerable scope for improving current forecasts by applying a more ophisticated method which captures the interaction of price and quantity.

In addition to developing a method of forecasting prices and quantities, there is need investigate other issues and areas in the fiber market. For example, research is needed the effects that some of the recent markets developments (discussed in section 1.3) may ve on future price levels and production and consumption patterns.

For example, as mentioned above, China recently became the most important oducer and stock-holder of cotton in the world market. Currently, no quantitative alyses have been undertaken to measure the degree to which China has affected the rld fiber market and how the expected expansion in production will impact on prices in 1990s. Such analyses would also be useful in assessing the impact of future changes China's cotton policy on world prices and supply and demand conditions in other ntries. There are also no studies which measure the impact of USSR cotton supplies the world fiber market.

Another important issue concerns how changes in United States cotton programs h as those in the 1990 Farm Bill) will affect United States producers and world fiber es. A quantitative analysis of US cotton policy would be of interest to many market icipants for monitoring future changes in United States agricultural programs.

Finally, while some research has been completed on the impact of the Multi-Fiber ement (MFA) on the developing countries and the cost of the distortions created o et al, 1989), its effects on raw fiber demand and prices have not been evaluated. uring the impact of the MFA on cotton and polyester producer prices will provide valuable input into the

markets.

1.3 Objective of the S

The objective o

is, to develop a comp

polyester prices, in ac

The framework will in

model of the world co

interaction of price a

improvement on the

the model will be sin

developments in indiv

1.4 Organization of th

This paper is c

are discussed in sec

determination compo

respectively. In each

theoretical issues, and

fibers component of

[1] The major non-cellulosic fibers a
production.

ıable input into the debate over the how the MFA may have distorted the world fibers ·kets.

Objective of the Study

The objective of the study is to address the research needs mentioned above. That o develop a complete framework with which to make price forecasts for cotton and ester prices, in addition to make projections for quantities produced and consumed. framework will involve the specification, estimation and simulation of an econometric el of the world cotton and manufactured fibers markets. This approach allows for the action of price and quantities to be forecast simultaneously and therefore is an ovement on the methods applied currently to fiber market forecasting. In addition, nodel will be simulated to provide quantitative measures of the impacts of recent lopments in individual countries on the world cotton and manufactured fibers markets.

rganization of the Paper

This paper is organized into ten sections. The research methods used in the study liscussed in section two. The cotton demand, cotton supply and cotton price nination components of the model are presented in sections three, four and five, ctively. In each of these sections a review of the relevant literature, a discussion of tical issues, and the regression results are presented. In section six the non-cellulosic component of the model is presented[2]. Section seven presents some model

---

ı-cellulosic fibers are polyester, nylon and acrylic. These make up about 80% of total world manufactured fibers validation results. In

reported and discussed

policy issues outlined i

model variables to ke

summary and conclusi

model development an

dation results. In section eight, forecasts from the model up to the year 2005 are orted and discussed. Also presented are model simulation results which address the cy issues outlined in section 1.3. In section nine, sensitivity analysis of some important del variables to key parameter estimates are presented. Finally, in section ten a mary and conclusion of the study are provided, along with some proposals for further el development and analyses.

In order to add

analytical tool was req

provide the best tech

modeling approaches

addressing the proble

commodity models in

non-cellulosic fibers n

2.1 Modeling Comm

2.1.1 Overview

A commodity n

a quantitative
relationships i
well as other r

A very simple com

demand/supply diagr

quantities demanded

the market clearing p

the two-equation mo

commodity models c

determined by extern

and changing tastes a

demand for raw fibe

2. Research Methods

In order to address the research problems outlined in the introductory section an alytical tool was required. A quantitative model of the world fiber market appeared to ovide the best technique to meet the study's objectives. In this section the various deling approaches are discussed followed by a description of one most suited to lressing the problems at hand. The stages involved in model building are reviewed for nmodity models in general, and then specifically for the model of the world cotton and -cellulosic fibers markets developed in this study.

Modeling Commodity Markets

Overview

A commodity model can be defined as:

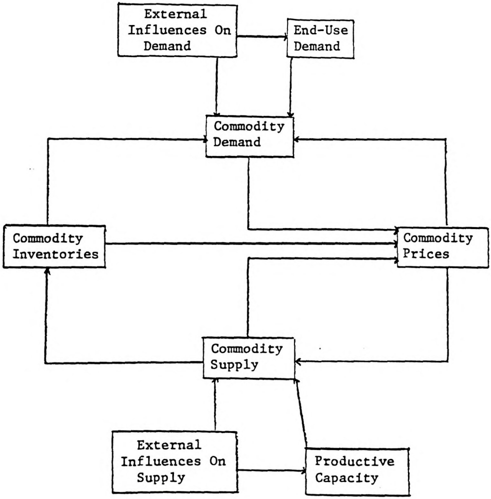
> a quantitative representation of a commodity market or industry; the behavioral relationships included reflect demand and supply aspects of price determination as well as other related economic, political and social phenomena (Labys (1988, p.4)).

ery simple commodity model can be represented by the standard Marshallian nd/supply diagram. Building such model would require specifying relationships for ities demanded and supplied and combining them to solve for two unknown variables, arket clearing price and equilibrium quantity. However, for most commodity markets o-equation model is inadequate to capture all components and complexities. Most odity models contain the elements shown in Figure 2.1. Commodity demand is nined by external factors, such as income levels, general price levels, population size, anging tastes and preferences; the demand by end users of the commodity (e.g., the d for raw fibers is derived ultimately from the demand by consumers for

Figu

Source: W.C.
and Policy A

Figure 2.1 Model Representation of a Commodity Market



Source: W.C. Labys and P. Pollak Commodity Models for Forecasting and Policy Analysis. London: Croom-Helm Publishing Co., 1984.

manufactured textile

substitutes and compl

weather, the state of

capacity, such as the

prices of the commod

to determine the pric

is relatively simple. N

supply and demand

countries or regions, a

2.1.2 Steps in Comm

Constructing a

it must be decided th

is sort from the mod

short- and long-term

used to undertake po

to specific economic

used to evaluate the

responses of market

The second st

structure given the s

involves finding a m

nature of the marke

nanufactured textile and apparel items); and the prices of the commodity and its ubstitutes and complements. Commodity supply is determined by external factors, (e.g., eather, the state of technology and government policy and programs); by productive apacity, such as the area of farm land allocated to producing the commodity; and by the rices of the commodity and its inputs. The demand and supply components are combined determine the price and level of inventories. Even the model represented in Figure 2.1 relatively simple. Many commodity models are more complex and contain, for example, pply and demand relationships for a number of distinct producing and consuming untries or regions, and relationships for the trade of commodities between model regions.

.2 Steps in Commodity Model Building

Constructing a commodity model requires a number of distinct steps or stages. First, nust be decided the purposes for which the model is to be used and what information ort from the model's output. For example, some commodity models are used to make rt- and long-term projections of prices, production and consumption, while others are d to undertake policy experiments, answering "what if" questions about market responses pecific economic, policy or institutional changes. Commodity market models can be d to evaluate the impact of such changes on past market responses, or predict the likely onses of markets participants to policy changes in the future.

The second stage in model construction involves choosing the appropriate model ture given the set of model requirements. This is perhaps the most crucial stage. It ves finding a model structure which has a strong theoretical basis and reflects the e of the market and how it actually operates, while allowing the model to meet the objectives of the resea

structure is how the pr

model can be structur

crucial because not o

policy experimentatio

relationships containe

The third step

capturing relationship

consistent with the r

variables for each equ

for the variables and

determined by the e

equation. However,

in practice more ad

choosing a specificati

'reasonable'.

The fourth sta

parameter values for

variables appearing a

own-price appearing

---

[1] For example, standard theory of
subject to their income constraint. Sol
This can be used by commodity model b
include prices and income as regressors)
should be lagged or not, what the funct

objectives of the research assignment. In general, the key issue in determining the model structure is how the price is established in the market. Once this has been determined the model can be structured to capture this price determination. The price determination is crucial because not only is the price variable usually of most interest in forecasting and policy experimentation, but also price enters the demand, supply, stock-holding and trade relationships contained in the model.

The third step in commodity model building is model specification. This involves apturing relationships between the model variables in the form of equations that are onsistent with the model structure. In addition to choosing the set of independent ariables for each equation, specification involves choosing the appropriate lag structures r the variables and functional forms for the equations. Initially model specification is etermined by the economic theory of the behavioral relationships captured in each uation. However, most commodity models are loosely based on economic theory and practice more ad hoc approaches to equation specification are used [1]. This involves oosing a specification that yields a good fit and provides elasticity measures that are asonable'.

The fourth stage in model building is estimation which involves obtaining the ameter values for the equations. Most commodity models contain current endogenous iables appearing as regressors on the right-hand side of the structural equations (e.g., 1-price appearing in demand equations is an endogenous variable in most market

---

ple, standard theory of consumer behavior tells us that consumers maximize their utility from consuming a set of goods income constraint. Solving this maximization problem yields demand functions with income and prices as arguments. l by commodity model builders in choosing the variables to go into the demand equations (i.e., demand equations should id income as regressors), however, the theory does not give direction as to which prices to include, whether the variables l or not, what the functional form the equation should take, and so on.

clearing models). In t

estimator (OLS) in th

of parameter values

(1978)). An estimat

technique of which

endogenous variables

created (in stage on

variables in the mode

endogenous regresso

are biased but consis

other techniques bas

are less sensitive to

error than other esti

costs. For these r

simultaneous equatio

The fifth step i

using a series of sta

historical data or to

data. A major proble

criteria or benchmar

---

[7] Systems methods of estimation i
equations as a set instead of estimati
techniques is that they use all the avai
specification however, are transmitted
These estimates require a large sample
large models.

clearing models). In this case, the model is simultaneous. Using the ordinary least squares estimator (OLS) in the estimation of a system of simultaneous equations provides estimates of parameter values that are both biased and inconsistent (Johnston (1972); Intriligator (1978)). An estimator within the single-equation method is the instrumental variable technique of which two stage least squares (2SLS) is the best known. In 2SLS, the endogenous variables which appear as regressors are replaced by instrumental variables, created (in stage one) by regressing the endogenous regressors on all the exogenous variables in the model. In stage two the instrumental variable replaces the right-hand side endogenous regressor and the equation is re-estimated using OLS. The 2SLS parameters are biased but consistent. Monte Carlo studies have shown 2SLS to be superior to most other techniques based on small sample properties. Moreover, these desirable properties are less sensitive to other estimation problems such as multicolinearity and specification error than other estimators. In addition to these benefits, 2SLS has low computational costs. For these reasons 2SLS is the most popular and widely used estimator of simultaneous equations [2].

The fifth step in model building is model validation which requires testing the model using a series of statistical tests. Typically, these tests are of the model's ability to track historical data or to determine how well the model captures turning points in the historical data. A major problem in validating a multi-equation model is that no statistically objective criteria or benchmarks exist by which to accept or reject a validation statistic. The criteria

---

methods of estimation include 3SLS and full information maximum likelihood techniques which estimate all the structural set instead of estimating the structural parameters of each equation separately. The major benefit of using these that they use all the available information in creating their estimates and provide consistent parameter values. Errors in however, are transmitted to estimates in the whole model and are not confined to the equations in which the errors occur. require a large sample size and have high computational costs. For these reasons systems methods are rarely used for used are arbitrarily

model as satisfactory

ex-ante forecasting a

evaluating alternativ

if models are used i

The final step

system of equations

variables. Models a

common algorithms

the Newton metho

econometric softwa

simulation results.

it allows normalize

Newton method do

than other techniqu

2.1.3 Modeling M

Commodity

modeling method

different classes o

models. These ar

sed are arbitrarily chosen. As in single-equation estimation, the decision to accept a odel as satisfactory depends upon the intended use of the model. Models designed for :-ante forecasting are typically put through more rigorous tests than those developed for aluating alternative policy scenarios. However, having an accurate baseline is important models are used in policy analysis.

The final step in commodity model building is simulation. This involves solving the tem of equations which make up the model to give values for the unknown endogenous iables. Models are normally simulated over successive time periods. The three most nmon algorithms used to solve these systems of equations are the Gauss-Seidel method, Newton method and the Jacobi method. These are available in most of the large nometric software packages. The use of any of these algorithms yields identical ulation results. However, the Gauss-Seidel method is the most commonly used because llows normalized equations to be solved within the system of equations (which the ton method does not) and is more efficient in terms of speed and computer capacity other techniques.

Modeling Methods

Commodity models are used to address a wide range of problems and no single eling method has become the standard. However, it is possible to categorize the ent classes of models. Labys (1988) identified the major classes of commodity ls. These are discussed briefly below.

2.1.3.1 Market Mode

Market model

specifying demand,

estimated relationsh

structure of such m

where: Q^d_t =
Q^s_t =
P_t =
I_t =
P^o_t =
Y_t =
T_t =
W_t
G_t =

This class of

determined compe

agricultural commo

may not be determ

appropriate.

2.1.3.1 Market Models

Market models are the most commonly applied form of commodity models involving specifying demand, supply, stock-holding and price behavior in terms of econometrically estimated relationships. Price is determined through a market clearing identity. A typical structure of such models is as follows,

$$Q^d_t = Q^d(P_t, P^o_t, I_t, T_t)$$

$$Q^s_t = Q^s(P_{t-i}, W_t, G_t)$$

$$P_t = P(I_t)$$

$$I_t = Q^s_t + I_{t-1} - Q^d_t$$

here: Q^d_t = quantity demanded at time t,
Q^s_t = quantity supplied at time t,
P_t = commodity price at time t,
I_t = level of stock-holding at time t,
P^o_t = price of other commodities at time t,
Y_t = income level at time t,
T_t = consumer tastes and preferences at time t,
W_t = weather at time t, and
G_t = government policy at time t.

This class of model is appropriate for those commodity markets in which price is ermined competitively. Models of this type have been most widely applied to cultural commodity markets. In modeling minerals and energy markets in which price not be determined by competitive adjustment, other modeling approaches are more ropriate.

2.1.3.2 Spatial Equili

Spatial price e

model used for con

model problem is de

> We are given
> given produ
> transportatio
> Under this
> equilibrium
> each locatio

Most models

the objective functi

curves, minus the a

function is then co

region must be less

region must be less

between regions m

solution to the prob

and trade flows be

commodity market

Programming

of commodity mar

and marketing a sp

of periods. The ob

regions are equal

2.1.3.2 Spatial Equilibrium Models and Programming Models

Spatial price equilibrium models are the most common form of agricultural trade model used for comparative static analysis of policy changes. The spatial equilibrium model problem is described by Takayama and Judge (1971) as follows:

> We are given in each of two or more regions demand and supply functions for a given product in terms of its market price at that location. In addition, unit transportation costs are also given for carrying the product between the locations. Under this specification we would like to know what will be the (i) competitive equilibrium price in each location, (ii) the amount of supplied and demanded at each location, and (iii) level and pattern of exports and imports.

Most models of this type are solved using quadratic programming. In these models the objective function is given by the maximization of the area under all excess demand curves, minus the area under all excess supply curves, minus transportation costs. This function is then constrained by the following requirements: (i) the quantity entering a region must be less than or equal to the quantity demanded, (ii) the quantities leaving a region must be less than or equal to the quantities supplied, and (iii) price differences between regions must not be greater than the transportation costs between them. The solution to the problem gives prices and quantities demanded and supplied in each region and trade flows between them. Such models have been applied to many agricultural commodity markets.

Programming techniques are also used in transportation and plant location studies f commodity markets. The objective function is minimization of the costs of producing nd marketing a specific amount of commodity in a given time period or over a number f periods. The objective function is constrained in that the total supplies of the producing gions are equal to the total demands of the consuming regions, and that for any intermediate node (e

node is equal to the

additional constraints

Some programming

establishing a new p

solved using mixed i

2.1.3.3 <u>Time Series</u>

A method co

Time series models

applications to polic

Orden and Fackler

following componen

observations on the

lagged random distu

variable are explain

However, more ofte

in a mixed autoregre

generating the vari

values, as well as a

economic data seri

---

[1] For example, Palaskas and Var
...ing one time.

intermediate node (e.g., transhipment region or processing plant) the quantity entering the node is equal to the quantity leaving the node. Optimal plant location models contain additional constraints limiting the amount of product passing through each processing plant. Some programming models contain zero-one variables allowing the fixed costs of establishing a new processing unit to enter the objective function. This class of model is solved using mixed integer programming.

2.1.3.3 Time Series Models

A method commonly used in commodity market modeling is time series analysis. Time series models have been used mainly for forecasting, although, more recently, applications to policy analysis have appeared in the literature (e.g., Myers et al (1991); Orden and Fackler (1989)). Time series models typically contain one or both of the following components, (i) a moving average model, in which the process generating observations on the variable are described completely by a weighted sum of current and lagged random disturbances; and (ii) an autoregressive model, in which the values of the variable are explained by the weighted sum of its past values and a random disturbance. However, more often, the moving average and autoregressive representations are combined in a mixed autoregressive-moving average model (ARMA model). In this case the process generating the variable is a function of both lagged random disturbances and its past values, as well as a current disturbance term (Pindyck and Rubinfeld (1981)). Often economic data series are found to be non-stationary[3]. When this is the case the ARMA

---

[3] ...mple, Palaskas and Varangis (1989) found that most commodity prices series are I(1). That is, they are stationary after ...one time.

representation is no

or more times to ob

model can be estim

integrated to obtain

autoregressive-movin

macroeconomic and

Another clas

This model has bec

model is given by th

Where: u_t = a (nx1)

identity covariance

contemporaneous in

defining dynamic in

From the eq

determined by curr

The model differs f

there are no exoge

variables. Second,

proponents of such

data, the true struc

restrictions normall

epresentation is no longer valid. However, non-stationary series can be differenced one r more times to obtain a stationary series and a mixed autorregressive-moving average nodel can be estimated with the differenced data. Forecasts from this model can be ntegrated to obtain forecasts in terms of the levels of the variable. Such integrated utoregressive-moving average models (ARIMA) have been applied widely to forecast acroeconomic and agricultural variables (Pindyck and Rubinfeld (1981)).

Another class of time series model is vector autoregression (VAR) (Sims, 1980). nis model has become a popular tool for forecasting. The basic structure of a VAR odel is given by the equation 2.1.

$$By_t=\sum_{i=1}^{m} B_i y_{t-1}+Au_t \qquad (2.1)$$

nere: u_t = a (nx1) vector of zero mean, serially uncorrelated disturbance terms with an ntity covariance matrix; A and B are (nxn) parameter matrices representing ntemporaneous interrelationships among y_t and u_t; and B_i are (nxn) parameter matrices ining dynamic interactions among y_t (Myers et al (1991)).

From the equation we see that current values of the endogenous variables are ermined by current and lagged values of all the endogenous variables in the system. model differs from a standard simultaneous model in two important respects. First, e are no exogenous variables in the system explaining variability in the endogenous ables. Second, there are no restrictions placed on the lagged variables. Also, onents of such models argue that by imposing minimal restrictions on the economic , the true structure of the economic system is revealed and that the over-identifying ictions normally imposed on structural models are overly-constraining and their validity often untested (Myer

While VAR m

problems in applicat

Sims (1986) discusses

One is that,

> such models
> usually based
> into a useful
> of policy cho
> understand t

Another argument is

Sargent (1984) claim

system and therefor

(1986) argues that th

models to guide po

greater structure is i

model type should n

Studies in whi

in recent literature

entails first setting u

by B^{-1} gives the red

where $C_i = B^{-1}B^i$ fo

This discussion of VAR models

often untested (Myers et al (1991), Fackler (1988)).

While VAR models have been used widely for forecasting, critics have pointed to problems in applications to policy analysis (e.g., Sargent (1979) and Leamer (1985)). Sims (1986) discusses arguments against the use of forecasting models for policy analysis. One is that,

> such models are nothing more than summary descriptions of the historical data, usually based on sample correlations. While such a description can be extrapolated into a useful forecast, supposing that it can be the basis for projecting the effects of policy choice amounts to taking correlations to indicate causation, which we all understand to be fallacious (Sims, 1986. p.2).

Another argument is that policy variables are treated as random variables in VAR models. Sargent (1984) claims that policy decisions are rarely made without regard to the economic system and therefore should not be treated as exogenous to the model. However, Sims (1986) argues that these arguments do not constitute an objection to the use of forecasting models to guide policy choice. VAR models differ from econometric models in which greater structure is imposed merely from differences in identifying interpretations, and one model type should not be considered superior based on theoretical criteria.

Studies in which VAR models have been used for policy analysis have been reported n recent literature (e.g., Myers et al (1991); Orden and Fackler (1989)). The procedure ntails first setting up a VAR model as in equation 2.1. Next, premultiplying equation 2.1 y B^{-1} gives the reduced form equation 2.2[4].

$$y_t=\sum_{i=1}^{m} C_i y_{t-i}+v_t \tag{2.2}$$

here $C_i = B^{-1}B^i$ for $i=1,2,....,m$; and $v_t = B^{-1}Au_t$. This equation is used to estimate the

cussion of VAR models is based largely on Myers et al.

covariance matrix of

The equation 2.2 is

covariance matrix (e

be expressed as equ

The likelihood funct

A and B. This ofte

in order for the nu

of unique paramete

a priori information

be set equal to zero

Policy analysi

Analysis (IRA) or

average representa

where $D_0 = B^{-1}A$; f

and, the matrices I

ovariance matrix of the reduced form disturbances (equation 2.3).

$$\Omega = B^{-1}AA'B^{-1} \tag{2.3}$$

The equation 2.2 is estimated using OLS. Then, assuming normality and employing the covariance matrix (equation 2.3), the log-likelihood for a set of T observations on y_t can be expressed as equation 2.4.

$$\Lambda = -0.5T\log|B^{-1}AA'B^{-1'}| - 0.5\sum_{t=1}^{T} v_t'B'A^{-1'}A^{-1}Bv_t. \tag{2.4}$$

The likelihood function is maximized to obtain estimates of the VAR parameter matrices A and B. This often requires that identification restrictions be placed on these matrices, in order for the number of estimated parameters in A and B to be equal to the number of unique parameters in the covariance matrix of the VAR. Restrictions can be based on a priori information of the structure of the market, allowing some elements of A and B to be set equal to zero.

Policy analysis can be undertaken with VAR models with either Impulse Response Analysis (IRA) or Forecast Error Variance Decomposition (FEVD). For IRA, a moving average representation of equation 2.2 is derived as equation 2.5.

$$y_t = \sum_{i=0}^{\infty} D_i u_{t-i} + f(t) \tag{2.5}$$

here $D_0 = B^{-1}A$; f(t) is a function of t that is identically zero if y_t is covariance stationary; d, the matrices D_i (i=1,2,....) can be computed from the recursion (equation 2.6), Equations 2.5 and 2.

variables y_t. For FE

A and B (from equ

prediction errors for

structural shock in u

Myers <u>et al</u> (1

policy shocks on de

industry. Orden ar

variables (such as mo

and agricultural pric

these macroeconomi

2.1.3.4 <u>Other Classe</u>

Hybrid prog

model, often involvi

supply side of some

demand is derived

fisheries sector are

Optimization

1970s as a result o

$$D_i = \sum_{j=1}^{\min(i,m)} C_j D_{i-j} \tag{2.6}$$

Equations 2.5 and 2.6 are used to show the impact of a shock in one element of u_t on the variables y_t. For FEVD, the covariance matrix of v_t depends on the parameter matrices A and B (from equation 2.3), which can be used to decompose the variance of the prediction errors for each element of y_t into components due to the variance of each structural shock in u_t.

Myers et al (1991) provide IRA and FEVD for the effects of demand, supply and policy shocks on demand, supply, price, and producer revenue in the Australian wool industry. Orden and Fackler report IRA for the effects on various macroeconomic variables (such as money supply, oil price, price level, output, interest rates, exchange rates, and agricultural prices), of shocks to the money supply; and for the effects of shocks to these macroeconomic variables on agricultural prices and general price levels.

2.1.3.4 Other Classes of Models

Hybrid programming models combine many different modeling methods in a single model, often involving the modeling techniques of other disciplines. For example, the supply side of some energy models are developed from engineering criteria, while the demand is derived econometrically. Similarly the supply side of many models of the fisheries sector are developed from biological growth models.

Optimization models were developed in response to the oil price shocks in the early '70s as a result of the non-competitive behavior of the institutions involved in oil production and cons

behavior based on t

forms of market stru

models using this tec

System Dyna

some form of cyclica

from a variety of sou

applied to livestock,

Input-Outpu

transformed into ou

primary commodity

consumption patter

macroeconomic vari

mineral markets, as v

income multipliers)

2.2 Modeling the W

2.2.1 The Cotton a

In order to

understanding of th

determinants of pro

are the most impor

these need to be gi

production and consumption. These models can be employed to model non-competitive behavior based on the Cournot equilibrium concept and can accommodate alternative forms of market structure ranging from the competitive market to monopoly. Most of the models using this technique have been applied to the oil market.

System Dynamics models have been applied to commodity markets which contain some form of cyclical behavior in production and prices. These models utilize information from a variety of sources including econometrics, engineering and biology and have been applied to livestock, oil, coal, and copper markets.

Input-Output models are used to analyze how resources in the form of inputs are transformed into outputs. However, they can not be used to explain the behavior of primary commodity markets. Instead they provide information on how production and consumption patterns for different commodities relate to industry structure or macroeconomic variables. Input-Output models have been applied mainly to energy and mineral markets, as well as to the measurement of economic impacts (e.g., employment and income multipliers) of an industry in a region.

2 Modeling the World Cotton and Non-Cellulosic Fibers Markets

2.1 The Cotton and Non-Cellulosic Fibers Market

In order to choose the correct model structure it is essential to have a full understanding of the cotton and non-cellulosic fibers markets, and especially of the determinants of production, consumption and prices. It is also important to decide which the most important producing and consuming countries and regions of the world, as these need to be given special attention in the model structure. This section provides a brief overview of the

account in the mode

2.2.1.1 Cotton Prod

Cotton is prod

40 degrees south. T

widely in terms of si

crops, such as soyb

relationship between

tends to be the ma

production has exp

improvements in co

Improved yields hav

and machinery costs

42%, while the area

resulted from consi

wider use of fertili

acreage. Cotton is

order to separate th

The major cot

quantities produced

increased from 12

increase occurring b

rief overview of the major features of the world fiber market which must be taken into ccount in the model's structure.

.2.1.1 Cotton Production

Cotton is produced in over 80 countries, spread widely between 40 degrees north and 0 degrees south. The types of farm on which cotton is grown are heterogeneous, ranging videly in terms of size, soil type and technology use. Cotton competes with other arable rops, such as soybeans, rice and coarse grains for farm resources and therefore the elationship between the price of cotton and the prices of these competing commodities ends to be the major determinant of the area planted to cotton. Over time, world roduction has expanded rapidly. This has been associated mainly with significant nprovements in cotton yields in most of the cotton producing countries of the world. nproved yields have maintained gross margins in cotton production despite higher labor id machinery costs. Between 1970 and 1989, world average cotton yields have increased %, while the area planted has expanded only 7%. The improvement of average yield sulted from considerable successes in the development of improved seed varieties, the der use of fertilizers and chemical treatments, and the expansion of irrigated cotton eage. Cotton is harvested in the form of seedcotton and is then processed (ginning) in ler to separate the seeds from the fiber or lint.

The major cotton producing countries and regions are shown in Table 2.1, along with ntities produced at five year intervals since 1970. World cotton production has eased from 12 million tons in 1970 to 17.5 million tons in 1989, with most of the ase occurring between 1975 and 1985 when production grew almost 50%. Most of the expansion occurred i

and 1989. In compa

As a result, the prop

about 60% in 1970

Of the devel

increasing slowly in

and 1980s, China en

more than 50% be

incentives to grower

appear that produ

fluctuated widely be

government. India

Between 1970 and

almost three-fold. I

greater availability

xpansion occurred in the developing countries where output increased 60% between 1970 nd 1989. In comparison, production of the industrialized countries increased only 23%. As a result, the proportion of world output supplied by the developing countries grew from bout 60% in 1970 to 67% in 1989.

Of the developing countries, production has risen most rapidly in Asia, while ncreasing slowly in South and Central America and stagnating in Africa. During the 1970s nd 1980s, China emerged as the world's leading producer and increased its production by nore than 50% between 1980 and 1985 following the introduction of favorable price ncentives to growers, as well as improved access to farm inputs. From Table 2.1 it may ppear that production stabilized between 1985 and 1989. In fact, production has luctuated widely between years as a result of unstable producer prices which are set by the overnment. India and Pakistan have also dramatically increased their cotton production. etween 1970 and 1989, production in India almost doubled, while in Pakistan it grew lmost three-fold. In both cases the expansion can be attributed to yield improvements and eater availability of inputs.

Table 2.1 Cotton Pr

Region
Industrialized
N.America
United States
Europe
EEC
East Europe
USSR
Asia/Oceania
Australia
Japan
Developing
Africa
Egypt
Central Africa
Asia/Oceania
China
India
Korea,Rep
Pakistan
Turkey
S.& Cent America
Argentina
Brazil
Mexico
World

Source: USDA. W

Table 2.1 Cotton Production by Major Countries and Regions, 1970-1989, '000 Tons.

Region	1970	1975	1980	1985	1989
Industrialized	4,772	4,556	5,648	6,067	5,887
N.America	2,220	1,808	2,422	2,925	2,632
United States	2,220	1,808	2,422	2,925	2,632
Europe	2,532	2,723	3,127	2,885	2,928
EEC	165	173	174	238	303
East Europe	22	22	13	12	12
USSR	2,345	2,528	2,940	2,634	2,613
Asia/Oceania	20	25	99	257	327
Australia	20	25	99	257	327
Japan	0	0	0	0	0
Developing	7,272	7,247	8,503	11,126	11,656
Africa	1,267	985	1,144	1,256	1,290
Egypt	509	382	529	435	283
Central Africa	263	381	501	697	821
Asia/Oceania	4,677	4,991	5,703	8,239	8,545
China	2,287	2,374	2,701	4,138	4,138
India	1,017	1,184	1,374	1,829	1,960
Korea,Rep	5	3	3	1	0
Pakistan	544	623	719	1,241	1,546
Turkey	400	480	500	518	599
S.& Cent America	1,328	1,271	1,656	1,631	1,821
Argentina	84	140	85	110	218
Brazil	490	395	622	820	751
Mexico	316	196	347	209	174
World	12,004	11,803	14,151	17,193	17,543

Source: USDA. World Cotton Situation, FAS, Various Issues.

The rise in pro

The major producer

95% of the total ind

the United States an

the Australian cotto

leading industrialize

2.2.1.2 Cotton Con

Cotton fibers

manufactured textil

common, mixed wit

to give the fabric d

competes most stro

reflects the relative

total world fiber co

made up 40% of th

for 10% and 5%, r

The major

with quantities con

risen steadily, incre

world consumption

developing countri

The rise in production in the industrialized countries has been much less dramatic. The major producers are the United States and the USSR which together supply about 95% of the total industrialized countries' output. Between 1970 and 1989, production in the United States and the USSR increased 19% and 16%, respectively. During this period, the Australian cotton sector became established and Australia is now third among the leading industrialized cotton growing countries, producing over 325,000 tons in 1989.

2.2.1.2 Cotton Consumption

Cotton fibers are consumed directly by the textile industry for processing into manufactured textile and clothing items. Cotton is used as a sole fiber or else, as is more common, mixed with other natural or non-cellulosic fibers. Manufacturers use fiber blends to give the fabric desired characteristics such as strength, durability and comfort. Cotton competes most strongly with polyester and rayon fibers and manufactures' consumption reflects the relative prices of these different fibers. In 1989, cotton contributed 45% to total world fiber consumption, while the non-cellulosic fibers (acrylic, nylon and polyester) made up 40% of the market. The cellulosic fibers (acetate and rayon) and wool accounted for 10% and 5%, respectively.

The major cotton consuming countries and regions are shown in Table 2.2 along with quantities consumed at five year intervals since 1970. World cotton consumption has risen steadily, increasing from 12.5 million tons in 1970 to 18.5 million tons in 1989. The world consumption expansion has been driven by the rapid increase in consumption in the developing countries.

Table 2.2 Cotton C

Region
Industrialized
N.America
United States
Europe
EEC
East Europe
USSR
Asia/Oceania
Australia
Japan
Developing
Africa
Egypt
Central Africa
Asia/Oceania
China
India
Korea,Rep
Pakistan
Turkey
S.& Cent America
Argentina
Brazil
Mexico
World

Source: USDA. W

Table 2.2 Cotton Consumption by Major Countries and Regions, 1970-1989, '000 Tons.

Region	1970	1975	1980	1985	1989
Industrialized	6,495	6,297	6,039	6,359	6,605
N.America	1,862	1,632	1,342	1,448	1,746
United States	1,787	1,579	1,283	1,394	1,697
Europe	3,838	3,948	3,957	4,205	4,137
EEC	1,263	1,204	1,077	970	1,287
East Europe	705	738	788	829	751
USSR	1,786	1,917	1,993	2,091	1,982
Asia/Oceania	795	717	740	706	722
Australia	31	28	22	21	25
Japan	764	689	718	685	697
Developing	5,983	7,185	8,361	9,898	11,821
Africa	431	528	656	742	758
Egypt	203	232	326	337	283
Central Africa	68	88	117	154	163
Asia/Oceania	4,778	5,695	6,672	7,938	9,836
China	2,287	2,505	3,289	3,811	4,356
India	1,136	1,364	1,398	1,566	1,851
Korea,Rep	120	199	315	370	457
Pakistan	442	467	445	510	926
Turkey	175	290	296	451	599
S.& Cent America	774	962	1,033	1,218	1,227
Argentina	105	116	83	114	120
Brazil	303	430	550	675	849
Mexico	155	174	160	146	147
World	12,478	13,482	14,400	16,251	18,426

Source: USDA. World Cotton Situation, FAS, Various Issues.

Between 1970 and 1
in the industrialized
consumption by the

Consumptio
example, China now
1970s India replace
Asian countries suc
have all expanded t
world manufacture
United States and E
the abundant supp
advantage in produ
countries prompted
Fiber Arrangement
resulted in higher
almost three-fold si
countries. In contr
States, the EEC, th

2.2.1.3 Cotton Pri

While there
there are a great n
or region which h

Between 1970 and 1989 the developing countries almost doubled their consumption, while in the industrialized countries it changed little. As a result, the proportion of world consumption by the developing countries increased from 48% in 1970 to 64% in 1989.

Consumption growth in the developing countries of Asia has been dramatic. For example, China now consumes almost one-quarter of the world's cotton, while since the late 1970s India replaced the United States as the third largest consumer of cotton. Other Asian countries such as Hong Kong, Singapore, Bangladesh, Taiwan, Thailand and Korea have all expanded their consumption substantially. The Asian region now dominates the world manufactured textile and clothing sector, replacing the traditional centers of the United States and Europe. Because of the labor intensive nature of textile production and the abundant supply of cheap labor, the Asian countries have found a comparative advantage in producing textile products. The loss of market share in the industrialized countries prompted the establishment of a system of tariffs and quotas (e.g., the Multi-fiber Arrangement). In other developing countries the availability of cheap labor also resulted in higher demand for cotton. For example, Brazil increased its consumption almost three-fold since 1970, while demand grew in Egypt and many of the central African countries. In contrast, the major consumers of the industrialized countries (i.e., the United States, the EEC, the USSR and Japan) changed their consumption little.

1.3 Cotton Price Determination

While there are a few major cotton producing and consuming countries and regions, there are a great many participants in the world fiber market. There is no single country or region which has either monopolistic or monopsonistic control over the market and there is freedom to e

homogenous commo

established and rec

framework is applica

Given a com

according to the lev

clearly in the relatio

Figure 2.2. As wor

1980 and 1981; and

1983; and 1985 and

in recent years thes

The 'world p

Cotton Outlook "A

Europe'[5]. The pric

cotton throughout t

and paid. The cotto

standards. Price c

marketing system

handlers. Tradition

factors for determi

that influence proc

---

[5] This price is the one reported
Special Statistics publications.

there is freedom to enter and exist the market at fairly low cost. Further, cotton is a fairly homogenous commodity and international grading and standards of cotton quality are well established and recognized. These conditions indicate that the competitive market framework is applicable to the cotton market.

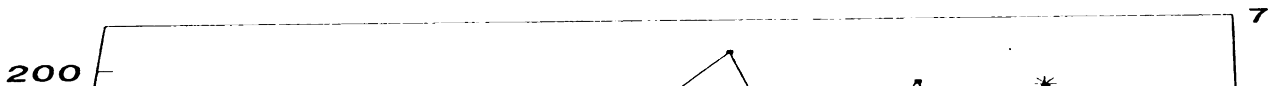
Given a competitive market framework, the price of cotton is expected to move according to the levels of production and consumption in the market. This is borne out clearly in the relationship between world price and world ending stocks which is shown in Figure 2.2. As world stocks increase, the world price falls (e.g., between 1976 and 1977; 1980 and 1981; and 1983 and 1985) and vice versa (e.g., between 1977 and 1980; 1981 and 1983; and 1985 and 1986). In Figure 2.2 world stocks exclude stocks held in China because n recent years these have been isolated from world markets.

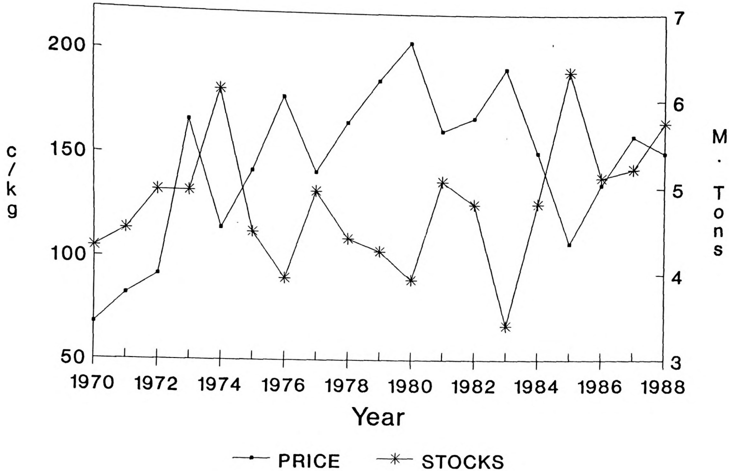
The 'world price' of cotton is generally accepted by market participants to be the Cotton Outlook "A" Index c.i.f price for middling 1&3/32" staple quoted for North urope[5]. The price is based on market intelligence provided by buyers and sellers of otton throughout the world, who provide information on a daily basis on the prices offered nd paid. The cotton market has a well established set of quality specifications and grading andards. Price determination based on well-known quality factors at all stages of the arketing system is necessary for transmitting the correct incentives to producers and ndlers. Traditionally, grade and staple length have been the most commonly used quality ctors for determining cotton's trading price. However, more recently, fiber characteristics it influence processing performances have earned a premium.

---

ce is the one reported by the World Bank in Price Prospects for Primary Commodities, and by the IMF in the International stics publications.

Fig. 2.2 World Cotton Price and Stocks
1970-1988 1/





1/ World Stocks Excluding China

2.2.1.4 Manufacture

The manufac

acetate and triaceta

cellulosic fibers dom

the non-cellulosic fi

fibers production

production. In co

fibers production a

In the 1930

production centere

cellulosic fibers inc

1960s, the producti

the place of cellulo

was largely the res

countries since the

pulp and energy, t

faced stiff price c

1980s, cellulosic f

However, producti

some developing c

World con

per capita world c

kg per year. Th

2.2.1.4 Manufactured Fibers Market

The manufactured fibers market includes the markets for cellulosic fibers (rayon, acetate and triacetate) and non-cellulosic fibers (nylon, polyester and acrylic). While cellulosic fibers dominated in the early stages of manufactured fiber development, recently the non-cellulosic fibers have become more important. In 1988, 83% of the manufactured fibers production was non-cellulosic fibers amounting to 45% of total world fiber production. In contrast, cellulosic fibers production contributed 17% to manufactured fibers production and only 8% to total fiber production.

In the 1930s, manufactured fiber production was mainly of cellulosic fibers with production centered in the United States and Western Europe. World production of cellulosic fibers increased to over 2 million tons in the 1950s and 1960s. However, in the 1960s, the production of non-cellulosic fibers (mainly polyester and acrylic) began to take the place of cellulosic fibers in textile products. The decline in cellulosic fiber production was largely the result of pervasive decreases in production capacity in the industrialized countries since the early 1970s. The cause of this decline was the increased cost of wood pulp and energy, the main inputs into cellulosic fiber production. Also, cellulosic fibers faced stiff price competition from cotton fibers during the 1960s and 1970s. During the 1980s, cellulosic fiber production continued to fall to about 1 million tons in 1989. However, production remained important in Eastern Europe and the USSR, as well as in some developing countries such as India and China.

World consumption of cellulosic fibers has fallen along with production. In 1970, per capita world consumption was 1 kg per year, while in 1988 it had fallen to below 0.5 kg per year. The decline in consumption occurred since the 1950s in industrialized countries, Africa an

USSR.

The major no

along with quantiti

increased from 4.7 r

by the developing co

5.2 million tons in

developing countrie

production capacity

especially in China,

to be dominated by

sharply, declining f

USSR and Eastern

currently supply ab

The major r

2.4 along with quar

there is no stock-h

imports. As indi

significantly since

and Western Euro

declined followin

developing countr

China, which by 1

ountries, Africa and Latin America, since 1970 in East Europe, and since 1980 in the SSR.

The major non-cellulosic producing countries and regions are shown in Table 2.3 ong with quantities produced at five year intervals since 1970. World production creased from 4.7 million tons in 1970 to 14.2 million tons in 1988. Production expansion the developing countries has been dramatic, increasing from 0.3 million tons in 1970 to 2 million tons in 1988. In 1970, 6% of total world production was produced by veloping countries and by 1988 their share had risen to over 36%. Rapid expansion of oduction capacity caused the production growth to be particularly strong in Asia and pecially in China, India and Korea. Production in the industrialized countries continues be dominated by the United States although its share of total world supplies has fallen arply, declining from 86% in 1970 to 63% in 1988. The non-market economies of the SR and Eastern Europe have also increased their production of non-cellulosic fibers and rently supply about 10% of the world market.

The major non-cellulosic fibers consuming countries and regions are shown in Table along with quantities available for consumption at five year intervals since 1970. Since e is no stock-holding of non-cellulosic fibers, availability is given by production plus net orts. As indicated earlier, the consumption of non-cellulosic fibers has increased ificantly since 1970. The main consuming areas in the 1970s were the United States Western Europe. Throughout the 1970s and 1980s the market share of these regions ined following the rapid development of textile manufacturing capacity in the loping countries. The most important consumer to emerge during the 1980s was a, which by 1988 had exceeded the consumption level of Western Europe.

Table 2.3 Non-cellu

'000 Tons

Region
Industrialized
N.America
United States
West Europe
Germany
Italy
Spain
United Kingdom
Japan
Others
Non-Market
USSR
East Europe
Developing
S.& Cent. Americ
Brazil
Mexico
Asia
China
India
Korea, Rep
Africa
World

Source: Textile O

Table 2.3 Non-cellulosic Fibers Production by Major Countries and Regions, 1970-1988, '000 Tons

Region	1970	1975	1980	1985	1988
Industrialized	4,044	5,421	6,861	6,893	9,007
N.America	1,573	2,541	3,364	2,997	3,281
United States	1,509	2,445	3,242	2,864	3,147
West Europe	1,475	1,839	2,128	2,478	2,565
Germany	492	625	720	762	759
Italy	214	277	355	563	565
Spain	64	119	202	275	268
United Kingdom	337	361	288	243	197
Japan	970	1,021	1,357	1,403	1,360
Others	25	21	12	16	63
Non-Market	355	792	1,139	1,412	1,738
USSR	167	362	550	413	868
East Europe	188	430	589	699	870
Developing	302	1,139	2,476	4,194	5,232
S.& Cent. America	147	395	612	699	783
Brazil	44	126	321	217	240
Mexico	47	155	239	306	345
Asia	136	718	1,797	3,369	4,299
China	52	280	806	1,756	2,398
India	16	33	70	194	321
Korea, Rep	43	263	536	812	1,115
Africa	19	26	66	127	150
World	4,700	7,353	10,476	12,499	14,239

Source: Textile Organon. Various Issues.

Table 2.4 Non-cellu

'000 Tons

Region
N.America
United States
West Europe
France
Germany
Italy
United Kingdom
East Europe a/
USSR
China b/
India
Indonesia
Korea Rep.
Japan
Other Asia
S. & Cent. Ameri
Brazil
Mexico
Africa

Source: Textile Or

a/ Data for only E

b/ Includes Taiwa

Table 2.4 Non-cellulosic Fibers Consumption by Major Countries and Regions, 1970-88, '000 Tons

	Production Plus Net Imports				
Region	1970	1975	1980	1985	1988
N.America	1,719	2,476	2,922	3,068	3,001
United States	1,619	2,332	2,746	2,857	2,978
West Europe	1,343	1,639	1,832	2,053	2,193
France	175	205	206	247	242
Germany	324	332	368	379	341
Italy	194	239	313	423	434
United Kingdom	269	335	233	287	363
East Europe a/	NA	189	240	807	764
USSR	NA	NA	NA	790	879
China b/	NA	NA	NA	2,000	2,280
India	22	44	90	232	252
Indonesia	NA	95	124	206	212
Korea Rep.	81	272	514	783	916
Japan	772	604	1,046	1,000	1,043
Other Asia	75	513	866	519	309
S. & Cent. America	176	448	680	700	791
Brazil	55	142	241	236	246
Mexico	48	158	251	230	292
Africa	35	38	167	164	175

ource: Textile Organon. Various Issues.

/ Data for only Hungry and Poland in 1975 and 1980.
/ Includes Taiwan

2.2.2 Model Structu

From this br

various types of com

2.1.3.1. was the mo

structure characteri

allows the forecasti

An overview

cotton is determine

of world production

defined in the mo

Regional cotton co

consumption and t

is derived as the pr

fiber consumption.

behaviorally as fu

determined by inc

fibers is estimated

the polyester pric

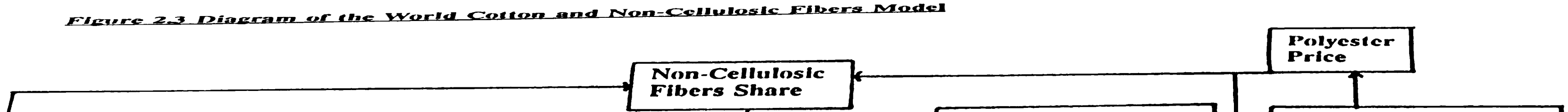
World region (the

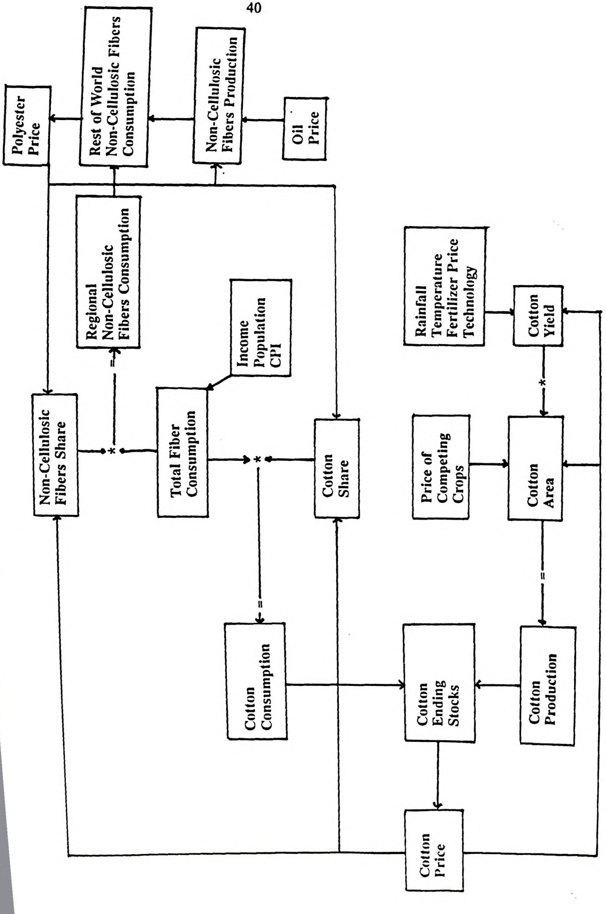
2.2.2 Model Structure and Specification

From this brief review of the world fiber market and from the discussion of the various types of commodity model, it appeared that the market model discussed in section 2.1.3.1. was the most appropriate form. The competitive nature and overall market structure characteristics of the fiber markets are well suited to this model class, which also allows the forecasting and policy analysis objectives of the study to be met.

An overview of the model is presented in Figure 2.3. As shown there, the price of cotton is determined by the level of world cotton stocks which is derived as the residual of world production plus ending stocks less consumption. Cotton production in each region defined in the model is derived from behavioral equations for yield and area levels. Regional cotton consumption is derived as the product of cotton's share of total fiber consumption and total fiber consumption. Similarly, the demand for non-cellulosic fibers is derived as the product of non-cellulosic fibers' share of total fiber consumption and total fiber consumption. The cotton and non-cellulosic fibers' share equations are estimated behaviorally as functions of cotton and polyester prices; and total fiber consumption is determined by income, population and general price levels. The supply of non-cellulosic fibers is estimated at the world level as a function of polyester and crude oil prices, while the polyester price is estimated using an inverted demand equation for the Rest-of-the-World region (there are no non-cellulosic fibers stocks).

Figure 2.3 Diagram of the World Cotton and Non-Cellulosic Fibers Model




Polyester Price
Rest of World Non-Cellulosic Fibers Consumption
Non-Cellulosic Fibers Production
Oil Price
Regional Non-Cellulosic Fibers Consumption
Income Population CPI
Rainfall Temperature Fertilizer Price Technology
Non-Cellulosic Fibers Share
Total Fiber Consumption
Cotton Share
Price of Competing Crops
Cotton Yield
Cotton Area
Cotton Consumption
Cotton Ending Stocks
Cotton Production
Cotton Price
*
=

2.2.3 Choice of Est

From the dis

to be the most app

by Monte Carlo exp

In the first

regressing current e

many models (inclu

exceeds the numbe

of 2SLS. To overc

used as regressors

of exogenous varia

> is to select
> endogenous
> variables b

This approach wa

knowledge of the r

markets[6].

2.2.4 Model Valid

A number

estimation stages

the model's ability

[6] Alternatively, principle com
ount of the variability in the set
is technique to be consistent th
ression of the first stage.

.2.3 Choice of Estimator

From the discussion of estimation techniques given in section 2.1.2, 2SLS appeared
 be the most appropriate to avoid the inconsistency of OLS. This choice is supported
y Monte Carlo experiments summarized by Intriligator (1978).

In the first stage of the 2SLS procedure, instrumental variables are created by gressing current endogenous variables on all exogenous variables within the system. For any models (including the one developed in this study) the number of exogenous variables ceeds the number of observations and the degrees of freedom problem prevents the use 2SLS. To overcome this problem a subset of exogenous variables can be selected and ed as regressors in the first stage. No hard and fast rules exist on how to choose the set exogenous variables used in the first stage. Intriligator suggests one criterion:

> is to select only those exogenous variables that are most closely related to the endogenous variable in the equation, excluding from each equation those exogenous variables believed to be unimportant on the basis of a priori considerations.

s approach was taken in this study with the set of instruments chosen based on wledge of the relationships between variables within the cotton and non-cellulosic fibers kets[6].

4 Model Validation

A number of validation statistics were performed after the specification and nation stages of the model building were successfully completed. The tests evaluated model's ability to reproduce actual data and to respond to external shocks in a way

ely, principle components can be created which are themselves instrumental variables and which capture a specified riability in the set of exogenous variables. The principle components are then used as regressors in the first stage. For be consistent the exogenous regressors on the right-hand side of the equations must be included explicitly in the first stage.

consistent with econ

included: (i) the Ro

Error (MSE), (iii)

to withstand these

it could be used fo

the results for the

2.2.5 Model Simul

Forecast a

objectives set out

forecast of price,

decrease in cotton

China, (iv) a 10%

evaluation of the

sectors. The Gau

The results

or elasticities. M

model is linear) a

an exogenous var

model simulation

an exogenous var

long-run multipl

variable on an en

:onsistent with economic theory and empirical observation. The validation statistics derived ncluded: (i) the Root Mean Squared Percentage Error (RMSPE), (ii) the Mean Squared :rror (MSE), (iii) Theil's U-statistic, and (iv) graphical validation. If the model was able ɔ withstand these testing procedures and to predict actual market values accurately, then could be used for policy experiments and forecasting. A description of these tests and ıe results for the fiber model are reported in full in section VII.

2.5 Model Simulation

Forecast and policy simulations were undertaken in order to meet the study ɪjectives set out in the introductory section. Five simulations were performed for (i) a recast of price, production and consumption for the period 1990-2005, (ii) a 10% crease in cotton production in the USSR, (iii) a 10% increase in cotton production in ıina, (iv) a 10% decline in domestic cotton price in the United States, and (v) an ɪluation of the Multi-Fiber Agreement (MFA) on the cotton and non-cellulosic fibers tors. The Gauss-Seidel method was used to produce the simulation results.

The results of shocking the model could be expressed in terms of either multipliers elasticities. Multipliers can be calculated using matrix manipulation (providing the del is linear) and show the change in an endogenous variable for a one unit change in exogenous variable (Labys, 1973). Three types of multipliers can be presented in the del simulation results. First, impact multipliers show the effect of a one unit change in exogenous variable on an endogenous variable within the same time period. Second, -run multipliers show the effect of a sustained one unit change in an exogenous ıble on an endogenous variable given a time period long enough for full adjustment to take place. Third,

variable, t-time peri

variable. Consequ

multipliers.

Elasticities

change in an exoge

elasticity can be c

percentage change

In this stud

the basic tool of a

the units in which

of policy changes a

and insensitive to

2.3 Summary

In order t

markets and to a

described in secti

markets was chos

The vari

discussed which

validation, and f

models were rev

take place. Third, cumulative multipliers show the effects on values of an endogenous variable, t-time periods ($t=2,3,...,n$), following a sustained one unit change in an exogenous variable. Consequently they show the adjustment between the impact and long-run multipliers.

Elasticities show the percentage change in an endogenous variable for a one percent change in an exogenous variable or in other endogenous variables. Again, three types of elasticity can be calculated to show initial, cumulative and final effects of a sustained percentage change in an exogenous variable.

In this study the results are reported chiefly in terms of elasticities and provided the basic tool of analysis. Multipliers are not employed because their values depend on the units in which the variables are measured making it difficult to tell whether the effects of policy changes are large or small. Elasticities, however, are ratios of percentage changes and insensitive to the units in which the data are measured.

2.3 Summary

In order to understand and predict better the cotton and non-cellulosic fibers markets and to assess the impact of each of the market developments and policy issues described in section I, an econometric model of the world cotton and non-cellulosic fibers markets was chosen as the most suitable research method.

The various steps and stages involved in commodity market modeling were discussed which include model structure, equation specification and estimation, model validation, and finally, model simulation. Then the different types of commodity market models were reviewed briefly. This review suggested that an econometrically estimated market model was

Then the stages of

the world fiber ma

As far as th

market of the det

analyzing the ques

market, and shoul

world textile and f

market model was the most flexible and best suited for addressing the problem at hand. Then the stages of commodity model building were discussed with respect to the model of the world fiber market developed in this study.

As far as the author is aware, there are no econometric models of the world fiber market of the detail and country coverage presented below. Therefore, in addition to analyzing the questions posed above, this study is unique in modeling the world fiber market, and should be of interest to other research institutions involved in analyzing the world textile and fiber industry.

In this sectio

econometrically-esti

modeling cotton de

differing results--es

sensitive to model c

with (i) the develo

and apparel man

government interv

determination, MF

3.1 Features of C

There are a

different from mo

theoretical rationa

is demanded by th

other manufacture

fact that manufac

of cotton and poly

insensitive to diff

to the prices of i

in general, the fi

3. Cotton Demand

In this section the method used to explain the demand for cotton in terms of onometrically-estimated equations is presented. Previous attempts have shown that odeling cotton demand is a formidable task. Empirical analysis has often led to widely ffering results--especially in the estimation of income and price elasticities--and seems nsitive to model construction and specification. Monke (1981) associates these difficulties h (i) the development of manufactured fibers, (ii) cotton's role as an input into textile d apparel manufacturing, (iii) variations in cotton quality, and (iv) widespread vernment intervention in cotton production and trade (e.g., input subsidies, price ermination, MFA).

Features of Cotton Demand

There are a number of features of cotton demand that make the estimation task erent from modeling the demand for many other agricultural products. There is no oretical rationale for directly estimating consumer demand for raw cotton. Raw cotton emanded by the processors in response to final consumer demand for apparel items and er manufactured textile products. This feature of cotton demand is complicated by the that manufactured textile and apparel items are often mixtures of fibers (e.g., blends otton and polyester), and within a fairly wide range of blends, consumers are relatively nsitive to different textile mixtures. Further, it appears that consumers are insensitive e prices of individual fibers (e.g., cotton prices relative to polyester prices) because, neral, the fiber value represents only a small proportion of the final purchase price.

Therefore, consume

supported empirica

(1971), Thigpen (1

Textile and

sensitive than cons

plant technology e

demand by manufa

Another co

world trade in ap

1970s. As a resul

may differ signific

An appropr

is measured by d

Some previous stu

Mues and Simm

consumer consum

3.2 Previous Stu

Several ea

of approaches ha

[1] Although it is now easier to

depending upon the age an

the machines recalibrated. Th

different physical attributes an

Therefore, consumer demand can be expected to be highly inelastic and this has been upported empirically in a number of recent studies [Dudley (1974), Magleby and Missaien 1971), Thigpen (1978)].

Textile and apparel manufacturers who purchase raw cotton tend to be much more ensitive than consumers to the relative prices of individual fiber types. Most processing ant technology enables manufactures to substitute fibers quickly at some cost[1]. Thus, emand by manufacturers tends to be much more price elastic than at the consumer level.

Another complicating factor is that there is substantial world trade in raw cotton and orld trade in apparel and other textile products has grown dramatically since the early 70s. As a result, the quantities of cotton produced and consumed in any one country y differ significantly.

An appropriate measure of consumer demand is the quantity for home use, which measured by domestic mill consumption plus imported textile products less exports. ne previous studies have used domestic mill consumption as the demand variable (e.g., es and Simmons (1988)). However, this variable does not accurately represent sumer consumption.

Previous Studies

Several earlier studies attempted to model the demand for cotton and a wide range pproaches have been taken. Because the demand for cotton is derived from the

---

is now easier to vary fiber content than 10 years ago, some difficulties remain. The cost of substituting fibers differs upon the age and design of the machinery and skill of plant managers. A whole assembly line has to be shut down recalibrated. The process can take a week if switching from 100% cotton to a blend. In addition, the resulting product ical attributes and therefore cannot be marketed as the original product.

demand for textile

rather than cotton

In an early s

was estimated as a

prices. Dudley use

income and lagged

global demand for

In these studies pe

was tested, includ

semi-log form per

fibers falls as cons

Many resea

Monke (1981) arg

> Color, fab
> end-produ
> placed anc
> demand fo
> previous t
> presumabl
> assumptio
> expression

Studies tha

(1987), Monke ar

1958 to 1975, Ec

consumption, lag

and Behrman es

demand for textile products and apparel, some studies have estimated total fiber demand rather than cotton directly.

In an early study by Donald et al. (1963) fiber consumption for the United States was estimated as a function of real income, the change in real income and an index of fiber prices. Dudley used a similar specification in which total fiber depended on current real income and lagged prices. Magleby and Missaien (1977) and Thigpen (1978) estimated the global demand for all fibers using time series data pooled over a large number of countries. In these studies per capita income was the only regressor and a variety of functional forms was tested, including the double-log, semi-log and log-inverse functions. Overall, the semi-log form performed best, which supports the hypothesis that income elasticity for fibers falls as consumption rises.

Many researchers have used adaptive expectations models to specify their equations. Monke (1981) argues that:

> Color, fabric coarseness and fiber mix are important characteristics of textile end-products, and at each level of textile fabrication and distribution, orders are placed and/or received for the delivery of goods in a future period. The current demand for cotton thus depends on textile production decisions made in some previous time period. These decisions, particularly with respect to fiber mix, are presumably influenced by expected prices of cotton and other inputs. The assumption of perfect forecast of income and population changes allows an expression of per capita demand for cotton based on expected prices for fibers.

Studies that have used this approach include Adams and Behrman (1976), Ecevit 1987), Monke and Taylor (1983), and Mues and Simmons (1988). Using world data for 958 to 1975, Ecevit estimated world cotton consumption as a function of lagged world nsumption, lagged real prices of cotton and polyester staple and a time trend. Adams d Behrman estimated per capita cotton consumption equations for industrial and developing countrie

form was used to c

Consumption in inc

lagged price ratio

specification was e

was replaced by p

capita income and

regressors.

Mues and S

and the Rest-of-th

than current price

mills accept order

raw cotton suppli

equations include

to adjust producti

Another cl

the work of Chow

and apparel produ

that individuals h

fraction of the di

depreciated old s

depends on price

current prices, la

developing countries and centrally planned economies (CPEs). A double-log functional form was used to constrain elasticities to be constant over all price and income ranges. Consumption in industrial countries was specified to depend on lagged consumption, the lagged price ratio of cotton to polyester, per capita income and time. A similar specification was employed for the equations for the CPEs except that the income variable was replaced by per capita production. The equation for the CPEs employed real per capita income and a four-period distributed lag of the cotton to polyester price ratio as regressors.

Mues and Simmons estimated mill consumption for the United States, West Europe and the Rest-of-the-World. The lagged ratio of cotton to polyester prices was used rather than current prices. The authors argued that lagged prices are more appropriate because mills accept orders for their goods up to 12 months in advance and hence need to secure raw cotton supplies by buying forward to ensure that they meet their contracts. The equations included a lagged dependent variable, "since mills are not expected to be able to adjust production levels instantaneously."

Another class of model that has been used to estimate textile demand is based on he work of Chow (1960). These models explicitly recognize the durable nature of textile nd apparel products which depreciate over a number of time periods. The model assumes hat individuals have a desired level of stocks of these items and that purchases are some raction of the difference between the desired stocks at the end of the time period and the epreciated old stock from the previous year. Assuming that the desired stock level also epends on prices and income, demand equations can be derived as functions of lagged and urrent prices, lagged and current income, and lagged consumption. Using this framework, equations for per c

1970) and Thigpen

3.3 Theoretical Is

The two-sta

modeling the dema

and Muellbauer (

across broad grou

follows. Let the c

where X is a vecto

function can be pa

where X_i i = 1,...

for broad commo

X_i are the quantit

are allocated am

sub-utility functio

in other sub-utilit

equations for per capita textile demand were estimated by Houthakker and Taylor (1966, 1970) and Thigpen and Mitchell (1988).

3 Theoretical Issues

The two-stage budgeting approach has often provided the theoretical structure for odeling the demand for agricultural commodities. The approach is discussed by Deaton d Muellbauer (1980) and is based on the assumption that preferences are separable ross broad groups of consumer goods. The model can be described algebraically as llows. Let the consumer's utility function be given by,

$$U = u(X)$$

ere X is a vector of all consumption goods. If preferences are separable then the utility nction can be partitioned into a set of sub-utility functions, such that

$$U = u[\ V_1(X_1),\ V_2(X_2),\ \ldots\ ,\ V_n(X_n)\ ]$$

ere X_i $i = 1,\ldots,n$ are partitions of X. Each $V_i(X_i)$ can be regarded as a utility function broad commodity groupings, such as food, clothing or housing, while the elements of re the quantities of individual goods consumed within the group. The elements of X allocated among the X_i partitions such that the preference structure within any utility function can be determined independently of the quantities of goods consumed ther sub-utility functions. This is known as weak separability.

Separability

and Muellbauer (

Sub-Groups

Individual T.
Commodities

These assu

In the first stage

This is achieved

subject to,

where: P_i = a p

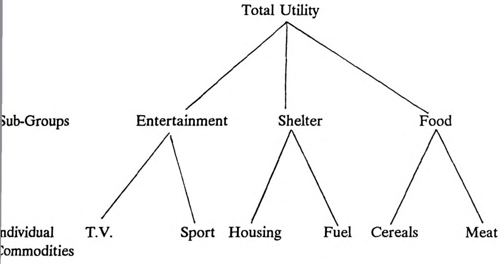
I = tota

This problem is

group i.

In the se

Separability is often illustrated with a utility tree. An example is taken from Deaton and Muellbauer (p. 123).



These assumptions about the utility function lead to the idea of two-stage budgeting. the first stage of this process consumers allocate expenditures to the commodity groups. his is achieved by maximizing the utility function,

$$U = [\ V_1(X_1),\ V_2(X_2),\ \dots\ ,\ V_n(X_n)\ ]$$

ject to,

$$\Sigma\ P_i.X_i\ =\ I$$

re: P_i = a price index for commodity group i,

I = total consumer income.

problem is solved to determine I_i , the proportion of I allocated to each commodity p i.

In the second stage consumers maximize the sub-utility function for each group, subject to the amo

subject to,

where p_i = a vect

this problem gives

Note that, the 'dir

groups are zero.

indirectly on the

changes affect th

constraints in the

is that it provide

the consumer's b

consumption of t

3.4 A Model of

While it is

the features of

derived from a tv

group, being con

fibers. From

individual items

ubject to the amount of expenditure determined in the first stage. That is,

$$\text{Max } V_i(X_i)$$

ıbject to,

$$\Sigma\, p_i.X_i \;=\; I_i$$

here p_i = a vector of individual commodity prices corresponding to X_i. The solution to ıis problem gives a demand function for each element of X_i,

$$x_i \;=\; x_i(p_i\,, I_i\,).$$

ote that, the 'direct' cross-price effects of individual commodities in different commodity oups are zero. However, price changes in commodities of one group can impact directly on the demand for commodities in another group. This occurs because price anges affect the income allocations in the first stage, which, in turn, alter the budget ıstraints in the second. The main advantage of this approach in empirical estimation hat it provides a justification for omitting the prices of all commodities considered in consumer's budget and focusing only on those prices considered most relevant to sumption of the commodity being modeled.

A Model of World Cotton Demand

While it is not possible to apply the two-stage budgeting approach in its purest form, features of cotton demand discussed in section 3.1 suggest that cotton demand is ed from a two-step process. Textile and apparel products seem a plausible commodity , being comprised of individual commodities such as cotton, wool and manufactured . From the discussion of manufacturers' behavior, the consumption of these dual items depends on their relative prices. This is captured by the second stage of the two-stage budg

expenditures which

total consumer inc

To capture

Demand in each sy

an identity. The f

the consumption o

use was estimated

from these equati

income. However

cotton, wool, cellu

constant with resp

argued earlier, th

income may lead

value can be asso

so on, rather tha

The price

the lack of data

component of the

and EEC count

If the two-stage budgeting a
be an equation explaining
total consumer income alloc
products as a function of
could not be undertaken
given data availability, w

the two-stage budgeting process. Consumption of all fibers is constrained by total fiber expenditures which can be proxied by total fiber demand; which, in turn, is determined by total consumer income[2].

To capture these characteristics of textile demand, a two-step approach was taken. Demand in each specified world region was estimated using two behavioral equations and an identity. The first behavioral equation explains total fiber use, which is a measure of the consumption of all fiber types in the form of apparel and textile products. Total fiber use was estimated as a function of current real income. Income elasticities are derived from these equations which express changes in total fiber use in response to changes in income. However, this specification forces the income elasticities for individual fibers (i.e., cotton, wool, cellulosic fibers, and non-cellulosic fibers) to be the same since the shares are constant with respect to income changes. This restriction may not be important since, as argued earlier, the fiber content of most textile items is generally small. An increase in income may lead consumers to purchase higher valued items. However, typically the higher value can be associated with higher quality products, brand named items, better styling and so on, rather than because of changes in the raw fiber composition.

The price of textiles was not included in the total fiber use equations because of the lack of data on textile prices. Indexes of prices of textiles and apparel do exist as a component of the overall consumer prices index for some countries (e.g., the United States and EEC countries) but use of these was econometrically unsuccessful. The lack of

---

wo-stage budgeting approach were to be strictly applied consistent with the theoretical model outlined in section 3.3, there equation explaining the consumption of individual fibers as a function of the prices of the fiber and its competing fibers, sumer income allocated to textile products. The second equation would explain the total consumer income allocated to cts as a function of a textile price index, indexes for other major consumption categories, and total consumer income. This l not be undertaken given the lack of data for the consuming countries in the model. The approach taken was considered n data availability, while still maintaining the general framework of the two-stage budgeting model.

statistical significan

of textile manufact

was estimated to a

it). Variations in f

in the prices of fi

The secon

processors as the

estimates the pro

cellulosic fibers) t

estimated as a fu

equations the rat

equations these p

these approaches

to be the same. V

equations in whic

To comp

equating the proc

capita total fiber

each region was

statistical significance may result from the fact that the fiber component of the total cost of textile manufacturing is often small (e.g., the cost of cotton delivered to US mill in 1976 was estimated to account for 10.8% of the retail price of a pair of dungarees made from it). Variations in fiber prices therefore account for only a small proportion of the variation in the prices of finished textile products.

The second behavioral equation attempts to capture the behavior of textile processors as they respond to changing relative prices of fiber types. This equation estimates the proportion of each fiber type (i.e., cotton, wool, cellulosic fibers, and non-cellulosic fibers) that makes up total fiber use. Thus the cotton share of total fiber use was estimated as a function of the prices of cotton and polyester staple. In most of the equations the ratio of these prices was used as the explanatory variable, while in a few equations these prices appeared as separate regressors. The major difference between these approaches is that in the ratio form, the elasticities of the two prices are constrained to be the same. While this specification leads to a reduction in flexibility, it was found that equations in which prices appeared in their ratio form tended to perform better.

To complete the demand system, cotton use was derived through an identity equating the product of the cotton share of total fiber use and total fiber use (given by per capita total fiber use multiplied by population). To summarize, the demand for cotton in each region was derived from:

$$\begin{aligned} CTU &= CTSH * PCTFU * POP, \\ CTSH &= f(CTP, PSP), \\ PCTFU &= f(GDP). \end{aligned}$$

Where,

CTU = C

CTSH = C

GDP = C

CTP = I

POP = I

PSP = I

PCTFU = I

An identica

discussed in detai

up total fiber use

fibers. The non-c

consumption of n

3.5 Empirical R

3.5.1 Cotto

The equat

countries and fro

the basis of data

obtained from t

Reasonably comp

published survey

for industrialize

endogenous vari

two-stage least s

ıere,

U	=	Quantity of Cotton for home use,
'SH	=	Cotton share of total fibers for home use,
)P	=	Gross Domestic Product,
'P	=	Price of cotton,
'P	=	Population,
P	=	Price of polyester staple, and
TFU	=	Per capita total fibers for home use.

An identical structure was used to estimate the use of non-cellulosic fibers and is cussed in detail in section VI. That is, the proportion of non-cellulosic fibers making total fiber use was estimated as a function of the prices of cotton and non-cellulosic ers. The non-cellulosic fiber share was then multiplied by total fiber use to obtain the ısumption of non-cellulosic fibers.

Empirical Results

3.5.1 Cotton Share Equations

The equations were estimated using annual data from 1964 to 1986 for developing ntries and from 1964 to 1987 for industrial countries. These periods were chosen on basis of data availability. The quantity data used in the demand side of the model was ined from the World Apparel Fiber Consumption Survey conducted by the FAO. sonably comparable data from this survey were available from 1964 to the most recently ished survey results (FAO, 1989 issue) up to 1986 for developing countries and 1987 industrialized countries. Given that the cotton share equations contain current genous variables on the right-hand side, the model is simultaneous. Consequently, the tage least squares estimator (2SLS) was used to avoid the inconsistency of OLS.

The price va

of non-cellulosic f

Domestic prices fo

these world prices

and consumer pri

Based on

equation for each

and the deflated p

either one or bot

amount of the va

United States and

and signed corre

other regions may

despite the deflat

[3] Source: Cotton O

[4] The price of non-c

[5] Source:IMF Intern

[6] This method of d
differences in cotton qu
deflating cotton prices
Central Africa). Howev
it was necessary to link
resources and the lack
a more sophisticated ap
States) domestic prices
Outlook "A" Index pric
as a ratio, the exchang
included in both the nu

The price variables used in the cotton share were the prices of cotton[3] and the price ıon-cellulosic fibers[4]. These prices were denominated in US cents per kilogram. ıestic prices for each region were obtained by applying the US dollar exchange rate to e world prices and deflating by a domestic consumer price index. The exchange rates consumer price indexes were obtained from the IMF[5] [6].

Based on the framework described above, the cotton share of total fiber use ation for each region was estimated initially as a function of the deflated price of cotton the deflated price of polyester. This specification was not successful in most cases with er one or both of these price variables not significant or else did not explain a large ount of the variability of the left-hand side variable. Only in the equations for the ted States and Brazil were the price variables included as separate regressors significant signed correctly (equations 3.3 and 3.14). The poor results of this specification in r regions may have been due to multicollinearity between cotton and polyester prices, ite the deflating of both price series. In light of this possibility, equations explaining

---

Source: Cotton Outlook A Index, Middling 1-3/32 Inch, CIF Europe.

he price of non-cellulosic fibers was represented by the polyester staple price, fob, US plants.

ource:IMF International Financial Statistics.

This method of deriving domestic cotton and polyester prices was somewhat crude since it ignored transportation costs, ıces in cotton qualities, the impact of trade restrictions on domestic prices in many countries, problems associated with g cotton prices and issues over how to obtain exchange rates and deflators for aggregate regions (e.g., the EEC and Africa). However, an important requirement of the model was to solve for the Outlook "A" Index price and therefore ecessary to link domestic prices in cotton producing and consuming regions to this price in some way. Given limited s and the lack of reliable and consistent domestic cotton price series for individual countries, it was infeasible to take ophisticated approach. However, for those countries where price data were available (e.g., China, India and the United domestic prices were used in the share equations. This meant that equations linking the domestic price and the "A" Index price had to be estimated (chapter 5). In the equations with the prices of cotton and polyester appearing o, the exchange rate and deflation conversions became irrelevant, since identical exchange rates and deflators are in both the numerator and denominator of the ratio.

the cotton share of

of cotton and poly

the equations of A

Japan, the Republ

In the mod

income elasticities

equations. This v

and was pursued

consumers to fibe

regression period

While the

in total fiber use

specifications we

that estimating t

a better fit than i

price and consum

many of the eq

---

[7]The Central Afric
Republic, Chad, Ethiop
Togo, Uganda, Zaire,

[8]It is important to
values, low standard e
a good fit if variables a
equations were estima
variables. In terms of
simultaneous equation
trends, or dummy va
stationarity and specifi

e cotton share of total fiber use in other regions were estimated as a function of the ratio cotton and polyester prices. This specification performed much better and was used in e equations of Argentina, Australia, Central Africa[7], China, the EEC-12, Egypt, India, pan, the Republic of Korea, Mexico and Pakistan.

In the modeling process other variables were tried. For example, to test whether ome elasticities differed across fiber types, an income variable was included in the share iations. This variable was not significant across all regions of the model, as expected, l was pursued no further. A possible explanation for this finding is that attention by sumers to fiber content is a fairly recent phenomenon which was not captured in the ression period.

While the price variables were significant generally, the variability of cotton share otal fiber use was not explained entirely by price relationships. In many equations, the ifications were modified to improve the "goodness-of-fit"[8]. For example, it was found estimating the cotton share equations with variables converted into logarithms gave tter fit than in the linear form. In these cases the elasticities were unchanged over all and consumption levels and were given by the coefficients of the price variables. In of the equations a zero-one dummy variable was added to the specification to

---

e Central Africa region includes the following countries: Angola, Benin, Burkina Faso, Cameroon, Central African c, Chad, Ethiopia, Ghana, Ivory Coast, Kenya, Malawi, Mali, Mozambique, Niger, Senegal, Somalia, Sudan, Tanzania, Jganda, Zaire, Zimbabwe.

s important to define what is meant by goodness-of-fit. Typically, this refers to obtaining high adjusted R-squared ow standard errors on parameter coefficients, and small sum of squared residuals. However, one can often achieve it if variables are non-stationary and/or if strong trends are present in the data series. In the case of the fiber model, ıs were estimated primarily to obtain elasticities which capture producer and consumer responses to changes in . In terms of a market model, elasticities of demand and supply are particularly important for solution of a set of eous equations. Therefore, concern over obtaining accurate elasticities led to the inclusion of variables capturing or dummy variables (which merely discards observations) in order obtain satisfactory elasticities. No tests for ity and specification error were undertaken. Future work on expanding the model will include these tests.

capture abnormal

variable. This var

non-cellulosic fibe

the time variable

cellulosic fibers th

For example, ma

strength and unif

Further, it has be

1950s and 1960s

A potenti

Identification ref

the reduced form

necessary and su

order and rank

exogenous varia

This condition is

rank condition

coefficients of th

of all the other e

one.

For larg

performed. Th

model's equatio

pture abnormal behavior in the data series, while many of the equations contained a time riable. This variable was added because much of the competition between cotton and n-cellulosic fibers is not directly price-related. In all the equations in which it was used, e time variable was negatively signed. This captured the substitution of cotton by non- llulosic fibers that has taken place following advances in manufactured fiber technology. r example, many important fiber characteristics demanded by manufacturers, such as ength and uniformity of length, are much easier to control by using manufactured fibers. rther, it has been argued (e.g., Monke) that much of the substitution for cotton in the 0s and 1960s depended on manufactured fiber use rather than price.

A potential problem in estimation is whether the equations are identified. ntification refers to the problem of whether there are enough restrictions imposed on reduced form parameters to obtain unique values of the structural parameters. A essary and sufficient condition for an equation to be identified is that it meets both the r and rank conditions. The order condition is met if the number of excluded enous variables is greater than the number of included endogenous variables less one. condition is a necessary, but not sufficient condition. A sufficient condition is that the condition is met. This occurs when the rank of the matrix containing (i) the icients of the endogenous variables omitted from the equation, and (ii) the coefficients the other equations in the model, is less that the number of endogenous variables less

For large econometric models, tests of equation identification are not usually rmed. This is because when there are a great many predetermined variables, the 's equations are likely to be over-identified, especially when a lot of structure has been imposed thro

usually find equati

although future res

carefully.

The estimat

selected diagnosti

Durbin Watson st

in the model sim

Appendix.

The cotton

LN CTSHARG = - 0.22

R-SQUARED (CORR.

Where: CTSHARG =
DFCTPARG =
DFPSPARG =
D76 =
LN =

The cotton shar

ratio of cotton a

of -/+ 0.07. A

high levels of do

very high levels

the equation.

en imposed through many parameter restrictions. As a result, tests of identification ually find equations to be over-identified. In this study identification was not tested, hough future research to expand the model will consider the identification problem more refully.

The estimated cotton share equations are presented in equations 3.1-3.14, along with ected diagnostics (i.e., t-values, corrected R-squared, standard error of the estimate, rbin Watson statistic or H-statistic). Reported are the final equation specifications used the model simulation. The variable definitions and specifications are given in the pendix.

The cotton share of total fiber use in Argentina is given in equation 3.1.

TSHARG = - 0.22 - 0.066 LN DFCTPARG/DFPSPARG + 0.074 D76 + 0.606 LN CTSHARG(-1) (3.1)
(-2.65) (1.85) (5.48)

UARED (CORR.): 0.89 SEE: 0.0208 H-STAT: 0.64 PERIOD OF FIT: 1964-1986

e:CTSHARG = Cotton share of total fiber use, Argentina,
DFCTPARG = Deflated cotton price, Argentina,
DFPSPARG = Deflated polyester price, Argentina,
D76 = Zero-one variable, equal 1 in 1976, 0 otherwise,
LN = Indicates variable transformed into logarithms.

cotton share equation was specified with variables converted into logarithms. The of cotton and polyester prices was significant and gave a short-run elasticity estimate + 0.07. A zero-one variable for 1976 was found to be important and captured the levels of domestic fiber use following a sudden run-down of stocks which had been at high levels during the early 1970s. A lagged dependent variable was also included in quation.

The cotton s

CTSHAUS = 0.544 - 0.
(-2.

R-SQUARED (CORR.)

Where:CTSHAUS = (
DPCTPAUS =
DFPSPAUS =
TIME =

The cotton share

and a time varia

significant when

elasticities were

which was small

capturing the no

throughout mos

size of the t-val

estimated price

The cotton

LN CTSHBRA = - 0.

R-SQUARED (COR

Where:CTSHBRA
DPCTPBRA
DFPSPBRA
D83
LN

The equation e

with variables

and price of p

elasticity estim

The cotton share of total fiber use in Australia is given in equation 3.2.

HAUS = 0.544 - 0.028 DFCTPAUS/DFPSPAUS - 0.006 TIME (3.2)
(-2.42) (-10.06)

QUARED (CORR.): 0.92 SEE: 0.0048 DW: 2.32 PERIOD OF FIT: 1964-1987

re:CTSHAUS = Cotton share of total fiber use, Australia,
DFCTPAUS = Deflated cotton price, Australia,
DFPSPAUS = Deflated polyester price, Australia,
TIME = Time variable.

e cotton share for Australia was a function of the ratio of cotton and polyester prices d a time variable. The price ratio was included after finding the cotton price not to be nificant when entered in the equation as a separate regressor. The own- and cross-price sticities were estimated to be -/+ 0.06 (when measured at the mean prices and quantity) ich was smaller than expected. A time variable was found to be highly significant, turing the non-price related substitution of cotton with manufactured fibers in Australia oughout most of the estimation period. The strength of this trend is indicated by the : of the t-value (-10.06) and corrected R-squared (0.92) which might explain why the mated price elasticities were small.

The cotton share of total fiber use in Brazil is given in equation 3.3.

TSHBRA = - 0.389 - 0.181 LN DFCTPBRA + 0.170 LN DFPSPBRA + 0.056 D83 (3.3)
(-6.15) (10.84) (1.92)

UARED (CORR.): 0.91 SEE: 0.0118 DW: 1.79 PERIOD OF FIT: 1964-1986

::CTSHBRA = Cotton share of total fiber use, Brazil,
DFCTPBRA = Deflated cotton price, Brazil,
DFPSPBRA = Deflated polyester price, Brazil,
D83 = Zero-one variable, equal 1 in 1983, 0 otherwise,
LN = Indicates variable transformed into logarithms.

equation explaining the cotton share of total fiber use in Brazil fitted the data better variables converted into logarithms. The share was explained by the price of cotton ›rice of polyester which entered the equation as separate regressors, and resulted in city estimates of 0.18 and 0.17, respectively. A dummy variable for 1983 accounted for the effect of th

cotton at the expe

The cotton

LN CTSHCAF = - 0.14

R-SQUARED (CORR.

Where: CTSHCAF =
DFCTPCAF =
DFPSPCAF =
TIME =
LN =

The logarithm of

polyester prices

Australia (equat

demand (-/+ 0.

strength of the

swing in consur

Africa in the 19

The cotton

CTSHCHI = 1.08 - (
(-8

R-SQUARED (COR

Where: CTSHCHI
DFCTPCHI
DFPSPCHI
D74

The cotton sha

and polyester

---

[9] See footnote 7

[10] Includes Taiwa

or the effect of the debt crisis in Brazil. The recession caused manufacturers to switch to otton at the expense of other fibers, although, overall, cotton demand declined sharply.

The cotton share of total fiber use in Central Africa[9] is given in equation 3.4.

$$\text{LN CTSHCAF} = -0.143 - \underset{(-3.91)}{0.042}\ \text{LN DFCTPCAF/DFPSPCAF} - \underset{(-10.8)}{0.08}\ \text{TIME} \qquad (3.4)$$

SQUARED (CORR.): 0.87 SEE: 0.0058 DW: 1.42 PERIOD OF FIT: 1964-1986

ere:CTSHCAF	=	Cotton share of total fiber use, Central Africa,
DFCTPCAF	=	Deflated cotton price, Central Africa,
DFPSPCAF	=	Deflated polyester price, Central Africa,
TIME	=	Time variable,
LN	=	Indicates variable transformed into logarithms.

e logarithm of the cotton share is explained by the logarithm of the ratio of cotton and lyester prices and a time variable. The results were similar to those reported for stralia (equation 3.2) with small estimates of the own- and cross-price elasticities of nand (-/+ 0.04) and a highly significant, negatively-signed time trend variable. The ength of the time trend variable in explaining the share was the result of the sharp up ng in consumption of cheaper textile and apparel items which occurred throughout ica in the 1970s and 1980s period.

The cotton share of total fiber use in China[10] is given in equation 3.5.

$$\text{CHI} = 1.08 - \underset{(-8.31)}{0.001}\ \text{DFCTPCHI/DFPSPCHI} + \underset{(3.08)}{0.11}\ \text{D74} \qquad (3.5)$$

UARED (CORR.): 0.83 SSE: 0.0070 DW: 1.89 PERIOD OF FIT: 1964-1986

e:CTSHCHI	=	Cotton share of total fiber use, China,
DFCTPCHI	=	Deflated cotton price, China,
DFPSPCHI	=	Deflated polyester price, China,
D74	=	Zero-one variable, equal 1 in 1974, 0 otherwise.

cotton share of total fiber use in China was estimated to depend on the ratio of cotton polyester prices and a zero-one variable for 1974. The price ratio was highly

---

e footnote 7 for region definition.

ncludes Taiwan Province.

significant with a

estimate of -/+ 0

coefficient estima

demand shift tow

for by price mov

The cotton

LN CTSHEEC = - 1.0

R-SQUARED (CORR

Where: CTSHEEC =
DFCTPEEC =
DFPSPEEC =
D83 =
LN =

The cotton shar

of cotton and p

data better whe

and cross-price

The cotto

LN CTSHEGY = 1.

R-SQUARED (COR

Where: CTSHEGY
DFCTPEGY
DFPSPEGY
TIME
LN

The cotton sha

found to fit th

declined cons

ficant with a t-value of -8.31 and gave an own- and cross-price elasticity of demand ate of -/+ 0.06. The initial specification with the prices as separate regressors gave icient estimates which were not significant. The dummy variable captured the sudden nd shift towards cotton following the oil price shock which was not fully accounted / price movements.

The cotton share of total fiber use in the EEC-12 is given in equation 3.6.

SHEEC = - 1.009 - 0.140 LN DFCTPEEC/DFPSPEEC + 0.121 D83 (3.6)
(-5.95) (2.44)

ARED (CORR.): 0.70 SEE: 0.0472 DW: 1.34 PERIOD OF FIT: 1964-1987

CTSHEEC = Cotton share of total fiber use, EEC-12,
DFCTPEEC = Deflated cotton price, EEC-12,
DFPSPEEC = Deflated polyester price, EEC-12,
D83 = Zero-one variable, equal 1 in 1983, 0 otherwise,
LN = Indicates variable transformed into logarithms.

otton share of total fiber use in the EEC-12 was estimated as a function of the ratio on and polyester prices and a dummy variable for 1983. The equation fitted the etter when the variables were converted into logarithms. The estimate of the own- oss-price elasticities were -/+ 0.14.

he cotton share of total fiber use in Egypt is given in equation 3.7.

EGY = 1.259 - 0.168 LN DFCTPEGY/DFPSPEGY - 0.065 TIME (3.7)
(-2.08) (4.26)

RED (CORR.): 0.84 SEE: 0.0536 DW: 1.33 PERIOD OF FIT: 1964-1986

SHEGY = Cotton share of total fiber use, Egypt,
FCTPEGY = Deflated cotton price, Egypt,
FPSPEGY = Deflated polyester price, Egypt,
ME = Time variable,
= Indicates variable transformed into logarithms.

ton share equation for Egypt estimated with variables converted into logarithms was o fit the data better than when estimated in the linear form. The cotton share l consistently throughout the estimation period which was captured by a time variable and foun

cotton and polyes

The cotton

LN CTSHIND = -0.039

R-SQUARED (CORR:

Where:CTSHIND = (
DFCTPIND =
DFPSPIND =
LN =

The cotton share

polyester price r

found to fit the

estimated at -/

responsive to pr

consumption. T

The cotton

CTSHJPN = 0.246 +

R-SQUARED (COR

Where:CTSHJPN =
DFCTPJPN =
DFPSPJPN =
D74 =

The cotton shar

of cotton and p

total fiber use

equation becau

sudden increas

able and found to be highly significant. Also statistically significant was the ratio of on and polyester prices with price elasticity estimates of -/+ 0.17.

The cotton share of total fiber use in India is given in equation 3.8.

TSHIND = -0.039 - 0.016 LN DFCTPIND/DFPSPIND + 0.829 LN CTSHIND(-1) (3.8)
(-1.98) (13.12)

UARED (CORR.): 0.95 SEE: 0.0042 H-STAT: 0.73 PERIOD OF FIT: 1964-1986

e:CTSHIND = Cotton share of total fiber use, India,
DFCTPIND = Deflated cotton price, India,
DFPSPIND = Deflated polyester price, India,
LN = Indicates variable transformed into logarithms.

cotton share of total fiber use in India was estimated as a function of the cotton and ester price ratio and a lagged dependent variable. A double-log functional form was ıd to fit the data better than the linear form. The price elasticity of demand was nated at -/+ 0.016, indicating that the consumption of cotton in India was not onsive to price changes. The lagged cotton consumption captured the strong trend in umption. This result casts doubt on the accuracy of the price elasticity estimate.

The cotton share of total fiber use in Japan is given in equation 3.9.

JPN = 0.246 + 0.466 CTSHJPN(-1) + 0.045 D74 - 0.017 DFCTPJPN/DFPSPJPN (3.9)
(2.21) (2.31) (-1.47)

JARED (CORR.): 0.61 SEE: 0.0045 DW: 1.88 PERIOD OF FIT: 1964-1987

:CTSHJPN = Cotton share of total fiber use, Japan,
DFCTPJPN = Deflated cotton price, Japan,
DFPSPJPN = Deflated polyester price, Japan,
D74 = Zero-one variable, equal 1 in 1974, 0 otherwise.

otton share of total fiber consumption in Japan was estimated to depend on the ratio ton and polyester prices, a zero-one dummy variable for 1974, and cotton's share of fiber use lagged one year. The price variable was not significant but kept in the ion because it had the correct sign. The dummy variable for 1974 captured the n increase in cotton imports in that year not explained by price movements.

The cotton

LN CTSHKOR = - 0.40

R-SQUARED (CORR.

Where: CTSHKOR =

DFCTPKOR =

DFPSPKOR =

D73 =

TIME =

LN =

The variables be

Korea were th

dummy variable

logarithmic fun

elasticities of de

are more respo

variable captur

period. Howev

sudden deman

accounted for b

The cotto

CTSHMEX = 0.091

R-SQUARED (COR

Where: CTSHMEX

DFCTPMEX

DFPSPMEX

The cotton sha

period with th

explained by t

The cotton share of total fiber use in Korea is given in equation 3.10.

HKOR = - 0.401 - 0.335 LN DFCTPKOR/DFPSPKOR - 0.192 LN TIME + 0.38 D73 (3.10)
(-4.37) (-2.64) (3.63)

ARED (CORR.): 0.89 SEE: 0.1318 DW: 2.22 PERIOD OF FIT: 1964-1986

CTSHKOR = Cotton share of total fiber use, Korea,
DFCTPKOR = Deflated cotton price, Korea,
DFPSPKOR = Deflated polyester price, Korea
D73 = Zero-one variable, equal 1 in 1973, 0 otherwise,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

ariables best able to explain the variability in cotton's share of total fiber use in were the ratio of cotton and polyester prices, a time variable, and a zero-one y variable for 1973. As with many of the equations reported above, a double-hmic functional form provided the best fit to the data. The estimated price ities of demand were -/+ 0.335 which indicated that Korean cotton manufacturers ore responsive to price movements than in most other regions studied. The time e captured the non-price related trend away from cotton during the regression . However, a zero-one dummy variable for 1973 was needed to account for the demand shift towards cotton following the oil price shock which is not fully ted for by price movements.

he cotton share of total fiber use in Mexico is given in equation 3.11.

X = 0.091 - 0.043 DFCTPMEX/DFPSPMEX + 0.857 CTSHMEX(-1) (3.11)
(-4.77) (37.69)

ED (CORR.): 0.99 SEE: 0.0024 H-STAT: 1.71 PERIOD OF FIT: 1964-1986

SHMEX = Cotton share of total fiber use, Mexico,
CTPMEX = Deflated cotton price, Mexico,
PSPMEX = Deflated polyester price, Mexico.

:on share of total fiber use in Mexico declined steadily throughout the regression /ith the result that more than 90% of the variation of the cotton share could be d by the dependent variable lagged one year. The ratio of cotton and polyester prices was foun

elasticity estimat

The cotton

CTSHPAK = 0.1572 -
(

R-SQUARED (CORR

Where:CTSHPAK =
DFCTPPAK =
DFPSPPAK =

The downward

lagged depende

addition to this

specification. W

because it has t

The cotto

CTSHTUR = 0.237

R-SQUARED (COR

Where:CTSHTUR
DFCTPTUR
D73

The cotton sha

of cotton in Tu

year. The coe

mean price an

towards cotto

movements.

was captured

; was found to be significant however, and gave own- and cross-price short-run city estimates of -/+ 0.09 when calculated at the mean price and quantity.

The cotton share of total fiber use in Pakistan is given in equation 3.12.

AK = 0.1572 - 0.030 DFCTPPAK/DFPSPPAK + 0.84 CTSHPAK(-1) (3.12)
(-1.72) (10.72)

ARED (CORR.): 0.91 SEE: 0.0142 H-STAT:- 1.86 PERIOD OF FIT: 1964-1986

CTSHPAK = Cotton share of total fiber use, Pakistan,
DFCTPPAK = Deflated cotton price, Pakistan,
DFPSPPAK = Deflated polyester price, Pakistan.

lownward trend in cotton's share of total fiber use in Pakistan was captured by a l dependent variable which appeared in the equation with a coefficient of 0.84. In on to this variable, the ratio of cotton and polyester prices was included in the final ication. While this variable was not statistically significant, it was kept in the equation se it has the correct sign.

The cotton share of total fiber use in Turkey is given in equation 3.13.

JR = 0.237 - 0.000007 DFCTPTUR + 0.090 D73 + 0.750 CTSHTUR(-1) (3.13)
(-2.46) (2.93) (8.07)

RED (CORR.): 0.92 SEE: 0.0111 H-STAT: - 0.68 PERIOD OF FIT: 1964-1986

TSHTUR = Cotton share of total fiber use, Turkey,
FCTPTUR = Deflated cotton price, Turkey,
73 = Zero-one variable, equal 1 in 1973 0 otherwise.

tton share of total fiber use in Turkey was estimated to depend on the deflated price n in Turkey, a zero-one dummy variable for 1973, and the cotton share lagged one he coefficient on the cotton price gave an elasticity of -0.13 when estimated at the rice and quantity. The zero-one dummy variable captured the sudden demand shift cotton following the oil price shock which was not fully accounted for by price nts. The trend away from cotton consumption throughout the regression period tured by the lagged dependent variable.

The cotton

CTSHUSA = 0.488 - 0.0
(-4.9

R-SQUARED (CORR.

Where: CTSHUSA =
DFCTPUSA =
DFPSPUSA =
TIME =

For the United

variability of def

the fit of the equ

and cross-price

calculated at th

the United Sta

counterparts in

cotton in the U

explained by e

The fit o

corrected R-sq

Tests for aut

auto-correlati

capturing a t

variable). Th

share of cott

1980s) which

to technolog

The cotton share of total fiber use in the United States is given in equation 3.14.

JSA = 0.488 - 0.0007 DFCTPUSA + 0.0004 DFPSPUSA - 0.004 TIME (3.14)
(-4.91) (4.42) (-2.86)

ARED (CORR.): 0.89 SEE: 0.0135 DW: 1.40 PERIOD OF FIT: 1964-1987

CTSHUSA = Cotton share of total fiber use, United States,
DFCTPUSA = Deflated cotton price, United States,
DFPSPUSA = Deflated polyester price, United States
TIME = Time variable.

he United States the cotton share of total fiber use was specified to depend on the bility of deflated cotton and polyester prices and a trend variable. It was found that t of the equation improved with the prices entering as separate regressors. The own-cross-price elasticities were estimated to be -0.30 and +0.22, respectively, when ated at the mean values of price and quantity. This indicated that manufacturers in Jnited States have been more responsive to fiber price movements than their erparts in other model regions. The time variable captured the trend away from in the United States during the regression period (1964-1987) which could not be ned by economic factors.

The fit of the share equations was satisfactory overall. Out of 14 regions, six had a ted R-squared value of over 90% and for only two equations was it below 80%. for auto-correlation (by the DW or H-statistic) failed to find the presence of orrelation in most of the equations. A major concern was the inclusion of variables ng a trend in the consumption data (e.g., time variable or lagged dependent e). These variables were included because there has been a steady decline in the of cotton in total fiber consumption during the regression period (1960s to mid-which was not price-related. As mentioned above, this trend was due, in most part, nological improvements in the manufactured fibers industry. Also in many equations, dumm

observations fron

was to estimate

significant or in

Their inclusion r

become projecti

in the forecasts

(e.g., growth rat

estimated price

out-weighed by

in the consump

3.5.2 Per Capi

The estin

to 3.28 below.

deflated gross

in terms of lo

incomes and

products falls

[11] Let: Q^T = D

I = Per

LN = Va

E_η = Ela

a,b = Int

Using a semi-log f

as Q^T rises, E_η f

tions, dummy variables were used, perhaps too frequently, to remove outlying rvations from the data set. However, what was important for the simulation model o estimate reliable price elasticities. In most cases, these were unreliable (i.e., not icant or incorrectly signed) with the omission of the trend and dummy variables. inclusion raises the question of how will the long-run forecasts be. Will they mainly ne projections of past trends? However, many other factors play an important role forecasts also, such as the assumptions made about the model's exogenous variables growth rates of income, general prices, exchange rates and population), as well as the ated price and income elasticities. It is unlikely that the impact of these factors are eighed by the trend variables; however, this is an issue which is considered carefully consumption forecasts which are reported in section VIII.

Per Capita Total Fiber Use Equations

he estimated equations for per capita total fiber use are presented in equations 3.15 below. Per capita total fiber use was estimated as a function of current per capita d gross domestic product. In most cases, the income variable entered each equation s of logarithms. This was consistent with empirical evidence that showed that as s and consumption rise, the income elasticity of demand for textile and apparel ts falls[11]. In many of the equations a trend variable was included to provide more

---

Q^T = Demand for textiles,
= Per capita income,
I = Variable transformed into logarithms,
$_I$ = Elasticity of textile demand with respect to income $(\delta Q^T/\delta I).(I/Q^T)$,
= Intercept and slope coefficients, respectively, in regression equation.
mi-log functional form, the demand equation is represented by, $Q^T = a + b.\ LN\ I$. Therefore $E_{TI} = b / Q^T$. Thus , E_{TI} falls.

reliable estimates

of this variable im

using caution wh

determine the ou

The per ca

PCTFUARG = 6.84 +

R-SQUARED (CORR

Where:PCTFUARG
PDGDPARG
D81
D82
LN

The equation e

capita deflated

The income va

calculated at th

result is explai

of which was r

The per

PCTFUAUS = - 88

R-SQUARED (CO

Where:PCTFUAUS
PDGDPAU
D83
LN

The variabilit

liable estimates of the elasticity of total fiber use with respect to income. The inclusion this variable improved the statistical fit of the equations considerably, although it implied ing caution when making long-run forecasts to see that the trend variables do not termine the outcome.

The per capita total fiber use in Argentina is given in equation 3.15.

TFUARG = 6.84 + 3.96 LN PDGDPARG - 1.33 D81 - 1.56 D82 (3.15)
(3.26) (-2.75) (-3.23)

QUARED (CORR.): 0.72 SEE: 1.88 DW: 2.42 PERIOD OF FIT: 1964-1986

re:PCTFUARG = Per capita total fiber use, Argentina,
PDGDPARG = Per capita deflated gross domestic product, Argentina,
D81 = Zero-one variable, equals 1 in 1981, 0 otherwise,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
LN = Indicates variable transformed into logarithms.

e equation explaining per capita total fiber use in Argentina included the log of per ita deflated gross domestic product and zero-one dummy variables for 1981 and 1982. income variable was highly significant with an estimated income elasticity of 0.58 ulated at the mean total fiber use level. The dummy variables were significant. This lt is explained in terms of capturing the recession caused by the debt crisis, the effect hich was not fully captured by the income variable.

The per capita total fiber use in Australia is given in equation 3.16.

UAUS = - 88.14 + 11.84 PDGDPAUS - 1.95 D83 (3.16)
(10.32) (-2.08)

JARED (CORR.): 0.88 SEE: 16.55 DW: 1.88 PERIOD OF FIT: 1964-1987

:PCTFUAUS = Per capita total fiber use, Australia,
PDGDPAUS = Per capita deflated gross domestic product, Australia,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise,
LN = Indicates variable transformed into logarithms.

variability of per capita total fiber use in Australia was estimated to depend on per capita deflated in

included to captu

for by the incom

The per ca

PCTFUBRA = -12.35

R-SQUARED (CORI

Where: PCTFUBRA
PDGDPBRA
D85
D86
LN

The equation f

However, this

1986 and no e

The income va

income elastici

The per

LN PCTFUCAF =

R-SQUARED (CO

Where: PCTFUCAF
PDGDPCA
LN

The chosen s

included per

found that re

linear transfo

[12] See footnot

capita deflated income and a zero-one dummy variable for 1983. The dummy variable was included to capture the sharp decline in textile imports in Australia in 1983 not accounted for by the income variable.

The per capita total fiber use in Brazil is given in equation 3.17.

PCTFUBRA = -12.35 + 1.55 LN PDGDPBRA - 2.46 D85 - 2.86 D86 (3.17)
(8.81) (-6.96) (-7.19)

R-SQUARED (CORR.): 0.95 SEE: 1.88 DW: 1.29 PERIOD OF FIT: 1964-1986

Where: PCTFUBRA = Per capita total fiber use, Brazil,
PDGDPBRA = Per capita deflated gross domestic product, Brazil,
D85 = Zero-one variable, equals 1 in 1985, 0 otherwise,
D86 = Zero-one variable, equals 1 in 1986, 0 otherwise,
LN = Indicates variable transformed into logarithms.

The equation for Brazil fitted the data very well with an adjusted R-squared of 0.95. However, this result was heavily affected by the zero-one dummy variables for 1985 and 1986 and no explanation was found why consumption declined suddenly in these years. The income variable was highly significant (t-value = 8.81) providing an estimate of the income elasticity of total fiber use equal to 0.32.

The per capita total fiber use in Central Africa[12] is given in equation 3.18.

LN PCTFUCAF = - 3.51 + 0.54 LN PDGDPCAF + 0.90 LN PCTFUCAF(-1) (3.18)
(2.56) (6.98)

R-SQUARED (CORR.): 0.92 SEE: 0.06 H-STAT: 0.46 PERIOD OF FIT: 1964-1986

Where: PCTFUCAF = Per capita total fiber use, Central Africa,
PDGDPCAF = Per capita deflated gross domestic product, Central Africa,
LN = Indicates variable transformed into logarithms.

The chosen specification of the equation explaining total fiber use in Central Africa included per capita deflated income and per capita total fiber use lagged one year. It was found that regressing the logarithms of variables provided a better fit to the data than their linear transformation. The income variable was significant with a coefficient (and elasticity

[12]See footnote 7 for region definition.

estimate) of 0.5

period meant th

in the equation l

with a coefficie

The per ca

PCTFUCHI = 6.07 +
(

R-SQUARED (COR

Where: PCTFUCHI
PDGDPCHI
D81
LN

Total fiber use

domestic produ

be treated wit

income trende

income elastic

appears to be

non-income re

The per

PCTFUEEC = - 11

R-SQUARED (CO

Where: PCTFUEE
PDGDPEE
UNEMPEI
DMFAI
DMFAII
DMFAIII
LN

estimate) of 0.54. The steady increase in fiber use in Africa throughout the regression period meant that the data contained a very strong upward trend. This was accounted for in the equation by the inclusion of a lagged dependent variable which entered the equation with a coefficient of 0.9 and t-value of 6.98.

The per capita total fiber use in China is given in equation 3.19.

PCTFUCHI = 6.07 + 2.88 LN PDGDPCHI + 0.58 D81 (3.19)
(18.28) (2.36)

R-SQUARED (CORR.): 0.95 SEE: 0.24 DW: 1.73 PERIOD OF FIT: 1964-1986

Where: PCTFUCHI = Per capita total fiber use, China,
PDGDPCHI = Per capita deflated gross domestic product, China,
D81 = Zero-one variable, equals 1 in 1981, 0 otherwise,
LN = Indicates variable transformed into logarithms.

Total fiber use in China was explained by the logarithm of per capita deflated gross domestic product and a zero-one dummy variable for 1981. The regression results should be treated with caution because both per capita consumption and per capita deflated income trended upwards consistently during the regression period with the result that the income elasticity was estimated at 0.91 with coefficient t-value of 18.28. This elasticity appears to be unduly large and could have resulted from the income variable capturing a non-income related trends in total fiber use.

The per capita total fiber use in the EEC-12 is given in equation 3.20.

PCTFUEEC = - 116.9 + 15.0 LN PDGDPEEC - 0.14 UNEMPEEC - 0.76 DMFAI - 0.58 DMFAII - 1.77 DMFAIII (3.20)
(7.84) (-1.71) (-2.39) (-1.71) (-4.90)

R-SQUARED (CORR): 0.93 SEE: 0.44 DW: 1.62 PERIOD OF FIT: 1964-1987

Where: PCTFUEEC = Per capita total fiber use, EEC-12,
PDGDPEEC = Per capita deflated gross domestic product, EEC-12,
UNEMPEEC = Unemployment rate (%), EEC-12,
DMFAI = Zero-one variable for MFAI period, equal 1 1974 to 1977 else 0,
DMFAII = Zero-one variable for MFAII period, equal 1 1978 to 1981 else 0,
DMFAIII = Zero-one variable for MFAIII period, equal 1 1982 to 1985 else 0,
LN = Indicates variable transformed into logarithms.

In the equation

unemployment v

of this variable v

In periods of g

especially the c

recessions. Alt

signed correctly

one dummy va

operated durin

which resulted

12 from develo

in an initial sp

(i.e., less than

The per

PCTFUEGY = -14

R-SQUARED (CO

Where: PCTFUEGY
PDGDPEC
D81
LN

The per capi

capita gross

variable was

mean fiber u

increase in y

the equation for the EEC-12, in addition to the per capita income variable, an
nemployment variable was added to the specification. The hypothesis behind the inclusion this variable was that textile products tend to be durable and purchases are infrequent. periods of general recession the sales of textile products fall significantly. This is pecially the case for lower income households which tend to be most affected by cessions. Although not significant, the variable was kept in the equation because it was ned correctly. Also included in this per capita total fiber use equation were three zero-e dummy variables, accounting for the three Multi-Fiber Agreements (MFA) which erated during the estimation period. The variables captured the decline in consumption ich resulted from restrictions placed on the importation of textile products into the EEC-from developing countries. An index of prices of textile and apparel products was tried an initial specification of this equation. However, the variable had a very low t-value ., less than unity) and was dropped from the specification.

The per capita total fiber use in Egypt is given in equation 3.21.

$$\text{FUEGY} = -14.87 + \underset{(12.10)}{3.55}\ \text{LN PDGDPEGY} + \underset{(-3.93)}{1.22}\ \text{D81} \qquad (3.21)$$

UARED (CORR.): 0.91 SEE: 1.66 DW: 1.84 PERIOD OF FIT: 1964-1986

e:PCTFUEGY = Per capita total fiber use, Egypt,
PDGDPEGY = Per capita deflated gross domestic product, Egypt,
D81 = Zero-one variable, equals 1 in 1981, 0 otherwise,
LN = Indicates variable transformed into logarithms.

per capita use of fibers in Egypt was estimated to depend on the logarithm of per a gross domestic product and a zero-one dummy variable for 1981. The income ble was highly significant, and gave an elasticity estimate of 0.68 when calculated at fiber use. The dummy variable for 1981 in the equation accounted for the sudden ase in yarn output and weak demand in its export markets.

The per ca

LN PCTFUIND = - 1.

R-SQUARED (CORR

Where: PCTFUIND =
PDGDPIND =
TIME =
D82 =
LN

The variability

capita gross dom

equation perfor

The per c

PCTFUJPN = - 110.

R-SQUARED (COR

Where: PCTFUJPN
PDGDPJPN
D73
LN

Per capita tot

product and a

variable gave

The dummy v

increase in in

The per capita total fiber use in India is given in equation 3.22.

PCTFUIND = - 1.00 + 0.28 LN PDGDPIND - 0.104 LN TIME - 0.08 D82 (3.22)
(2.81) (-3.46) (-2.62)

SQUARED (CORR.): 0.62 SEE: 0.013 DW: 2.08 PERIOD OF FIT: 1964-1986

ere:PCTFUIND = Per capita total fiber use, India,
PDGDPIND = Per capita deflated gross domestic product, India,
TIME = Time variable,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
LN = Indicates variable transformed into logarithms.

e variability of per capita total fiber use in India was explained by variability in per pita gross domestic product, a time trend and a zero-one dummy variable for 1982. The uation performed better with variables converted into logarithms than in the linear form.

The per capita total fiber use in Japan is given in equation 3.23.

TFUJPN = - 110.0 + 8.68 LN PDGDPJPN + 4.21 D73 (3.23)
(2.45) (3.30)

QUARED (CORR.): 0.81 SEE: 32.47 DW: 1.23 PERIOD OF FIT: 1964-1987

re:PCTFUJPN = Per capita total fiber use, Japan,
PDGDPJPN = Per capita deflated gross domestic product, Japan,
D73 = Zero-one variable, equals 1 in 1973, 0 otherwise,
LN = Indicates variable transformed into logarithms.

capita total fiber use in Japan was explained by per capita deflated gross domestic duct and a zero-one dummy variable for 1973. The estimated coefficient on the income able gave and income elasticity of 0.58 when calculated at the mean of total fiber use. dummy variable for 1973 captured the increase in consumption due to the sudden ease in imports in that year.

The per ca

PCTFUKOR = - 20.85

R-SQUARED (CORR

Where:PCTFUKOR =
PDGDPKOR
D72
LN

The upward tr

regression peri

equation speci

product and a

variable in the

due to politica

The per

PCTFUMEX = - 1

R-SQUARED (CO

Where:PCTFUMEX
PDGDPME
D82
LN

The variables

capita gross c

use lagged on

in an income

needed in the

The dummy

result of the

The per capita total fiber use in Korea is given in equation 3.24.

$$PCTFUKOR = -20.85 + 1.75\ LN\ PDGDPKOR + 0.71\ PCTFUKOR(-1) - 2.57\ D72 \quad (3.24)$$
$$\qquad\qquad\qquad (2.49) \qquad\qquad (5.83) \qquad\qquad (-3.48)$$

R-SQUARED (CORR.): 0.97 SEE: 9.13 H-STAT: 2.01 PERIOD OF FIT: 1964-1986

Where: PCTFUKOR = Per capita total fiber use, Korea,
PDGDPKOR = Per capita deflated gross domestic product, Korea,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
LN = Indicates variable transformed into logarithms.

The upward trend in per capita use of fibers in Korea was very strong during the regression period. because of this, lagged per capita fiber use was included in the final equation specification along with the logarithm of per capita deflated gross domestic product and a zero-one dummy variable for 1972. The statistical significance of a dummy variable in the equation for Korea in 1972 captured the substantial economic disruption due to political unrest during the early 1970s.

The per capita total fiber use in Mexico is given in equation 3.25.

$$PCTFUMEX = -15.98 + 1.77\ LN\ PDGDPMEX + 0.43\ PCTFUMEX(-1) - 0.82\ D82 \quad (3.25)$$
$$\qquad\qquad\qquad (2.49) \qquad\qquad (2.07) \qquad\qquad (-2.17)$$

R-SQUARED (CORR.): 0.84 SEE: 2.01 H-STAT: 2.86 PERIOD OF FIT: 1964-1986

Where: PCTFUMEX = Per capita total fiber use, Mexico,
PDGDPMEX = Per capita deflated gross domestic product, Mexico,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
LN = Indicates variable transformed into logarithms.

The variables used to explain per capita total fiber use in Mexico were the logarithm of per capita gross domestic product, a zero-one dummy variable for 1982, and per capita fiber use lagged one year. The coefficient on the income variable was significant and resulted in an income elasticity estimate of 0.33. The lagged per capita fiber use variable was needed in the equation to capture the rising trend in use throughout the regression period. The dummy variable for 1982 was included to account for the decline in fiber use as a result of the debt crisis in the early 1980s.

The per ca

PCTFUPAK = 0.44 ·

R-SQUARED (CORI

Where:PCTFUPAK
D72
D82
LN

Of all the equa

all regions exc

dependent vari

regression peri

1972 and 1982.

capita fiber us

supplies going

The per

PCTFUTUR = - 7

R-SQUARED (CO

Where:PCTFUTU
PDGDPTU
D74
LN

The equation

capita gross

fiber use lagg

by the stron

dummy vari

resulting fro

The per capita total fiber use in Pakistan is given in equation 3.26.

CTFUPAK = 0.44 + 0.84 PCTFUPAK(-1) + 0.94 D72 - 0.82 D82 (3.26)
(8.40) (2.51) (-2.17)

SQUARED (CORR.): 0.83 SEE: 2.40 H-STAT: 0.78 PERIOD OF FIT: 1964-1986

here:PCTFUPAK = Per capita total fiber use, Pakistan,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
LN = Indicates variable transformed into logarithms.

f all the equations explaining per capita fiber use, the income variable performed well in regions except for Pakistan, where it had the wrong sign (negative). A lagged pendent variable performed well, reflecting the strong trend in the data throughout the gression period. Zero-one dummy variables were included in the regression for the years 72 and 1982, when there was an unexplained increase and decrease, respectively, in per oita fiber use. The increase in fiber use in 1972 may have been caused by disruption of oplies going to Bangladesh soon after its independence.

The per capita total fiber use in Turkey is given in equation 3.27.

FUTUR = - 7.20 + 0.85 LN PDGDPTUR + 0.67 D74 + 0.73 PCTFUTUR(-1) (3.27)
(2.20) (2.50) (5.76)

QUARED (CORR.): 0.95 SEE: 1.02 H-STAT: 1.48 PERIOD OF FIT: 1964-1986

re:PCTFUTUR = Per capita total fiber use, Turkey,
PDGDPTUR = Per capita deflated gross domestic product, Turkey,
D74 = Zero-one variable, equals 1 in 1974, 0 otherwise,
LN = Indicates variable transformed into logarithms.

equation explaining per capita total fiber use in Turkey contained the logarithm of per ita gross domestic product, a zero-one dummy variable for 1974 and per capita total r use lagged one year. The large coefficient on the lagged fiber use variable was caused he strong upward trend in per capita fiber use during the regression period. The my variable accounted for an unexplained increase in fiber consumption in 1974, lting from sharply lower exports of textiles to other countries which were experiencing a recession.

The per ca

PCTFUUSA = - 191.0

R-SQUARED (COR

Where:PCTFUUSA
PDGDPUSA
UNEMPUSA
DMFAI
DMFAII
DMFAIII
LN

The specificati

same as used f

to account for

the variable wa

per capita tota

for the three

textile and app

the variable

specification.

Overall,

seven had a

between 0.8 a

auto-correlat

[13]Autocorrela
textile consumpti
collecting the raw
fiber equivalents
contain errors.
variable may con

a recession.

The per capita total fiber use in the United States is given in equation 3.28.

PCTFUUSA = - 191.0 + 23.1 LN PDGDPUSA - 0.28 UNEMPUSA - 1.21 DMFAI - 2.30 DMFAII - 2.74 DMFAIII (3.28)
(7.79) (-1.32) (-1.65) (-3.42) (-3.12)

R-SQUARED (CORR): 0.82 SEE: 0.77 DW: 1.51 PERIOD OF FIT: 1964-1987

Where: PCTFUUSA = Per capita total fiber use, United States,
PDGDPUSA = per capita deflated gross domestic product, United States,
UNEMPUSA = Unemployment rate (%), United States,
DMFAI = Zero-one variable for MFAI period, equal 1 1974 to 1977 else 0,
DMFAII = Zero-one variable for MFAII period, equal 1 1978 to 1981 else 0,
DMFAIII = Zero-one variable for MFAIII period, equal 1 1982 to 1985 else 0,
LN = Indicates variable transformed into logarithms.

The specification used to explain the variability of fiber use in the United States was the same as used for the EEC-12. An unemployment variable was added to the specification to account for declining textile sales during periods of recession. Although not significant, the variable was kept in the equation because it was signed correctly. Also included in the per capita total fiber use equations were the three zero-one dummy variables, accounting for the three MFAs which operated during the estimation period. An index of prices of textile and apparel products was tried in an initial specification of this equation. However, the variable had a very low t-value (i.e., less than unity) and was dropped from the specification.

Overall, the equations fitted the data reasonably well. Of the 14 equations estimated, seven had a corrected R-squared above 0.9, five equations had a correct R-squared of between 0.8 and 0.9, and for only two equations was it less than 0.8. Some equations were auto-correlated as evidenced by the DW and H-statistics[13]. Initially this problem was

[13]Autocorrelation may have arisen from model misspecification. The most important source of measurement error in any textile consumption model is measurement error in the dependent variable. There are standard procedures used by statisticians collecting the raw data in estimations of end use cotton consumption (especially conversion factors used to estimate the raw fiber equivalents of textile trade). These methods rest on data and assumptions that are periodically revised and known to contain errors. Since these errors are unlikely to be random from period to period, the vector that denotes the dependent variable may contains an autocorrelation structure.

corrected using
required that a
In most cases, t
simulation perf
in the cotton sh
While improvin
is needed in de
elasticity estim
and general p
forecasts.

3.6 Demand

3.6.1 P

The pri
elasticities ar
Korea. With
and newly-inc
the EEC -0.1
-0.07, China
the use of
manufacture
relative pric

corrected using the Cochrane Orcutt transformation. However, using this technique required that a lagged dependent variable appear on the right-hand side of the equation. In most cases, the coefficient on this variable was very large and resulted in unsatisfactory simulation performance. Therefore, the equations were left uncorrected. As was the case in the cotton share equations, it was necessary to use time and lagged dependent variables. While improving the fit of the equations considerably, their inclusion means that caution is needed in deriving model forecasts. Nonetheless, the equations provided plausible income elasticity estimates, which together with the assumptions about future population, income and general prices, as well as the trend components, were used to make consumption forecasts.

3.6 Demand Elasticity Estimates

3.6.1 Price Elasticities

The price elasticities for cotton use are presented in Table 3.1. The demand elasticities are highly inelastic, ranging from -0.02 for India to -0.33 in the Republic of Korea. With the exception of Australia, the elasticities are higher for the industrialized and newly-industrialized countries (e.g., the United States -0.3, the Republic of Korea -0.33, the EEC -0.14) and lower in the developing countries (e.g., Central Africa -0.02, Argentina -0.07, China -0.08). The higher elasticities in the industrialized countries most likely reflect the use of more modern processing facilities in these countries, which enables manufacturers to quickly change the mix of fibers processed in response to changes in relative prices.

Table 3.1 Pri

Region[2]
Argentina
Australia
Brazil
Cent. Africa
China
EEC-12
Egypt
India
Japan
Korea
Mexico
Pakistan
Turkey[4]
USA

[1]Based on a
countries.

The elasticitie
share equatio
$E_{CTU/P}$ = (∂C
+ $b_k P_k$). (∂C

Values for C

[2]No elasticit
demand equa

[3]Where poly
used in the

[4]The price o
wrong sign.

Table 3.1 Price Elasticities of Cotton Use

Region[2]	Cotton Price	Polyester Staple Price[3]
Argentina	- 0.07	+ 0.07
Australia	- 0.06	+ 0.06
Brazil	- 0.18	+ 0.17
Cent. Africa	- 0.04	+ 0.04
China	- 0.08	+ 0.08
EEC-12	- 0.14	+ 0.14
Egypt	- 0.17	+ 0.17
India	- 0.02	+ 0.02
Japan	- 0.04	+ 0.04
Korea	- 0.33	+ 0.33
Mexico	- 0.09	+ 0.09
Pakistan	- 0.04	+ 0.04
Turkey[4]	- 0.13	
USA	- 0.30	+ 0.22

[1]Based on a regression period 1964-1986 for developing 1964-1987 for industrialized countries.

The elasticities of cotton use with respect to price ($E_{CTU/P}$) were derived from the cotton share equations.
$E_{CTU/P} = (\partial CTU/\partial P).(P/CTU)$. Recall $CTU = CTSH * TFU$ and that $CTSH = (\Sigma_i^k b_i.X_i + b_k.P_k)$. $(\partial CTU/\partial P) = b_k.TFU$ and $E_{CTU/P} = b_k.TFU.P/CTU$.

Values for CTU, P and TFU were taken as historical means.

[2] No elasticities can be reported from model regions for which prices do not appear in the demand equations (ie. India, Pakistan, Japan and Egypt).

[3]Where polyester price elasticities equal the cotton elasticities a ratio of these prices was used in the share equation.

The price of polyester was dropped from the share equation for Turkey because it had the wrong sign. Hence no elasticity could be reported.

The low

ten years less th

mills, with 80%

price changes

traded goods, i

price variable

consumed is in

A rathe

that it would

capacity. How

in this case fro

cotton industr

be that China

In Tab

estimates are

period 1955-

1954-86). C

price elastici

more elastic

studies are n

specification

The low elasticity for Australia may reflect the fact that, on average, over the past ten years less than 20% of cotton goods sold to consumers has been provided by domestic mills, with 80% coming from imports. Given that the domestic consumption response to price changes in the model is through the milling sector and not through the price of traded goods, it is expected that the elasticity will be small. This may explain also why the price variable was not significant in the case of Japan, where about one-third of cotton consumed is imported.

A rather surprising result is the low elasticity reported for China. It was expected that it would be larger given that China has recently invested heavily in modern plant capacity. However, the elasticity reflects average relationships over the estimation period--in this case from 1964 to 1986--and therefore encompasses periods of stagnation in China's cotton industry during the mid-1970s and earlier. Another reason for the low elasticity may be that China's wholesale cotton prices are different from world producer prices.

In Table 3.2 the elasticities obtained from previous studies are reported. All estimates are inelastic and range from -0.09 (Thigpen, for developing countries over the period 1955-75) to -0.34 (Mues and Simmons, for the United States over the period 1954-86). Consistent with the results from this study, other researchers have found the price elasticities to be higher for the higher income countries. Elasticities also tend to be more elastic for the more recent time periods. Generally, the elasticities reported in other studies are not dissimilar to the ones found in this study despite major differences in model specification, period of estimation and regional coverage.

Table 3.2 Pric

Author
Donald et al
Dudley
Thigpen
Adams & Be
Mues & Sim

3.6.2 Incom

The i

are differen

The most st

for the hig

results do

consumptio

respectively

cotton pro

Table 3.2 Price Elasticities Estimates Obtained From Previous Studies

Author	Region	Dep.Var.	Period	Elasticity
Donald et al	U.S.	Fiber Dem.	1948-60	- 0.14
Dudley	World	Fiber Dem.	1953-70	- 0.25
Thigpen	DCs	Cotton Dem.	1955-75	- 0.20
	LDCs	Cotton Dem.	1955-75	- 0.09
Adams & Behrman	DCs	Fiber Dem.	1955-73	- 0.23
Mues & Simmons	U.S.	Mill Con.	1954-86	- 0.34
	W.Europe	Mill Con.	1954-86	- 0.26
	ROW	Mill Con.	1954-86	- 0.10

3.6.2 Income Elasticities

The income elasticities of total fiber demand are reported in Table 3.3. The results are different from what was expected, ranging from 0.12 in Turkey to 1.08 in the EEC. The most striking feature of the results is that, in general, income elasticities are greater for the higher-income countries (e.g., the United States, Japan and the EEC). These results do not support the hypothesis that income elasticities decline as income and consumption increase. The elasticities of 1.08 and 1.04 for the EEC and the United States, respectively, seem high. A possible explanation is that the large increases in the use of cotton products in the United States and the EEC are mainly cheap imports, especially from the newl

consumption m

For the reason

use equations.

influences on

Table 3.3 Inc

Region
Argentina
Australia
Brazil
Central Afric
China
EEC-12
Egypt
India
Japan
Korea
Mexico
Turkey
United State

1/ Based o
industrialize

2/ Elastic
PCDFGDP
region.

from the newly-industrialized countries of Southeast Asia as well as China. Increased consumption may have resulted from lower import prices as well as from income increases. For the reasons discussed in section 3.4, prices do not appear in the per capita total fiber use equations. Therefore, the income variable may be capturing both price and income influences on consumption.

Table 3.3 Income Elasticities of Demand for All Fibers[1].

Region	Income[2] Elasticity
Argentina	0.58
Australia	0.65
Brazil	0.32
Central Africa	0.54
China	0.91
EEC-12	1.08
Egypt	0.68
India	0.28
Japan	0.58
Korea	0.24
Mexico	0.33
Turkey	0.12
United States	1.04

1/ Based on a regression period 1964-1986 for developing countries and 1964-1987 for industrialized countries.

2/ Elasticities derived from the semi-log functional form PCTFU = $\Sigma_i^k b_i X_i$ + b_kLN PCDFGDP are given by b_k / PCTFU. The historical mean of PCTFU is used in each region.

Income

study by Thig

industrial and

elasticities dec

period Thigpe

data. Interest

industrial cou

industrial cou

Table 3.4 In

Author
Donald et al
Dudley
Magleby & Missaien
Thigpen
Adams & Behrman

Income elasticity estimates from other studies are reported in Table 3.4. In the study by Thigpen, income elasticities for cotton and total fiber are reported for the industrial and developing countries and for the CPEs. His findings show that income elasticities decline as incomes rise. However, using cross-sectional data over a three-year period Thigpen avoids the multicollinearity problems associated with using only time-series data. Interestingly, Adams and Behrman found the income elasticity to be larger for the industrial countries than for the developing countries, although the magnitudes for the industrial countries were much lower than in this study.

Table 3.4 Income Elasticities Estimates Obtained From Previous Studies

Author	Region	Dep. Var.	Period	Elasticity
Donald et al	U.S.	Fiber Dem.	1948-60	0.80
Dudley	World	Fiber Dem.	1953-70	0.27
Magleby & Missaien	World	Fiber Dem.	1964	0.62
Thigpen	DCs	Cotton Dem.	1970-72	0.07
	LDCs	Cotton Dem.	1970-72	0.50
	CPEs	Cotton Dem.	1970-72	0.20
	DCs	Fiber Dem.	1970-72	0.30
	LDCs	Fiber Dem.	1970-72	1.40
	CPEs	Fiber Dem.	1970-72	0.60
Adams & Behrman	DCs	Fiber Dem.	1955-73	0.60
	LDCs	Fiber Dem.	1955-73	0.47

3.7 Summary

This section des

demand for cotton. Th

there is no direct consu

cotton is a substitutab

composition and that

purchase price, equat

The cotton share of t

of cotton and manuf

relative prices. This

provided the theoret

performed well with,

important was that t

with previous econo

Summary

This section described the econometrically estimated equations used to explain the ıand for cotton. The task of modeling cotton demand was complicated by the fact that e is no direct consumer demand for raw cotton but rather for textile products, in which on is a substitutable input. Given that individuals are relatively insensitive to fiber position and that the fiber component represents only a small proportion of the final :hase price, equations for total fiber demand were estimated as a function of income. cotton share of total fiber demand was estimated as a function of the relative prices otton and manufactured fibers and captures the price sensitivity of manufactures to tive prices. This framework was consistent with the two-stage budgeting model which rided the theoretical basis for the econometric estimation. The regression equations ormed well with, in general, high explanatory power and significant coefficients. More ɔrtant was that the price and income elasticity measures are reasonable and consistent previous econometric studies of the textile market.

4.1 Introduction

An important

output since the early

of area. Since 1963, a

an increase of over 6

at around 30 million

separately as importa

product of these con

Cotton produ

annual crop which

cereals and oilseeds

become fairly stand

sight of the theore

theoretical issues is

4.2 Theoretical Issu

A theoretic

to maximize their

inputs and output.

4. Cotton Production

1 Introduction

An important feature of world cotton production is that the substantial increase in utput since the early 1960s has resulted from yield increases and not from an expansion f area. Since 1963, average world yields have risen from 338 kg/ha to 545 kg/ha in 1988, n increase of over 60%. Over this period the cotton area has remained fairly constant t around 30 million hectares. This suggests that yields and area should be modeled eparately as important information may be lost if production is estimated directly as the roduct of these components.

Cotton production is more straight forward to model than demand. Cotton is an nnual crop which has similar production requirements to other annual crops such as ereals and oilseeds. While the specification of models of annual crop supply have ecome fairly standard over the years and can be used here, it is important not to lose ght of the theoretical rationale behind their specification. A brief overview of the heoretical issues is presented below.

2 Theoretical Issues

A theoretical model of agricultural supply assumes that individual farmers attempt maximize their profits, subject to technological constraints and exogenous prices of puts and output. Assume farmers produce a number of commodities and are cost minimizers. Then tec

where, Y = vector of
X = vector of
Z = vector of
W = vector o
V = producti

Given a vector of ex

maximization, with p

The profit maximiza

Finally using Hotelli

Production of each

opportunity set (i.e.

complementary con

Most mode

these components

prices and fixed inp

the price of the m

the area equation.

commodity and on

resources such as

mizers. Then technology can be expressed in terms of a cost function,

$$C(Y,W,Z) = \min_{(x)}(WX : (Y,X,Z \text{ is in } V))$$

re, Y = vector of i outputs,
X = vector of j variable inputs,
Z = vector of k fixed inputs,
W = vector of input prices, and
V = production possibility set.

en a vector of exogenous output prices, P, cost minimization is equivalent to profit imization, with profit given by,

$$\pi = PY - C(Y,W,Z).$$

profit maximization for the function G(P,W,Z) is given by,

$$G(P,W,Z) = \max_{(y)}(PY - C(Y,W,Z)).$$

ally using Hotelling's lemma, the vector of production Y(P,W,Z) can be obtained from,

$$Y(P,W,Z) = \partial G(P,W,Z) / \partial P.$$

duction of each output is a function of all prices of products within the farmers' ortunity set (i.e., the price of the commodity itself plus the prices of all competing and plementary commodities), all input prices and the levels of fixed inputs.

Most models of annual crop production separate yields from area and estimate e components separately. According to the theory presented above, input and output es and fixed inputs are determinants of production. Typically, the relationship between price of the modeled commodity and the prices of competing products is captured in rea equation. The area equation is often specified as function of lagged prices of the nodity and one or two commodities believed to compete with the commodity for farm rces such as land and labor.

The relationsh

the yield equation. Th

Exogenous factors aff

the yield equation.

4.3 Literature Revie

Compared t

production and of th

estimated a United S

areas (i.e., the Delta

variables used incluc

incorporated prices

and soybeans). Al

diversion payments

States into four sep

appropriate becaus

regions and becaus

resources.

Starbird an

United States. The

Plains (non-irrigat

planted and weath

crop year. In addi

The relationship between the price of inputs and the price of output is captured in
rield equation. The effect of the fixed inputs are felt through the equation coefficients.
genous factors affecting supply, such as weather and technology, are often included in
yield equation.

Literature Review

Compared to cotton demand, relatively few studies have focused on cotton duction and of these most have been for the United States. For example, Evans (1977) mated a United States cotton acreage response equation for the four major producing as (i.e., the Delta region, the Southeast, the Southwest, and the West). The explanatory ables used included average variable and opportunity costs of producing cotton, which orporated prices and costs of cotton and competing crops (e.g., corn, barley, sorghum, soybeans). Also policy variables were used, such as national acreage allotments, rsion payments and direct payments. Of most interest is the division of the United es into four separate producing regions and the use of region-specific data. This is ropriate because United States cotton production practices differ significantly across ons and because of differences in the types of crop that compete with cotton for farm urces.

Starbird and Hazera (1981) estimated cotton yield equations for four regions of the ed States. These were the Mississippi Delta, Texas High Plains (irrigated), Texas High s (non-irrigated) and California. Yields were explained by the number of acres ed and weather variables for rainfall and temperature during crucial periods of the year. In addition, a policy dummy variable was used to capture the effect of the skip-row policy rules[1]. No

which explained a high

Monke (1983)

countries for the peri

prices of a number o

coefficients on compe

equation is that a lag

coefficient of 0.95 (a

explains the lack of s

Mues and Si

States, Australia and

world price of cotton

used as regressors.

including dummy va

years, the guarantee

requirement for par

policy, were signific

World except that

Hamid et a

Sind regions of P

[1]During the allotment years of

ze rows not planted. During 1962-

enalties were reimposed in 1966-67

mpliance with program provisions

v policy rules[1]. No economic variables were included in the United States equations ich explained a high proportion of yield variability.

Monke (1983) estimated an equation for the production of all price-responsive untries for the period 1960-80. The world price lagged one period as well as current ces of a number of competing commodities were used as regressors. None of these efficients on competing commodities were significant, however. A concern about the uation is that a lagged dependent variable was added to the specification which had a efficient of 0.95 (and t-value of 52.84). This variable drives the model and probably plains the lack of significance of the coefficients on competing crops.

Mues and Simmons (1988) estimated the area planted to cotton for the United tes, Australia and the Rest-of-the-World. For the United States equation the lagged rld price of cotton, the price received for soybeans and a lagged dependent variable were d as regressors. Various policy instrument variables were added to the specification, uding dummy variables for the payment-in-kind (PIK) program and for the soil bank rs, the guaranteed price to growers under the farm program, and the acreage-reduction uirement for participation in the program. All the variables, including those capturing cy, were significant. A similar specification was used for Australia and the Rest-of-the-rld except that the policy variables were dropped from the equations.

Hamid <u>et al.</u> (1987) estimated cotton area and yield equations for the Punjab and regions of Pakistan. The equations reported did not perform well with most

allotment years of 1954-61, all acreage in fields planted to skip-rowed cotton were counted as cotton acreage, including nted. During 1962-65, these rules were relaxed, and only the planted rows were counted as acreage planted. Acreage imposed in 1966-67. Since 1968, only land actually planted to cotton has been counted as cotton land in determining program provisions" (Starbird and Hazera, p. 18).

coefficients not signific

were significant. The

number of tubewells in

such as improvements

Thigpen and M

determined by lagged

more competing crop

linear trend, lagged c

the competing crop r

4.4 Model of Cotto

As suggeste

specification for ann

equation for yield a

these components.

P
C
C

where,

PD = C
CTYD = C
CTHA = N
PCC = P
PCT = P
PF = P
W = W

As mention

:oefficients not significant and some with the wrong sign. None of the economic variables vere significant. The most significant variable was water availability, measured by the iumber of tubewells in operation. This variable may have also been capturing other factors uch as improvements in cotton varieties.

Thigpen and Mitchell (1988) estimated equations for both area and yield. Area was letermined by lagged cotton area, lagged cotton revenue and lagged revenue of one or nore competing crops such as coarse grains and soybeans. Yields were determined by a inear trend, lagged cotton price and the current fertilizer price. The fertilizer price and he competing crop revenue were exogenous in the model.

.4 Model of Cotton Supply

As suggested above, cotton supplies were estimated using a fairly standard pecification for annual crops. Production in each region was determined by a behavioral quation for yield and area planted, and an identity giving production as the product of iese components. That is,

$$PD = CTYD * CTHA,$$
$$CTYD = f(PCT, PF, W),$$
$$CTHA = f(PCT(-1), PCC(-1)),$$

iere,

) = Cotton production,
TYD = Cotton yield per hectare,
THA = Number of hectares planted,
C = Price of competing crops,
T = Price of cotton,
= Price of fertilizer, and
= Weather.

As mentioned in the theoretical review, yields are determined by profitability of the cotton enterprise whic

To capture these relat

explanatory variables

of the model regions.

and temperature play

little irrigated cotton

temperature data for

the specification the

cases weather data a

period.

Another fact

of high-yielding and

variable was added

trended upwards th

variation in yield.

the logarithm of ti

to measure the pe

upper-limit (i.e.,

Unfortunately, dat

available. Howeve

for new technolog

The rationale for

forced onto land

cotton enterprise which depends on the relationship between product and factor prices. To capture these relationships the cotton price and price of fertilizer were used initially as explanatory variables in the yield equations. This specification performed badly for many of the model regions. On careful inspection of the yield data it was observed that rainfall and temperature play a crucial role in determining yields, especially in those countries with ittle irrigated cotton area. This led to the collection of large amounts of rainfall and emperature data for the major producing countries. When these variables were added to he specification the performance of the equations improved dramatically and in some cases weather data alone explained up to 80% of the variations in yield over the historical eriod.

Another factor affecting cotton yields is the impact of the rapid growth in the use f high-yielding and drought-resistent cotton varieties. To capture this development, a time ariable was added to the specifications. In some regions of the model in which yields ended upwards throughout the estimation period, a time trend explained almost all the ariation in yield. In forecasting production up to 2005 the time variable was replaced by e logarithm of time. Perhaps a better variable to capture this historical effect would be measure the percentage of total crop under high-yielding varieties. This would give an pper-limit (i.e., 100%) to increases in yield from the uptake of new technology. nfortunately, data on area allocated to high-yielding varieties of cotton are not readily ailable. However, this variable would raise problems in forecasting as it would not allow r new technology. Another variable that was successful in some cases was area planted. e rationale for the inclusion of this variable was that as area increases, production is rced onto land of lower quality, forcing average yields to decline.

The number

profitability of the cot

farm resource requi

determining cotton ar

as coarse grains and

The productio

competing commodit

using the United Sta

index for each moc

significant or wrong

may be explained b

prices. In many c

farmers facing a se

In an attempt to

competing crops we

These prices were

without exception

considerably. Nex

Only in the equati

between the local

---

[2] Outlook Index "A" price.

[3] The consumer price index wa
price index) was not available. Ho

The number of hectares planted with cotton is specified to depend on the profitability of the cotton enterprise relative to the profitability of crops which have similar farm resource requirements. To capture substitution between crop enterprises in determining cotton area, the lagged prices of cotton and the prices of competing crops such as coarse grains and soybeans were included in the regression equations.

The production equations were estimated using international prices for cotton [2]and competing commodities. These prices were adjusted by converting into domestic currency using the United States dollar exchange rate and by deflating using the consumer price index for each model region[3]. The results were unsatisfactory with many prices not significant or wrongly signed. The poor performance of price variables in the equations may be explained by the fact that producers in many of the regions do not face world prices. In many countries government intervention in production and trade results in farmers facing a set of local prices which differ substantially from the world price levels. In an attempt to capture farmer response to prices, local price data for cotton and competing crops were collected for some regions (i.e., India, China, and the United States). These prices were also in local currency and deflated by the consumer price index. Almost without exception local prices were significant and the area equations improved considerably. Next, local prices were related to world prices using price linkage equations. Only in the equations for the United States were statistically significant relationships found between the local and world cotton prices. Local prices of other countries (e.g., China and

---

Index "A" price.

sumer price index was used because for many regions a more appropriate index (e.g., a wholesale price index or producer as not available. However, the consumer price index is likely to be highly correlated with other more appropriate deflators.

India) were treated as

In many count

United States cotton

West. In each region

crops (e.g., cotton co

region, with sorghum

barley in the West).

substantially across r

and area and total

production. A regio

for area and yield fo

and Western region

4.5 Empirical Res

4.5.1 Yield Eq

The estima

1964-1988 and are

to estimate becaus

overall the equati

than 80%. In ma

variables. In gen

cotton productio

India) were treated as policy variables and made exogenous in the model.

In many countries, cotton production takes place in distinct regions. For example, United States cotton output is produced in the Delta region, Southeast, Southwest and West. In each region farmers face different prices and choices with respect to alternative crops (e.g., cotton competes with soybeans in the Southeast, with soybeans in the Delta region, with sorghum and winter wheat in the Southwest and with alfalfa, wheat, corn and barley in the West). Also, yields are affected by rainfall and temperature which differ substantially across regions. United States production was obtained by the product of yield and area and total United States production was obtained by summing the regional production. A regional disaggregation was attempted for India and Pakistan. Equations for area and yield for the Punjab and Sind regions of Pakistan and the Northern, Southern and Western regions of India were estimated successfully.

.5 Empirical Results

4.5.1 Yield Equations

The estimated equations for cotton yields were estimated using OLS for the period 964-1988 and are presented in equations 4.1 - 4.17 below. Yield equations were difficult estimate because there was often a lot of randomness contained in the series. However, erall the equations perform well with 14 out of 17 having a corrected R-squared greater an 80%. In many equations the fit was improved by the inclusion of zero-one dummy riables. In general, these were capturing abnormally good or bad weather conditions for tton production.

The estimatec

4.1.

CTYDARG = 0.26 CTYDAR
(1.88)

R-SQUARED (CORR.): 0.8

Where: CTYDARG = C
DFCTPARG = D
TIME = T
D70 = Z
D81 = Z
LN = I

The cotton y

a time trend variabl

was included to cap

technology, such a

responses, and othe

this was accounted

the 1981 crop seas

access to special cr

in which the price

The estima

4.2.

CTYDAUS = 0.77 + 0.0
(5.2

R-SQUARED (CORR.)

Where: CTYDAUS =
TIME =
D72 =
D75 =
D76 =

The cotton yield

The estimated equation explaining cotton yields in Argentina is given in equation

$$\text{DARG} = 0.26\ \text{CTYDARG(-1)} + 1.09\ \text{DFCTPARG} + 0.90\ \text{D81} - 0.06\ \text{D70} + 0.06\ \text{LN TIME} \quad (4.1)$$
$$\quad (1.88) \qquad (3.74) \qquad (2.49) \quad (-1.62) \quad (3.11)$$

QUARED (CORR.): 0.82 SEE: 0.02 H-STAT: 0.03 PERIOD OF FIT: 1964-1988

re: CTYDARG = Cotton yield, Argentina (m.tons / hectare),
DFCTPARG = Deflated cotton price, Argentina,
TIME = Time variable,
D70 = Zero-one variable, equals 1 in 1970, 0 otherwise,
D81 = Zero-one variable, equals 1 in 1981, 0 otherwise,
LN = Indicates variable transformed into logarithms.

The cotton yield series for Argentina was explained by the deflated price of cotton, ne trend variable and zero-one dummy variables for 1970 and 1981. The time variable included to capture the improvement in yields through time as a result of improved nology, such as higher yielding seed varieties, improved fertilizer and chemical onses, and other better farming practices. The rate of increase declined over time and was accounted for by converting the time variable into logarithms. The high yield in 1981 crop season was a consequence of the policy change which gave cotton growers ss to special credit to purchase inputs. The equation for Argentina was one of the few hich the price of cotton was significant.

The estimated equation explaining cotton yields in Australia is given in equation

$$\text{AUS} = 0.77 + 0.02\ \text{TIME} - 0.27\ \text{D72} - 0.24\ \text{D75} - 0.27\ \text{D76} \quad (4.2)$$
$$\quad (5.29) \quad (-2.03) \quad (-1.81) \quad (-2.03)$$

JARED (CORR.): 0.68 SEE: 0.34 DW: 1.82 PERIOD OF FIT: 1964-1988

CTYDAUS = Cotton yield, Australia (m.tons / hectare),
TIME = Time variable,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D75 = Zero-one variable, equals 1 in 1975, 0 otherwise,
D76 = Zero-one variable, equals 1 in 1976, 0 otherwise.

cotton yields in Australia were explained by a time trend and zero-one dummy variables for 1972, 19

to be significant. The

uptake of improved c

zero-one dummy vari

low rainfall in those

The estimate

CTYDBRA = 0.13 + 0.27 C
(1.68)

R-SQUARED (CORR.): 0.8

Where: CTYDBRA = C
DFCTPBRA = D
DFFNPBRA = D
TIME = T
D70 = Z
D84 = Z

Brazilian cotton yiel

zero-one dummy va

and fertilizer prices

the variable was ke

used in the equati

especially in the us

included because

levels.

The estima

CTYDCAF = 0.08 + 0.8
(13.3

R-SQUARED (CORR.)

Where: CTYDCAF =
CTHACAF =

iables for 1972, 1975 and 1976. Prices of cotton and competing crops were found not be significant. The trend variable was highly significant (t-value of 5.29), reflecting the ake of improved cotton production technology, especially since the early 1980s. The -one dummy variables captured yields substantially below trend, mainly the result of rainfall in those years.

The estimated equation explaining cotton yields in Brazil is given in equation 4.3.

DBRA = 0.13 + 0.27 CTYDBRA(-1) + 0.03 DFCTPBRA/DFFNPBRA + 0.003 TIME - 0.06 D70 + 0.10 D84 (4.3)
(1.68) (1.72) (2.21) (-2.56) (4.03)

UARED (CORR.): 0.84 SEE: 0.009 H-STAT: - 0.45 PERIOD OF FIT: 1964-1988

e: CTYDBRA = Cotton yield, Brazil (m.tons / hectare),
DFCTPBRA = Deflated cotton price, Brazil,
DFFNPBRA = Deflated fertilizer price, Brazil,
TIME = Time variable,
D70 = Zero-one variable, equals 1 in 1970, 0 otherwise,
D84 = Zero-one variable, equals 1 in 1984, 0 otherwise.

ilian cotton yields were explained by cotton and fertilizer prices, a time trend variable, -one dummy variables for 1970 and 1984, and cotton yield lagged one year. The cotton fertilizer prices were entered in the equation as a ratio and, although not significant, ariable was kept in the equation because it had the correct sign. The time trend was in the equation to capture improved technology use in the Brazilian cotton sector, cially in the use of higher-yielding cotton varieties. The dummy variable for 1984 was ded because the near-perfect growing conditions in that year sent yields to record .

The estimate equation for cotton yields in Central Africa is given in equation 4.4.

AF = 0.08 + 0.87 CTYDCAF(-1) - 0.05 D75 - 0.00001 CTHACAF (4.4)
(13.31) (-3.77) (-1.54)

ARED (CORR.): 0.92 SEE: 0.0044 H-STAT: - 0.26 PERIOD OF FIT: 1964-1988

CTYDCAF = Cotton yield, Central Africa (m.tons / hectare),
CTHACAF = Cotton area, Central Africa,

D75 = Zero

In the equation for th

one year, the cotton

trend in yields was ca

weather-related yield

was significant in the

area within the regio

where yields were lo

because it had the

The estimat

CTYDCHI = - 2.58 + 0.00
(1.95

R-SQUARED (CORR.): 0

Where: CTYDCHI = (
DFCTPCHI =
DFFNPCHI =
TIME =
D88 =
LN =

The variability of c

to 1988. This shor

incentives were

introduction of m

cotton and fertili

fertilizer prices w

technological imp

result was not su

D75 = Zero-one variable, equals 1 in 1975, 0 otherwise.

In the equation for the Central Africa region cotton yields were explained by yield lagged one year, the cotton area, and a zero-one dummy variable for 1975. The strong upward :rend in yields was captured by lagged yield and the dummy variable for 1975 captured the veather-related yield reduction in many African countries in that year. The cotton area vas significant in the equation. The negative sign on this variable showed that as greater ırea within the region was planted to cotton, production moved onto land of lower quality vhere yields were lower. While this variable was not significant it was kept in the equation ecause it had the correct sign.

The estimated equation explaining cotton yields in China is given in equation 4.5.

$$\text{TYDCHI} = -2.58 + \underset{(1.95)}{0.003\ \text{DFCTPCHI}} - \underset{(-3.45)}{0.001\ \text{DFFNPCHI}} + \underset{(9.20)}{1.15\ \text{LN TIME}} - \underset{(2.67)}{0.16\ \text{D88}} \qquad (4.5)$$

-SQUARED (CORR.): 0.95 SEE: 0.0289 DW: 2.31 PERIOD OF FIT: 1977-1988

here: CTYDCHI = Cotton yield, China (m.tons / hectare),
DFCTPCHI = Deflated cotton price, China,
DFFNPCHI = Deflated fertilizer price, China,
TIME = Time variable,
D88 = Zero-one variable, equals 1 in 1988, 0 otherwise,
LN = Indicates variable transformed into logarithms.

ıe variability of cotton yields in China was explained by a regression estimated from 1977 1988. This shortened time period was used because prior to the late 1970s, before price centives were introduced into China, yields were almost unchanged. With the troduction of market incentives Chinese producers became highly responsive to both tton and fertilizer prices. This was demonstrated in the equation in which cotton and rtilizer prices were statistically significant. The logarithm of time was added to capture chnological improvements. Rainfall was found not to be significant in the equation. This sult was not surprising given that most of China's cotton growing area is highly irrigated.

The zero-one dummy

during the crucial mo

The estimate

CTYDEGY = 0.99 CTYDE
(63.26)

R-SQUARED (CORR.): 0.8

Where: CTYDEGY = Co
D78 = Ze
D88 = Ze

Cotton yields in Eg

variables for the yea

was evidence of a s

model (Outlook Inc

of the high-quality

of the more comm

provided by the lo

cotton prices[4].

The estima

equation 4.7.

CTYDINDN = 0.32 + 0.
(3.

R-SQUARED (CORR.):

Where: CTYDINDN
CTHAINDN
TIME
D71
D73

[4] An econometric study of the
used to explain the variability in
Therefore, the results reported he

e zero-one dummy variable for 1988 was included to account for poor weather in China ing the crucial months of August and September which resulted in extremely low yields.

The estimated equation explaining cotton yields in Egypt is given in equation 4.6.

$$DEGY = 0.99\ CTYDEGY(-1) + 0.21\ D78 - 0.12\ D88 \quad (4.6)$$
$$(63.26) \qquad (3.38) \quad (-1.96)$$

UARED (CORR.): 0.81 SEE: 0.0851 H-STAT: 0.02 PERIOD OF FIT: 1964-1988

e: CTYDEGY = Cotton yield, Egypt (m.tons / hectare),
D78 = Zero-one variable, equals 1 in 1978, 0 otherwise,
D88 = Zero-one variable, equals 1 in 1988, 0 otherwise.

ton yields in Egypt were explained by yields lagged one year and zero-one dummy ables for the years 1978 and 1988. The coefficient on the lagged yield variable (0.99) evidence of a strong trend in Egyptian cotton yields. The price of cotton used in the el (Outlook Index "A") was not significant. However, most of Egyptian production is e high-quality extra-long staple (ELS) cotton, with a market quite separate from that e more common medium staple cotton. Evidence that the markets are distinct is ided by the low price transmission elasticities between the ELS and medium staple n prices[4].

The estimated equation explaining cotton yields in Northern India is given in tion 4.7.

$$NDN = 0.32 + 0.06\ LN\ TIME - 0.0002\ CTHAINDN + 0.0001\ RINDN + 0.15\ D71 + 0.06\ D73 \quad (4.7)$$
$$(3.49) \qquad (-2.78) \qquad (2.92) \qquad (5.70) \quad (2.51)$$

ARED (CORR.): 0.86 SEE: 0.0076 DW: 1.89 PERIOD OF FIT: 1965-1984

CTYDINDN = Cotton yield, Northern India (m.tons / hectare),
CTHAINDN = Cotton area, Northern India,
TIME = Time variable,
D71 = Zero-one variable, equals 1 in 1971, 0 otherwise,
D73 = Zero-one variable, equals 1 in 1973, 0 otherwise,

ric study of the Egyptian ELS cotton market is being undertaken at the World Bank. In the model the ELS price is e variability in cotton production. At a later stage the Egyptian ELS model will be incorporated in to this model. ilts reported here should be treated as preliminary.

RINDN = An
LN = Inc

Cotton yields in Nort

region, rainfall, time,

increase declined o

logarithms. The area

yields as cotton was

significant No statis

variables, even whe

equation.

The estima

equation 4.8.

CTYDINDS = 0.10 + 0.0
(3.4

R-SQUARED (CORR.):

Where: CTYDINDS =
CTHAINDS =
TIME =
D84 =
RINDS =
LN =

The equation exp

rainfall, and a zer

variables was sim

and of farm inpu

RINDN = Annual rainfall, Northern India (mm),
LN = Indicates variable transformed into logarithms.

ton yields in Northern India were explained by the area of land planted to cotton in the on, rainfall, time, and zero-one dummy variables for 1971 and 1973. Since the rate of ease declined over the regression period the time variable was converted into rithms. The area planted variable was significant and captured the decrease in average ds as cotton was grown on land of lower quality. The annual rainfall variable was highly ificant No statistically significant relationships were found between yield and economic ables, even when the local prices of cotton and competing crops were included in the ation.

The estimated equation explaining cotton yields in Southern India is given in ation 4.8.

INDS = 0.10 + 0.05 LN TIME - 0.00001 CTHAINDS + 0.00009 RINDS - 0.20 D84 (4.8)
(3.49) (-0.76) (2.19) (8.87)

JARED (CORR.): 0.94 SEE: 0.00426 DW: 1.64 PERIOD OF FIT: 1965-1984

: CTYDINDS = Cotton yield, Southern India (m.tons / hectare),
CTHAINDS = Cotton area, Southern India,
TIME = Time variable,
D84 = Zero-one variable, equals 1 in 1984, 0 otherwise,
RINDS = Annual rainfall, Southern India (mm),
LN = Indicates variable transformed into logarithms.

equation explaining cotton yields in Southern India contained time, cotton area, ll, and a zero-one dummy variable for 1984. The rationale for the inclusion of these les was similar to that for the Northern India equation. Again, the prices of cotton f farm input were not found to be significant.

The estimate

equation 4.9.

CTYDINDW = 0.04 LN TIM
(30.69)

R-SQUARED (CORR.): 0.8

Where: CTYDINDW = C
TIME = T
D76 = Z
D83 = Z
RSUINDW = S
LN = I

The specification o

logarithmic time tre

1983. The yield in

prohibited timely s

significant relations

The estima

CTYDMEX = 0.34 + 0.1
(9.5

R-SQUARED (CORR.):

Where: CTYDMEX =
TIME =
D78 =
D88 =
LN =

Cotton yields in

variable converte

improvements in

varieties, improv

prices of cotton

The estimated equation explaining cotton yields in Western India is given in
ation 4.9.

DINDW = 0.04 LN TIME + 0.00006 RSUINDW - 0.03 D76 - 0.02 D83 (4.9)
(30.69) (6.61) (-5.50) (-2.43)

UARED (CORR.): 0.88 SEE: 0.0006 DW: 2.21 PERIOD OF FIT: 1965-1984

re: CTYDINDW = Cotton yield, Western India (m.tons / hectare),
TIME = Time variable,
D76 = Zero-one variable, equals 1 in 1976, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise,
RSUINDW = Summer rainfall (mm), Western India,
LN = Indicates variable transformed into logarithms.

specification of the equation explaining cotton yields in Western India included a rithmic time trend, rainfall in the summer months, and a zero-one dummy variable for 3. The yield in 1983 was abnormally low as a results of heavy unseasonal rainfall. This ibited timely spraying of insecticides and led to severe pest damage. No statistically ficant relationships were detected between cotton yields and cotton and inputs prices.

The estimated equation explaining cotton yields in Mexico is given in equation 4.10.

MEX = 0.34 + 0.18 LN TIME + 0.09 D78 + 0.16 D88 (4.10)
(9.59) (3.38) (3.46)

JARED (CORR.): 0.87 SEE: 0.0422 DW: 2.11 PERIOD OF FIT: 1964-1988

: CTYDMEX = Cotton yield, Mexico (m.tons / hectare),
TIME = Time variable,
D78 = Zero-one variable, equals 1 in 1978, 0 otherwise,
D88 = Zero-one variable, equals 1 in 1988, 0 otherwise,
LN = Indicates variable transformed into logarithms.

on yields in Mexico increased throughout the regression period and only a time ble converted into logarithms was found to be significant. This variable captured the ovements in yields resulting from improved technology, such as higher yielding seed ies, improved fertilizer and chemical responses, and better production practices. The s of cotton and inputs were not statistically significant when included in the equation.

The estimate

is given in equation

CTYDPAKP = 0.27 + 0.03
(7.36)

R-SQUARED (CORR.): 0.

Where: CTYDPAKP = (
TIME = T
D71 = Z
D83 = Z

The impact of techr

No significant relat

A zero-one dummy

heavy unseasonal r

pest damage.

The estima

given in equation

CTYDPAKS = 0.00002
(2.69)

R-SQUARED (CORR.)

Where: CTYDPAKS
DFCTPPAK
IRRPAK
CTHAPAKS
TIME
D72
D78
D83

The variables fo

Pakistan were th

Sind region, a v

dummy variable

which the price

The estimated equation explaining cotton yields in the Punjab region of Pakistan

ven in equation 4.11.

PAKP = 0.27 + 0.03 TIME + 0.09 D71 - 0.26 D83 (4.11)
(7.36) (2.05) (-5.61)

JARED (CORR.): 0.80 SEE: 0.0296 DW: 1.00 PERIOD OF FIT: 1965-1985

: CTYDPAKP = Cotton yield, Punjab region, Pakistan (m.tons / hectare),
TIME = Time variable,
D71 = Zero-one variable, equals 1 in 1971, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise.

mpact of technology on cotton yields in the Punjab region of Pakistan was very strong. gnificant relationships were found between yield and economic or climatic variables. o-one dummy variable for 1983 was added to the equation to capture the effect of unseasonal rainfall which prohibited timely spraying of insecticides and led to severe damage.

The estimated equation explaining cotton yields in the Sind region of Pakistan is in equation 4.12.

AKS = 0.00002 DFCTPPAK - 0.0005 CTHAPAKS + 0.00001 IRRPAK + 0.08 D72 - 0.12 D78 - 0.11 D83 (4.12)
(2.69) (-13.83) (6.08) (3.41) (-5.46) (-4.54)

RED (CORR.): 0.91 SEE: 0.00613 DW: 2.01 PERIOD OF FIT: 1965-1985

CTYDPAKS = Cotton yield, Sind region of Pakistan (m.tons / hectare),
DFCTPPAK = Deflated cotton price, Pakistan,
IRRPAK = Number of tubewells constructed in the Sind region of Pakistan,
CTHAPAKS = Cotton area, Sind region of Pakistan,
TIME = Time variable,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D78 = Zero-one variable, equals 1 in 1978, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise.

ariables found to best explain variability of cotton yields in the Sind region of an were the deflated cotton price in Pakistan, the area planted with cotton in the egion, a variable for the number of tubewells in the Sind region, and zero-one variables for the years 1972, 1978 and 1983. This equation was one of the few in the price of cotton was found to be statistically significant. The elasticity of yield with respect to pric

irrigation variable, n

This was consistent

tubewells has been

captured yield incre

The estimat

CTYDTUR = 0.54 + 0.81
(17.27

R-SQUARED (CORR.):

Where: CTYDTUR =
CTHATUR =
D65 =

Cotton yields in T

and a zero-one d

strong upward tr

function of the a

land of lower qua

The estimated

given in equation

CTYDUS1 = 8.73 - 0.0
(-3.1

R-SQUARED (CORR

Where: CTYDUS1
CTHAUS1
D67
D82
RSPUS1
TSMUS1
TFLUS1

Variation in co

by weather vari

respect to price was estimated to be 0.01 at the mean yield and price levels. The ation variable, measured by the number of tubewells constructed, was very significant. was consistent with the findings of Hamid et al. However, since the number of wells has been increasing over the last 20 years this variable may, in addition, have ired yield increases from technological change.

The estimated equation explaining cotton yields in Turkey is given in equation 4.13.

TUR = 0.54 + 0.81 CTYDTUR(-1) - 0.0006 CTHATUR - 0.06 D65 (4.13)
(17.27) (-7.05) (-1.98)

JARED (CORR.): 0.95 SEE: 0.0165 DW: 2.23 PERIOD OF FIT: 1964-1988

CTYDTUR = Cotton yield, Turkey (m.tons / hectare),
CTHATUR = Cotton area, Turkey,
D65 = Zero-one variable, equals 1 in 1965, 0 otherwise.

on yields in Turkey were explained by yield lagged one year, area of cotton planted, ı zero-one dummy variable for 1965. The lagged dependent variable captured the g upward trend in yields throughout the regression period. Yields were also a on of the area planted that captured the decline in yield as cotton was planted on of lower quality.

e estimated equation explaining cotton yields in the United States, Delta region is in equation 4.14.

S1 = 8.73 - 0.00032 CTHAUS1 - 0.24 RSPUS1 - 3.13 TSMUS1 + 1.95 TFLUS1 - 0.30 D67 + 0.20 D82 (4.14)
(-3.17) (-4.27) (-3.18) (4.18) (-2.72) (2.21)

RED (CORR.): 0.81 SEE: 0.12236 DW: 1.68 PERIOD OF FIT: 1964-1988

CTYDUS1 = Cotton yield, Delta region of United States (m.tons / hectare),
CTHAUS1 = Cotton area, Delta region of United States,
D67 = Zero-one variable, equals 1 in 1967, 0 otherwise,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
RSPUS1 = Spring rainfall (inches), Delta region of United States,
TSMUS1 = Summer temperature (degrees C), Delta region of United States,
TFLUS1 = Fall temperature (degrees C), Delta region of United States.

ion in cotton yields in the Delta region of the United States was explained mainly ther variables, as well as by planted cotton area and zero-one dummy variables for

1967 and 1982. No

to be significant. In

reduced yield, while

with knowledge of g

Hazera (1983).

The estima

region is given in e

CTYDUS2 = 1.78 - 0.000
(-1.68)

R-SQUARED (CORR.):

Where: CTYDUS2 =
CTHAUS2 =
D67 =
D82 =
TSMUS2 =
TFLUS2 =

The selected equa

for the spring ra

cotton area was a

sign.

The esti

region is given i

CTYDUS3 = - 63.53 -

R-SQUARED (COR

Where: CTYDUS3
CTHAUS3
D70
D83
TSMUS3
TFLUS3
SMUS3

967 and 1982. No economic factors, such as the price of cotton or fertilizer, were found be significant. In the Delta region, excess spring rainfall and summer temperatures duced yield, while high temperatures in the fall improved yields. This result is consistent ith knowledge of growing conditions for cotton and the results reported by Starbird and azera (1983).

The estimated equation explaining cotton yields in the United States Southeast gion is given in equation 4.15.

YDUS2 = 1.78 - 0.00016 CTHAUS2 - 0.03 TSMUS2 + 0.026 TFLUS2 + 0.26 D82 - 0.18 D67 (4.15)
(-1.68) (-2.55) (3.48) (2.84) (-1.72)

QUARED (CORR.): 0.67 SEE: 0.1319 DW: 2.02 PERIOD OF FIT: 1964-1988

ere: CTYDUS2 = Cotton yield, Southeast region of United States (m.tons / hectare),
CTHAUS2 = Cotton area, Southeast region of United States,
D67 = Zero-one variable, equals 1 in 1967, 0 otherwise,
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
TSMUS2 = Summer temperature (degrees C), Southeast region of United States,
TFLUS2 = Fall temperature (degrees C), Southeast region of United States.

e selected equation contained the same variables as the Delta region equation, except the spring rainfall variable which was found not to be significant. The variable for ton area was also not significant but was kept in the equation because it had the correct n.

The estimated equation explaining cotton yields in the United States, Southwest ion is given in equation 4.16.

DUS3 = - 63.53 - 0.000006 CTHAUS3 + 1.58 TSMUS3 + 0.04 SMUS3 + 0.02 TFLUS3 - 0.01 D70 - 0.12 D83 (4.16)
(-0.40) (3.14) (3.19) (4.53) (-5.09) (-4.81)

UARED (CORR.): 0.85 SEE: 0.01225 DW: 1.40 PERIOD OF FIT: 1964-1988

re: CTYDUS3 = Cotton yield, Southwest region of United States (m.tons / hectare),
CTHAUS3 = Cotton area, Southwest region of United States,
D70 = Zero-one variable, equals 1 in 1970, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise,
TSMUS3 = Summer temperature (degrees C), Southwest region of United States,
TFLUS3 = Fall temperature (degrees C), Southwest region of United States,
SMUS3 = Soil moisture level, Southwest region United States.

Cotton yields in the

fall temperature, an

1970 and 1983. T

Consistent with ot

explaining the vari

The estima

region is given in

CTYDUS4 = 2.37 - 0.02
(-1.87)

R-SQUARED (CORR.):

Where: CTYDUS4 =
D71 =
D78 =
TSMUS4 =
TIME =

The variability of

by summer temp

and 1978. Other

gave the wrong

subsequently exc

4.5.2 Area Equ

The equ

below. In gene

corrected R-squ

variable was ad

and to estimate

on yields in the Southwest region of the United States were explained by summer and emperature, an index of soil moisture, cotton area, and zero-one dummy variables for and 1983. This specification is similar to that presented by Starbird and Hazera. sistent with other United States regions, prices were found not to be important in ining the variability of cotton yields.

The estimated equation explaining cotton yields in the United States, Western n is given in equation 4.17.

US4 = 2.37 - 0.02 TSMUS4 + 0.007 TIME - 0.23 D71 - 0.33 D78 (4.17)
(-1.87) (2.63) (-2.63) (-3.84)

ARED (CORR.): 0.67 SEE: 0.12612 DW: 1.39 PERIOD OF FIT: 1964-1988

CTYDUS4 = Cotton yield, West region of United States (m.tons / hectare),
D71 = Zero-one variable, equals 1 in 1971, 0 otherwise,
D78 = Zero-one variable, equals 1 in 1978, 0 otherwise,
TSMUS4 = Summer temperature (degrees C), West region of United States,
TIME = Time variable.

ariability of cotton yields in the Western region of the United States was explained nmer temperatures, a time trend variable, and zero-one dummy variables for 1971 978. Other variables, such as area planted, fall temperatures and rainfall, and prices he wrong signs when entered into initial specifications of this equation and were uently excluded.

Area Equations

The equations for cotton area planted are presented in equations 4.18 to 4.34 In general, the equations fit the data well with ten of the 17 equations having a ed R-squared of 90% or greater. In many of the equations a lagged dependent was added. This was included in order to capture adaptively-formed expectations estimate long-run elasticities. In some cases (e.g., Australia, Brazil, and Northern

India) the

captured a

The

4.18.

CTHAARG =

R-SQUARED

Where: CT
DF
DP
TI
D8
D8

the area

lagged or

zero-one

also incl

Both pri

for cotto

price ar

central-

previou

CTHAAU

R-SQUA

Where:

ndia) the coefficient on the lagged dependent variable was very large and obviously aptured a trend in the data series.

The estimated equation explaining cotton area in Argentina is given in equation 18.

CTHAARG = 0.38 CTHAARG(-1) + 5603 DFCTPARG(-1) - 3148 DFCGPARG(-1) - 117 D80 - 166 D85 + 1.83 TIME (4.18)
(3.48) (4.56) (-2.56) (-2.13) (-3.88) (1.30)

SQUARED (CORR.): 0.85 SEE: 35028 H-STAT: - 0.23 PERIOD OF FIT: 1964-1988

here: CTHAARG = Cotton area, Argentina,
DFCTPARG = Deflated cotton price, Argentina,
DFCGPARG = Deflated coarse grain price, Argentina,
TIME = Time variable,
D80 = Zero-one variable, equals 1 in 1980, 0 otherwise,
D85 = Zero-one variable, equals 1 in 1985, 0 otherwise.

e area planted to cotton in Argentina was explained by the deflated price of cotton gged one year, the deflated price of coarse grains lagged one year, a time variable, and ro-one dummy variables for the years 1980 and 1985. Cotton area lagged one year was o included to capture adaptively-formed expectations and to provide long-run elasticities. th price variables were statistically significant. The derived short-run elasticity estimates cotton and coarse grains were, respectively, 0.87 and 0.38, when estimated at the mean ce and area. The dummy variable for 1985 captured the 22% decline in area in the tral-south region of Argentina due to bad weather and difficulties in marketing the vious year's crop.

The estimated equation explaining cotton area in Australia is given in equation 4.19.

AAUS = 39.11 + 0.75 CTHAAUS(-1) - 0.18 DFCGPAUS(-1) + 44.14 D83 + 96.42 D87 (4.19)
(11.76) (-1.39) (3.83) (8.05)
UARED (CORR.): 0.98 SEE: 2275 H-STAT: 1.28 PERIOD OF FIT: 1964-1988

e: CTHAAUS = Cotton area, Australia,
DFCGPAUS = Deflated coarse grain price, Australia,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise,
D87 = Zero-one variable, equals 1 in 1987, 0 otherwise.

Variability

deflated pr

variables fo

an initial s

was signifi

mean pric

which cap

Th

CTHABRA

R-SQUARE

Where: C
D
D

The area

and zero

variable

period.

followin

crops w

variabl

in the

South

preven

ariability in the area placed under cotton in Australia was explained by variability in the eflated price of coarse grains, the cotton area lagged one period and zero-one dummy riables for 1983 and 1987. The price of cotton was incorrectly signed when included in initial specification of the equation. However, the coefficient on the coarse grain price s significant and negative and provided an elasticity estimate of 0.35 when calculated at ean price and area. The coefficient on the lagged area variable was very large (0.75) ich captured a strong trend in the cotton area series.

The estimated equation explaining cotton area in Brazil is given in equation 4.20.

HABRA = 633.4 + 0.71 CTHABRA(-1) + 396.5 D68 + 401.7 D84 (4.20)
(6.32) (3.11) (3.07)

QUARED (CORR.): 0.76 SEE: 310198 H-STAT: 1.77 PERIOD OF FIT: 1964-1988

re: CTHABRA = Cotton area, Brazil,
D68 = Zero-one variable, equals 1 in 1968, 0 otherwise,
D84 = Zero-one variable, equals 1 in 1984, 0 otherwise.

e area planted to cotton in Brazil was explained by cotton area planted lagged one year l zero-one dummy variables for 1968 and 1984. The large coefficient on the lagged area iable was evidence of the strong upward trend in cotton area throughout the regression iod. The 1984 dummy variable captured the sudden substitution of cotton for soybeans owing changes in relative domestic producer prices. The prices of cotton and competing os were found not to be significant. The reason for the poor performance of the price ables may be that Brazilian producers face domestic prices which are not determined e international market. Also, there are two distinct growing regions in Brazil (i.e., h and Northeast) with different characteristics and growing conditions. Lack of data ented these regions from being separated in the model.

The estimated equation explaining cotton area in the Central Africa region is given in equation

CTHACAF =

R-SQUARED

Where: CT
DF
DF
TI
D8
D8
LN

The area

deflated

for 1980

gave an

of fertil

requirer

variable

enterpr

CTHACH

R-SQUA

Where:

The a

cottor

econo

uation 4.21.

CAF = 1261 + 0.70 CTHACAF(-1) + 315.4 DFCTPCAF(-1)/DFFNPCAF(-1) - 265.5 LN TIME (4.21)
(10.39) (3.84) (-4.87)
- 370.9 D80 + 356.1 D88
(-3.23) (3.04)

JARED (CORR.): 0.93 SEE: 215536 H-STAT: - 1.48 PERIOD OF FIT: 1964-1988

: CTHACAF = Cotton area, Central Africa,
DFCTPCAF = Deflated cotton price, Central Africa,
DFFNPCAF = Deflated fertilizer price, Central Africa,
TIME = Time variable,
D80 = Zero-one variable, equals 1 in 1980, 0 otherwise,
D88 = Zero-one variable, equals 1 in 1988, 0 otherwise,
LN = Indicates variable transformed into logarithms.

area of cotton grown in Central Africa was explained by area lagged one period, ted cotton and fertilizer prices, a time trend variable, and zero-one dummy variables 980 and 1988. The cotton price variable was found to be statistically significant and an elasticity estimate of 0.12 when calculated at the mean price and area. The price rtilizer was also added to the specification to account for the fact that fertilizer rements are higher for cotton than for most other competing crops. The time trend le was included to capture the trend away from cotton into other more profitable prises.

The estimated equation explaining cotton area in China is given in equation 4.22.

HI = 4705.53 + 26.21 DFCTPCHI(-1) + 1376.7 D84 -1087.0 D86 (4.22)
(2.63) (3.28) (-2.67)

RED (CORR.): 0.82 SEE: 383.0 DW: 2.32 PERIOD OF FIT: 1977-1988

CTHACHI = Cotton area, China,
DFCTPCHI = Deflated cotton price, China,
D84 = Zero-one variable, equals 1 in 1984, 0 otherwise,
D86 = Zero-one variable, equals 1 in 1986, 0 otherwise.

ea equation for China was estimated for the period 1977-1988, since prior to 1977 area was largely a policy decision of the government and not dependent on ic factors. A domestic Chinese cotton price lagged one year was found to be statistica

In additi

and 198

increase

Even th

respons

1986 w

season

of the

CTHAE

R-SQU

Where:

Cotto

zero-

estin

expl

sign

be

inte

stically significant and provided an elasticity estimate of 0.11 at mean price and area. ddition to price, zero-one dummy variables were added to the specification for 1984 1986. The dummy variable for 1984 captured the change in policy which substantially eased producer prices, coupled with significantly more generous fertilizer allocations. though the domestic producer price was included in the equation, the actual area onse in 1984 was in excess of that predicted by the model. The dummy variable for was included to account for the fall in area resulting from the experience of the 1985 n when income was reduced by weather-induced poor cotton quality for roughly 60% e growing area.

The estimated equation explaining cotton area in Egypt is given in equation 4.23.

EGY = 1276 - 255.1 LN TIME - 188.2 D64 - 100.3 D68 (4.23)
(-17.02) (-5.06) (-2.96)

ARED (CORR.): 0.93 SEE: 21531 DW: 1.86 PERIOD OF FIT: 1964-1988

CTHAEGY = Cotton area, Egypt,
TIME = Time variable,
D64 = Zero-one variable, equals 1 in 1964, 0 otherwise,
D68 = Zero-one variable, equals 1 in 1968, 0 otherwise,
LN = Indicates variable transformed into logarithms.

n area in Egypt was explained by a time variable transformed into logarithms and ne dummy variables for 1964 and 1968. The decline in cotton area over the tion period was reflected in the fact that over 90% of the variation of area was ned by the trend variable. Economic variables were found not to be statistically cant in initial specifications of the equation. A reason for this lack of success may t, as explained in the description of the cotton yield equation for Egypt, the tional price used in the equation was for medium staple cotton, while most of

Egyptian

India an

CTHAIND

R-SQUAR

Where:

CTHAIN

R-SQUA

Where:

CTHAI

R-SQU

Where:

Cotto

cotto

(i.e.,

Indi

perf

com

wer

[5] see footno

gyptian cotton production is of extra-long staple[5].

The estimated equations explaining cotton area in Northern, Southern and Western dia are given in equations 4.24, 4.25 and 4.26, respectively.

'HAINDN = 0.95 CTHAINDN(-1) + 13.86 DFCTPINDN(-1) + 117.4 D83 - 225.D85 (4.24)
(23.14) (1.95) (2.66) (-4.99)

SQUARED (CORR.): 0.94 SEE: 29026 H-STAT: 0.46 PERIOD OF FIT: 1966-1986

ere: CTHAINDN = Cotton area, Northern India,
DFCTPINDN = Deflated cotton price, Northern India,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise,
D85 = Zero-one variable, equals 1 in 1985, 0 otherwise.

HAINDS = 1504 + 44.65 DFCTPINDS(-1) - 236.9 D73 + 233.2 D76 (4.25)
(1.92) (-3.08) (-8.76)

QUARED (CORR.): 0.87 SEE: 87647 DW: 1.65 PERIOD OF FIT: 1966-1986

ere: CTHAINDS = Cotton area, Southern India,
DFCTPINDS = Deflated cotton price, Southern India,
D73 = Zero-one variable, equals 1 in 1973, 0 otherwise,
D76 = Zero-one variable, equals 1 in 1976, 0 otherwise.

IAINDW = 6231 + 134.1 DFCTPINDW(-1) - 510.3 LN TIME - 497.1 D74 (4.26)
(4.97) (-10.27) (-4.26)

QUARED (CORR.): 0.91 SEE: 95789 DW: 2.03 PERIOD OF FIT: 1966-1986

re: CTHAINDW = Cotton area, Western India,
DFCTPINDW = Deflated cotton price, Western India,
TIME = Time variable,
D74 = Zero-one variable, equals 1 in 1974, 0 otherwise,
LN = Indicates variable transformed into logarithms.

ton area in the three regions of India was specified to depend on the local price of on, zero-one dummy variables and variables capturing a strong trend in the area data , lagged area in the Northern India equation and the logarithm of time in the Western a equation). Producer prices in regional markets were used in the equations and these ormed well, giving elasticity estimates ranging between 0.07 and 0.17. The prices of peting crops (i.e., corn in the North, sorghum in the South, and millet in the West) included but no statistically significant relationships were found. The dummy

: 4.

variables

commoc

CTHAME

R-SQUAI

Where:

The ec

logarit

1975.

of the

elasti

Pakis

CTHA

R-SQ

Wher

CTH

R-S(

Whe

ıbles included were most likely capturing the effect of the prices of competing nodities, as well as changes in policy in certain years.

The estimated equation explaining cotton area in Mexico is given in equation 4.27.

MEX = 1146 - 255.1 LN TIME + 0.05 DFCTPMEX(-1) + 131.1 D68 - 214.1 D75 (4.27)
(-16.53) (4.02) (2.45) (-4.03)

JARED (CORR.): 0.94 SEE: 52065 DW: 1.51 PERIOD OF FIT: 1964-1988

CTHAMEX = Cotton area, Mexico,
DFCTPMEX = Deflated cotton price, Mexico,
TIME = Time variable,
D68 = Zero-one variable, equals 1 in 1968, 0 otherwise,
D75 = Zero-one variable, equals 1 in 1975, 0 otherwise,
LN = Indicates variable transformed into logarithms.

ɜquation explaining cotton area in Mexico contained a time variable (converted into ithms), the deflated price of cotton, and zero-one variables for the years 1968 and The trend variable captured the decline in cotton area in Mexico throughout much ɜ regression period. The cotton price was statistically significant and provided an city estimate of 0.56 at the mean area and price.

The estimated equation explaining cotton area in the Punjab and Sind regions of an are reported in equations 4.28 and 4.29, respectively.

AKP = 0.957 CTHAPAKP(-1) + 0.070 DFCTPAKP(-1) + 163.6 D71 - 270.1 D75 - 276.8 D76 (4.28)
(31.41) (2.94) (2.68) (-4.33) (-4.64)

RED (CORR.): 0.90 SEE: 50293 H-STAT: 0.27 PERIOD OF FIT: 1965-1985

CTHAPAKP = Cotton area, Punjab region Pakistan,
DFCTPAKP = Deflated cotton price, Punjab region Pakistan,
D71 = Zero-one variable, equals 1 in 1971, 0 otherwise,
D75 = Zero-one variable, equals 1 in 1975, 0 otherwise,
D76 = Zero-one variable, equals 1 in 1976, 0 otherwise.

KS = 41.48 + 0.94 CTHAPAKS(-1) - 210.8 D76 - 159.7 D77 (4.29)
(11.84) (-6.53) (-4.50)

RED (CORR.): 0.91 SEE: 15664 H-STAT: - 1.45 PERIOD OF FIT: 1965-1985

CTHAPAKS = Cotton area, Sind region Pakistan,
D76 = Zero-one variable, equals 1 in 1976, 0 otherwise,
D77 = Zero-one variable, equals 1 in 1977, 0 otherwise.

otton area in the Punjab and Sind regions trended strongly throughout the regression eriod. This trend was captured by cotton area lagged one year. The international price cotton was statistically significant in the equation for the Punjab region. Prices for otton and competing crops were not available on a regional basis for Pakistan. Use of gional price data may have improved the results considerably and their omission could count for the significance of a number of zero-one variables included in the equations.

The estimated equation explaining cotton area in is given in equation 4.30.

HATUR = 686 + 0.01 DFCTPTUR(-1) - 80.74 LN TIME - 102 D70 (4.30)
(3.53) (-3.39) (-1.84)

QUARED (CORR.): 0.56 SEE: 54831 DW: 1.83 PERIOD OF FIT: 1964-1988

ere: CTHATUR = Cotton area, Turkey,
DFCTPTUR = Deflated cotton price, Turkey,
TIME = Time variable,
D70 = Zero-one variable, equals 1 in 1970, 0 otherwise,
LN = Indicates variable transformed into logarithms.

riability in cotton yields in Turkey was explained by the deflated price of cotton lagged year, a logarithmic time variable, and a zero-one dummy variable for 1970. The time iable captured the trend away from cotton over the regression period. The deflated ton price was significant and provided a supply elasticity of 0.33 when calculated at the an of the price and area series.

The estimated equations explaining cotton area in the Delta, Southeast, Southwest West regions of the United States are given in the equations 4.31, 4.32, 4.33 and 4.34, ectively.

US1 = 1426 + 220 DFCTPUS1(-1) - 0.87 DFFNPUSA(-1) - 18.8 TIME - 396 SKRWUS1 + 439.5 D72 - 437.9 D83 (4.31)
(3.02) (-2.48) (-3.94) (-3.94) (2.96) (-3.00)

UARED (CORR.): 0.81 SEE: 350928 DW: 1.02 PERIOD OF FIT: 1964-1988

: CTHAUS1 = Cotton area, Delta region, United States,
DFCTPUS1 = Deflated cotton price, Delta region, United States,
DFFNPUSA = Deflated fertilizer price, United States,
TIME = Time variable,

CTHAUS

R-SQUAI

Where:

CTHAU

R-SQUA

Where:

CTHAU

R-SQU

Where:

The

each

row

the

the

sea

tak

SKRWUS1 = Zero-one variable for Skip-Row policy, equals 1 1966-67, otherwise 0,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise.

US2 = 479.5 + 105.3 DFCTPUS2(-1) - 0.51 DFFNPUSA(-1) - 11.1 TIME - 244 SKRWUS2 + 0.62 CTHAUS2(-1) (4.32)
(2.60) (-3.31) (-3.86) (-5.09) (6.15)
- 0.67 DFSBPUSA(-1)
(-2.88)

JARED (CORR.): 0.94 SEE: 58595 H-STAT: 0.38 PERIOD OF FIT: 1964-1988

CTHAUS2 = Cotton area, Southeast region, United States,
DFCTPUS2 = Deflated cotton price, Southeast region, United States,
DFSBPUSA = Deflated soybean price, Southeast region, United States,
DFFNPUSA = Deflated fertilizer price, United States,
TIME = Time variable,
SKRWUS2 = Zero-one variable for Skip-Row policy, equals 1 1966-67, otherwise 0,

JS3 = 596 + 417 DFCTPUS3(-1) - 617 SKRWUS3 + 0.55 CTHAUS3(-1) - 89 DFSGPUSA(-1) - 650 (D82+D83) (4.33)
(2.25) (-3.09) (4.88) (-0.59) (-3.03)

ARED (CORR.): 0.76 SEE: 1280438 H-STAT: 0.70 PERIOD OF FIT: 1964-1988

CTHAUS3 = Cotton area, Southwest region, United States,
DFCTPUS3 = Deflated cotton price, Southwest region, United States,
DFSGPUSA = Deflated sorghum price, United States,
SKRWUS3 = Zero-one variable for Skip-Row policy, equals 1 1966-67, otherwise 0.
D82 = Zero-one variable, equals 1 in 1982, 0 otherwise,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise.

S4 = 175.4 DFCTPUS4(-1) + 10.01 TIME + 0.43 CTHAUS4(-1) - 16.88 DFRIPUSA(-1) - 223.4 D83 (4.34)
(4.02) (3.32) (3.58) (-1.39) (-2.68)

RED (CORR.): 0.83 SEE: 124078 H-STAT: 2.12 PERIOD OF FIT: 1964-1988

CTHAUS4 = Cotton area, West region, United States,
DFCTPUS4 = Deflated cotton price, West region, United States,
DFRIPUSA = Deflated rice price, United States,
TIME = Time variable,
D83 = Zero-one variable, equals 1 in 1983, 0 otherwise.

quations for the United States were estimated as functions of the price of cotton in egion, the price of a competitive crop, a policy variable to account for different skip-les, and a lagged dependent variable. A dummy variable for 1983 was included in uations for the Delta, Southwest and West regions of the United States to capture nge in farm policy as a result of large stock levels in 1982. For the 1983 crop the acreage reduction and PIK programs resulted in more than 7 million acres being ut of cotton production. Since the fertilizer requirements were higher for cotton ı for most other competing crops, the price of fertilizer was used in the equation for Delta region.

Cotton Area Elasticity Estimates

The elasticities of planted cotton area with respect to price are presented in Table All elasticities are inelastic in the short-run, ranging from 0.07 for Northern India to for Argentina. In general, the elasticities are larger for the higher-income countries ı may reflect greater flexibility and choice in producing alternative crops to cotton.

e 4.1 Elasticities of Cotton Area Planted with respect to Price.

on	Short-run Elasticity	Long-run Elasticity
ıtina	0.87	1.40
al Africa	0.12	0.40
ı	0.11	
North	0.07	
South	0.17	
West	0.09	
o	0.56	
an Punjab	0.08	
y	0.33	
outheast	0.27	
outhwest	0.36	0.95
elta	0.27	0.60
'est	0.41	0.72
ıtes of Mues & Simmons (1988)		
l States	0.48	0.64
lia	0.59	2.46
f World	0.06	0.25

Of the studies reviewed in section 4.3 only Mues and Simmons reported elasticities. ese are shown in Table 4.1 also, and were similar in magnitude to the ones obtained in s study. For the United States the short-run elasticities were slightly smaller than those Mues and Simmons but the long-run ones were larger. The long-run elasticity estimate Australia (2.46) seems very high and resulted from the large coefficient on the lagged ɔendent variable in the area equation.

Summary

In this section the method used to explain the production of cotton in terms of nometrically-estimated equations was presented. Based on theory of individual firm avior and drawing on earlier models of cotton supply, production was derived from the duct of yield and area planted. Both of these supply components were estimated in a ırate equation for each region of the model. The econometric equation results were sented along with supply elasticity estimates. Overall, the econometric results were factory although in many cases world price variables for cotton, competing crops and ts were not significant. However, when local prices were used in some equation the lts improved significantly.

5. Cotton Price Determination

.1 Introduction

In an earlier version of the model, cotton demand, production and stock equations ere estimated for each region and combined in an identity equating production and eginning stocks with consumption and ending stocks. When simulating the model, this lentity solved for consumption in one region and price solved as a right-hand side ndogenous variable in the demand function for this region. This formulation did not erform satisfactorily in that forecasted values of the price did not track the actual value ell, even though consumption and production forecasts performed adequately.

The reason for this result was twofold. First, the estimates of stock equations were isatisfactory; only in a few equations were the price variables significant. This may be cause in many regions (e.g., China) stock levels were more the residual between oduction and consumption, than the result of profit-maximizing behavior of stockholders. cond, as seen from Table 3.1 the elasticities of demand for cotton were highly inelastic. ierefore, small errors in quantity variables tended to lead to relatively larger errors in the ice variables.

These problems were discussed by Ghosh et al. (1987) who noted that most studies ploy inverted stock demand functions where price is specified as a function of stocks. ey noted that otherwise,

> in forecasting or model simulation the price is forced to move too much in order to clear the market. This is a consequence of the incompleteness and inaccuracy of stock data which result in poorly fitting demand equations.

a result of the poor results obtained using the market-clearing approach, a pricing ation was estimated as an inverted world stock demand function.

Theoretical Issues

Demand for stocks comes from both producing and consuming countries and ves from two separate motives. The first is from a transactions demand for which ks are held to ensure that unanticipated changes in demand can be met. The second erived from a speculative demand. Stocks are held if prices are expected to increase e future in excess of the cost of storage.

Suppose stock levels are determined by current prices. That is,

$$S_t = s(P_t).$$

h et al. discuss two simple models in which price dynamics can be introduced. First, an assume that stocks follow a partial adjustment process in which stock levels adjust year towards a certain desired stock level S^*. The S^* is given by,

$$S^*_t = a_0 - a_1 P_t \tag{5.1}$$

$$S_t - S_{t-1} = (1 - \lambda)(S^*_t - S_{t-1}), \text{ and } \quad (0 < \lambda < 1). \tag{5.2}$$

tuting the partial adjustment equation 5.2 into the stocks equation and inverting gives,

$$P_t = b_0 - b_1 S_t + b_2 S_{t-1}. \tag{5.3}$$

osh et al. noted that almost all researchers find a lagged price term necessary in ation 5.3 and rarely is the coefficient on the S_{t-1} term significantly different from zero. ne S_{t-1} term in equation 5.3 is substituted j times using equation 5.3, the price equation ven by,

$$P_t = c_0 - c_1S_t - c_2\Sigma_i\lambda^jP_{t-j}. \qquad (5.4)$$

equation is not useful for estimation because it implies an infinite series of past prices a negative relationship between current and past prices. Therefore investigators have ified equations in which prices adjust to stock levels (instead of stocks adjusting to s). This gives an estimable equation of the form,

$$P_t = b_0 + b_1P_{t-1} - b_2S_t,$$

n has been applied widely. Researchers often find the coefficient on lagged price to ose to one, and that the coefficient on stocks is not significantly different from zero. is case, the equation provides forecasts that are too smooth and unresponsive to es in quantity variables.

The second method of incorporating dynamics into the pricing equation relates levels to an expected price. This approach was developed by Hwa (1981, 1985) who d a stocks equation given by,

$$S_t = a_0 + a_1C_t + a_2(\ln P^e_{t+1/t} - \ln P_t) - a_3\ln r_t \qquad (5.5)$$

ere C_t is consumption, $p^e_{t+1/t}$ is the expected price in time t for the period t+1 and r_t is rate of interest. Assuming that prices adjust to the market clearing value, equation 5.5 be inverted to give,

$$\partial \ln P_t = b_0 + b_1 C_t + b_2(\ln P^e_{t+1/t} - \ln P_t) - b_3 r_t - b_4 S_t. \qquad (5.6)$$

difficulty with empirically estimating equation 5.6 is to formulate an expectations hanism for the $(\ln P^e_{t+1/t} - \ln P_t)$ variable.

Gilbert and Palaskas (1989) argued that instead of reacting to expected future es, stockholders respond to expected future excess supplies, which are conditioned on nally-formed price expectations. In their pricing equation, expected future supplies used as one of the regressors. This variable is obtained by estimating the entire el (excluding the price equation) with price set at its mean value. That is, a variable,

$$ES_{t+1/t} = (Q_{t+1/t}(P) - C_{t+1/t}(P))/\ Q$$

e P and Q are mean values of price and quantity) is added to the price equation ner, with lagged price and interest rates.

eview of Literature

Most of the econometric studies of the cotton sector discussed in previous sections ised single equation models where prices have been exogenous. Only in the studies ies and Simmons (1988) and Agbadi (1988) were the models closed with price endogenous. In the study by Mues and Simmons, a market clearing identity was used to solve for price and no price equation was estimated. Agbadi estimated the mill cotton price for the United States as an inverted mill demand function using domestic mill consumption of cotton and manufactured fibers as regressors. The CPI for textile products was estimated as an inverted consumer demand function, with price explained by consumer consumption and income.

The ICAC (1988) estimated a single-equation regression model of the price of cotton in order to forecast near-term price movements. Price was regressed on net exports by China (expressed as a percentage of non-Chinese world consumption) and a ratio of stocks held outside China to use outside China (i.e., world ending stocks net of China's stocks and trade, divided by world consumption net of China's consumption). The rationale behind this specification was that,

> cotton prices are clearly related to the actual or perceived tightness of supply. Perhaps the best single indicator of this tightness is a ratio of available stocks to use. In recent years the size of Chinese stocks and the fact that a large proportion of those stocks were isolated from world markets have made it necessary to look at world stocks and consumption net of China.

The equation fitted that data very well for the period 1974 to 1986 and provided accurate forecasts of the 1987 and 1988 prices.

A Model of Cotton Price Determination and Estimation Results

The pricing equation used in this model was based on the ICAC model. The price equation and identities are presented in equation 5.7.

$$\text{CTPWOR} = 7.24 - \underset{(-6.32)}{0.78}\ \text{LN CTESWORXCHI} + \underset{(5.12)}{0.92}\ \text{LN MUV} + \underset{(1.75)}{0.31}\ \text{LN CTCONWORXCHI} - \underset{(-3.33)}{0.86}\ \text{LN TIME} \qquad (5.7)$$

SQUARED (CORR): 0.94 SEE: 0.03 DW: 2.09 PERIOD OF FIT: 1964-88

re: CTPWOR = World cotton price (Outlook Index "A"),
CTESWORXCHI = World cotton stocks excluding stock held in China (also see equation 5.8),
MUV = Manufacturing unit value[1],
CTCONWORXCHI = World cotton consumption excluding consumption of China (also see equation 5.9),
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

rld price was specified as a function of ending world stocks net of China's stocks, a eral deflator (MUV)[1], world cotton consumption net of China's cotton consumption, and me trend variable. All variables were converted into logarithms which fit data the er than in the linear form[2]. The coefficient on the stocks variable was highly significant correctly signed. The flexibility of price with respect to stocks, given by the coefficient the stocks variable, was estimated to be -0.78. No other study has reported a esponding elasticity for comparison. In order to capture the transactions demand for on stocks, world consumption, net of China's consumption, and time were added to the ification. Consumption was used based on the assumption that a certain fixed ortion of the quantity consumed is held each period to cover unanticipated changes emand. Time was added to account for these stocks having declined over the ation period. This is because improved milling technology and marketing and portation channels have meant that less stocks are required for unforeseen demand ations. Since prices were estimated in levels, the MUV deflator[1] was added to the fication to capture the effect of inflation.

US dollar terms of manufactures exported from the G-5 countries (France, Germany, Japan, United Kingdom and weighted proportionally to the countries' exports to the developing countries.

approach is to estimate the equation using a semi-logarithm functional form. This would have the benefit of allowing to change over different price and quantity levels (e.g., the price flexibility may be higher at low stocks-to-use levels). approach was not taken in this study.

The stocks and consumption variables used in the pricing equation 5.7 were btained from the identities shown in equations 5.8 - 5.13.

TESWORXCHI = CTESWOR - CTESCHI (5.8)

TCONWORXCHI = CTCONWOR - CTCONCHI (5.9)

TESWOR = CTPDWOR + CTESWOR(-1) - CTCONWOR (5.10)

TESCHI = CTPDCHI + CTESCHI(-1) - CTCONCHI - CTNECHI (5.11)

TPDWOR = Σ_i(CTHA$_i$*CTYD$_i$) + CTPDROW (5.12)

TCONWOR = Σ_i(CTSH$_i$*TFU$_i$) + CTCONROW (5.13)

here:	CTESWORXCHI	= World cotton stocks excluding stock held in China,
	CTESWOR	= World cotton stocks,
	CTESCHI	= China's cotton stocks,
	CTCONWORXCHI	= World cotton consumption excluding consumption of China,
	CTCONWOR	= World cotton consumption,
	CTCONCHI	= China's cotton consumption,
	CTPDWOR	= World cotton production,
	CTPDCHI	= China's cotton production,
	CTNECHI	= China's net exports of cotton,
	$CTHA_i$	= Cotton area in country i,
	$CTYD_i$	= Cotton yield in country i,
	CTPDROW	= Rest-of-the-World cotton production (production by countries not explicitly modeled, i.e., exogenous),
	$CTSH_i$	= Cotton share of total fiber use in country i,
	TFU_i	= Total fiber use in country i,
	CTCONROW	= Rest-of-the-World cotton consumption (consumption by countries not explicitly modeled, i.e., exogenous).

World stocks were derived from a world market clearing identity (equation 5.10) d the stocks of China were derived from China's market clearing identity (equation 5.11). r China's market clearing identity, net exports were estimated (equation 5.14) as a ction of lagged net exports and a variable capturing excess supplies. Price variables re found not to be significant in determining net exports.

ECHI = - 326 + 0.23 * (CTPDCHI + CTESCHI(-1) - CTCONCHI) + 0.34 CTNECHI(-1) - 528.4 D84 (5.14)
(5.78) (2.70) (-2.80)
UARED (CORR): 0.92 SEE: 142.9 DW: 1.80 PERIOD OF FIT: 1974-88

re:	CTNECHI	= China's net exports of cotton,
	CTPDCHI	= China's cotton production,
	CTESCHI	= China's cotton stocks,
	CTCONCHI	= China's cotton consumption,
	D84	= Zero-one variable, equals 1 in 1984, 0 otherwise.

Price Linkage Equations

In the supply equations for the four regions of the United States, for the three ons of India and for China, local prices (in terms of local currency) were used instead vorld prices adjusted for exchange rates. These were the prices most relevant to ıers' decision making and this was borne out by the estimation results. These local es were linked to the world price of cotton in order to make these regions responsive 'orld market conditions.

In the case of the United States, price linkage equations were estimated linking ! and world cotton prices. These are presented in equations 5.15 - 5.18.

ΓPUS1 = 0.25 + 0.92 LN CTPWOR - 0.31 D74 (5.15)
(15.39) (-2.38)

JARED (CORR): 0.92 SEE: 0.34 DW: 1.81 PERIOD OF FIT: 1964-1987

: CTPUS1 = Cotton price in the Delta region of the United States,
CTPWOR = World cotton price,
D74 = Zero-one variable, equals 1 in 1974, otherwise 0,
LN = Indicates variable transformed into logarithms.

PUS2 = 0.34 + 0.91 LN CTPWOR - 0.30 D74 (5.16)
(15.10) (-2.32)

ARED (CORR): 0.92 SEE: 0.34 DW: 1.85 PERIOD OF FIT: 1964-1987

CTPUS2 = Cotton price in the Southeast region of the United States,
CTPWOR = World cotton price,
D74 = Zero-one variable, equals 1 in 1974, otherwise 0,
LN = Indicates variable transformed into logarithms.

'US3 = 0.32 + 0.90 LN CTPWOR - 0.31 D74 (5.17)
(15.05) (-2.38)

ARED (CORR): 0.92 SEE: 0.34 DW: 1.83 PERIOD OF FIT: 1964-1987

CTPUS3 = Cotton price in the Southwest region of the United States,
CTPWOR = World cotton price,
D74 = Zero-one variable, equals 1 in 1974, otherwise 0,
LN = Indicates variable transformed into logarithms.

:TPUS4 = 0.09 + 0.96 LN CTPWOR - 0.32 D74 (5.18)
(13.74) (-2.11)

)UARED (CORR): 0.90 SEE: 0.46 DW: 1.79 PERIOD OF FIT: 1964-1987

:e:	CTPUS4	= Cotton price in the West region of the United States,
	CTPWOR	= World cotton price,
	D74	= Zero-one variable, equals 1 in 1974, otherwise 0,
	LN	= Indicates variable transformed into logarithms.

louble-log functional form was used in all cases and a dummy variable for 1974 was ed to account for very low prices in that year. In 1974 target price policy was oduced, with direct payments made to growers if market prices fell below the target e. The transmission elasticities ranged from 0.90 in the Southwest region to 0.96 in the st region.

Price transmission equations were also estimated linking local prices in India and na with world prices. These equations performed badly, with world price not significant. s finding was consistent with price policy in these countries which is formed in isolation vorld markets. However, it is unlikely that over the long-run world prices can be red by policy-makers in these countries. Rather than have administered prices ;enous in the forecast period these prices were linked to the world price assuming an icity of 0.25 for China and 0.50 for India[3]. These elasticities entered the model using dentity shown in equation 5.19.

$$P_t = \text{LN } LPP_0 + \lambda * \text{LN}(WPP_t / WPP_0) \quad (5.19)$$

: LPP_t = local producer price in period t,
LPP_0 = local producer price in period 0,
WPP_t = world producer price in period t,
WPP_0 = world producer price in period 0, and
λ = 0.5 for India and 0.25 for China.

f elasticities was based on a study by Mundlak and Larson (1990) of the relationships between local and international

Summary

In this section, the equations for the determination of cotton prices were discussed. e equation explaining the world cotton price was specified as an inverted world stocks ıation. The world price was explained by world stocks (net of stocks held in China). nsactions demand for cotton stocks was captured in the equation by a time variable and ·ld consumption (net of consumption in China). The regression results were satisfactory gave a flexibility estimate of the cotton price with respect to stocks of -0.78. In the del simulations this method of price determination gave results far superior to those ıined when price was derived through a world market clearing identity. This finding ɔnsistent with Ghosh et al.

AN ECONOMETRIC ANALYSIS OF THE WORLD COTTON

AND NON-CELLULOSIC FIBERS MARKETS

Volume II

By

Jonathan R. Coleman

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1991

6. Non-Cellulosic Fibers Model

.1 Introduction

Elasticities of demand, supply and price equations for the non-cellulosic fibers (i.e., olyester, nylon and acrylics) are described in this section. The market for cellulosic fibers .e., acetate, rayon and triacetate), the other major group of manufactured fibers has not een modeled. The reason for this was that cellulosic fibers contributed less than 10% of tal world fiber use in 1985 and less than 23% of manufactured fiber use. Further, these ercentages have decreased significantly over time and are expected to continue to fall espite a recent resurgence of rayon consumption). A cellulosic fiber model can be added a later stage, if necessary.

In previous sections the theoretical issues and relevant literature were presented d reviewed. The theoretical assumptions for non-cellulosic demand were the same as for ton demand (section 3.3). The theoretical basis for the pricing equation is similar to t of cotton, except that prices were determined from an inverted consumer demand uation rather than from a stocks demand equation. There are no stocks data for non-ulosic fibers. The supply equation for non-cellulosic fibers was developed from the umption of profit maximization by manufacturers. As far as the author is aware there no published econometric studies of the non-cellulosic fiber sector upon which to draw.

Demand for Non-Cellulosic Fibers

The demand equations for non-cellulosic fibers was specified using a structure ical to that for cotton use. The proportion of non-cellulosics fibers of total fiber use vas estimated as a function of the prices of cotton and polyester. The non-cellulosic share ibers was then multiplied by total fiber use to obtain the consumer demand for ıon-cellulosic fibers. That is,

NCU = NCSH * PCTFU * POP,
NCSH = f(PCT, PSP),
PCTFU = f(GDP).

Vhere: NCU = Quantity of non-cellulosic fibers for home use;
NCSH = Non-cellulosic fibers share of total fibers for home use.

he non-cellulosic fibers share was not specified as one minus the cotton share because ıere are other fiber types that make up total fiber demand. The per capita total fiber use juations were discussed in section 3.5.2. The non-cellulosic share equations are presented equations 6.1 - 6.14 below.

The equation specifications are very similar to the cotton share equations reported section 3.5, which in most cases fitted the data well. The non-cellulosic share is a nction of polyester and cotton prices[1] which appears as a ratio in most of the equations. many of these equations, price parameters are significant and with the correct sign. ice variables that were not significant but correctly signed were maintained in the model ., for Argentina and Central Africa). In initial equations for Egypt, India and Pakistan price variables were not significant and were incorrectly signed and were dropped from specification. To capture the effect of prices in these equations the cotton share of al fiber use was added to the specifications which, as shown in section 3.5, were ctions of relative prices.

---

polyester price used was the polyester staple price fob U.S. plants taken from Cotton and Wool Situation and Outlook, gton D.C.
cotton price was the cotton outlook "A" Index cif N. Europe, taken from Cotton Outlook.

As reported in section 3.5.1, the non-cellulosic fibers share in these regions followed ɜry strong time trend throughout the estimation period. A time variable was significant nany of the equations, capturing the non-price determined substitution of cotton with -cellulosic fibers. This point was discussed in section 3.4. In some cases a logarithmic ctional form gave a better fit to the data. Dummy variables were used to capture iers in the data. For example, dummy variables for 1972 and 1973 in the equation for Republic of Korea captured the impact of political unrest on that economy during the / 1970s.

The non-cellulosic fibers share of total fiber use in Argentina is given in equation

ARG = 0.016 - 0.034 DFPSPARG/DFCTPARG + 0.81 NCSHARG(-1) (6.1)
(-1.82) (10.84)

JARED (CORR.): 0.92 SEE: 0.0106 H-STAT: 0.47 PERIOD OF FIT: 1964-1986

NCSHARG = Non-cellulosic fibers share of total fiber use in Argentina,
DFPSPARG = Deflated polyester price in Argentina,
DFCTPARG = Deflated cotton price in Argentina.

The non-cellulosic fibers share of total fiber use in Australia is given in equation

.US = 0.018 - 0.049 DFPSPAUS/DFCTPAUS + 0.85 NCSHAUS(-1) (6.2)
(-3.01) (15.79)

ARED (CORR.): 0.96 SEE: 0.0087 H-STAT: - 0.86 PERIOD OF FIT: 1964-1987

NCSHAUS = Non-cellulosic fibers share of total fiber use in Australia,
DFPSPAUS = Deflated polyester price in Australia,
DFCTPAUS = Deflated cotton price in Australia.

The non-cellulosic fibers share of total fiber use is given in equation 6.3.

HBRA = - 1.55 - 1.239 LN DFPSPBRA/LN DFCTPBRA (6.3)
(-11.85)

.RED (CORR.): 0.87 SEE: 0.8879 DW: 1.19 PERIOD OF FIT: 1964-1986

NCSHBRA = Non-cellulosic fibers share of total fiber use in Brazil,
DFPSPBRA = Deflated polyester price in Brazil,

DFCTPBRA = Deflated cotton price in Brazil.
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in Central Africa is given in uation 6.4.

NCSHCAF = - 4.98 - 0.10 LN DFPSPCAF/LN DFCTPCAF - 1.03 LN TIME (6.4)
(-1.11) (-11.66)

QUARED (CORR.): 0.95 SEE: 0.2824 DW: 1.31 PERIOD OF FIT: 1964-1986

ere: NCSHCAF = Non-cellulosic fibers share of total fiber use in Central Africa,
DFPSPCAF = Deflated polyester price in Central Africa,
DFCTPCAF = Deflated cotton price in Central Africa,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in China is given in equation 6.5.

NCSHCHI = - 3.77 - 1.02 LN DFPSPCHI/LN DFCTPCHI - 6.40 LN CTSHCHI (6.5)
(-9.41) (-16.42)

QUARED (CORR.): 0.97 SSE: 0.6521 DW: 1.85 PERIOD OF FIT: 1964-1986

re: NCSHCHI = Non-cellulosic fibers share of total fiber use in China,
CTSHCHI = Cotton share of total fiber use in China,
DFPSPCHI = Deflated polyester price in China,
DFCTPCHI = Deflated cotton price in China.
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in the EEC-12 is given in equation

CSHEEC = - 1.00 - 0.58 LN DFPSPEEC/LN DFCTPEEC + 0.38 D86 (6.6)
(-10.43) (3.05)

UARED (CORR.): 0.85 SEE: 0.2525 DW: 1.45 PERIOD OF FIT: 1964-1986

: NCSHEEC = Non-cellulosic fibers share of total fiber use in the EEC-12,
DFPSPEEC = Deflated polyester price in the EEC-12,
DFCTPEEC = Deflated cotton price in the EEC-12,
D86 = Zero-one variable, equals 1 in 1986 0 otherwise.
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in Egypt is given in equation 6.7.

EGY = - 0.497 + 0.29 LN TIME - 0.38 CTSHEGY (6.7)
(7.65) (-7.51)

ARED (CORR.): 0.99 SEE: 0.0062 DW: 2.65 PERIOD OF FIT: 1964-1986

NCSHEGY = Non-cellulosic fibers share of total fiber use in Egypt,
CTSHEGY = Cotton of total fiber use in Egypt,

TIME = Time variable,
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in India is given in equation 6.8.

NCSHIND = - 3.01 + 0.73 LN TIME + 0.67 LN NCSHIND(-1) (6.8)
(2.93) (5.33)

QUARED (CORR.): 0.98 SEE: 0.3198 H-STAT: 1.12 PERIOD OF FIT: 1964-1986

re: NCSHIND = Non-cellulosic fibers share of total fiber use in India,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in Japan is given in equation 6.9.

CSHJPN = - 0.34 - 0.19 LN DFPSPJPN/LN DFCTPJPN + 0.65 LN NCSHJPN(-1) - 0.28 D72 - 0.32 D74 (6.9)
(-4.19) (7.69) (-2.68) (-3.99)

UARED (CORR.): 0.92 SEE: 0.0965 H-STAT: - 0.28 PERIOD OF FIT: 1964-1987

e: NCSHJPN = Non-cellulosic fibers share of total fiber use in Japan,
DFPSPJPN = Deflated polyester price in Japan,
DFCTPJPN = Deflated cotton price in Japan,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D74 = Zero-one variable, equals 1 in 1974, 0 otherwise,
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in Korea is given in equation 6.10.

KOR = - 0.70 - 0.82 DFPSPKOR/DFCTPKOR - 0.47 D72 - 0.61 D73 (6.10)
(-2.99) (-1.17) (-3.76)

JARED (CORR.): 0.83 SEE: 0.5866 DW: 1.02 PERIOD OF FIT: 1964-1986

: NCSHKOR = Non-cellulosic fibers share of total fiber use in Korea,
DFPSPKOR = Deflated polyester price in Korea,
DFCTPKOR = Deflated cotton price in Korea,
D72 = Zero-one variable, equals 1 in 1972, 0 otherwise,
D73 = Zero-one variable, equals 1 in 1973, 0 otherwise.

The non-cellulosic fibers share of total fiber use in Mexico is given in equation 6.11.

MEX = - 0.058 DFPSPMEX/DFCTPMEX + 0.92 NCSHMEX(-1) (6.11)
(-3.60) (27.24)

ARED (CORR.): 0.99 SSE: 0.0093 H-STAT: 1.04 PERIOD OF FIT: 1964-1986

NCSHMEX = Non-cellulosic fibers share of total fiber use in Mexico,
DFPSPMEX = Deflated polyester price in Mexico,
DFCTPMEX = Deflated cotton price in Mexico.

The non-cellulosic fibers share of total fiber use in Pakistan is given in equation 12.

SHPAK = 0.64 - 0.70 CTSHPAK (6.12)
(-21.81)

QUARED (CORR.): 0.97 SSE: 0.0001 DW: 1.91 PERIOD OF FIT: 1964-1986

ere: NCSHPAK = Non-cellulosic fibers share of total fiber use in Pakistan,
CTSHPAK = Cotton share of total fiber use in Pakistan.

The non-cellulosic fibers share of total fiber use in Turkey is given in equation 6.13.

NCSHTUR = - 4.75 - 0.27 LN DFPSPTUR/LN DFCTPTUR + 1.12 LN TIME (6.13)
(-2.78) (11.92)

QUARED (CORR.): 0.96 SSE: 0.1992 DW: 1.64 PERIOD OF FIT: 1964-1986

re: NCSHTUR = Non-cellulosic fibers share of total fiber use in Turkey,
DFPSPTUR = Deflated polyester price in Turkey,
DFCTPTUR = Deflated cotton price in Turkey,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

The non-cellulosic fibers share of total fiber use in the United States is given in ation 6.14.

HUSA = 0.17 + 0.0012 DFCTPUSA - 0.0005 DFPSPUSA + 0.012 TIME (6.14)
(6.13) (-3.72) (6.27)

UARED (CORR.): 0.94 SSE: 0.0209 DW: 1.78 PERIOD OF FIT: 1964-1986

e: NCSHUSA = Non-cellulosic fibers share of total fiber use in the United States,
DFPSPUSA = Deflated polyester price in the Unites States,
DFCTPUSA = Deflated cotton price in the United States,
TIME = Time variable.

The own- and cross-price elasticities are reported in Table 6.1. They ranged from in Central Africa to 1.24 in Brazil. In most cases the elasticities were inelastic but all are higher than the own-price elasticities estimated for cotton. This may have cted the high degree of substitutability of non-cellulosic fibers with cellulosic fibers. ntrast to the cotton own-price elasticities, the responsiveness to prices does not tend greater or less in the industrial countries than in the developing countries.

Cross-price elasticities can be compared using Tables 3.1 and 6.1. The comparisons

able 6.1 Price Elasticities of Non-Cellulosic Fibers Use[1].

egion[2]	Polyester Staple Price	Cotton Price[3]
rgentina	- 0.15	+ 0.15
ustralia	- 0.13	+ 0.13
razil	- 1.24	+ 1.24
entral Africa	- 0.10	+ 0.10
hina	- 1.02	+ 1.02
EC-12	- 0.58	+ 0.58
gypt[4]	- 0.42	+ 0.42
ıpan	- 0.19	+ 0.19
orea, Repub. of	- 0.83	+ 0.83
lexico	- 0.12	+ 0.12
akistan[4]	- 0.32	+ 0.32
urkey	- 0.27	+ 0.27
'nited States	- 0.22	+ 0.42

3ased on a regression period 1964-1986 for developing countries and 1964-1987 for ıdustrialized countries.

he elasticities of non-cellulosic use with respect to price ($E_{NCU/P}$) were derived from the ›n-cellulosic share equations.
$_{NCU/P}$ = (∂NCU/∂P).(P/NCU). Recall NCU = NCSH * TFU and that NCSH = (b_i + .P_k). (∂NCU/∂P) = b_k.TFU and $E_{NCU/P}$ = b_k.TFU.P/NCU.

ılues for NCU, P and TFU were taken as historical means.

Io elasticities can be reported from model regions for which prices did not appear in the mand equations (i.e., India)

'here polyester price elasticities equal the cotton elasticities a ratio of these prices was ›d in the share equation.

asticities calculated using cotton share elasticity estimates.

w that non-cellulosic demand is more responsive to cotton price changes than is cotton nand to changes in the price of polyester. This may reflect the fact that historically the ts of raw cotton in textile manufacturing have exceeded those of non-cellulosic fibers[2]. erefore, the income effect of a change in the cotton price is larger than for a change in polyester price. This finding was consistent with the Slutsky condition from consumer nand theory. This states that,

$$e_{ij} = (w_i/w_j).e_{ji} + w_j.(e_{jy} - e_{iy})$$

ere: e_{ij} = the demand elasticity of good i with respect to the price of good j,
e_{ji} = the demand elasticity of good j with respect to the price of good i,
w_i = the income expenditure share allocated to good i,
w_j = the income expenditure share allocated to good j,
e_{iy} = the income elasticity of good i,
e_{jy} = the income elasticity of good j.

good i be cotton and j non-cellulosic fibers. Since historically manufacturers have spent :e on cotton than non-cellulosic fibers, (i.e., w_i exceeded w_j), then the elasticity of cotton ıand with respect to the price of polyester was expected to be less than the elasticity on-cellulosic fiber with respect to the cotton price (assuming the $w_j.(e_{jy} - e_{iy})$ term were ll).

---

so for the 1970s than 1980s. Another factor is that polyester prices change less frequently than cotton prices. At times ı the United States remain constant for several months while cotton prices change daily.

Supply of Non-Cellulosic Fibers

The supply of non-cellulosic fibers has been described by Thigpen and Mitchell

8) as follows:

> Non-cellulosic fibers are produced by industrial processes from long-chain non-cellulosic polymers and are usually of petroleum origin. The levels of production can be adjusted quickly to market conditions within the limits of plant capacity. These fibers are produced by industrial processes which give producers a considerable degree of control of output over a relatively short period of time and within the limits of total capacity. The non-cellulosic fiber market is comprised of a relatively small number of firms with individual firms large enough to influence the level of production and price.

The supply of non-cellulosic fibers is expected to depend on the profitability of lucing non-cellulosic fibers, which is determined by the price of non-cellulosic fibers ive to input costs, such as oil costs and interest rates. Equations were estimated for major producing regions. However, difficulties were encountered in estimating uction at a regional level with the prices of oil and polyester not significant in many ;. Poor results may have resulted from the lack of accurate regional level data. uction of non-cellulosic fibers was therefore estimated at the world level using a single tion which is reported in equation 6.15

)D = - 27116 - 4397. DFOILPR - 127.6 RIRUSA + 1077. DFPSPWOR(-1) + 12211. LN TIME (6.15)
(-2.77) (-2.53) (5.49) (13.18)

ARED (CORR.): 0.99 SEE: 488.7 DW: 1.65 PERIOD OF FIT: 1964-88

NCPROD = Non-cellulosic fibers production, world,
DFOILPR = Deflated price of oil, (OPEC petroleum average prices),
RIRUSA = Real rate of interest (long term U.S. bond yield),
DFPSPWOR = Deflated polyester price,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

n-cellulosic production is estimated as a function of the deflated price of oil, the deflated ce of polyester and the real rate of interest. The coefficients have the right signs and all significant. The elasticities of supply with respect to the price of oil and own-price re - 0.08 and 0.36, respectively. The logarithm of time was added to the specification capture the dramatic increase in production of non-cellulosic fibers associated with hnological innovations in the non-cellulosic fiber sector.

Price Determination

The polyester price was determined by an inverted demand equation (6.16). nand in the Rest-of-the-World was included, and, in turn, was determined endogenously ne difference between supply and the demand from regions modeled explicitly (equation). The lagged price of oil captured the effects of oil prices on non-cellulosic fibers, e the MUV deflator accounted for general inflation throughout the estimation period. equations fitted the data well with all coefficients significant and correctly signed. The oility of the polyester price with respect to the demand in the Rest-of-the-World is 0.90 h is consistent with the elasticity estimates reported in Table 6.1. The polyester price icity with respect to the MUV was 1.04.

$$\text{)R} = 79.6 + \underset{(6.83)}{1.74}\ \text{MUV} - \underset{(-5.66)}{0.05}\ \text{NCUROW} + \underset{(6.16)}{1.81}\ \text{OILPR(-1)} \qquad (6.16)$$

ARED (CORR.): 0.96 SEE: 5.56 DW: 2.61 PERIOD OF FIT: 1969-88

'SPWOR = Polyester price, World,
MUV = Manufactures unit value (deflator),
NCUROW = Non-cellulosic fibers use, Rest-of-the-World,
)ILPR = Price of oil.

$NCUROW = NCPROD - \Sigma_i(NCSH_i \cdot TFU_i)$ (6.17)

Where: NCUROW = Non-cellulosic fibers use, Rest-of-the-World,
NCPROD = Non-cellulosic fibers production, world (from equation 6.15),
$NCSH_i$ = Non-cellulosic fibers share of total fiber use in country i (from equations 6.1-6.14),
TFU_i = Total fiber use in country i (from equations 3.15-3.28).

6.5 Summary

In this section, an econometric model for the non-cellulosic fiber sector was presented. Equations for the non-cellulosic fibers share of total fiber use were estimated for each of the model regions, which were then combined with total fiber use to determine non-cellulosic fibers consumption. The supply of non-cellulosic fibers was estimated for the world. The polyester price was determined from an inverted demand equation for non-cellulosics in the Rest-of-the-World which was derived from a market clearing identity. The model was linked to the cotton model through the polyester price which entered the cotton demand equations. Overall, the econometric equations were satisfactory with good explanatory power and coefficients and elasticity estimates at reasonable levels.

7. Validation of the Model

The single equation estimates presented in earlier chapters were accepted or jected on the basis of a set of standard diagnostics such as the corrected R-squared, the ırbin-Watson statistic and standard error of residuals. The decision to accept or reject equation often ultimately depends on the purpose for which the equation is being imated. For example, models estimated for forecasting should have small standard ors, while those used for evaluating alternative policy scenarios or calculating structural sticities should be specified to be consistent with economic theory. Once such single ıations have been put together to form a multi-equation model, a similar evaluation cedure is necessary to test the properties of the entire model. This section presents erent statistics which cover various aspects of model evaluation.

A major problem in validating a multi-equation model is that no statisically ective criteria or benchmarks exist by which to accept or reject a validation statistic. criteria used are arbitarily chosen by the modeler. As in single equation estimation, decision to accept a model as satisfactory depends on the intended use of the model. lels designed for forecasting are typically put through more rigorous tests than those loped for evaluating alternative policy scenarios.

In this section, four sets of validation statistics are presented. These cover various ts of the model's ability to plot historical data and to respond to economic stimuli in nner consistent with both economic theory and empirical observation.

ıe validation statistics include:

(1) Root Mean Square Percentage Error (RMSPE);

(2) Mean Squared Error (MSE);

(3) Theil's U-statistic;

(4) Graphical validation.

e validation statistics presented below were based on a simulation period from 1966 to 38 for production and price variables and from 1966 to 1986 for consumption variables.

Validation using the Root Mean Squared Percentage Error

The root mean square percentage error (RMSPE) statistic shows how well ulated values of the endogenous variables match with their actual historical values. The SPE is defined as,

$$\text{RMSPE} = (1/n\Sigma_t((A_t-P_t)/A_t)^2)^{1/2}$$

e: A_t = the actual value of an endogenous variable,

P_t = the simulated value of an endogenous variable, and

n = the number of periods in the simulation.

statistic is very useful in that it provides a single value measuring the variation of the ted values around actual values of the endogenous variables. The statistic does have awbacks. First, the RMSPE is an average which as a measure of central tendency ask the true nature of the series which it represents. For example, a few very large rrors can raise the RMSPE of a series that otherwise tracks very well. Second, in cases here the actual values are small (e.g., net exports), small errors in absolute terms give rise o substantial errors in percentage terms.

The RMSPEs for the endogenous cotton variables of the model are reported in able 7.1. At the world level the RMSPEs for cotton use and cotton production are 1.56% nd 2.2%, respectively. The RMSPE for the world price of cotton is 8.42%. Thus, the acking of the quantity variables tends to be better than for prices. This can be explained the inelasticity of the supply and demand curves in which inaccuracies had a greater fect on prices than quantities.

For the individual regions the results for cotton use tends to perform better than ose for production. Of the 14 consumption regions in the model all recorded a RMSPE less than 15% and only for two regions (i.e., Pakistan and the Republic of Korea) have lues of less than 10% been reported. On the cotton production side of the model, the ults are less good. However, only for three producing regions were RMSPEs of more n 20% obtained (i.e., Australia, Southeast region, United States and Sind region, kistan), while for seven regions the simulation gave RMSPEs of less than 10%.

As mentioned above, the RMSPEs are sensitive to the levels of the variables. This lains the very high values recorded for stock and net trade in China (CTESCHI = 73.88 CTNECHI = 191.34). Both these variables are very close to zero during some periods he simulation, resulting in very large percentage errors between actual and simulated es. This is also the reason for the very high value reported for per capita total fiber in Central Africa (PCTFUCAF = 83.3). In these circumstances, other validation stics must be used to evaluate the performance of the variable in the model.

able 7.1. Root Mean Square Percentage Errors for the Model's Endogenous Variables[1].

egion	RMSPE	Region	RMSPE	Region	RMSPE	Region	RMSPE
TYDARG	10.50	CTYDAUS	11.63	CTYDBRA	7.50	CTYDCAF	6.78
TYDCHI	3.35	CTYDEGY	13.90	CTYDINDN	5.92	CTYDINDS	11.43
YDINDW	4.15	CTYDMEX	5.08	CTYDPAKP	12.33	CTYDPAKS	9.21
YDTUR	6.35	CTYDUS1	9.19	CTYDUS2	15.18	CTYDUS3	7.90
YDUS4	6.63						
HAARG	11.82	CTHAAUS	29.78	CTHABRA	5.36	CTHACAF	2.51
HACHI	5.94	CTHAEGY	5.38	CTHAINDN	10.49	CTHAINDS	4.02
HAINDW	1.24	CTHAMEX	17.41	CTHAPAKP	5.48	CTHAPAKS	11.76
HATUR	7.47	CTHAUS1	11.88	CTHAUS2	23.51	CTHAUS3	11.68
HAUS4	14.44						
PDARG	13.72	CTPDAUS	38.51	CTPDBRA	9.68	CTPDCAF	6.79
PDCHI	4.75	CTPDEGY	14.48	CTPDINDN	8.28	CTPDINDS	11.93
PDINDW	3.87	CTPDIND	4.30	CTPDMEX	17.44	CTPDPAKP	11.71
PDPAKS	21.72	CTPDPAK	10.19	CTPDTUR	7.96	CTPDUS1	12.18
PDUS2	27.50	CTPDUS3	15.88	CTPDUS4	16.14	CTPDUSA	8.31
PDWOR	2.20						
HARG	2.71	CTSHAUS	3.17	CTSHBRA	2.60	CTSHCAF	1.33
HCHI	2.48	CTSHEEC	3.33	CTSHEGY	5.78	CTSHIND	3.38
HJPN	3.33	CTSHKOR	7.50	CTSHMEX	3.07	CTSHPAK	2.86
HTUR	5.51	CTSHUSA	5.28				
FUARG	4.70	PCTFUAUS	4.54	PCTFUBRA	6.11	PCTFUCAF	83.30
FUCHI	6.11	PCFUAEEC	2.82	PCTFUEGY	5.07	PCTFUIND	1.70
FUJPN	6.95	PCFUAKOR	11.05	PCTFUMEX	4.69	PCTFUPAK	12.81
UATUR	3.59	PCTFUUSA	2.63				
ARG	4.36	CTUAUS	5.45	CTUBRA	6.11	CTUCAF	6.52
CHI	6.51	CTUEEC	3.79	CTUEGY	7.95	CTUIND	3.02
JPN	7.54	CTUKOR	13.80	CTUMEX	7.52	CTUPAK	14.19
TUR	7.13	CTUUSA	5.97	CTUWOR	1.56	CTESWOR	9.69
ECHI	73.88	CTNECHI	191.34	CTPAWOR	8.42		
DWOR	11.58	NCUWOR	8.62	PSPWOR	14.40		
HARG	11.24	NCSHAUS	9.62	NCSHBRA	25.43	NCSHCAF	22.32
ICHI	26.62	NCSHEEC	12.53	NCSHEGY	12.05	NCSHIND	17.88
IJPN	6.28	NCSHKOR	24.21	NCSHIND	17.88	NCSHJPN	6.28
IKOR	24.21	NCSHMEX	14.94	NCSHPAK	112.92	NCSHTUR	10.49
IUSA	11.00						
RG	12.52	NCUAUS	12.51	NCUBRA	25.17	NCUCAF	24.27
HI	29.36	NCUEEC	13.03	NCUEGY	13.78	NCUIND	18.25
PN	12.59	NCUKOR	22.15	NCUMEX	20.80	NCUPAK	104.87
UR	10.78	NCUUSA	11.70	NCUROW	14.97		

iable definitions are provided in Appendix.

The RMSPEs for the non-cellulosic fibers variables are also reported in Table 7.1. 'he RMSPEs for world supply, demand and price are 11.58, 8.62 and 14.4, respectively. 'hese are higher than their cotton counterparts but still indicate good model predictions f the historical series. Again, the price variable performs less well than the quantity ıriables, reflecting the inelasticity of demand for non-cellulosic fibers. The non-cellulosic ɔers share equations do not perform as well as the cotton share equations. This may flect the fact that non-cellulosic fibers share has been historically below the cotton share that percentage differences are computed from a lower base level--accounting for the rge RMSPEs reported for China, the Republic of Korea and Pakistan. The RMSPEs for e non-cellulosic fibers use reflect errors in the share and total fiber use equations which ve been discussed already. The value for non-cellulosic fibers use in the Rest-of-the-ɔrld (NCUROW) is relatively low at 14.97. Accuracy in tracking this variable is ɔortant as it was the demand variable in the polyester price equation.

Validation Using Mean Squared Error (MSE)

The mean squared error (MSE) is similar to the RMSPE in that it measures the ın of the squared difference between actual and simulated variables. It can be defined erms of the differences in the levels of the variables (MSEL) with,

$$MSEL = 1/n \ \Sigma_t (P_t - A_t)^2$$

re: A_t = the actual value of an endogenous variable,

P_t = the simulated value of an endogenous variable, and

n = the number of periods in the simulation, r in terms of percentage changes (MSEP) with,

$$MSEP = 1/n\ \Sigma_t(p_t - a_t)^2$$

here: $p_t = (P_t - A_{t-1})/A_{t-1}$

$a_t = (A_t - A_{t-1})/A_{t-1}$.

nce the MSEL will depend on the units in which the variable is measured, the MSEP is ore useful in providing comparisons of forecasting accuracy for variables measured in fferent units.

The major usefulness of this statistic is that it can be broken down into separate mponents to reveal the sources of discrepancy between actual and simulated values. Two ethods of decomposition can be derived. Theil (1966) suggested that the MSE should broken down into its bias, variance and covariance components and these are derived follows,

$$MSE = (P - A)^2 + S^2 p\text{-}a,$$

$$MSE = (P - A)^2 + S^2_p + S^2_a - 2rS_pS_a,$$

$$MSE = (P - A)^2 + (S_p - S_a)^2 + 2(1-r)S_pS_a,$$

$$1 = \frac{(P - A)^2}{MSE} + \frac{(S_p - S_a)^2}{MSE} + \frac{2(1-r)S_pS_a}{MSE},$$

ere: P = the mean of the simulated values,
A = the mean of the actual data,
S_p = the standard deviation of the simulated data,
S_a = the standard deviation of the actual data,
r = the correlation coefficient between the simulated and actual data.

Theil defined,

$$\frac{(P - A)^2}{MSE} \quad \text{as the bias component } (U^b),$$

$$\frac{(S_p - S_a)^2}{MSE} \quad \text{as the variance component } (U^v),$$

$$\frac{2(1-r)S_pS_a}{MSE} \quad \text{as the covariance component } (U^c).$$

lote that $U^b + U^v + U^c = 1$.

The bias component shows whether the simulated values tend to be higher or lower ıan the actual values, while the variance component indicates to what extent the MSE is fluenced by the variance of the actual and simulated values. The covariance component easures the unsystematic error (i.e., that which remains after errors in average values and erage variabilities have been accounted for).

Maddala (1977) argues that there is no reason to insist that the variances of actual d simulated data should be equal and suggests that a decomposition into bias, regression d disturbance terms is more illuminating. These are derived as follows,

$$MSE = (P - A)^2 + S^2_{p-a},$$

$$MSE = (P - A)^2 + S^2_p + S^2_a - 2rS_pS_a,$$

$$MSE = (P - A)^2 + (S_p - rS_a)^2 + (1-r^2)S^2_a,$$

$$1 = \frac{(P - A)^2}{MSE} + \frac{(S_p - rS_a)^2}{MSE} + \frac{(1-r^2)S^2_a}{MSE},$$

Maddala defines

$$\frac{(P - A)^2}{MSE}$$ as the bias component (U^b),

$$\frac{(S_p - rS_a)^2}{MSE}$$ as the regression component (U^r),

$$\frac{(1-r^2)S^2_a}{MSE}$$ as the disturbance component (U^d).

Jote again that $U^b + U^r + U^d = 1$.

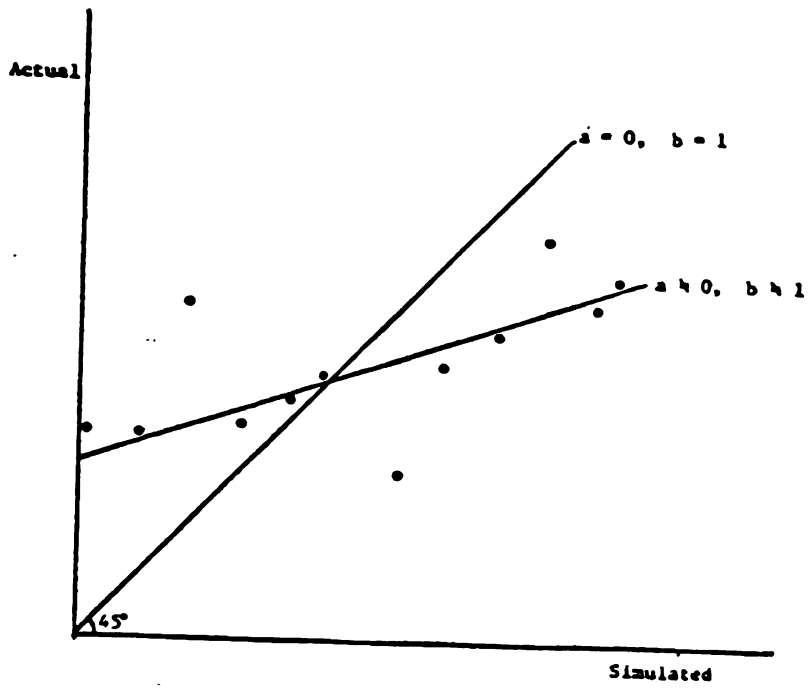
Maddala describe the benefits of this approach using the regression of actual on imulated values as follows,

$$A_t = a + b * P_t$$

perfect forecast yields $a = 0$ ($U^b = 0$) and $b = 1$ ($U^r = 0$). Figure 7.1 shows a gression line between actual and simulated values in which the 45° line represents a rfect forecast ($P_t = A_t$). The error in the intercept ($a \neq 0$) is accounted for by U^b while e error in the slope is accounted for by U^r. The U^d represents unsystematic errors, rived from random disturbances that are contained within the actual data series. Since ey are random and cannot be explained by the model, the forecast cannot be expected capture these disturbances. Given that a perfect forecast yields $U^b = 0$ and $U^r = 0$ the idation statistics improve as,

$\rightarrow 0$, $U^v \rightarrow 0$, $U^c \rightarrow 1$, $U^r \rightarrow 0$, and $U^d \rightarrow 1$.

Figure 7.1 The Regression of Actual Against Simulated Values.



The MSE and its decompositions are presented in Table 7.2. Overall the model performs well in terms of this criterion. Most of the U^b and U^r values are close to zero, indicating that the simulated values do not tend to be higher or lower than their actual values. The U^d for most of the variables are close to one. This indicates that most of the errors in the simulated values are associated with randomness in the actual data series. Using the Theil decomposition of MSE into bias, variance and covariance, the model results further suggest that the errors in predicted values can be associated with unsystematic errors. The RMSPEs showed poor performance for some model variables--especially cotton stocks and net exports of China, per capita total fiber use in Central Africa, and the non-cellulosic fibers share in Pakistan. Using the MSE criterion it appears that net trade of China and fiber use in Central Africa validate better. However, the Chinese stocks variable do not perform well, with a U^b as high as 27.7%.

Table 7.2. Mean-Square Error and its Decompositions for the Model's Endogenous Variables[1]

	MSE	U^b	U^r	U^d	U^v	U^c
CTYDARG	0.001	0.013	0.055	0.932	0.011	0.976
CTYDAUS	0.011	0.016	0.033	0.952	0.028	0.956
CTYDBRA	0.000	0.001	0.002	0.996	0.036	0.993
CTYDCAF	0.003	0.155	0.002	0.843	0.025	0.820
CTYDEGY	0.016	0.008	0.022	0.971	0.110	0.883
CTYDINDN	0.001	0.037	0.035	0.929	0.138	0.625
CTYDINDS	0.001	0.007	0.021	0.972	0.069	0.923
CTYDINDW	0.000	0.001	0.034	0.965	0.000	0.999
CTYDMEX	0.002	0.043	0.041	0.916	0.177	0.780
CTYDPAKP	0.001	0.005	0.116	0.879	0.004	0.990
CTYDPAKS	0.000	0.104	0.008	0.888	0.000	0.396
CTYDPRR	0.251	0.065	0.080	0.855	0.159	0.775
CTYDTUR	0.002	0.368	0.089	0.542	0.017	0.615
CTYDUS1	0.003	0.003	0.008	0.989	0.140	0.858
CTYDUS2	0.006	0.010	0.009	0.980	0.062	0.928
CTYDUS3	0.005	0.008	0.022	0.971	0.110	0.883
CTYDUS4	0.004	0.100	0.000	0.899	0.055	0.845
CTHAARG	3286.0	0.003	0.000	0.997	0.102	0.895
CTHAAUS	273.69	0.003	0.245	0.752	0.417	0.580
CTHABRA	15898.	0.009	0.069	0.922	0.252	0.739
CTHACAF	5345.7	0.001	0.071	0.928	0.126	0.874
CTHACHI	45086.	0.073	0.037	0.889	0.072	0.354
CTHAEGY	1094.3	0.000	0.016	0.984	0.085	0.915
CTHAINDN	5081.3	0.095	0.169	0.736	0.265	0.340
CTHAINDS	4306.7	0.000	0.000	1.000	0.030	0.969
CTHAINDW	4186.2	0.000	0.002	0.998	0.013	0.986
CTHAMEX	2344.4	0.012	0.012	0.976	0.070	0.918
CTHAPAKP	6013.9	0.040	0.199	0.761	0.111	0.450
CTHAPAKS3	474.9	0.071	0.013	0.516	0.000	0.428
CTHATUR	2365.3	0.012	0.024	0.954	0.270	0.718
CTHAUS1	18037.	0.044	0.006	0.949	0.103	0.852
CTHAUS2	5002.5	0.077	0.051	0.872	0.000	0.923
CTHAUS3	68040.	0.036	0.118	0.846	0.341	0.623
CTHAUS4	8397.2	0.041	0.635	0.324	0.766	0.192
CTPDARG	452.45	0.000	0.001	0.999	0.065	0.935
CTPDAUS	435.45	0.009	0.272	0.720	0.430	0.561
CTPDBRA	3153.5	0.000	0.037	0.963	0.002	0.998
CTPDCAF	2144.8	0.156	0.000	0.844	0.048	0.795
CTPDCHI	31460.	0.054	0.244	0.702	0.307	0.637
CTPDEGY	5445.0	0.573	0.087	0.339	0.005	0.421
CTPDINDN	622.6	0.154	0.006	0.839	0.014	0.832
CTPDINDS	713.4	0.017	0.074	0.909	0.017	0.966
CTPDINDW	697.5	0.002	0.025	0.973	0.001	0.997
CTPDIND	2672.3	0.055	0.006	0.939	0.003	0.942
CTPDMEX	1808.7	0.058	0.002	0.939	0.029	0.913
CTPDPAKP	2529.9	0.037	0.251	0.712	0.112	0.851
CTPDPAKS	1375.5	0.026	0.025	0.948	0.000	0.973
CTPDPAK	3026.2	0.128	0.153	0.719	0.064	0.808

Table 7.2. Mean-Square Error and its Decompositions for the Model's Endogenous Variables[1]

	MSE	U^b	U^r	U^d	U^v	U^c
CTPDTUR	1454.4	0.011	0.077	0.911	0.002	0.987
CTPDUS1	2788.3	0.139	0.002	0.859	0.033	0.828
CTPDUS2	1813.	0.158	0.197	0.645	0.056	0.787
CTPDUS3	11783.	0.039	0.070	0.891	0.218	0.743
CTPDUS4	11661.	0.010	0.442	0.548	0.624	0.366
CTPDUSA	47389.	0.000	0.104	0.896	0.283	0.716
CTPDWOR	79929.	0.036	0.294	0.671	0.354	0.610
CTSHARG	0.000	0.210	0.073	0.716	0.146	0.644
CTSHAUS	0.000	0.004	0.002	0.994	0.031	0.965
CTSHBRA	0.000	0.003	0.013	0.984	0.082	0.915
CTSHCAF	0.000	0.030	0.129	0.841	0.311	0.659
CTSHCHI	0.000	0.001	0.000	0.999	0.017	0.982
CTSHEEC	0.000	0.003	0.002	0.995	0.084	0.913
CTSHEGY	0.002	0.556	0.054	0.389	0.154	0.289
CTSHIND	0.000	0.002	0.050	0.948	0.165	0.833
CTSHJPN	0.000	0.032	0.004	0.964	0.151	0.081
CTSHKOR	0.001	0.005	0.003	0.993	0.011	0.984
CTSHMEX	0.000	0.097	0.026	0.877	0.043	0.860
CTSHPAK	0.001	0.007	0.019	0.974	0.080	0.913
CTSHTUR	0.001	0.061	0.022	0.917	0.140	0.799
CTSHUSA	0.000	0.000	0.018	0.981	0.074	0.926
PCTFUARG	0.105	0.001	0.015	0.984	0.119	0.880
PCTFUAUS	0.686	0.008	0.030	0.962	0.132	0.860
PCTFUBRA	0.104	0.536	0.227	0.238	0.284	0.181
PCTFUCAF	0.002	0.005	0.021	0.974	0.044	0.951
PCTFUCHI	0.039	0.004	0.004	0.991	0.004	0.992
PCTFUEEC	0.146	0.022	0.011	0.967	0.001	0.976
PCTFUEGY	0.079	0.004	0.002	0.994	0.011	0.985
PCTFUIND	0.002	0.005	0.021	0.974	0.044	0.951
PCTFUJPN	0.005	0.005	0.015	0.980	0.014	0.982
PCTFUKOR	0.349	0.005	0.010	0.986	0.039	0.956
PCTFUMEX	0.173	0.022	0.409	0.569	0.631	0.348
PCTFUPAK	0.169	0.000	0.051	0.949	0.283	0.717
PCTFUTUR	0.069	0.031	0.000	0.969	0.033	0.936
PCTFUUSA	0.309	0.002	0.010	0.987	0.080	0.918
CTUARG	21.18	0.090	0.013	0.897	0.105	0.805
CTUAUS	32.71	0.006	0.080	0.914	0.000	0.994
CTUBRA	535.81	0.551	0.104	0.344	0.147	0.301
CTUCAF	344.20	0.118	0.060	0.822	0.001	0.882
CTUCHI	18677.	0.004	0.008	0.988	0.001	0.995
CTUEEC	3152.2	0.003	0.019	0.978	0.003	0.994
CTUEGY	198.96	0.329	0.018	0.653	0.057	0.614
CTUIND	1101.7	0.008	0.008	0.984	0.022	0.970
CTUJPN	3055.4	0.023	0.000	0.977	0.053	0.924
CTUKOR	128.97	0.006	0.014	0.979	0.073	0.920
CTUMEX	110.81	0.018	0.206	0.776	0.006	0.975
CTUPAK	691.70	0.000	0.033	0.966	0.119	0.880
CTUTUR	188.37	0.016	0.131	0.853	0.008	0.976

Table 7.2. Mean-Square Error and its Decompositions for the Model's Endogenous Variables[1]

	MSE	U^b	U^r	U^d	U^v	U^c
CTUUSA	10276	0.001	0.000	0.999	0.052	0.948
CTUWOR	149.8	0.001	0.000	0.999	0.011	0.988
CTESWOR	271926	0.231	0.000	0.768	0.047	0.722
CTESCHI	160018	0.277	0.012	0.711	0.074	0.649
CTNECHI	23664	0.004	0.05	0.937	0.295	0.701
CTPWOR	149.89	0.001	0.000	0.999	0.011	0.988
NCPDWOR	188388.0	0.083	0.123	0.794	0.082	0.835
NCUWOR	130798.0	0.004	0.086	0.910	0.124	0.872
PSPRWOR	396.9	0.119	0.014	0.867	0.029	0.853
NCSHARG	0.0006	0.027	0.000	0.973	0.026	0.947
NCSHAUS	0.0007	0.255	0.082	0.662	0.141	0.603
NCSHBRA	0.0010	0.007	0.002	0.992	0.059	0.935
NCSHCAF	0.0004	0.001	0.148	0.850	0.325	0.673
NCSHCHI	0.0004	0.000	0.048	0.952	0.005	0.995
NCSHEEC	0.0010	0.007	0.013	0.979	0.132	0.861
NCSHEGY	0.0012	0.008	0.002	0.980	0.105	0.893
NCSHIND	0.0000	0.040	0.113	0.848	0.174	0.786
NCSHJPN	0.0003	0.013	0.000	0.987	0.021	0.967
NCSHKOR	0.0042	0.004	0.042	0.954	0.004	0.991
NCSHMEX	0.0008	0.044	0.122	0.833	0.174	0.781
NCSHPAK	0.0003	0.012	0.044	0.944	0.134	0.854
NCSHTUR	0.0005	0.000	0.018	0.982	0.000	1.000
NCSHUSA	0.0010	0.028	0.256	0.716	0.361	0.611
NCUARG	27.76	0.018	0.007	0.975	0.008	0.974
NCUAUS	91.86	0.078	0.095	0.828	0.169	0.753
NCUBRA	387.79	0.171	0.079	0.750	0.160	0.668
NCUCAF	79.01	0.004	0.042	0.954	0.186	0.810
NCUCHI	6629.4	0.010	0.049	0.941	0.008	0.982
NCUEEC	19270.37	0.001	0.097	0.902	0.208	0.791
NCUEGY	90.91	0.005	0.041	0.954	0.183	0.813
NCUIND	98.85	0.056	0.162	0.781	0.224	0.720
NCUJPN	3400.4	0.000	0.089	0.911	0.179	0.821
NCUKOR	288.5	0.008	0.015	0.976	0.047	0.945
NCUMEX	214.23	0.003	0.234	0.763	0.301	0.696
NCUPAK	22.06	0.115	0.009	0.876	0.004	0.881
NCUTUR	51.86	0.003	0.022	0.975	0.000	0.994
NCUUSA	27161.7	0.011	0.210	0.779	0.303	0.686
NCUROW	64444.1	0.009	0.243	0.747	0.148	0.843

1/ Variable definitions are provided in Appendix.

7.3 Validation Using Theil's U-Statistic

A useful statistic related to both the RMSPE and the MSE is Theil's inequality coefficient. Theil's inequality statistic has been defined as,

$$U_1 = \frac{[1/n\Sigma_t(P_t-A_t)^2]^{1/2}}{[1/n\Sigma_t(P_t)^2]^{1/2} \; [1/n\Sigma_t(A_t)^2]^{1/2}}$$

This statistic is scaled so that U_1 will lie between 0 and 1 ($U_1 = 0$ represents a perfect fit while $U_1 = 1$ indicates a predictive performance as bad as it can possibly be). A major shortcoming is described by Leuthold (1975),

> for both actual data and changes the error depends on the predictions themselves, that is, the purpose is to assess P_t but the assessment is made relative to P_t itself since P_t is in the denominator.

For this reason, a second Theil statistic was used given by,

$$U_2 = [MSE \; / \; 1/n \; \Sigma_t(A_t-A_{t-1})^2]^{1/2}$$

U_2 takes on a value of 0 for a perfect forecast (as in the case of U_1) but has no upper limit. It can be shown also that U_2= 1 indicates a prediction performance the same as a naive, no-change extrapolation.

The U_2 statistics for the endogenous variables of the model are presented in Table 7.3. All variables have a U_2 very close to zero, indicating that the model performed well. The variables that perform least well are stocks and trade in China and the non-cellulosic fibers share in Pakistan. This result is consistent with the findings suggested by the other validation statistics discussed earlier.

Table 7.3. Theil U-Statistics (U_2) for the Model's Endogenous Variables[1].

Region	U_2	Region	U_2	Region	U_2	Region	U_2
CTYDARG	0.0525	CTYDAUS	0.0517	CTYDBRA	0.0369	CTYDCAF	0.0380
CTYDCHI	0.0502	CTYDEGY	0.0829	CTYDINDN	0.0316	CTYDINDS	0.0424
CTYDINDW	0.0201	CTYDMEX	0.0248	CTYDPAKP	0.0579	CTYDPAKS	0.0402
CTYDTUR	0.0332	CTYDUS1	0.0446	CTYDUS2	0.0756	CTYDUS3	0.0300
CTYDUS4	0.0307						
CTHAARG	0.0637	CTHAAUS	0.1196	CTHABRA	0.0285	CTHACAF	0.0124
CTHACHI	0.0210	CTHAEGY	0.0281	CTHAINDN	0.0428	CTHAINDS	0.0202
CTHAINDW	0.0061	CTHAMEX	0.0531	CTHAPAKP	0.0277	CTHAPAKS	0.0525
CTHATUR	0.0360	CTHAUS1	0.0524	CTHAUS2	0.0796	CTHAUS3	0.0585
CTHAUS4	0.0699						
CTPDARG	0.0755	CTPDAUS	0.1283	CTPDBRA	0.0462	CTPDCAF	0.0369
CTPDCHI	0.0309	CTPDEGY	0.0849	CTPDINDN	0.0397	CTPDINDS	0.0503
CTPDIND	0.0183	CTPDIND	0.0200	CTPDMEX	0.0593	CTPDPAKP	0.0575
CTPDPAKS	0.0884	CTPDPAK	0.0428	CTPDTUR	0.0382	CTPDUS1	0.0347
CTPDUS2	0.0960	CTPDUS3	0.0632	CTPDUS4	0.0756	CTPDUSA	0.0435
CTPDWOR	0.0104						
CTSHARG	0.0138	CTSHAUS	0.0159	CTSHBRA	0.0129	CTSHCAF	0.0068
CTSHCHI	0.0121	CTSHEEC	0.0167	CTSHEGY	0.0306	CTSHIND	0.0167
CTSHJPN	0.0306	CTSHKOR	0.0334	CTSHMEX	0.0107	CTSHPAK	0.0145
CTSHTUR	0.0248	CTSHUSA	0.0256				
PCTFUARG	0.0238	PCTFUAUS	0.0226	PCFUABRA	0.0341	PCTFUCAF	0.0330
PCTFUCHI	0.0313	PCTFUEEC	0.0142	PCTFUEGY	0.0266	PCFUAIND	0.0096
PCTFUJPN	0.0333	PCTFUKOR	0.0396	PCTFUMEX	0.0390	PCFUAPAK	0.0585
PCTFUTUR	0.0181	PCTFUUSA	0.0126				
CTUARG	0.0222	CTUAUS	0.0273	CTUBRA	0.0335	CTUCAF	0.0321
CTUCHI	0.0285	CUAEEC	0.0182	CTUEGY	0.0418	CTUIND	0.0150
CTUJPN	0.0372	CUAKOR	0.0550	CTUMEX	0.0370	CTUPAK	0.0649
CTUTUR	0.0374	CTUUSA	0.0285	CTUWOR	0.0078	CTESWOR	0.0452
CTNCHI	0.1528	CTNEPR	0.5029	CTPWOR	0.0448		
NCPDWOR	0.0280	NCUWOR	0.0226	PSPRWOR	0.0784	NCSHARG	0.0520
NCSHAUS	0.0343	NCSHBRA	0.0673	NCSHCAF	0.0742	NCSHCHI	0.0851
NCSHEEC	0.0430	NCSHEGY	0.0481	NCSHIND	0.0585	NCSHJPN	0.0267
NCSHKOR	0.0674	NCSHMEX	0.0322	NCSHPAK	0.1046	NCSHTUR	0.0477
NCSHUSA	0.0316						
NCUARG	0.0603	NCUAUS	0.0464	NCUBRA	0.070	NCUCAF	0.0889
NCUCHI	0.0916	NCUEEC	0.0431	NCUEGY	0.0402	NCUIND	0.0584
NCUJPN	0.0481	NCUAKOR	0.0501	NCUMEX	0.0433	NCUPAK	0.1113
NCUTUR	0.0479	NCUUSA	0.0334	NCUROW	0.0588		

1/ Variable definitions are provided in Appendix 1.

7.4. Graphical Validation

A common method of validation involves examining plots of actual and simulated values against time. Graphs for world production, consumption and price for cotton and non-cellulosic fibers are presented in Figures 7.2-7.7, providing visual evidence of how well the model tracks. They also may indicate that for some periods within the simulation period the model tracks better than in others. While providing an instantaneous perceptual measure, graphical validation may be misleading because the size of the differences between actual and predicted values, when portrayed graphically, depends on the scale of the graph. The smaller the scale, the better the validations appear.

Simulated and actual values for world cotton production are presented in Figure 7.2. The model tracks well, although tending to underestimate supplies in the late 1970s. However, all of the major turning points in the actual data are captured by the model, including the wide fluctuations in production which occurred in the early 1980s. The graph for cotton use is presented in Figure 7.3. Again the model tracks the actual data fairly well, especially before 1975 and after 1982. From 1976 to 1981 the model predicts consumption to be much more variable than actually occurred. During this period consumption did not seem to respond to the widely fluctuating prices and tended to trend slowly upwards. In the model, consumption is much more responsive to price fluctuations. Simulated and actual price data are plotted in Figure 7.4. Overall, the model appears to track cotton prices reasonably well, especially in the late 1960s and early 1970s. Most of the major turning points of the data are captured such as in 1976, 1980, 1983 and 1986.

Figure 7.2 World Cotton Production

Actual Vs Simulated Values

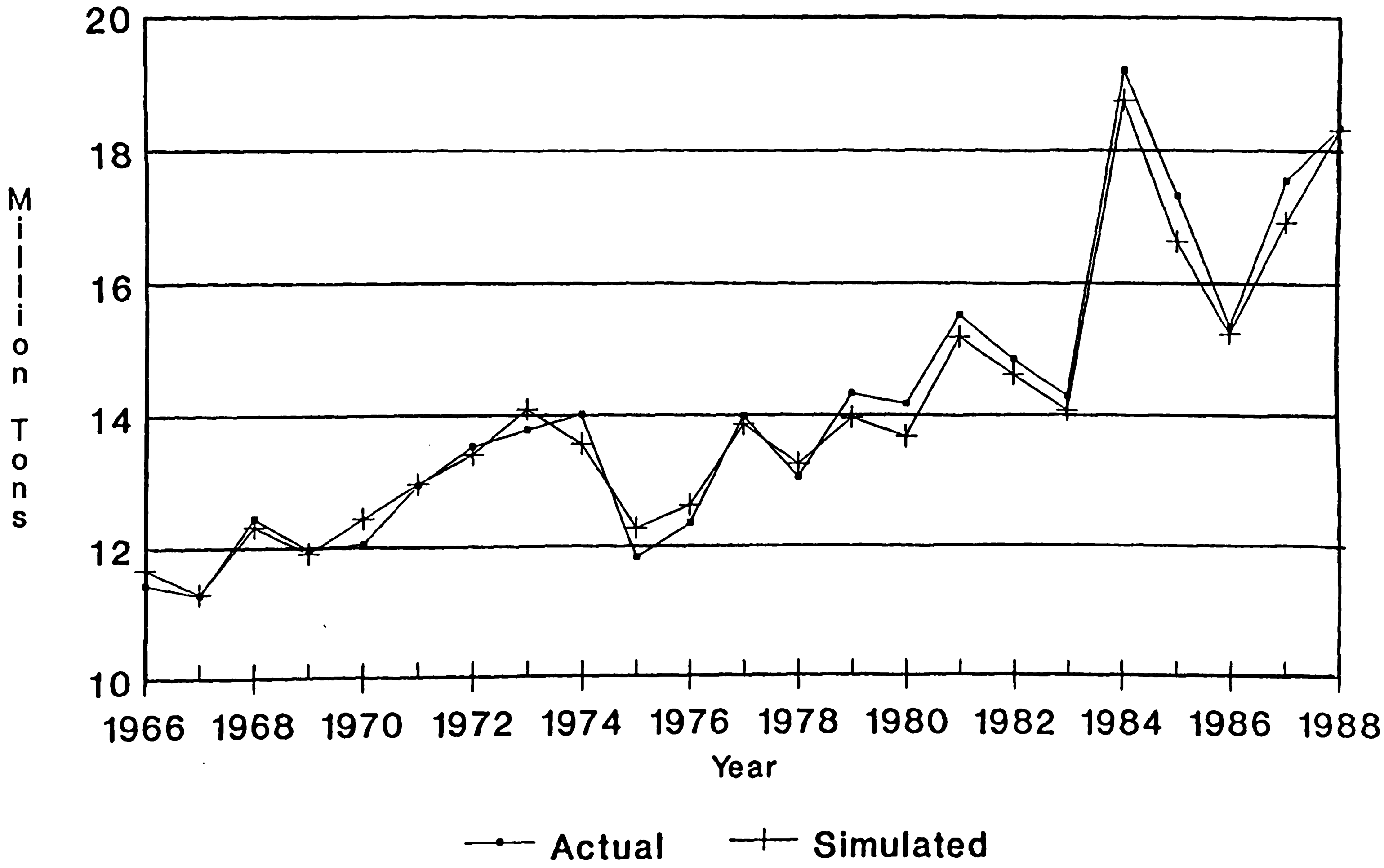


Figure 7.3 World Cotton Consumption

Actual Vs Simulated Values

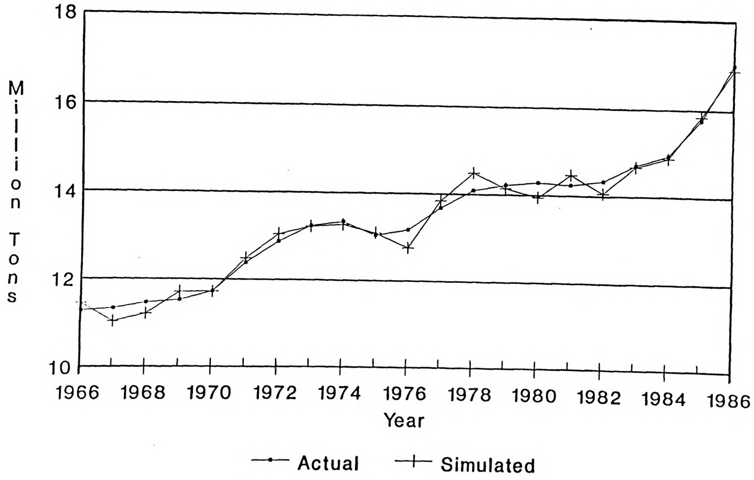
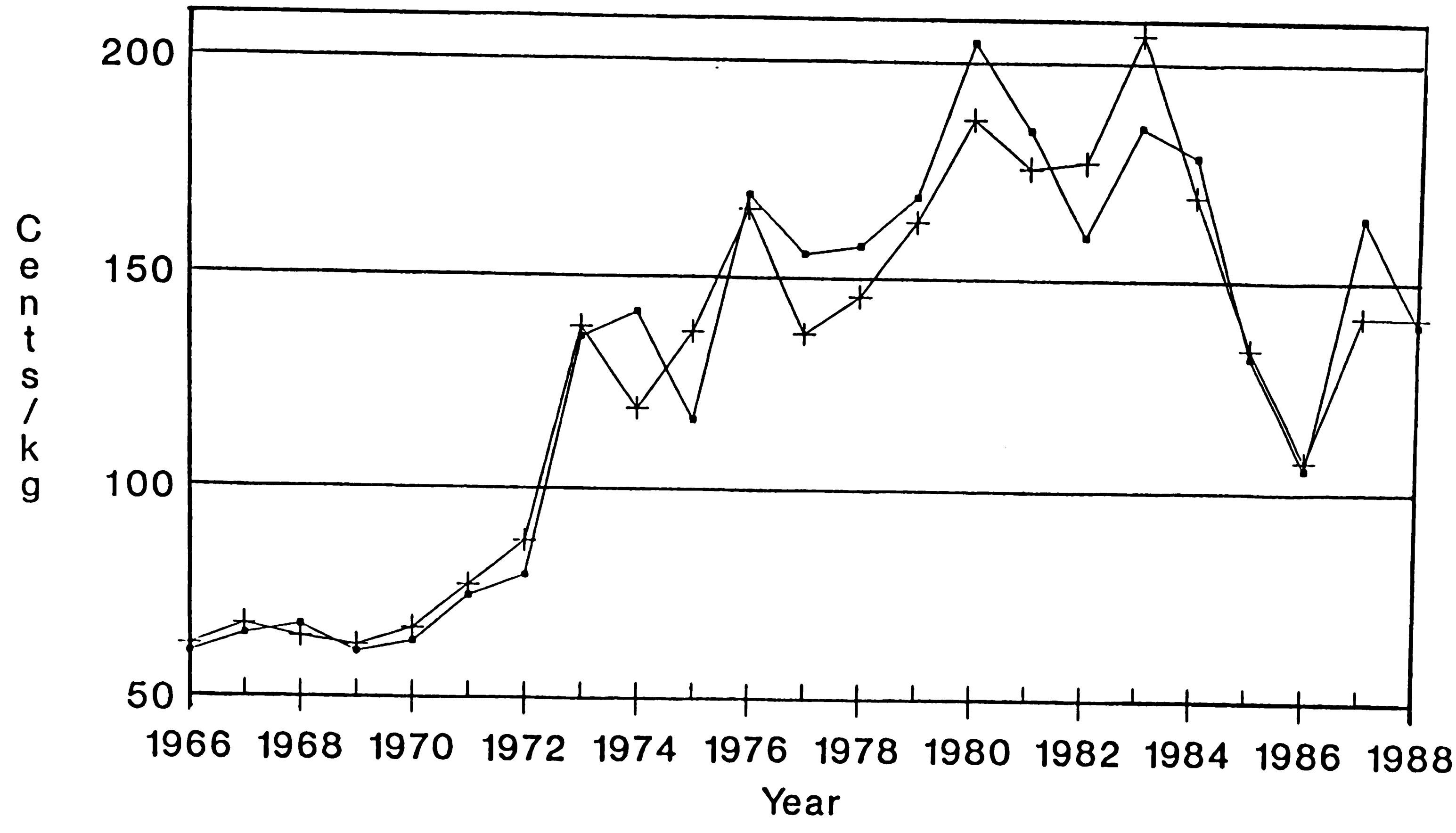


Figure 7.4 World Cotton Price 1/
Actual Vs Simulated Values



1/ Outlook "A" Index

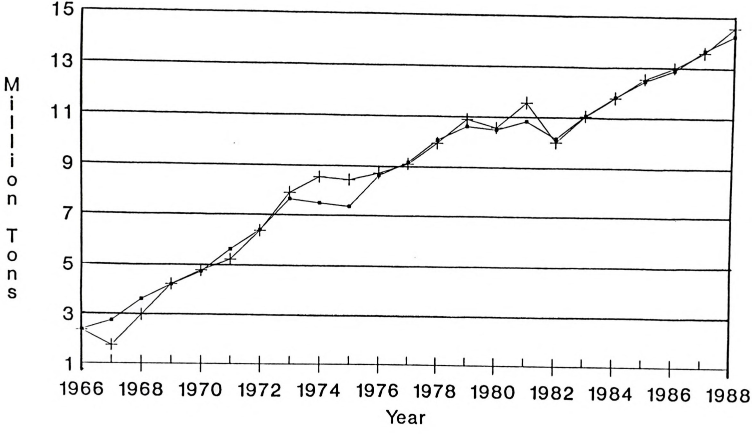
The underprediction of price during the late 1970s explains the underestimation of production during the same period. This underestimation should not persist if the demand side of the model is responsive to price levels.

The production and consumption of non-cellulosic fibers at the world level trend up throughout the simulation period as shown in Figures 7.5 and 7.6. This is captured well by the model except for the 1974/75 and 1981/82 periods. The polyester price shown in Figure 7.7 is tracked well by the model, with the simulated series catching the decline in the late 1960s, the increase in the 1970s, and the slight decline in the early 1980s.

7.5 Summary

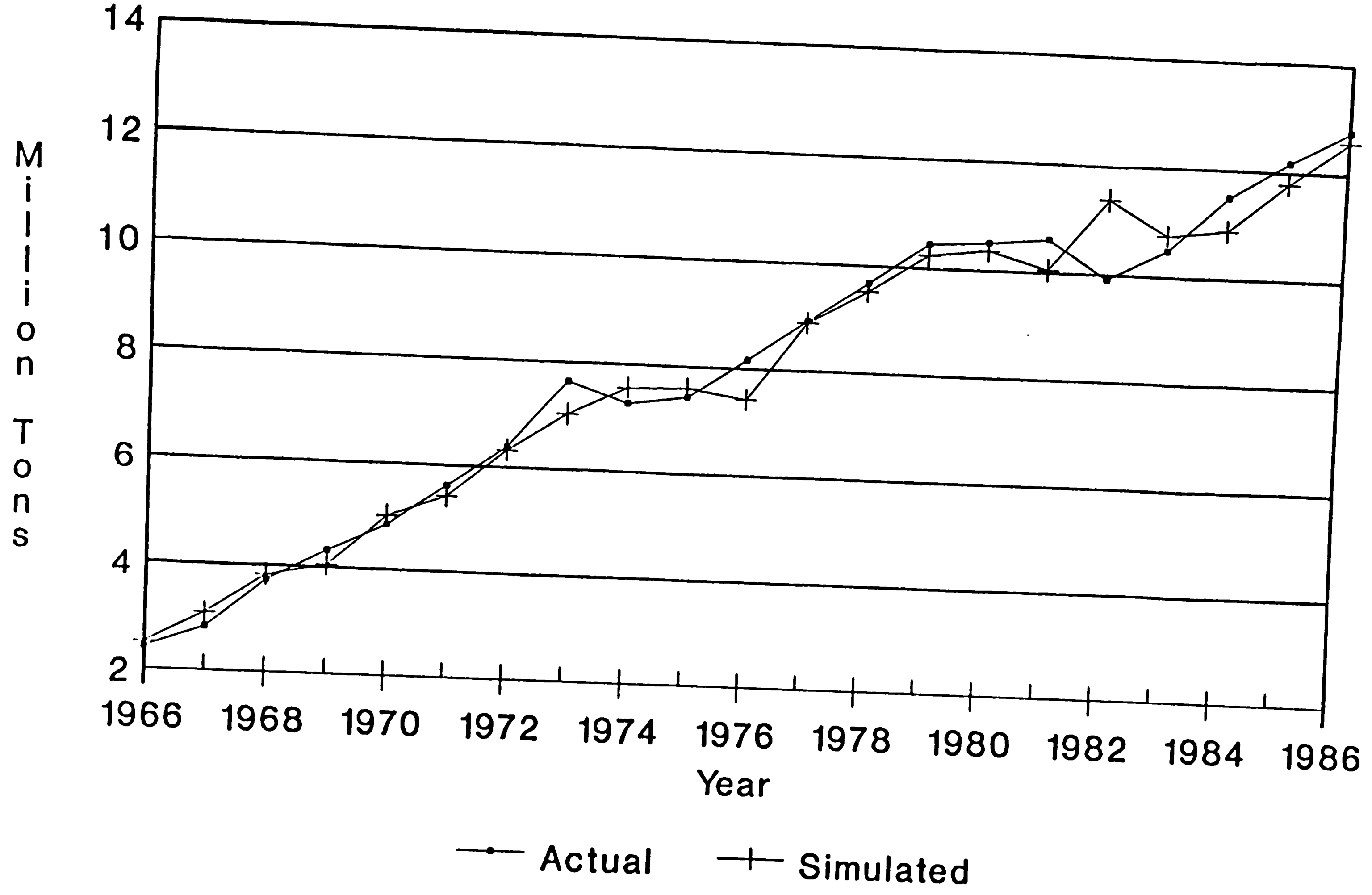
The simulation results for cotton stocks and net exports in China and non-cellulosic fibers use in Pakistan were poor for all validation tests undertaken, which suggested that future modeling efforts should focus on these variables. However, in general, the model performed well and was able to predict actual market values reasonably accurately.

Figure 7.5 Non-Cellulosic Production 1/
Actual Vs Simulated Values



1/ World Total

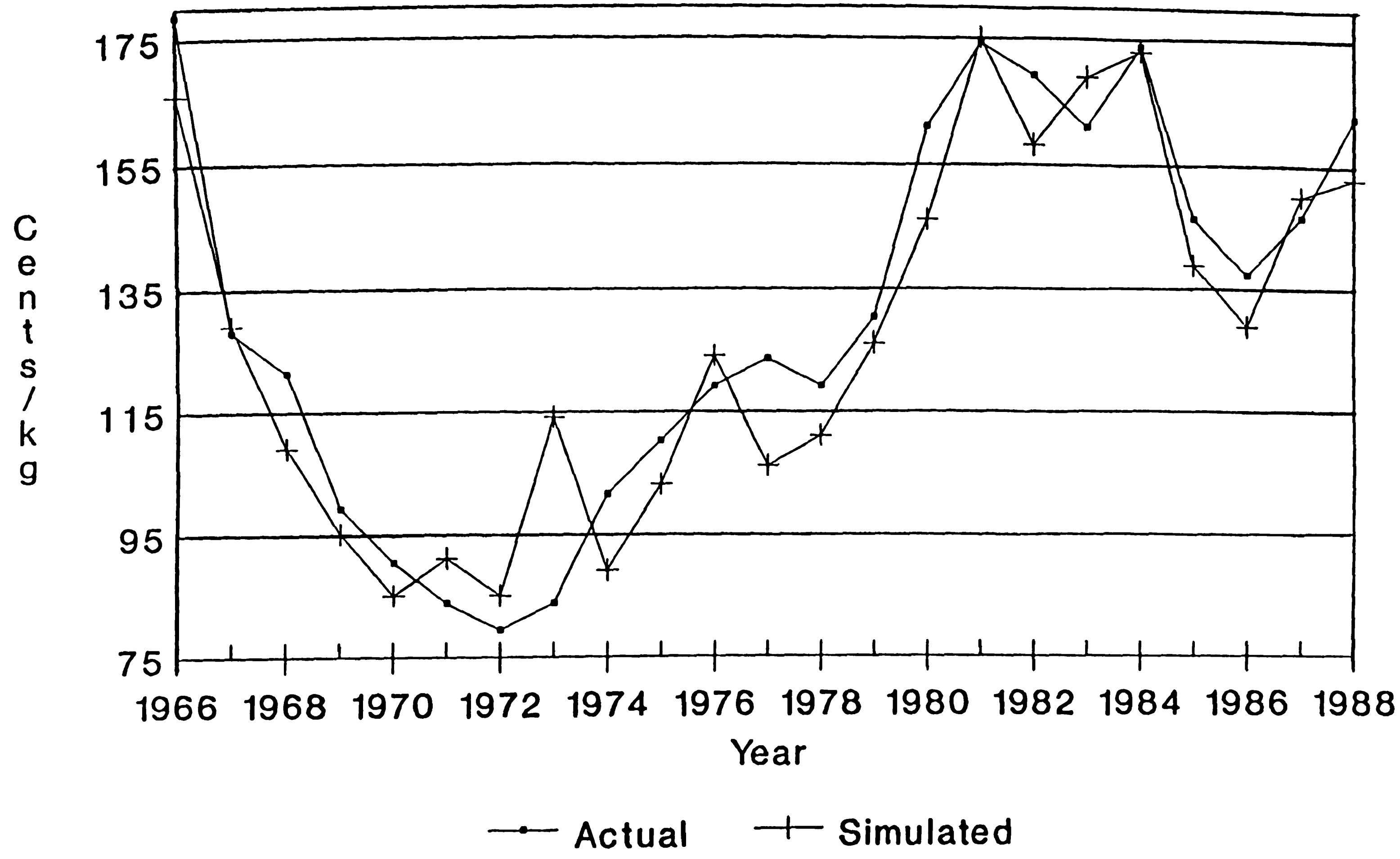
Figure 7.6 Non-Cellulosic Consumption 1/
Actual Vs Simulated Values



1/ World Total

Figure 7.7 World Polyester Price

Actual Vs Simulated Values



8. Model Simulations

A number of model simulations were undertaken in order to meet the research objectives outlined in the introductory chapter. In all, five model simulations were performed. These were:

(i) forecast of price, production and consumption variables for the period 1989-2005, given a basic set of macro-economic assumptions,

(ii) a 10 percent decrease in cotton production in the Soviet Union,

(iii) a 10 percent increase in cotton production in China,

(iv) a 10 percent decrease in domestic cotton prices in the U.S., and

(v) an evaluation of the effects of the Multi-Fiber Agreement on the cotton and non-cellulosic fibers sectors.

8.1 Simulation One - Forecast for the Fiber Market to Year 2005

8.1.1 Rationale for Forecasting Prices

Accurate price forecasts are useful to many groups, such as governments, lending institutions, as well as producers and consumers of cotton. Informed guesses about future fiber prices are especially important to decision makers in those countries where earnings from cotton represent a very large percentage of export earnings. Fiber price forecasts are essential for planners and policy-makers who make decisions about fiscal and investment policy, as well as set the levels of cotton prices and other forms of cotton market interventions. Other groups interested in price forecasts are producers and consumers of cotton and synthetic fiber. Accurate forecasts of future fiber prices improve resource allocation decisions in all stages from production at farm and industry levels to textile and apparel purchases by final consumers.

In addition to price forecasts, production and consumption forecasts are also important to decision makers. While forecasts of total world levels of production and consumption determine expected futures prices, projections of production and consumption trends for different countries and regions are valuable to producers and consumers of fiber products. For example, the identification and development of potential export markets for many countries depend on accurate forecasts of where demand will be strong in the future. This is especially important for developing countries, many of which have recently emerged as major participants in world fibers markets.

8.1.2 Forecasts of Exogenous Variables

The model was simulated through to 2005 in order to provide forecasts of price, production and consumption in the cotton and non-cellulosic fibers sectors. This required that values for all the exogenous variables be evaluated for each year to the end of the simulation period. Annual percent growth rates in income and population for each region were used to project the levels of these variables for each year between 1990 and 2005. Exchange rates and CPIs were given their 1989 values, thus assuming that purchasing power parity was maintained over the long-run. Weather variables which appeared in the yield equations were set at their mean values and production and consumption in the Rest-of-the-World region were forecasted based on a regression against time. More details of the assumptions made for the exogenous variables in the forecast period are given in

Appendix B.

8.1.3 Forecast Results

8.1.3.1 Cotton Price Forecasts

The nominal and deflated price forecasts are presented in Table 8.1 and Figures 8.1 and 8.2. The nominal cotton price is forecast to be 189.8 c/kg in 1990 and to increase at an average of 1.8% annually over the next five years to reach 207.2 c/kg by 1995. Between 1995 and 2000 price is projected to grow at an average of 2.9% p.a., reaching 239.4 c/kg by the end of the century. The annual rate of increase in price is forecast to remain at 2.9% between 2000 and 2005, and for the nominal price to be 276.4 c/kg by the year 2005. Nominal prices were deflated by the MUV and U.S GDP deflator (1985=100) and are reported in Table 8.1. Based on the MUV deflator, the real price is predicted to decline throughout the forecast period, falling at an average annual rate of 1.76%, 2.25% and 2.84% for the periods 1990-1995, 1995-2000 and 2000-2005, respectively. The differing rates of change in prices can be associated with cyclical movements in cotton prices that were captured by the model.

The projection of a decline of 12%-13% in real cotton prices between 1990 and 2005 is a troublesome result for cotton producers. This suggests that improvements in yields, through, for example, the development of better seed varieties, the use of lower cost fertilizers, more effective pest and disease controls and improved management, are crucial for cotton to be a profitable enterprise. Alternatively, domestic producer price incentives will have to be maintained and even extended at high budget cost. This would involve a move away from the current trend, especially in industrialized countries, of reducing levels of government agricultural supports. The forecast of declining real cotton prices is significant for the main user of cotton, that is, the textile manufacturing sector which accounts for approximately 50 percent of consumption. A lower price of its major input should encourage the sector to further invest in textile manufacturing.

Table 8.1 Nominal and Deflated Cotton Price Projections, 1990-2005.

Year	Nominal (c/kg)	Nominal (c/lb)	MUV Deflated[1] (1985=100)	US GDP Deflated[2] (1985=100)
1990	189.8	93.7	133.0	159.5
1991	192.5	95.1	131.6	154.9
1992	195.4	96.5	128.3	151.2
1993	202.0	100.1	126.3	151.9
1994	204.4	101.0	121.7	148.1
1995	207.2	102.3	119.1	145.3
1996	211.4	104.4	117.6	143.7
1997	216.5	106.9	116.9	142.8
1998	223.5	110.4	117.3	142.5
1999	232.0	114.6	118.0	143.0
2000	239.4	118.2	117.7	142.9
2001	246.1	121.6	117.2	141.9
2002	252.8	124.9	116.6	141.0
2003	259.9	128.4	116.0	140.4
2004	267.2	132.0	116.2	139.9
2005	276.4	136.5	116.1	140.4

[1] Unit value index in US dollar terms of manufactures exported from the G-5 countries (i.e., France, Germany, Japan, United Kingdom and United States) weighted proportionally to the countries' exports to the developing countries. Source: IECAP, World Bank.

[2] Source: International Monetary Fund.

Figure 8.1. Nominal Cotton Price Projections, 1990-2005. Outlook Index "A".

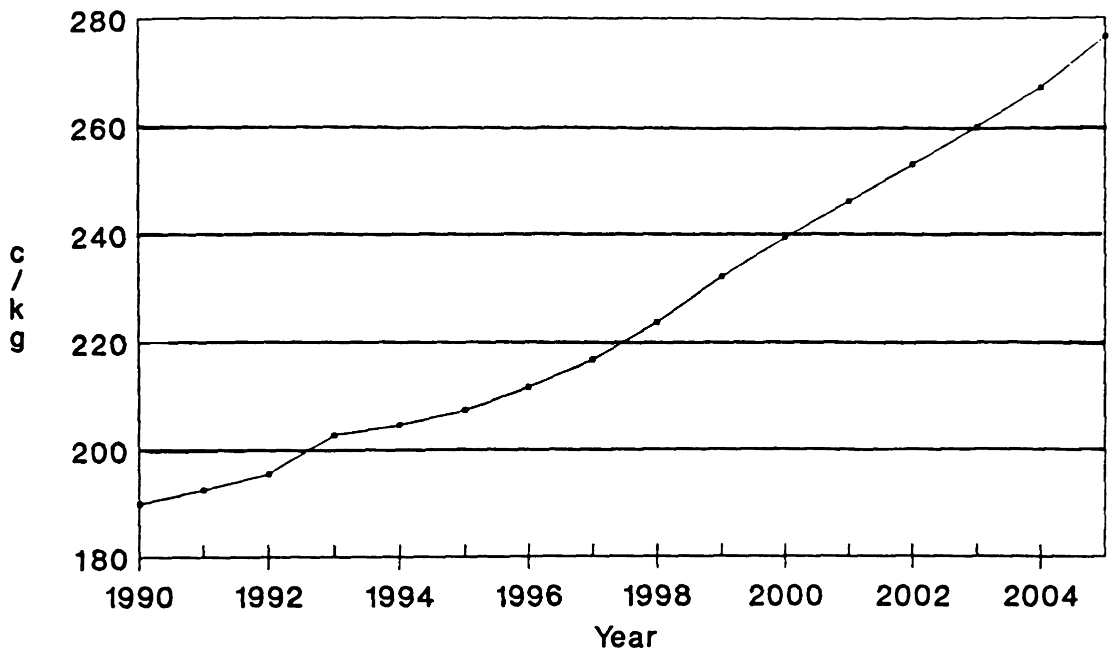
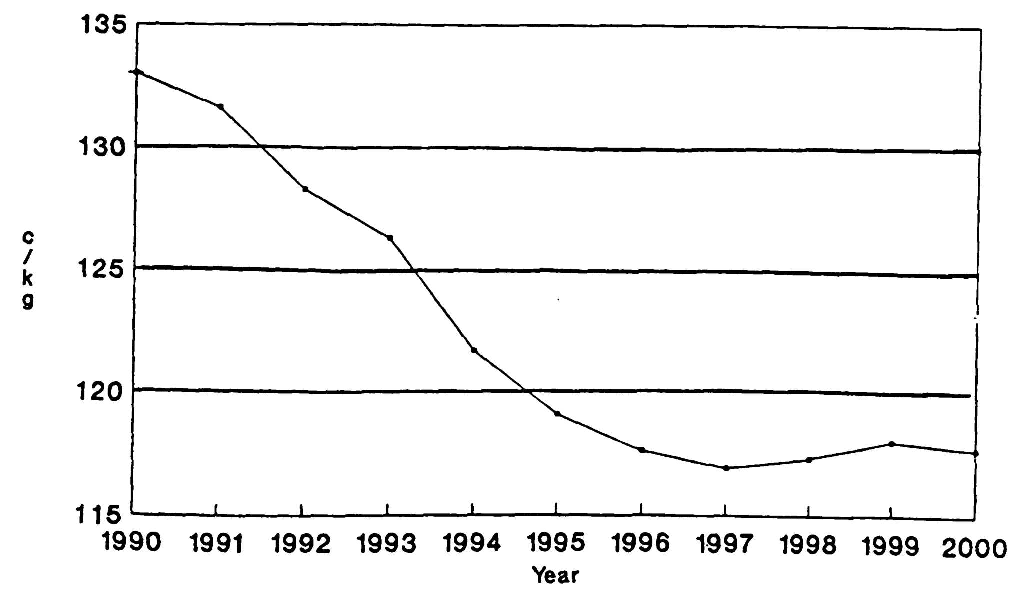


Figure 8.2. Deflated (MUV) Cotton Price Projections, 1990-2005. Outlook Index "A".



8.1.3.2 Cotton Production Forecasts

The model production forecasts are presented in Table 8.2. In 1990 production is projected to reach 18.3 million tons and to increase at an annual growth rate of 1.1% per year, reaching 21.8 million by 2005. The largest contributor to world production is China whose production is projected to grow on average at 1.5% per year, increasing from 4.4 million tons in 1990 to 5.5 million tons in 2005. The increase is mainly associated with yield increases, since the potential for area expansion is limited given that China's total

Table 8.2 Model Cotton Production Forecasts for the Years 1990, 1995, 2000 and 2005.

Region	1990	1995	2000	2005	Growth Rate[1]
	('000 tons)				(%)
Argentina	168	245	304	391	5.8
Australia	232	259	277	290	1.5
Brazil	711	761	793	838	1.1
Central Africa	754	799	822	833	0.7
China	4,449	4,799	5,176	5,529	1.5
Egypt	341	335	328	322	-0.4
India	1,901	2,167	2,347	2,674	2.3
Mexico	144	148	151	154	0.4
Pakistan	1,367	1,427	1,689	1,830	2.0
Turkey	578	607	645	661	1.1
United States	2,995	3,331	3,702	4,090	2.1
Rest-of-the-World[2]	4,702	4,639	4,392	4,214	-0.7
WORLD	18,342	19,517	20,626	21,826	1.1

[1] Average percentage growth rates per annum 1990-2005.

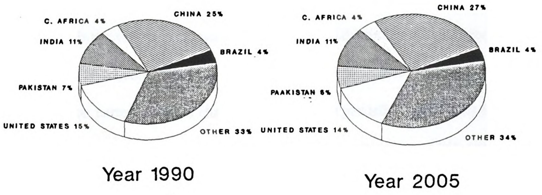
[2] Exogenous in the model.

cultivated area is being used at a maximum and that the costs of bringing new land into production are very high. Since the introduction of market incentives in China in the late 1970s, production has been determined largely by Government administered prices of cotton. In the model, China's cotton area and yields were explained by the administered price, which was exogenous. However, over the forecast period the Chinese price was linked to the world price with an assumed transmission elasticity of 0.25 (equation 5.19). As it was not possible to predict accurately the future direction of China's cotton price movements, the forecasts must be treated with caution. However, in order to provide a sensitivity analysis of the cotton price assumption on the model forecasts, a simulation was performed with Chinese production set 10% above its historical level. The results of this simulation are presented in section 8.3.

Production in the United States is projected to increase at an average of 2.1% per year, from 3.0 million tons in 1990 to 4.1 million tons in 2005. This expansion results in large part from greater cotton area in the West and Southwest regions. On average, production is expected to grow at 2.3% per year, in India. This growth is associated mainly with improved yields as irrigated acreage continues to increase in the North and West regions of India. Pakistan's output is forecast to increase from 1.4 million tons in 1990 to 1.8 million tons in 2005. This expansion is the result of improved yields in both the Punjab and Sind regions.

World cotton production trends are illustrated in Figure 8.3 which compares the shares of world production produced by the major suppliers for the years 1990 and 2005. The most striking feature is that shares do not change significantly over the time period. For example, in 1990 the three largest producers - China, the United States and India - will account for 530 of world production. In year 2005 these three countries are expected to supply 56%, with a small increase in the United States' share and shares in Brazil, Central Africa, China, India and Pakistan all expected to be maintained throughout the next 15 years. To some extend the stability of market shares over the period 1990 through 2005 results from the fact that the exogenous variables used for forecasting are based on constant growth rates through time. Due to uncertainty over future production levels in China and the USSR where cotton growing decisions are made administratively, simulations of the model were performed to determine the effect on the world market of a 10% change in the production in these regions. The results from these simulations are reported later in this section.

Figure 8.3. World Cotton Production Trends. Years 1990 and 2005 Compared.



8.1.3.3 Cotton Consumption Forecasts

A comparison of the model's consumption forecasts are reported in Table 8.3. World consumption is forecast by the model to rise from 18.0 million tons in 1990 to 21.6 million tons in 2005. This is an average annual growth rate of 1.2%.

The largest growth rates are forecast for some developing countries. For example, consumption in Argentina, Central Africa, Egypt, Mexico and Pakistan are expected to increase at growth rates of 2.8% 5.2%, 2.1%, 3.2% and 3.0%, per year, respectively. These growth rates can be explained by the high population growth rates assumed in these regions. With low base consumption levels in these regions large percentage growth rates are be recorded for a relatively small expansion in consumption in absolute terms (e.g., Argentina and Mexico).

World cotton consumption trends are shown in Figure 8.4 which compares the proportions of total world consumption by the major purchasers of cotton for the years 1990 and 2005. Overall the pattern of consumption does not change dramatically over the period, with the top three consumers (China, the EEC and the United States) decreasing their share of consumption from 51% in 1990 to 49% in 2005. Again, the fact that world consumption patterns do not change significantly is partially explained by the fact that the growth rates of the exogenous variables used in the projection period are held constant.

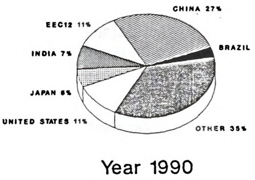
Table 8.3 Model Cotton Consumption Forecasts for the Years 1990, 1995, 2000 and 2005.

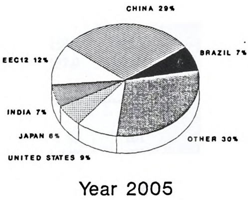
Region	1990	1995	2000	2005	Growth Rate[1]
	('000 tons)				(%)
Argentina	114	129	148	173	2.8
Australia	101	106	110	114	0.8
Brazil	543	588	640	679	1.5
Central Africa	184	187	249	393	5.2
China	4,597	4,803	5,001	5,121	0.7
EEC-12	2,405	2,553	2,697	2,876	1.2
Egypt	196	218	242	269	2.1
India	1,383	1,523	1,673	1,781	1.7
Japan	983	1,074	1,168	1,263	1.7
Korea, Rep. of	176	189	207	231	1.8
Mexico	129	140	167	207	3.2
Pakistan	240	292	338	377	3.0
Turkey	222	233	260	291	1.8
United States	2,314	2,420	2,569	2,686	1.0
Rest-of-the-World[2]	4,456	4,696	4,936	5,173	1.0
WORLD	18,043	19,151	20,328	21,634	1.2

[1] Average percentage growth rates per annum 1990-2005.

[2] Exogenous in the model.

Figure 8.4. World Cotton Consumption Trends. Years 1990 and 2005 Compared.





8.1.3.4 Non-Cellulosic Fibers Sector Forecasts

The model forecasts for consumption, production and price for non-cellulosic fibers are presented in Table 8.4. The nominal polyester staple price is expected to increase from 167.8 c/kg in 1990 to 357.0 c/kg in 2005. This is an annual average growth rate of 5.2%. In real terms, prices are expected to increase on average 1.6% per year over the same period (Figure 8.5 and 8.6).

While a 12%-13% decline has been predicted for cotton price, the model forecasts a 10% increase in the price of polyester. This result should provide non-cellulosic fibers manufacturers an incentive to increase productive capacity through new investments. However, the forecast is closely associated with the forecast of future oil prices which is not easy to make accurately (Appendix B).

Table 8.4 Model Non-cellulosic Fibers Forecasts of Price, Consumption and Production.

Variable	Region	1990	1995	2000	2005	Gr.Rate[1]
Polyester Price		(c/kg)				(%)
Nominal	World	167.8	196.3	258.3	357.0	5.2
Deflated[2]	World	117.6	112.8	127.0	149.9	1.6
Consumption		('000 tons)				
	Argentina	70	83	93	101	2.5
	Australia	154	180	188	187	1.1
	Brazil	204	274	293	280	2.1
	C.Africa	33	32	36	46	2.2
	China	645	695	749	807	1.5
	EEC-12	2,084	2,142	2,112	2,048	-0.1
	Egypt	56	92	135	187	8.4
	India	308	452	632	853	7.0
	Japan	923	1,028	1,044	1,026	0.7
	Korea	269	286	284	282	0.3
	Mexico	243	285	309	318	1.8
	Pakistan	46	57	69	82	3.9
	Turkey	188	232	290	357	4.4
	U.S	4,651	5,646	6,743	7,946	3.7
	World	13,770	15,706	17,219	18,615	2.0
Production						
	World	14,870	16,806	18,319	19,715	2.0

[1] Average annual growth rates 1990-2005.

[2] Deflated by MUV (1985=100).

Figure 8.5 Nominal Polyester Price Projections, 1990-2005.

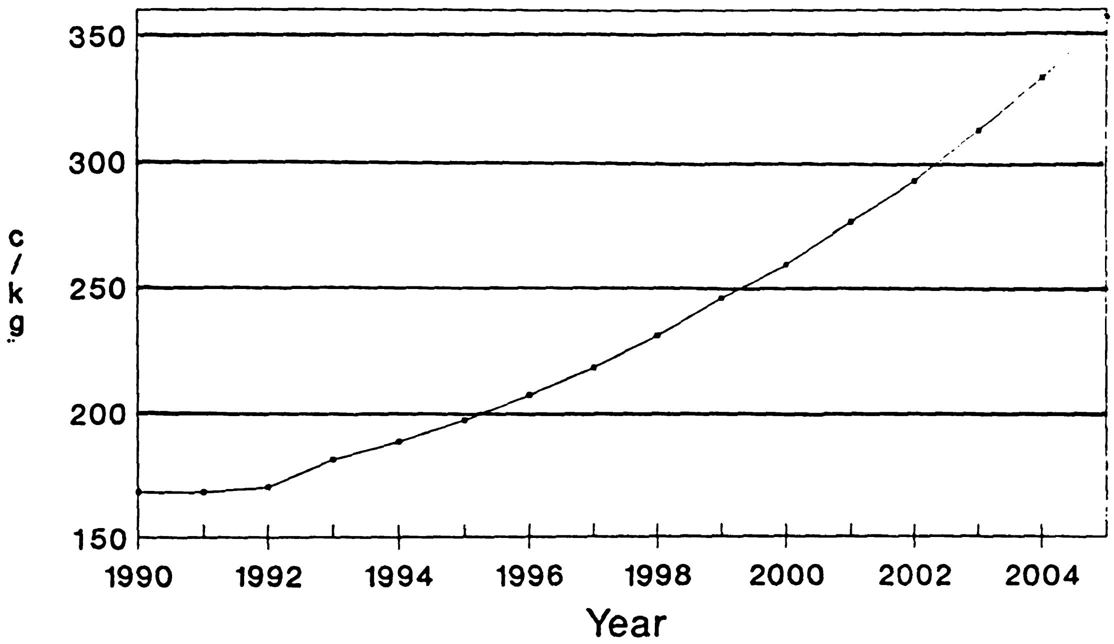
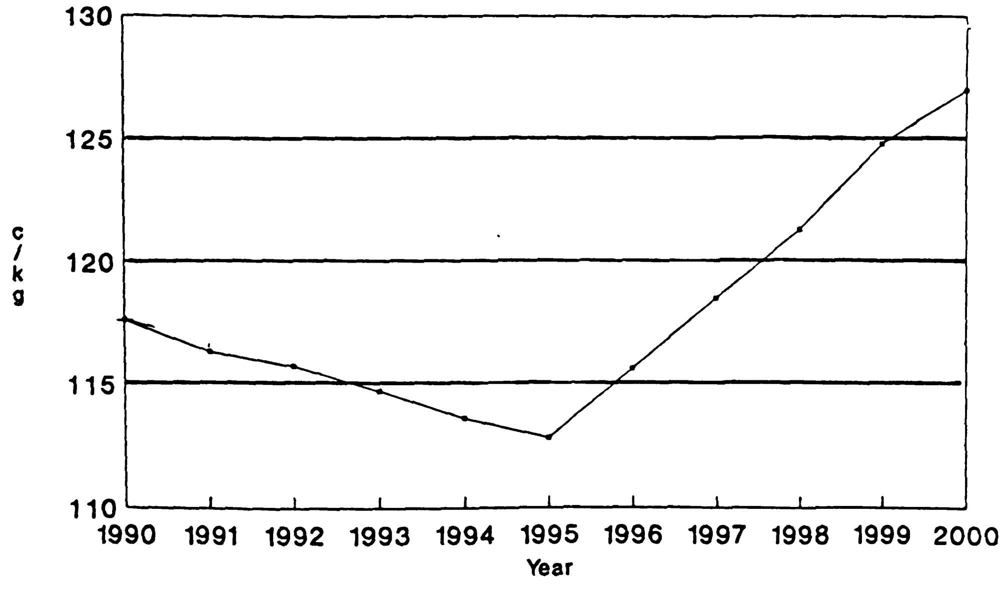


Figure 8.6. Deflated Polyester Price Projections, 1990-2005.



Also, higher polyester prices will result in lower demand by the textile manufacturers who will demand less non-cellulosic fibers in response to the ratio of cotton to polyester prices. This ratio is depicted in Figure 8.7 which indicates a small increase in the price of cotton compared to polyester in 1991 and 1992. After 1992 the ratio falls at a fairly constant rate through to year 2005, declining more than 25 percent over the period.

Non-cellulosic fibers production is expected to increase at 2% per year, increasing from 14.9 million tons in 1990 to 18.6 million tons in 2005. This expansion is driven by the increasing price of polyester (Figures 8.5 and 8.6) relative to the price of oil which is the largest input in non-cellulosic fibers production. Non-cellulosic fibers consumption is also expected to increase at 2% annually between 1990 and 2005. The United States is the largest contributor to this expansion with an annual average growth rate of 3.7% over the forecast period. Large rates of growth are also expected in India, Egypt and Turkey, but these are all increases from small base levels. The important trends in non-cellulosic fibers consumption between 1990 and 2005 are shown in Figure 8.8. As well as increasing production substantially over the period, the United States is expected to increase its share of world consumption--from 34% in 1990 to 43% in 2005. India is also expected to increase its share, reaching 5% of world consumption by 2005. All the other regions show small declines in market share (e.g., EEC from 15% to 11%; China from 5% to 4% and, Japan from 7% to 6%). Overall these trends suggest that over the next 15 years the United States will strengthen its position in the non-cellulosic fibers market at the expense of the rest-of-the-world.

Figure 8.7. Ratio of Cotton and Polyester Prices.

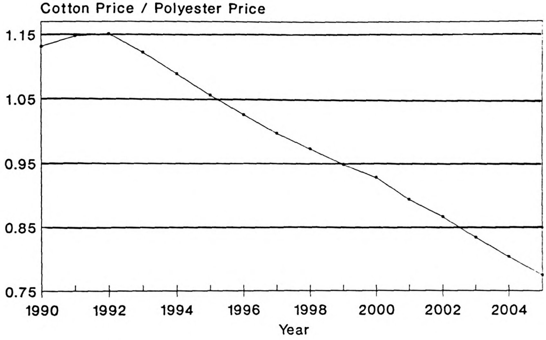
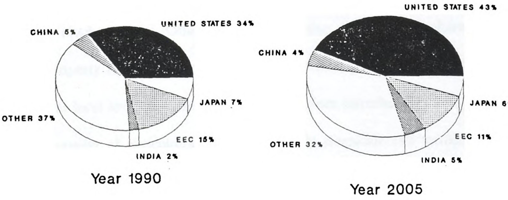


Figure 8.8. World Non-Cellulosic Fibers Consumption Trends. Years 1990 and 2005 Compared.



1/ Non-Cellulosic Fibers
%- Percent of Total World Consumption
Also Given Quantities Consumed (M.Tons)

8.2 Simulation Two - A 10 Percent Decline in Cotton Production in the USSR

8.2.1 Background

The performance of the USSR cotton sector has been stagnant during the 1980s with production ranging from 8 million and 9 million metric tons annually. A primary cause has been poor management practices involving the over-irrigation of cotton land, resulting in salinization and leaching of nutrients from the soil. Another problem has been the failure of producers to establish effective crop rotations with cotton. It had been demonstrated that a cotton-alfalfa rotation increases yield, improves efficiency, reduces fertilizer and irrigation costs, and combats wilting. In addition to management practices, cotton production growth has been impeded by poor quality inputs, inadequate infrastructure and lack of price incentives.

To combat these problems the Government is taking steps to improve cotton production performance. The main thrust of its program is to improve rotations and to move away from the monoculture of cotton by restricting cotton area. However, this policy has not met with much success.[1] Other initiatives affecting all USSR agriculture include price reforms; property right expansion (e.g., Lease Terms); greater accountability and decision-making at local level (e.g., Self-Financing provisions introduced in 1988); efforts to improve the quality of agricultural inputs, especially chemicals and fertilizers; and, improving the linkages between agricultural research and science and the farming community. These will impact on the cotton sector substantially if they are implemented

---

[1] 'Despite plans to restrict cotton area and to improve crop rotation cycles, Urbek cotton area increased 118,000 hectares from 1985 to 1987 and the cotton-alfalfa rotation areas fell from 55% of the arable land to 42%.' USSR Agriculture and Trade Report, May 1989, ERS, USDA (p.37).

effectively.

Despite these measures it is unlikely that USSR cotton production will increase in the 1990s. More likely is a decline, as cotton land is taken out of production in order to establish cotton-alfalfa rotations and to replenish the soils previously damaged through extensive over-irrigation.

8.2.2 Simulation Objectives

The USSR is the world's third largest cotton producer, contributing about 15% to world production in 1988. USSR cotton production is not determined by world market prices. Instead, output is controlled administratively by Government planning agencies which set area limits and determine seed and fertilizer use. Since data were not available to model the decision making of these Government agencies, USSR production was exogenous in the model. However, in order to assess how USSR production affects the world market, the model was simulated over an 11-year period with production set 10% below its historical level. The percentage changes from the base simulations for some of the endogenous variables are reported in Tables 8.5 and 8.6.

8.2.3 Simulation Results

The initial effect of decreased production in the USSR was to decrease world production by 2.07%. Lower production led to the cotton price rising by 5.07% above the base level and to consumption decreasing by 0.19%. The net effect of lower production and consumption was for world stocks to decrease 5.76% below the base simulation. In most production regions output was unchanged initially. This was because lagged prices were used as regressors in most of the supply equations. Decreases in cotton consumption led to an increase in consumption of non-cellulosic fibers and caused the price of polyester to rise 2.09% above the base level. This rise partially offset the impact of high cotton prices on demand and accounted for the small changes in consumption in the initial period.

On average a 10% decrease in USSR production caused the world cotton price to rise by 9.16%. Production in the price responsive-regions increased (e.g., United States up 2.77%, Mexico up 5.36%, Pakistan up 1.42%) and this partially offset the effect of lower USSR production. The net effect was for world production to decrease an average of only 0.94% below the base simulation level. The rise in price caused consumption to decrease on average 0.48%, and for stocks to fall 10.13% below the base level. The average effect on the non-cellulosic fibers market was for non-cellulosic fibers consumption to rise by 0.35%. This increased the price by 3.72% and caused non-cellulosic fibers production to rise by 0.34%.

The long-run (or final) impact of the USSR production shock was to increase price by 12.60%. By the end of the 11-year simulation period the increase in production in the rest-of-the-world offset almost all of the USSR production decrease, with production only 0.69% below the base simulation. Consumption continued to decline, but at a slower rate, in response to the falling rate of price increases in the later periods. The net effect of production and consumption changes was to lower ending stock levels 16.15% below their base values. The final impact on the non-cellulosic fibers sector was to raise the price of polyester by 5.39% above the base level and for production and consumption to increase by 0.40% and 0.43%, respectively.

Table 8.5 Percentage Change in Cotton Variables for a 10% Decrease in Production in the USSR

Variable	Region	Impact	Average	Final
Production	Soviet Union	-10.00	-10.00	-10.00
Price	World	5.07	9.16	12.60
Production	Argentina	0.54	10.22	12.57
	Brazil	0.34	1.12	1.42
	Cent. Africa	0.43	1.00	1.53
	Mexico	0.00	5.36	11.13
	Pakistan	0.15	1.42	1.53
	Turkey	0.00	0.56	0.76
	USA	0.00	2.77	3.76
	World	-2.07	-0.94	-0.69
Consumption	Argentina	-0.06	-0.63	-1.10
	Australia	-0.13	-0.34	-0.51
	Brazil	-0.70	-1.80	-2.59
	Cent. Africa	-0.31	-0.32	-0.39
	China	-0.23	-0.57	-1.06
	EEC	-0.25	-0.74	-1.05
	Korea	-0.68	-2.04	-2.85
	Mexico	-0.31	-2.61	-4.41
	Turkey	-0.60	-3.75	-5.81
	USA	-0.74	-1.13	-1.67
	World	-0.19	-0.48	-0.80
Ending Stocks	World	-5.76	-10.13	-16.15

Table 8.6 Percentage Change in Non-Cellulosic Fibers Variables for a 10% Decrease in Cotton Production in the USSR.

Variable	Region	Impact	Average	Final
		----------------------(% changes)----------------------		
Price	World	2.09	3.72	5.39
Production	World	0.00	0.34	0.40
Consumption	Argentina	0.15	1.31	2.10
	Australia	0.28	2.21	3.77
	Brazil	2.35	6.30	9.54
	Cent. Africa	2.07	5.34	7.23
	China	2.81	8.63	13.40
	EEC	0.97	2.54	3.55
	Japan	0.35	2.37	3.69
	Korea	1.28	3.51	4.91
	Mexico	0.24	2.10	3.71
	Pakistan	0.00	0.00	0.00
	Turkey	0.20	0.49	0.83
	USA	0.88	1.23	1.55
	Rest-of-the-World	-2.67	-4.75	-7.30
World		0.00	0.35	0.43

8.2.4 Conclusions and Implications

With the current emphasis within the USSR on environmental protection and soil conservation by improving cropping rotations, USSR cotton production is expected to decline in the 1990s. This is in spite of new innovations (e.g., the introduction of the Self-Financing Program and changes in land leasing arrangements) which are hoped to improve agricultural performance. The effects of the 10% fall in USSR cotton production on the model forecasts are presented in Figures 8.9-8.15. Figure 8.9 shows that while real cotton prices are forecast to fall between 1990 and 2000, the effect of declining production in USSR is to slow substantially the rate of decline and to hold real prices relatively constant over the period 1995 through 2000. This result illustrated the responsiveness of world cotton prices to exogenous production shocks. Figure 8.10 shows how consumption forecasts are affected by the USSR production decline. Higher cotton prices reduce the level of forecast production by a fairly constant margin between 1990 and 2000, ranging between 35,000 tons and 160,000 tons below. The impact on the world cotton production forecasts are presented in Figure 8.11. While production forecasts fall initially as a result of the exogenous decline in the USSR production, higher forecast prices create a supply response from other regions. The effect is to close the gap between the two forecasts especially in the 1990 to 1995 period. The forecasts for cotton stocks are shown in Figure 8.12. Stocks are forecast to be lower between 1990 and 2000. Initially the major contributing factor is the decline in USSR production. However, the gap between the two forecasts tends to increase throughout the forecast period. This is because the decline in production exceeds the decline in consumption and the forecast of stock levels falls by over 1 million tons by 2000.

The impact of the USSR production shock on the non-cellulosic fibers forecasts is presented in Figures 8.13, 8.14 and 8.15. While only small changes are shown for non-cellulosic fibers production and consumption, polyester prices are significantly higher than in the base forecast.

The message from this simulation is that production in the USSR is a very important factor in price determination in the world market. For example, given a permanent 10% decrease in production, the world price rises by about 9.0%. This indicates that forecasts of price, both near- and long-term, must embody some prediction of USSR cotton policy and producer incentive structures and some analysis of how these might impact on its production performance.

Figure 8.9 The Impact of a 10% Decrease in Cotton Production in the USSR on World Cotton Price.

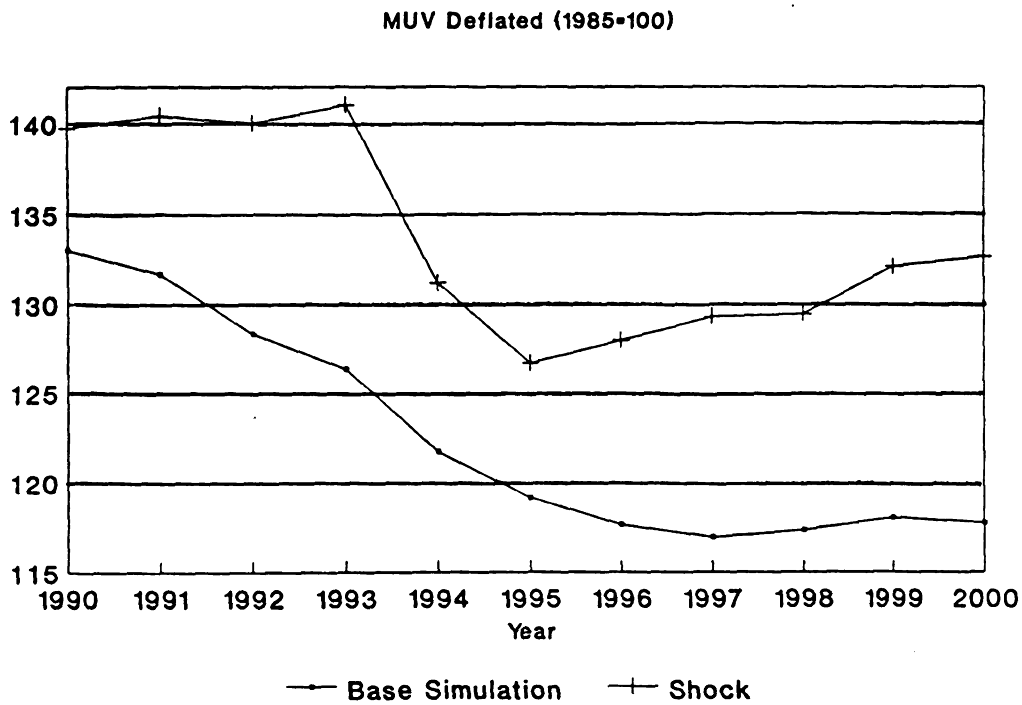


Figure 8.10 The Impact of a 10% Decrease in Cotton Production in the USSR on World Cotton Consumption.

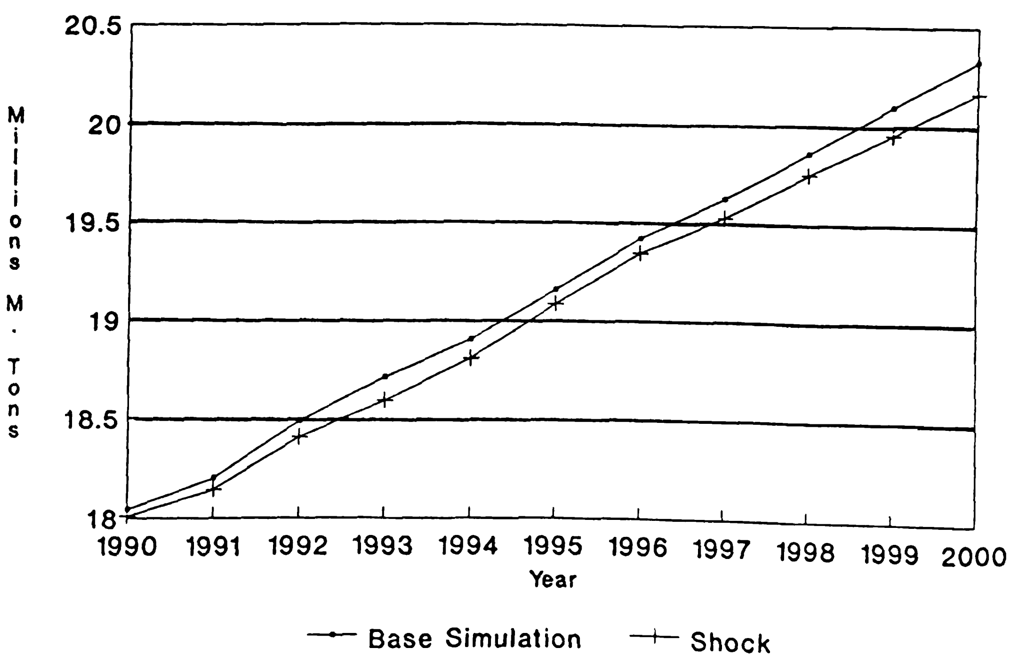


Figure 8.11 The Impact of a 10% Decrease in Cotton Production in the USSR on World Cotton Production

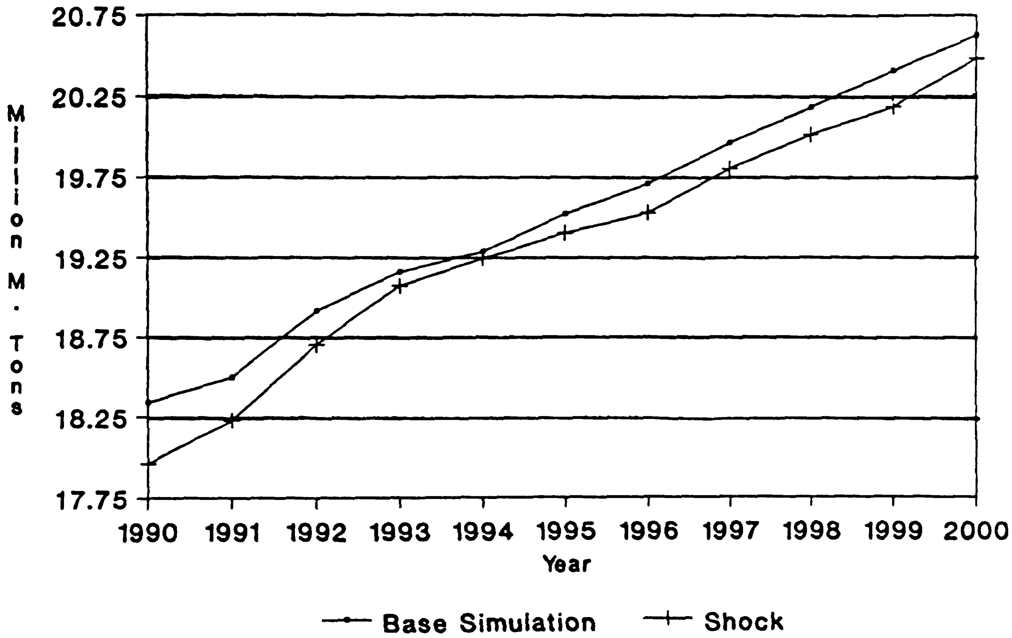


Figure 8.12 The Impact of a 10% Decrease in Cotton Production in the USSR on World Cotton Stocks.

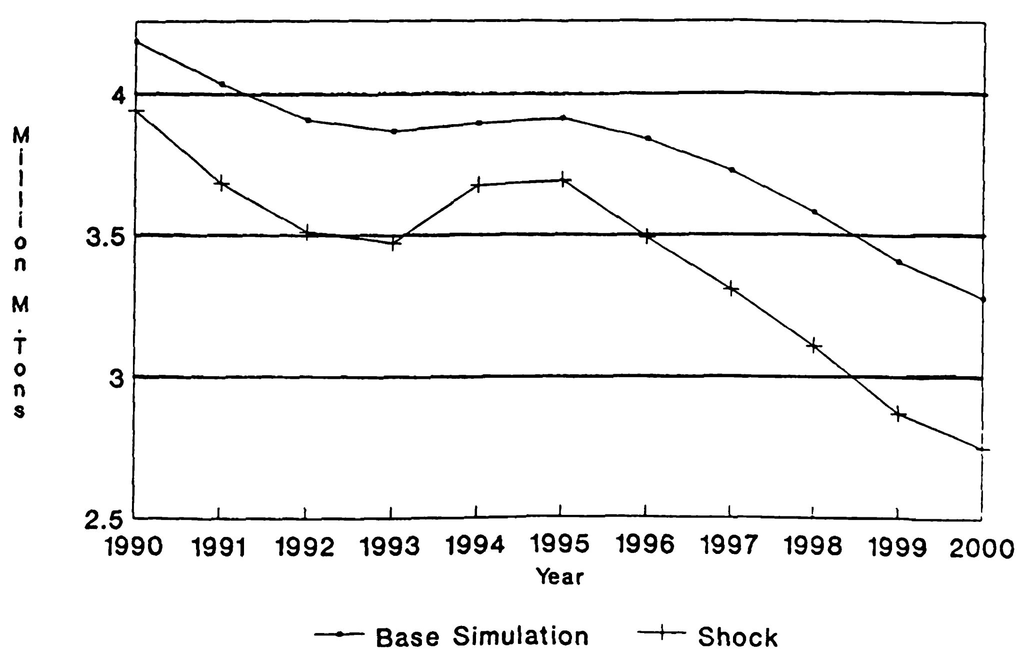


Figure 8.13 The Impact of a 10% Decrease in Cotton Production in the USSR on World Polyester Price.

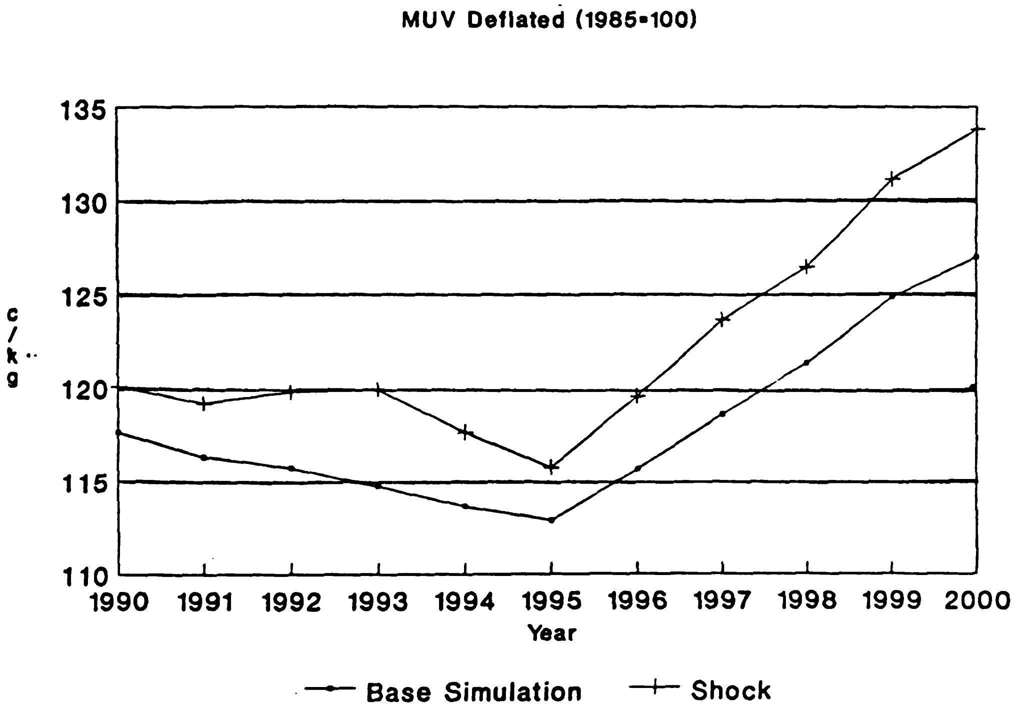


Figure 8.14 The Impact of a 10% Decrease in Cotton Production in the USSR on World Non-Cellulosic Fibers Consumption.

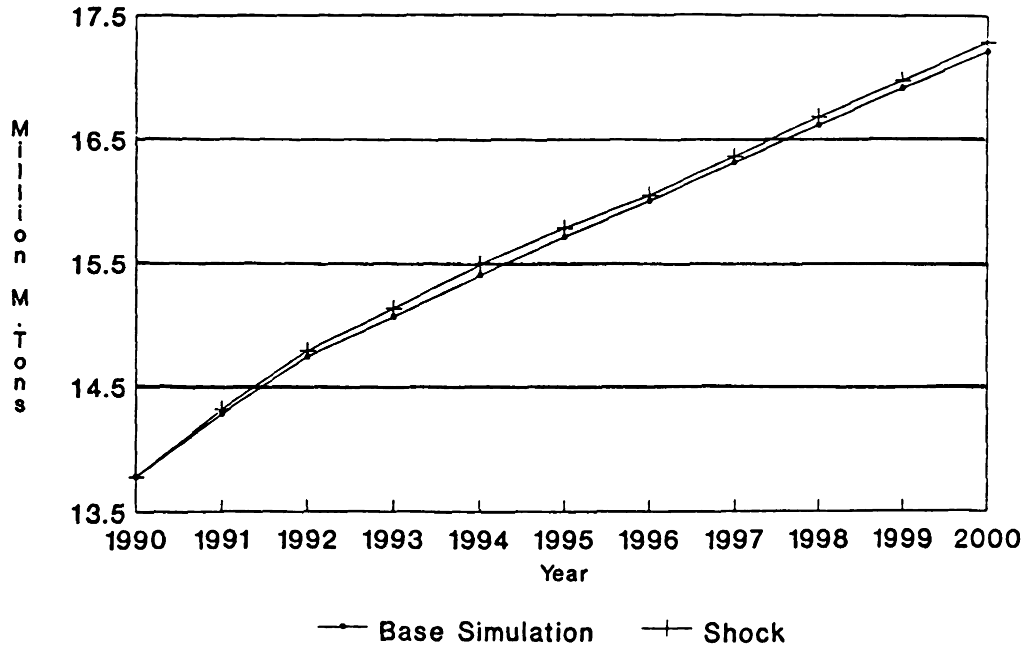
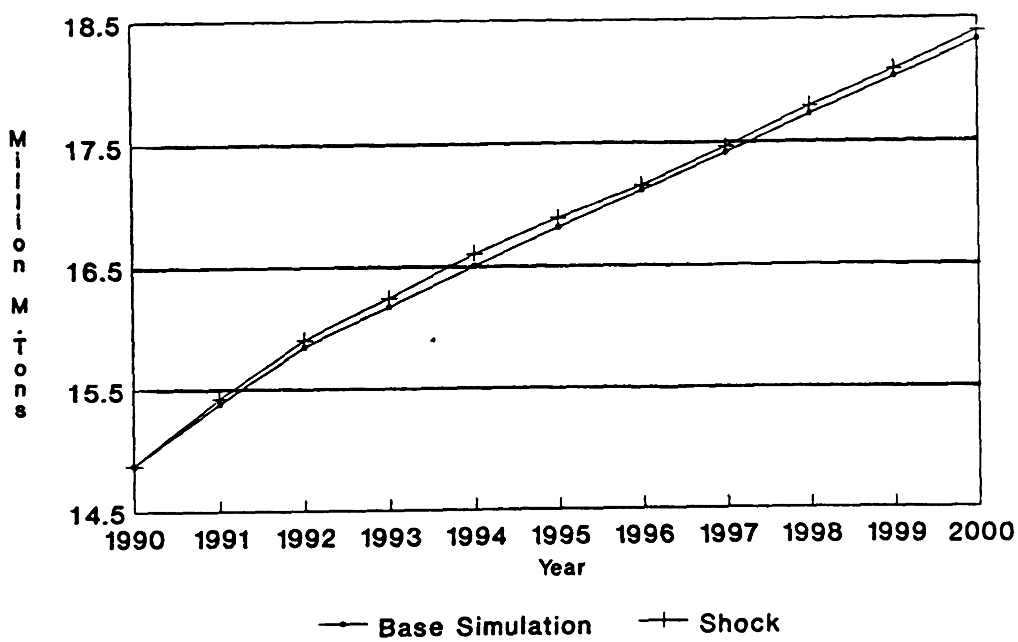


Figure 8.15 The Impact of a 10% Decrease in Cotton Production in the USSR on World Non-Cellulosic Fibers Production.



8.3 Simulation Three - A 10 Percent Increase in Cotton Production in China.

8.3.1 Background

The Chinese cotton and textile sectors have undergone significant changes since the 1950s. Prior to the mid-1960s, the State's agricultural development strategy emphasized the need to expand the use of improved industrially produced agricultural inputs, such as chemical fertilizers, equipment and machinery. State investment in agricultural production and inputs increased dramatically during the late 1950s and mid-1960s. Input prices, which were determined administratively by the State, were cut by 30-50% during this period. Also, an Agricultural Bank was established in 1963 to allocate credit in rural areas. Production was further stimulated by higher producer prices.

Between 1966 and 1976, the input orientation of agricultural development was further intensified as physical directives again became the dominant mode of agricultural planning. However, agricultural policy was dominated more by political slogans than economic considerations and technical criteria. During this time, the major emphasis was on self-sufficiency in grains and as a result, the production of cotton stagnated along with the production of most other crops.

Under new leadership, wide ranging policy changes began in 1978. Economic incentives were introduced and growers were given much greater freedom over planning and production choices. Between 1977 and 1983, average procurement prices for cotton increased progressively, rising 64.5% over the period. In response to the improved price incentives, production expanded rapidly, increasing from 2 million tons in 1977 to 6.25 million in 1984. Record stock levels resulted and led the State to reduce procurement prices for the following crop year, as well as to introduce a special consumer subsidy to increase low-grade cotton use in padded furnishings and clothing. Following two years of low producer prices and production in 1985 and 1986, stocks had reached a desirable level in 1987 and the State once again raised producer prices. Production in 1987 and 1988 remained fairly constant at about 4.2 million tons.

Meanwhile, the demand for cotton had been strong following the expansion of investment and production capacity in the textile manufacturing sector. In 1989, the lack of available cotton supplies created a black market for cotton where the price paid by textile mills was as much as twice the State's procurement price. Exports of cotton fell almost 40% between 1987 and 1988, while imports increased six-fold over the same period.

The State responded to the excess demand by increasing procurement prices 34% for the 1990 crop. Also the State is providing cotton growers with heavily subsidized fertilizer and diesel oil and improving the availability of other crucial inputs such as pesticides and plastic sheeting. A production target for 1990 had been set at about 4.3 million tons.

Given the importance of the textile sector for employment and as a generator of foreign exchange, the State is expected to continue to support the cotton sector further into the 1990s. Unofficial forecasts are for production to increase at 3% per year during the early part of the 1990s. As well there is possibility of State support for a policy of increasing cotton production at the expense of wheat which can be purchased relatively more cheaply in the world market.

8.3.2 Simulation Objectives

While production is expected to increase significantly in the future, it is hazardous to make guesses about the future direction of the Chinese cotton sector. Therefore, it is useful to measure of the effects on the world fiber market of a given change in China's cotton policy, to which, as the 1980s have shown, farmers are highly responsive. The objective of this simulation is to quantify the effects a production change in China has on the rest of the world fibers markets. A simulation of the model was performed with Chinese production set at 10% above its historical level. This simulation provides useful information on how China may affected the world market in the recent past and how developments in China might impact on the cotton and non-cellulosic fibers sectors in the future.

8.3.3 Simulation Results

The results of the simulation are reported in Tables 8.7 and 8.8. The initial effect of a 10% increase in Chinese production is to raise world production 1.82% above the base level. This increase in cotton production causes the price of cotton to fall by 1.02% which increases demand for cotton by 0.04%. The increase in cotton demand causes the demand for non-cellulosic fibers to decline and for the polyester price to fall 0.41% below the base levels. This polyester price increase partly offsets the impact of lower cotton prices on cotton demand.

On average, the 10% production increase in China raises world production by 1.84%. This is the net effect of higher Chinese production and lower production in the rest of the world in response to lower cotton prices. World consumption rises by 0.42% above the base run. The changes in world production and consumption cause stocks to rise 17.94% above the base level and world price to decrease by 10.10%. In the non-cellulosic fibers sector, consumption decreases 0.30% below the base simulation, causing the price of polyester to fall by 3.63%. Lower polyester prices reduces production by 0.29% and slows the rate of cotton consumption increases.

By the end of the 11-year simulation period, world cotton production is only 1.53% above the base level. This expansion is the net effect of the increase in China's production and the decrease in production in the price-responsive regions. Despite lower cotton prices, consumption is only 0.91% higher. The consumption increase is dampened by lower polyester prices in the non-cellulosic fibers sector. The fall in non-cellulosic fibers demand continues to the end of the simulation period, which reduces production and price by 0.49% and 8.25%, respectively.

Table 8.7 Percentage Change in Cotton Variables for a 10% Increase in China's Cotton Production

Variable	Region	Impact	Average	Final
		------------------------(% changes)----------------------		
Production	China	10.00	10.00	10.00
Price	World	1.02	-10.10	-22.17
Production	Argentina	-0.11	-9.27	-13.30
	Brazil	-0.07	-1.10	-2.79
	Cent. Africa	-0.08	-1.63	-3.65
	Mexico	0.00	-2.23	-5.50
	Pakistan	-0.03	-1.03	-1.95
	Turkey	0.00	-0.23	-1.20
	USA	0.00	-1.97	-3.80
	World	1.82	1.84	1.53
Consumption	Argentina	0.12	0.40	1.00
	Australia	0.03	0.32	0.72
	Brazil	0.14	1.65	3.53
	Cent. Africa	0.01	0.18	0.42
	China	0.04	0.49	1.01
	EEC	0.05	0.68	1.43
	Korea	0.13	1.87	3.82
	Mexico	0.06	1.73	4.09
	Turkey	0.12	2.90	6.19
	USA	0.14	1.04	2.23
	World	0.04	0.42	0.91
Ending Stocks	World	5.47	17.94	31.23
	China	36.19	39.91	58.34
Net Trade	China	-8.71	43.87	468.91

Table 8.8 Percentage Change in Non-Cellulosic Fibers Variables for a 10% Increase in China's Cotton Production

Variable	Region	Impact	Average	Final
		(% changes)		
Price	World	0.41	3.63	8.25
Production	World	0.00	0.29	0.49
Consumption	Argentina	0.03	0.83	2.04
	Australia	0.05	1.48	3.61
	Brazil	0.46	7.21	14.87
	Cent. Africa	0.40	5.22	10.94
	China	0.54	8.38	18.60
	EEC	0.19	2.47	5.33
	Japan	0.07	1.83	4.31
	Korea	0.25	3.43	7.39
	Mexico	0.05	1.33	3.29
	Turkey	0.04	0.53	1.16
	USA	0.17	1.18	2.35
	Rest of World	-0.52	-4.33	-10.39
	World	0.00	0.30	0.54

8.3.4 Conclusions and Implications

The results show that China's cotton production has a major impact on the world fiber market. Over the 11-year simulation of the model for every 1% increase in China's production the world price of cotton falls, on average, about 1% and the price of polyester falls 0.36%. Therefore, if production increases at the unofficial forecast growth rate of 3% per year, the cotton price can be expected to fall substantially. Figure 8.16 shows the forecast of world cotton ending stocks following the 10% production increase in China. By 2000 world stocks are forecast to be more than 1 million tons above the base forecast, causing the world cotton price to be more than 20% below the base forecast level (Figure 8.17). The possibility of higher future cotton production in China has important implication for the price of polyester as depicted in Figure 8.18. This shows considerably lower polyester price forecasts than in the base scenario, with the difference between the two forecasts increasing over time. Figures 8.19 and 8.20 show the change in cotton production and consumption forecasts, respectively.

Although most of the pricing and production decisions are made internally, China is now the largest player in the world fiber market. The importance of China in determining world price and thereby production and consumption levels in the price-responsive regions of the world is demonstrated by the model. While future cotton policies of China are unknown, the results show that developments in China during the early 1990s must be monitored closely and included in future fiber sector forecasting and policy analyses.

Figure 8.16 The Impact of a 10% Increase in Cotton Production in China on World Cotton Stocks.

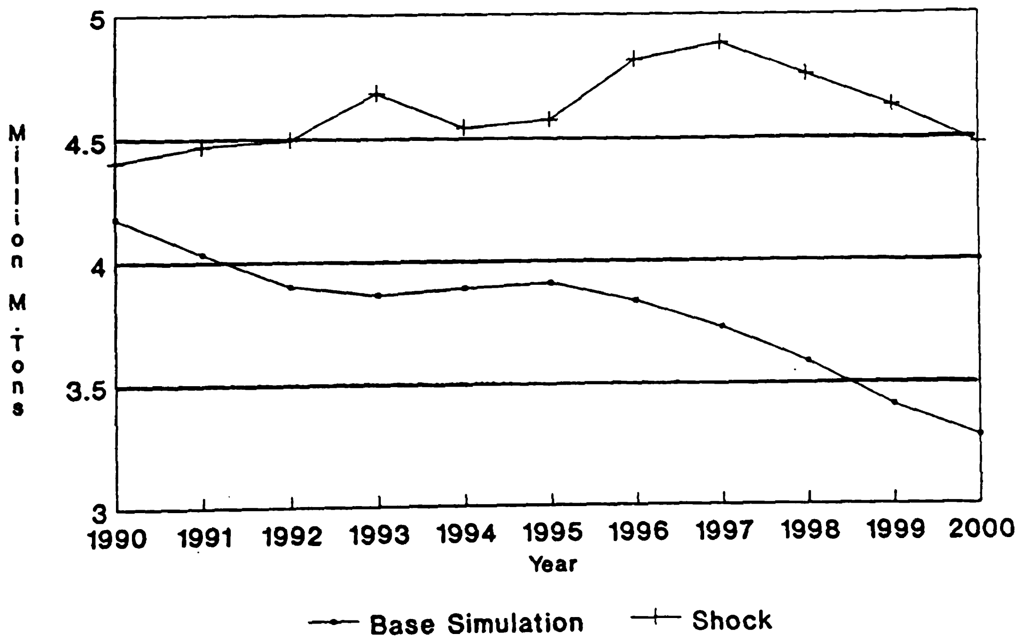


Figure 8.17 The Impact of a 10% Increase in Cotton Production in China on World Cotton Price.

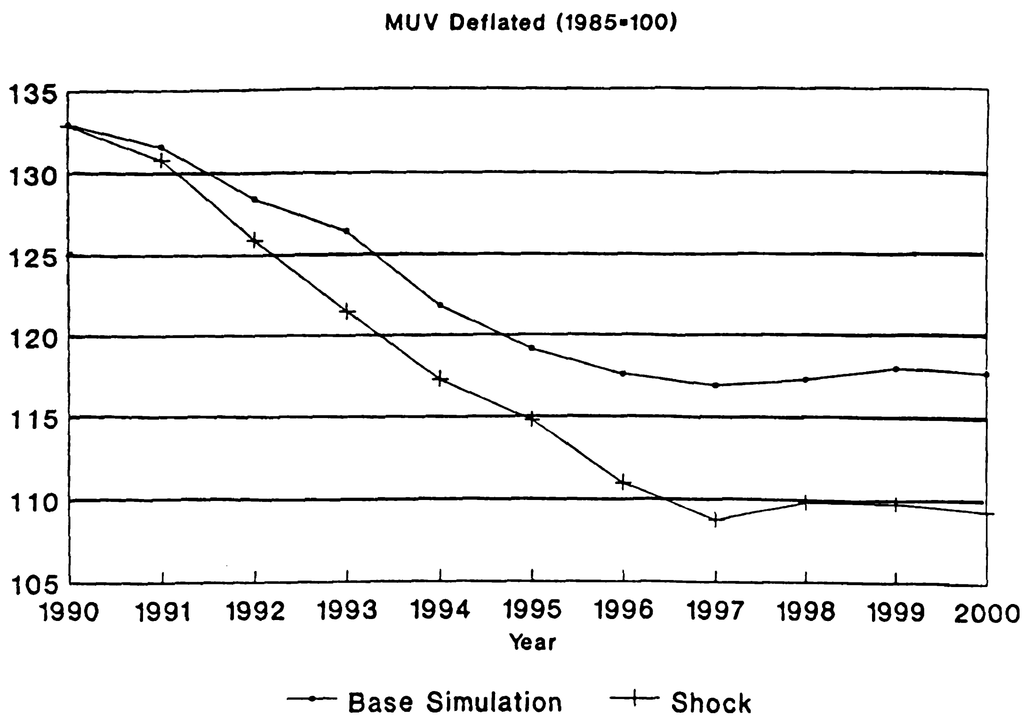


Figure 8.18 The Impact of a 10% Increase in Cotton Production in China on World Polyester Price.

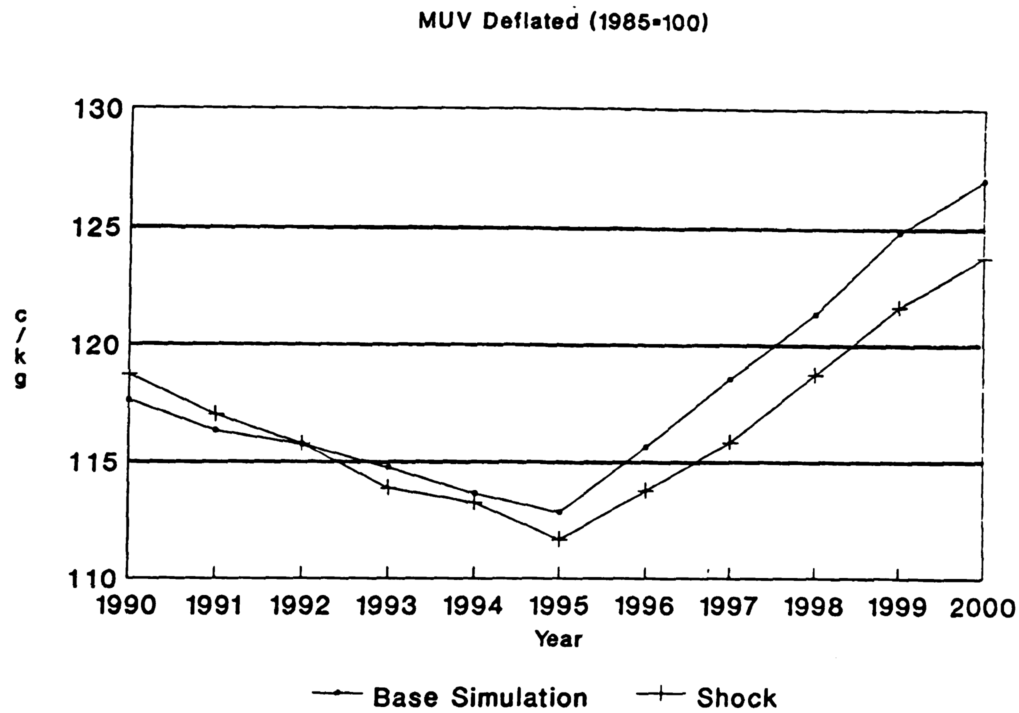


Figure 8.19 The Impact of a 10% Increase in Cotton Production in China on World Cotton Production.

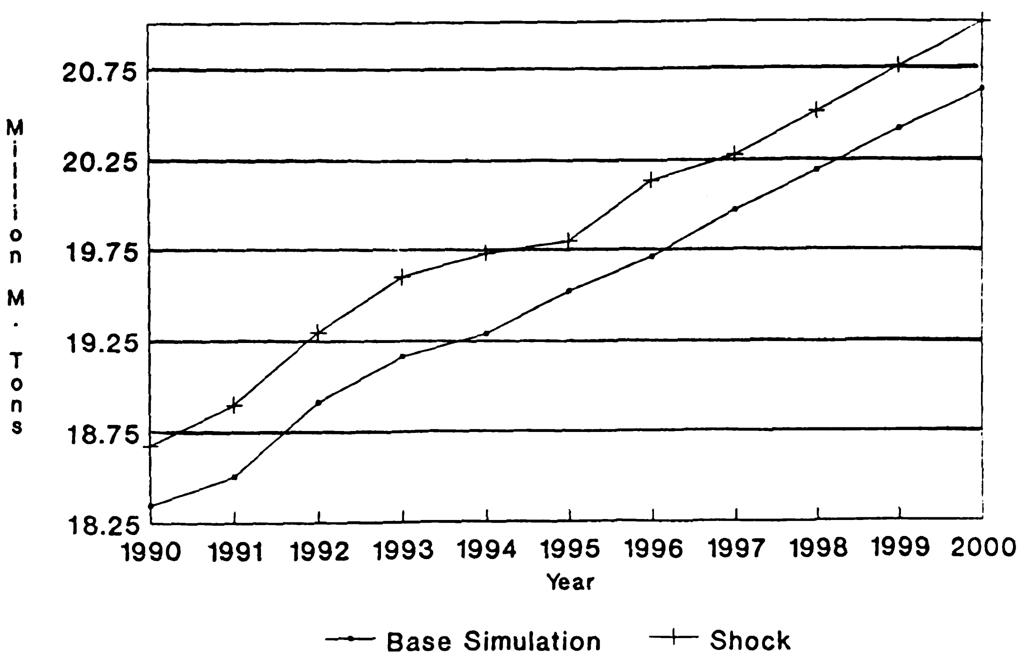
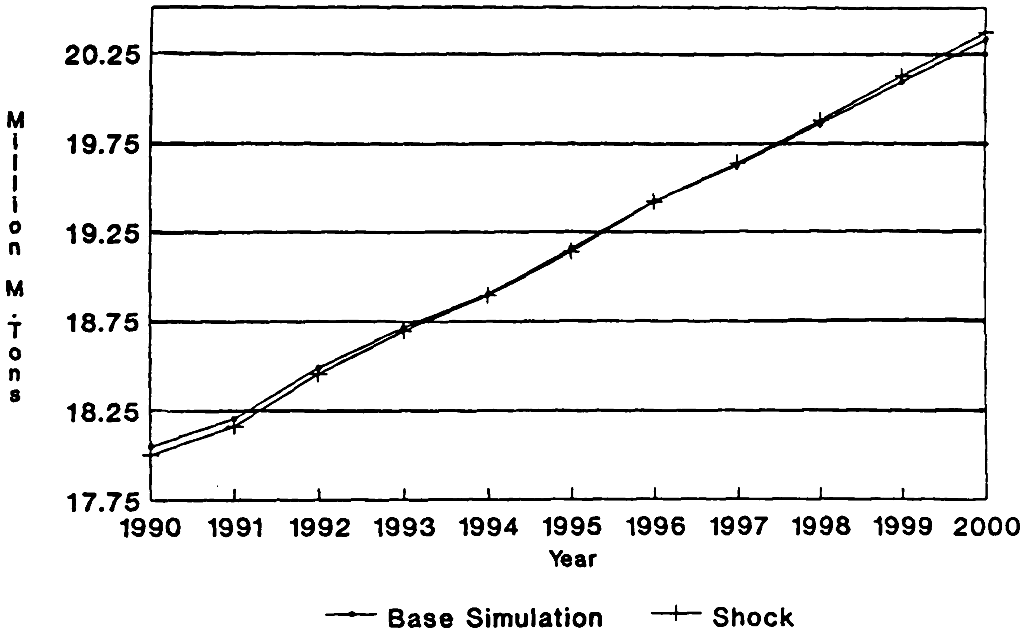


Figure 8.20 The Impact of a 10% Increase in Cotton Production in China on World Cotton Consumption.



8.4 Simulation Four - A 10 Percent Reduction in the United States Cotton Price

8.4.1 Background

Since 1933 US cotton growers have been supported by several government programs. While the level of support given to growers has changed over the years, the policy orientation has remained the same. This has been to provide cotton producers with price incentives consistent with the global cotton market conditions and to adjust cotton acreage and production to meet market needs.

Cotton growers are provided with a floor price through the loan rate. This a nonrecourse loan meaning that repayments can be made by delivering stored cotton to the Commodity Credit Corporation (CCC). Typically the loan rate is set at some proportion of the average of recent past world cotton prices. In addition to the loan rate, growers who participate in the program by setting aside a certain amount of cotton acreage from production are entitled to a deficiency payment. This payment is equal to the difference between the target price (first established in 1973) and the loan rate. The target price is based on a cost-of-production formula as well as current market price trends.

During the 1970s and 1980s a number of agricultural acts were brought into legislation[2]. Each of these Acts established new specifications for the loan rate, deficiency payments, target price, acreage diversion requirements and so on. However, while the specifications were changed through time to accommodate the prevailing market conditions, the actual instruments of support have been preserved [3]. Other support measures provided in recent agricultural legislation have included limits on the total amount of payments received by any one grower, disaster relief provisions and the payment-in-kind program.

The most recent legislation came in the Food, Agriculture, Conservation, and Trade Act of 1990. This Act continues the market-orientated legislation established in the 1985 Food Security Act[4]. The Act includes provisions designed to make US producers competitive in the international cotton market, by fixing the target price for the 1991-95 period at the 1990 level at 72.5c/lb. This is in an effort to meet Gramm-Rudman deficit reduction targets, and to support domestic producers at levels consistent with expected

---

[2] The major pieces of legislation were the Agricultural Act 1970, Agricultural and Consumer Protection Act 1973, Food and Agricultural Act 1977, Agriculture and Food Act 1981, Agricultural Programs Adjustment Act 1984, and Food Security Act 1985. The provisions of each of these Acts are discussed by Starbird et al (1987).

[3] Perhaps the most significant policy change was the introduction of the payment-in-kind (PIK) program which was introduced in 1983. This was in response to an unprecedented build up of stocks in 1982 and government deficiency payment expenditures of $520 million.

[4] These conditions were mainly the result of the production boom in China with production increasing from 3.3 million tons in 1982 to 5.9 million tons in 1984.

falling world cotton prices during the 1991-95 period.

8.4.2 Simulation Objectives

In the past US cotton programs have had a major impact on world prices. For example, the establishment of target prices in the mid-1970s led to a reduction in planted acreage in 1975 and 1976 and was largely responsible for the 46% decline in the world price between 1975 and 1976. Then, following the introduction of the Payment-In-Kind (PIK) program in 1983, the dramatic reduction in United States stocks led to strong world prices in 1983 and 1984 despite the large expansion of production and stocks in China. The 1985 Food Security Act was aimed at reducing world prices and reducing the cotton stocks held in the United States. This policy was a major contributory factor in the 42% drop in the world cotton price between the 1984 and 1985 crop years.

The 1990 Food, Agriculture, Conservation, and Trade Act came into law in November 1990. The most significant impact of the Act on the US cotton market is the fixing of the target price for the 1991-95 period at the 1990 level. Assuming a 4%-5% annual inflation rate for 1991-95, the average real target price for the 1991-95 period is expected to be about 25% lower than for the 1986-90 period. This represents a significant fall in the support level given to domestic producers of cotton.

Given that real US target prices are expected to fall over the 1990-1995 period and the importance of the United States cotton sector on the world fiber market, the model was simulated with the prices in the United States production equations set 10% below the base simulation levels. The results on this simulation will provide useful estimates of the impact that the 1990 legislation will have on the world fiber market.

8.4.3 Simulation Results

In order to test how such policy developments may impact on the world market, the model was simulated with US domestic prices set 10% below their historical values. The results are reported in Tables 8.9 and 8.10. The initial values are for the second period of the simulation. In the first period, no changes are experienced in any variables. This is because only lagged values of producer prices enter the supply equations.

Initially the 10% fall in the US cotton price led to a decline in United States production by 3.16% below the base simulation. Lower supplies caused ending stocks to fall by 1.63% and for the world price to increase by 1.30%. The higher cotton price led to a reduction of world cotton demand by 0.58% and to a small expansion of production in other regions, partially offsetting the effect of lower United States supplies. The reduction in the demand for cotton created an expansion of non-cellulosic fibers demand, which caused the price of polyester to increase 0.42% above the base simulation. Higher polyester prices dampened the impact of higher cotton prices on cotton consumption.

The average impact was for United States cotton production to fall by 2.93% and world production to fall 0.31% below the base simulation. The reduction in supplies caused the world demand for cotton with world consumption falling 0.19%. As expected, lower cotton consumption increased the demand for non-cellulosic fibers which increased on average 0.13% above the base level. Strong demand increased the polyester price by 1.46% and production by 0.13%.

Table 8.9 Percentage Change in Cotton Variables for a 10% Decline in U.S. Cotton Prices

Variable	Region	Impact	Average	Final
		------------------------(% changes)-----------------------		
Price	United States	-10.00	-10.00	-10.00
	World	1.30	3.70	5.30
Production	Argentina	0.10	4.29	4.15
	Brazil	0.08	0.45	0.73
	Cent. Africa	0.10	0.39	1.00
	Mexico	0.00	2.73	4.90
	Pakistan	0.03	0.48	0.64
	Turkey	0.00	0.21	0.36
	USA	-3.16	-2.93	-2.42
	World	-0.58	-0.31	-0.15
Consumption	Argentina	-0.02	-0.23	-0.54
	Australia	-0.03	-0.13	-0.19
	Brazil	-0.18	-0.67	-0.96
	Cent. Africa	-0.01	-0.09	-0.14
	China	-0.05	-0.23	-0.26
	EEC	-0.07	-0.28	-0.39
	Korea	-0.16	-0.76	-1.06
	Mexico	-0.07	-0.95	-1.40
	Turkey	-0.14	-1.44	-2.00
	USA	-0.14	-0.43	-0.55
	World	-0.58	-0.19	-0.27
Ending Stocks	World	-1.63	-3.34	-4.64

Table 8.10 Percentage Change in Non-Cellulosic Fibers Variables for a 10% Decline in U.S. Cotton Prices

Variable	Region	Impact	Average	Final
		(% changes)		
Price	World	0.42	1.46	2.12
Production	World	0.00	0.13	0.15
Consumption	Argentina	0.03	0.48	0.71
	Australia	0.06	0.82	1.22
	Brazil	0.77	2.81	3.85
	Cent. Africa	0.70	2.06	2.87
	China	1.17	3.50	4.68
	EEC	0.25	0.99	1.40
	Japan	0.10	0.90	1.37
	Korea	0.34	1.36	1.93
	Mexico	0.05	0.76	1.13
	Turkey	0.05	0.22	0.31
	USA	0.18	0.46	0.59
	Rest of World	-0.68	-1.82	-2.67
	World	0.00	0.13	0.16

Over the long-run, the world price increased by 5.30% above the base level, with much of the fall in United States production offset by an expansion in other regions. Higher prices continued to constrain world consumption which fell only 0.27% below the base level. In the long-run the polyester price increased by 2.12%, stimulated by higher non-cellulosic fibers consumption following the decline in cotton demand.

8.4.4 Conclusion and Implications

Overall the results indicate that effects of a decline in the US price will not have a substantial effect on the world market. The US production falls, on average, less than 3% below the base simulation, while world prices increase an average of 3.7%. Consumption is affected by less than 1% in all regions of the model. While a fall in both loan rate and target price are expected in the early 1990s, the declines are not expected to be as large as the 10% in the simulation. Therefore the actual effects are expected to be much smaller than those reported in Tables 8.9 and 8.10. Also the decline in world production will tend to increase the world market prices and this will offset, to some extent, the decline in the US domestic price.

Some of the effects of the 10% decline in US cotton prices on the model forecasts are shown in Figures 8.21-8.25. The forecast of production in the United States is significantly below the base forecast, especially in the early 1990s. On average, the price shock reduces the United States cotton production forecast by about 100,000 tons. Figure 8.23 shows that the forecast of deflated cotton price falls when the United States price is set 10% lower, but that the rate of decline is less than in the base scenario forecast. The effects on the cotton stocks and consumption forecasts are shown in Figures 8.25 and 8.26, respectively, and illustrates that, in generally, the effects are quite small.

Figure 8.21 The Impact of a 10% Decrease in Cotton Price in the United States on United States Cotton Production.

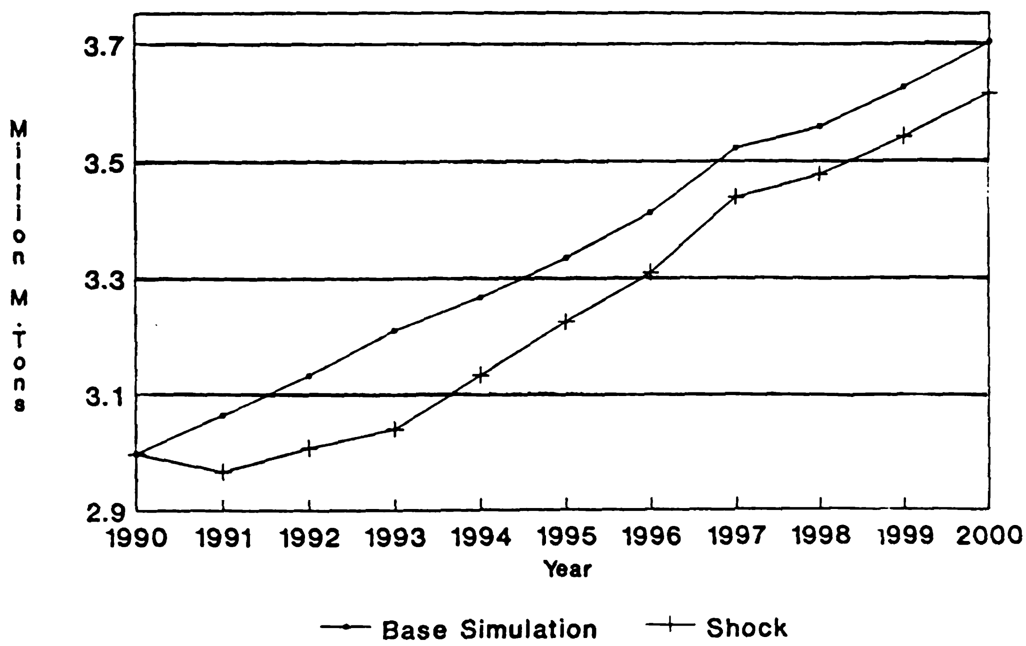


Figure 8.22 The Impact of a 10% Decrease in Cotton Price in the United States on World Cotton Production.

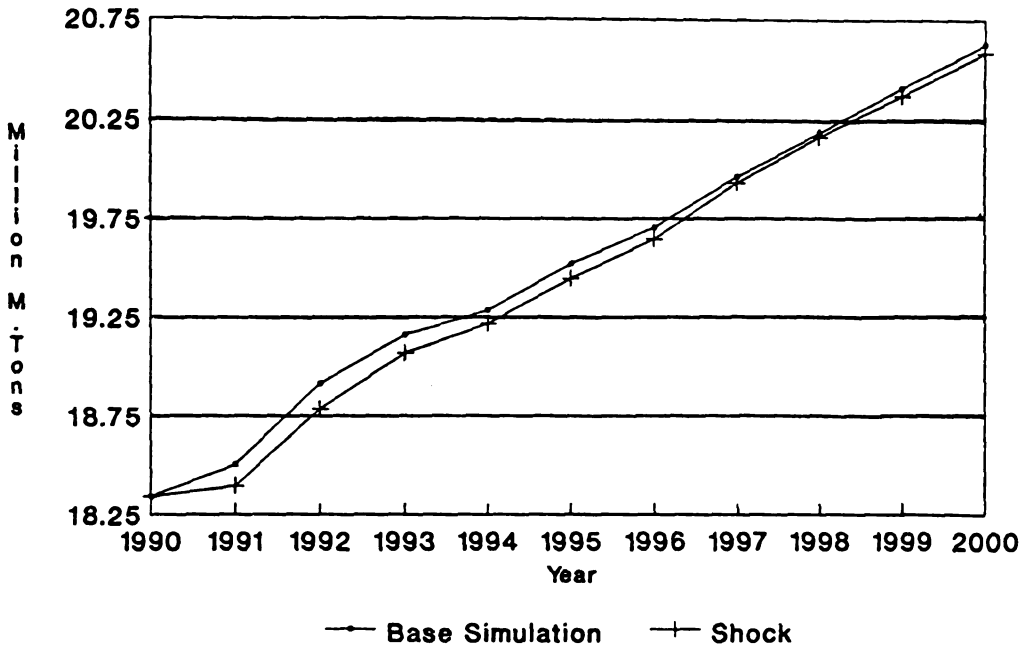


Figure 8.23 The Impact of a 10% Decrease in Cotton Price in the United States on World Cotton Price.

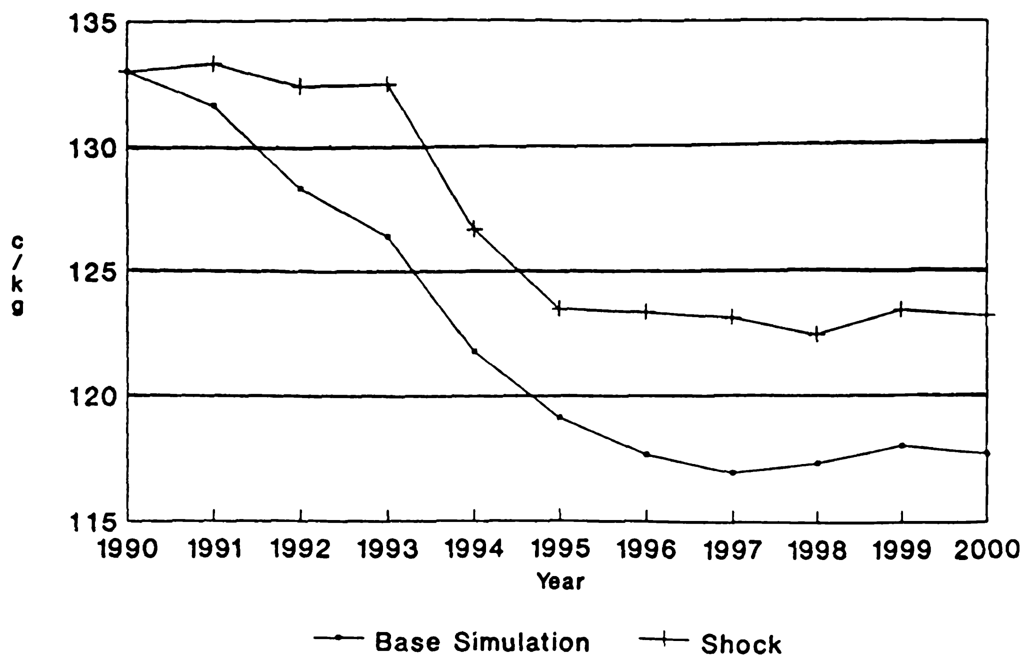


Figure 8.24 The Impact of a 10% Decrease in Cotton Price in the United States on World Polyester Price.

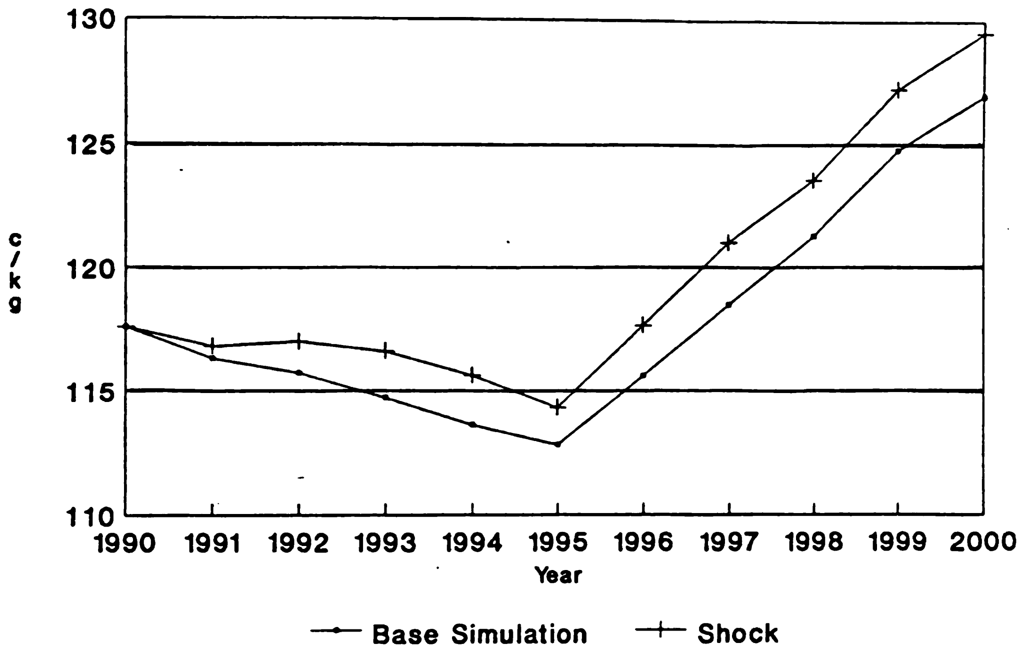


Figure 8.25 The Impact of a 10% Decrease in Cotton Price in the United States on World Cotton Stocks.

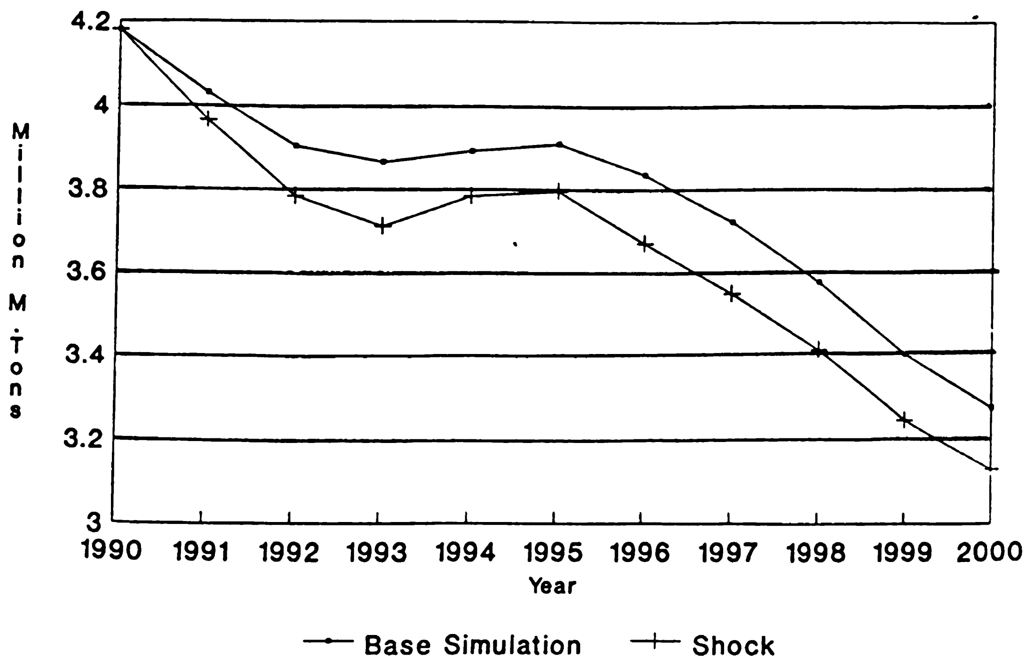
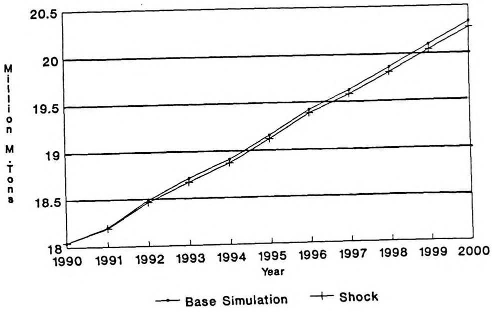


Figure 8.26 The Impact of a 10% Decrease in Cotton Price in the United States on World Cotton Consumption.



8.5 Simulation Five - Analysis of the Multi-Fiber Agreement

8.5.1 Background

The exporting of textile and clothing (T&C) products is very important to the economies many developing countries, especially as a source of foreign exchange and employment. Given that T&C production technology is labor-intensive, developing countries have achieved a comparative advantage in production relative to the industrialized countries where wages are much higher. In 1986 developing countries produced about one-half of total world supplies of manufactured T&C products, while accounting for less than 17% of total manufactured production. More than 50% of the T&C exports of developing countries are purchased by industrialized countries--especially Japan, the EEC and the United States. The largest T&C exporters are Hong Kong, Korea and Taiwan, and recently China has emerged as a major supplier to the world market.

Despite the importance of the international T&C markets to the developing countries, tariff and non-tariff restrictions have been a constant feature of T&C trade. Trade between the developing country exporters and the industrialized countries has been restricted since January 1974 through the Multi-Fiber Agreement (MFA), and before then by the Short- and Long-Term Arrangements (1961-1973).

Negotiated under GATT, the MFA provides for the imposition of bilateral quotas on developing country T&C exports to the industrialized countries. Such agreements are negotiated to avoid "market disruption" in the industrialized countries from (i) sharp increases in the import of a particular T&C item from a particular source, (ii) import prices being below domestic prices, and (iii) imported T&C items causing injury to domestic producers [5].

So far four MFA agreements have been negotiated since MFAI was introduced in 1974. The current MFA (MFA IV) is due to expire in 1991. With each new agreement the controls have become more stringent, with more developing countries restricted and wider coverage of T&C items falling into restricted categories. During the MFA I period (January 1974 through December 1977) the United States placed heavy restrictions on many countries, while the EEC and Japan imposed relatively minor quantity restrictions.

---

[5] Some researchers have questioned how the MFA became to be negotiated under GATT while being in violation of its most-favored-nation clause and requirements that, except under special circumstances, trade restriction should be in the form of tariffs only (Keesing and Wolf (1980), Sampson (1986)). Possible explanations for this are that T&C trade has had a long history of trade restrictions and is dominated by the United States as the major player in the market, especially in the 1950s and 1960s when the foundations of the MFA were being laid. At this time the United States textile sector employed between 15 and 20 percent of the total manufacturing sector labor force and was dominated by very powerful interest groups. Further, Keesing and Wolf argue that many developing countries had good reason to agree to the restrictions because they felt that uncontrolled restrictions would impair the long-run development of their T&C sectors.

In the MFA II (January 1978 through December 1981) the EEC substantially tightened its quota levels and in MFA III (January 1982 through July 1986) a greater number of unilateral and bilateral agreements were installed. MFA IV includes further restrictions.

8.5.2 Past Studies of the Economic Effects of the MFA

A number of studies have appeared which estimate the effects of the MFA on both importing and exporting countries. In terms of the effects on importing countries (i.e., the United States, Japan, and the EEC), Cline (1985) estimated that MFA cost United States consumers $20.3 billion in 1985, while saving 434,200 jobs ($47,000 per job saved). Hufbauer et al (1984) reported that the consumer cost was $27 billion in 1984, saving 640,000 jobs at a cost of $42,000 per job. Both studies concluded that the MFA was an inefficient method of protecting employment from cheap T&C imports.

Another set of studies has looked at the costs incurred by the developing countries as a result of the MFA. For example, UNCTAD (1986) estimated that by removing all restrictions on T&C imports into the United States, EEC and Japan, export revenues would increase by $15 billion--and increase of almost 100%. Whalley, using a general equilibrium model, estimated the loss to be $11 billion, while Kirmani (1984) showed that by removing tariff and non-tariff barriers from imports of T&C products to OECD countries, the textile and clothing export revenues of the developing countries would increase 82% and 92%, respectively. Other effects of the MFA observed by other researchers are trade diversion, upgrading of exports and the impact of the MFA on economic development. Some developing countries fill all their quota under the MFA (e.g., Hong Kong and Korea) while others use only a small part of their allocation. This provides incentives for the restricted countries to set up T&C production capacity in countries where quotas are not binding. This has provided a stimulus to economic development in some countries. For example, according to Spinanger (1987), with the help of a Korean company, Bangladesh increased its T&C from nothing in 1979 to $500 million in 1987. However, this rapid growth led to the imposition of quotas under the MFA and as a result 400 plants were forced to close down.

8.5.3 Simulation Objectives

Most of the past studies into the effects of the MFA have focused on measuring the costs and benefits of the agreement and to whom they have accrued, such as consumers and producers of T&C products. Also research has been aimed at measuring the cost-effectiveness of the agreement on employment and job-saving. No research, as far as the author is aware, has tried to estimate the effects of the MFA on the supply and demand of raw fibers. Clearly with the restrictions imposed by the MFA, the demand for T&C products has fallen, lowering the demand for raw fibers by the T&C manufacturers. In turn, the lower demand by manufacturers will have reduced the prices of raw product which will impact on suppliers, such as cotton growers and non-cellulosic fibers producers.

In view of the recent negotiations of the MFA in the current Uruguay round of GATT, it is timely to measure fully the impact that the T&C trade restrictions impose. One such impact, not yet explored in the literature, is the effect of the MFA on the primary producers of raw fibers. In this simulation the effects of the MFA on primary producers, intermediate consumers and raw fiber prices are measured. The results may provide a better picture of how the MFA affects other sectors of the world fiber market.

8.5.4 Problems of Modeling the MFA

For a number of reasons modeling the impact of the MFA on the fiber market was found to be extremely difficult and eventually a rather crude method of capturing the MFA in the model was employed. The difficulties encountered were as follows.

Restrictions on trade in textiles has evolved slowly since the early 1960s within the scope of the Short- and Long-Term Arrangements followed by the four MFAs. With each new agreement, restrictions have become more stringent, but it has only been with MFA III (January 1982 - July 1986) and MFA IV (August 1986 - July 1991) that restrictions have been significantly prohibitive. The FAO data set used to estimate the demand side of the fiber model ends in 1986 for developing countries and in 1987 for industrialized countries and therefore does not cover the most restrictive time period.

Another problem is that the fiber model is based on quantities measured in tons of raw fiber equivalents. The MFA restricts the numbers of specific manufactured textile products and clothing items, such as the number of pairs of gloves or the number of table-cloths; it is almost impossible to measure these items in terms of fiber content and weight. Therefore, the MFA cannot be quantified in a way compatible with the econometric model.

The MFA is negotiated bilaterally whereby trade flows between individual countries are specifically restricted (e.g., there are restrictions on the number of shirts imported into the United States from Hong Kong). To model the impact of such restrictions requires that bilateral trade flows be estimated for each importing and exporting country party to the MFA. Time series data are insufficient to allow such trade flows to be modeled. Further, where restrictions have become binding, countries have managed to maintain trade

levels by either exporting through a third country whose exports are not restricted, or by establishing new processing plants in such countries. These 'leakages' are widespread. A final problem is that most of the textile trade has grown rapidly since the 1960s. The strong trend in these data prevented estimation of useful response parameters.

Several approaches were attempted in an effort to capture the effects of the MFA in the fiber model. Given that the MFA cannot be quantified in terms of raw fiber, dummy variables were constructed for each for the three MFA regimes operating during the estimation period (i.e., MFA I, 1974-1977; MFA II, 1978-1981; MFA III 1982-1986). It was hypothesized that the MFA, by restricting imports, would result in higher textile prices which would, in turn, reduce fiber availability. The textile and clothing component of the Consumer Price Index for the United States and the EEC (the two major importers under the MFA) were obtained and regressed on the following variables: prices of cotton and polyester, a measure of efficiency in the textile manufacturing sector, wage rates, and MFA dummy variables. While the equation fitted the data well for both regions, the MFA dummy variables were incorrectly signed. This is because, despite what effect the MFA has had, deflated textile prices have declined consistently throughout the estimation period. Even the regression of textile price growth rates against the MFA dummy variables revealed no statistically significant relationships. Further, the price of textiles was not significant in the total fiber use equations in both regions.

Another approach was based on the assumption that the decline in textile prices in the United States and the EEC is due to the penetration of cheap imports into these markets and that this penetration might have been slowed over time with the imposition of tighter MFA restrictions. Again, this hypothesis was not borne out by the data, with market penetration increasing at an increasing rate, despite increasingly stringent MFA controls.

Thus no statistical evidence could be found that supported the hypothesis that the MFA has led to increases in the prices of textile and clothing products, or that the agreements have slowed the penetration of imported products into the United States and the EEC markets.

8.5.5 Method of Incorporating the MFA into the Model

While analysis of the MFA cannot be easily handled in this model some crude estimates of the impact of the MFA on the fiber markets were obtained from a model simulation. The approach taken was to measure the percentage consumption reduction in the importing countries which resulted from the MFA (using elasticities derived in other studies) and then to use the model to measure how this decline affected fiber prices, production and consumption. This procedure involved a two-step approach. First, tariff equivalents of the MFA quotas were taken from Pelzman (1988), showing the percentage change in the price of textiles resulting from the trade restrictions imposed by the agreements. Second, an elasticity of textile demand with respect to the price of textiles was used, based on the study by Houthakker (1965). Combining these elasticities gave the percentage change in textile consumption resulting from the MFAs. The model was then simulated with demand set below the historical level according to these percentage declines and the results compared with the base simulation.

The effect of the MFA was incorporated into the model using the results from a study by Pelzman (1988). The approach taken by Pelzman was to estimate a model of textile and clothing trade between developing countries and the United States which takes into account market disequilibria that is introduced by the MFA quotas[6]. Supply, demand and price relationships are estimated separately for trade-restricted and trade-unrestricted markets. The consumption of textiles and clothing in both markets is estimated as a function of prices in both restricted and unrestricted markets as well as of prices in the importing country and variables capturing the levels of economic activity. The supply function for the restricted market is estimated for two scenarios. First, when the quantity supplied is below the quota level, equilibrium prices and quantities are derived from the intersection of the import supply and import demand relationships. Second, when the restriction is binding, Pelzman estimated a predicted value of excess demand or supply using the tobit two-stage method (Maddala, 1983) as a function of prices in the restricted, unrestricted and import markets and of the level of the quota. The estimate of excess supplies or demand was then used in a pricing equation for the restricted market. This price equation was used to generate equilibrium prices that would have existed in the absence of the trade restriction. Supplies in the unrestricted market were estimated as a function of the prices in the restricted and unrestricted markets. The equilibrium price in the unrestricted market is determined by the market clearing identity.

Pelzman reports estimates of tariff equivalents of the MFA for numerous textile and apparel items based on the three digit textile category system for the period 1979 through 1986. These estimate the percent change in price as a result of the MFA. These

---

[6] Pelzman criticized previous studies, such as those by Halbauer et al and Tarr and Morke, which estimate the dead-weight loss of the MFA based on market clearing partial equilibrium models. The constraints on trade through quotas creates excess demand at the price prevailing in the absence of any restrictions. Thus the market equilibrium, crucial to the standard methods of estimating the welfare costs of trade distortions, is violated.

differ substantially over time and between the individual textile and apparel items.

The tariff equivalents of the MFA quotas were estimated for the United States for the period 1979 through to 1986. This period covered most of the MFA II (January 1978 - December 1981) and the entire MFA III (January 1982 - August 1986). Pelzman provided tariff equivalent estimates for over 80 separate textile and apparel items. These were aggregated using a weighted average, with weights assigned to individual items according to their proportion of the total value of imports in each year. The aggregated tariff equivalents are reported in Table 8.11. Since no estimates were provided by Pelzman for the EEC, the reduction in fiber consumption for this region was based on the percentage declines in the United States. The elasticity of textile demand with respect to the price of textiles was set at -0.282. This estimate has been used widely in other studies (e.g., Tarr and Monke, 1984; Erzan, Goto and Holmes, 1989).

8.5.6 Simulation Results

The effects of the MFA II and MFA III on the world fiber market are presented in Table 8.11. The impact of the MFA was to raise textile prices, ranging from an increase of 12.11% in 1986 to 19.10% in 1981. This increase reduced total fiber consumption in the United States and the EEC as shown in Figures 8.27 and 8.28. In both regions during the 1979-81 period (MFA II), consumption was on average 4.98% lower than it would have been without the agreement, while consumption averaged 3.84% lower for the MFA III period (1982-86).

The reduction in fiber consumption in the EEC and United States led to a small decline in world cotton consumption, ranging from 0.58% in 1983 to 1.23% in 1979. The reduction in consumption caused cotton stocks to accumulate which led to a decline in price (Figure 8.29). Over the MFA II period the price of cotton fell an average of 4.87% as a result of the agreement, while during the MFA III period price averaged 5.51% below the base level. The decline in price caused a reduction in cotton production. However, the production response was less than 1% below the base level in each year of the simulation.

In the non-cellulosic fibers sector the results were similar to those in the cotton sector (Table 8.11). The reduction in fiber consumption in the United States and the EEC caused world consumption of non-cellulosic fibers to decline by up to 0.7% below the base level. The decline in consumption caused the price of polyester to fall. The price decline for the MFA II period was 5.01, and there was a decline of 4.44% during MFA III (Figure 8.30). The lower prices resulted in a small reduction in production, but the decline never exceeded 1% below the base level.

With cotton and polyester prices declining by different percentages, consumption of individual fibers in each region either increased or decreased. For example, in Argentina, Australia and Mexico during the MFA II period, the effect of lower cotton prices out-weighed the effect of lower polyester prices, so that cotton consumption increased. Conversely, during the MFA III period, the response to relative prices was reversed, with non-cellulosic fibers consumption increasing at the expense of cotton. Overall the consumption effects of the MFA on the countries which have not imposed restrictions were quite small, with most changes less than 1% above or below the base simulation levels. However, the effect on consumption in the United States was much higher.

Table 8.11 Percent Change in Cotton Variables Associated with the Multi-Fiber Agreement, 1979-1986.

Variable	Region	1979	1980	1981	1982	1983	1984	1985	1986
MFA Tariff[1] Equivalent(%)	US & EEC	16.93	16.90	19.10	16.25	13.39	13.29	12.98	12.11
Total Fiber[2] Use	US & EEC	-4.77	-4.77	-5.39	-4.58	-3.78	-3.75	-3.66	-3.41
Cotton									
Price	World	-3.38	-5.62	-5.61	-6.90	-7.47	-4.74	-3.63	-4.83
Production	World	-0.03	-0.26	-0.56	-0.65	-0.89	-0.82	-0.71	-0.57
Consumption									
	Australia	-0.20	0.02	0.02	0.12	0.17	0.08	0.01	0.01
	Brazil	0.47	0.92	1.11	1.31	1.50	1.09	0.83	0.93
	China	-0.33	0.03	0.04	0.19	0.27	0.15	0.02	0.02
	EEC	-5.12	-4.74	-5.34	-4.36	-3.45	-3.57	-3.63	-3.38
	Korea	-0.95	0.09	0.11	0.62	1.06	0.52	0.08	0.09
	Mexico	-0.46	-0.37	-0.27	0.04	0.44	0.56	0.51	0.45
	Turkey	0.26	0.94	1.54	2.33	3.26	3.64	3.25	2.86
	U.S.	-5.07	-4.30	-5.12	-3.94	-2.95	-3.36	-3.58	-3.34
	World	-1.23	-1.01	-1.08	-0.77	-0.58	-0.73	-0.69	-0.65
Non-Cellulosic Fibers									
Price	World	-5.07	-4.93	-5.04	-4.92	-4.74	-4.20	-3.93	-4.40
Production	World	0.00	-0.60	-0.63	-0.74	-0.64	-0.63	-0.56	-0.37
Consumption									
	Argentina	0.30	0.22	0.16	-0.01	-0.20	-0.27	-0.25	-0.24
	Australia	0.44	0.32	0.22	-0.05	-0.36	-0.47	-0.42	-0.39
	Brazil	3.41	-0.30	-0.52	-2.16	-2.84	-2.45	-0.30	-0.35
	China	4.34	-0.35	-0.77	-2.83	-3.18	-2.18	-0.36	-0.39
	Cent Afr.	2.50	-0.26	-0.47	-1.63	-2.53	-1.34	-0.22	-0.26
	EEC	-3.38	-4.89	-5.54	-5.41	-4.94	-4.39	-3.76	-3.53
	Japan	0.50	0.30	0.13	-0.23	-0.60	-0.65	-0.48	-0.37
	Korea	1.91	-0.16	-0.23	-1.16	-1.61	-0.92	-0.15	-0.16
	Mexico	0.37	0.28	0.21	-0.01	-0.28	-0.38	-0.36	-0.35
	Turkey	0.34	-0.03	-0.04	-0.18	-0.24	-0.13	-0.02	-0.03
	U.S.	-4.84	-5.59	-6.05	-5.53	-4.83	-4.40	-3.93	-3.64
	World	0.00	-0.57	-0.61	-0.70	-0.63	-0.61	-0.58	-0.41

[1] Tariff equivalent of MFA is the percentage increase in the price of textiles resulting from the MFA trade restriction.

[2] Note: the decline is equal to the tariff equivalent * the elasticity of fiber demand with respect to textile price (= -0.282).

Figure 8.27 Impact of Multi-Fiber Agreement on United States Total Fiber Consumption, 1979-1986.

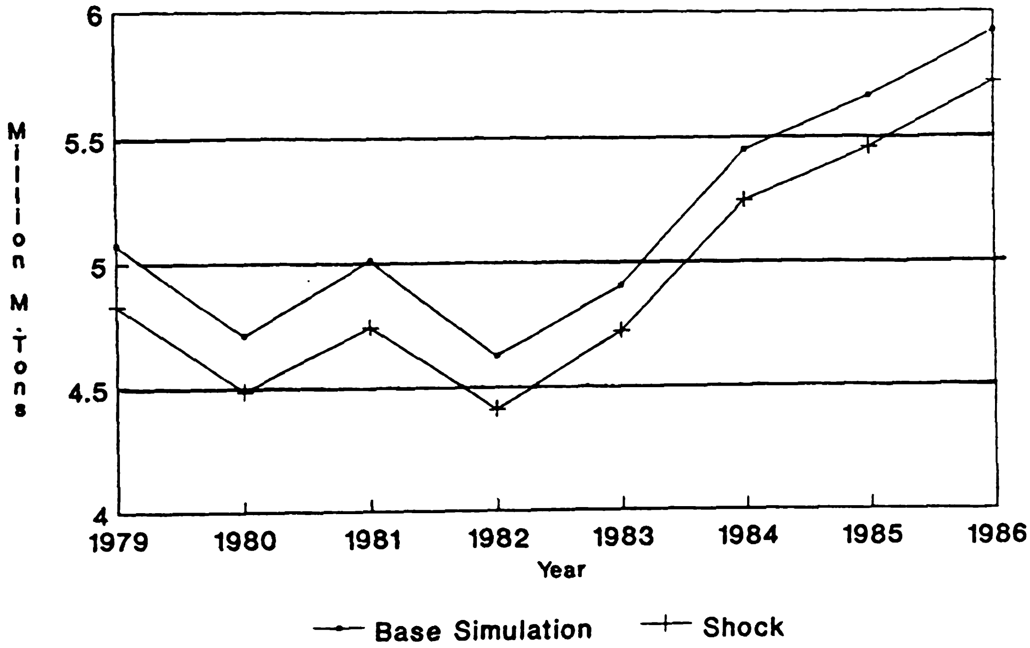


Figure 8.28 Impact of Multi-Fiber Agreement on EEC Total Fiber Consumption, 1979-1986.

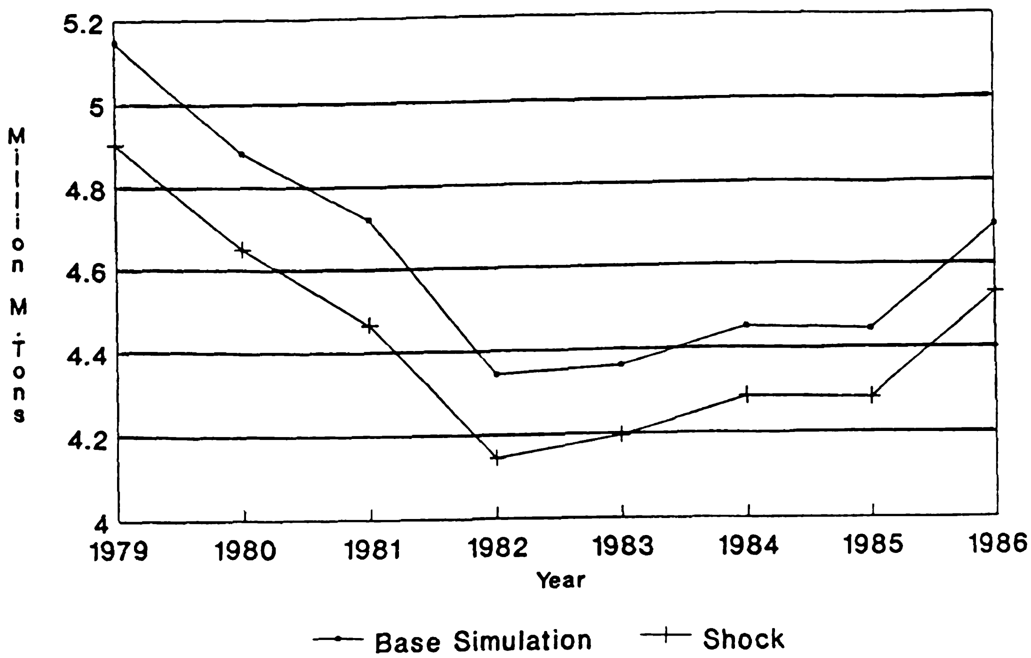


Figure 8.29 Impact of Multi-Fiber Agreement on World Price of Cotton, 1979-1986.

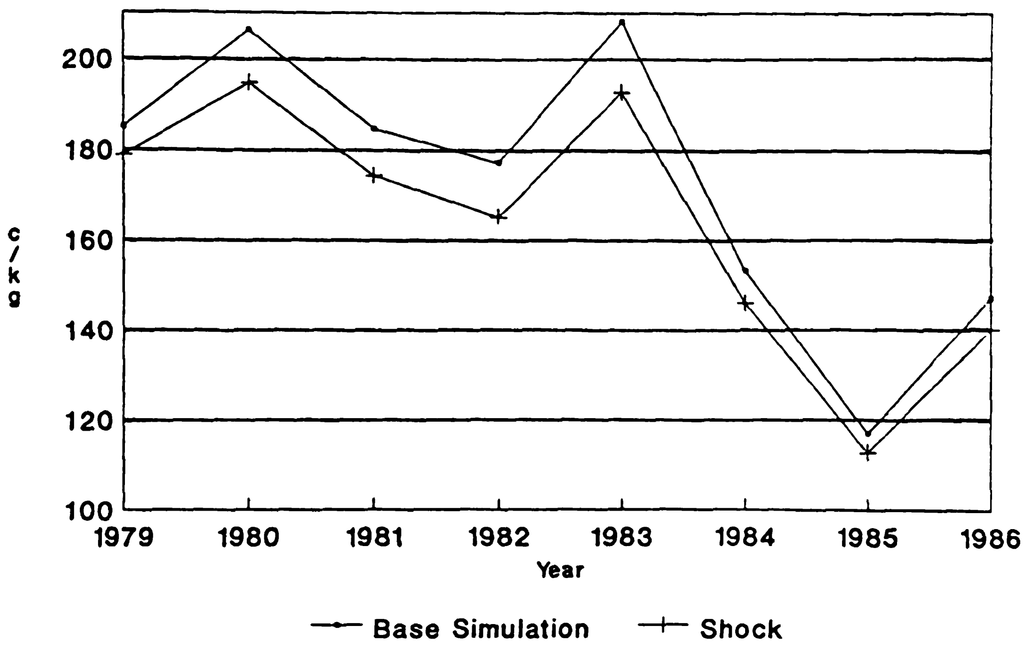
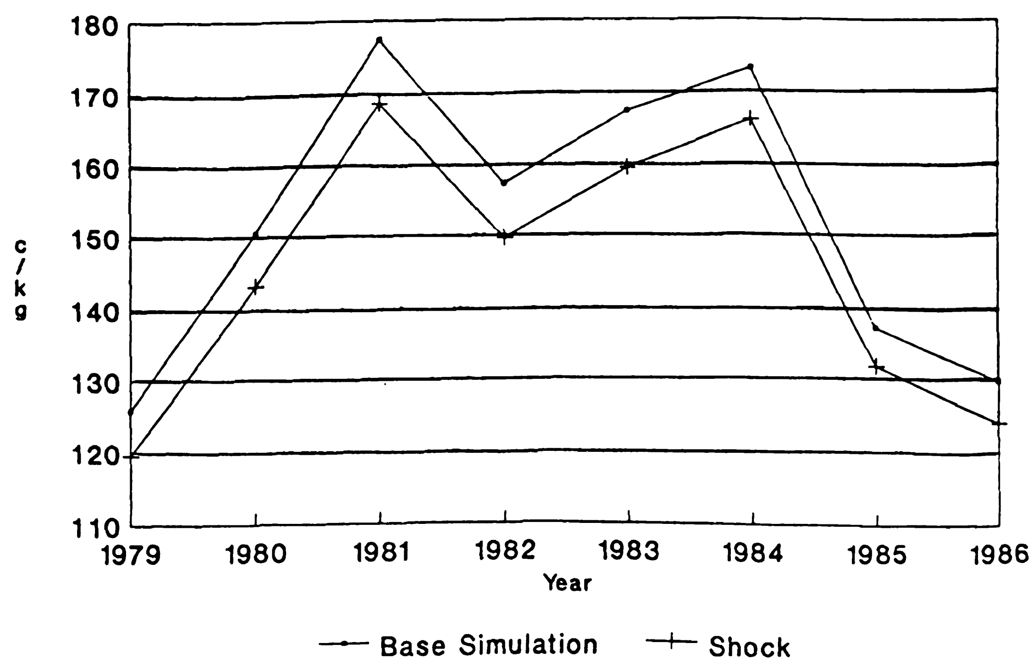


Figure 8.30 Impact of Multi-Fiber Agreement on World Polyester Price, 1979-1986.



8.5.7 Conclusions and Implications

Given the crude method used to derive these estimates, it is important to down-play the results somewhat. However, some general conclusions can be made. For example, the MFA has reduced world prices of cotton and polyester by, on average, about 5% between 1979 and 1986 (within a range between 3% and 7%). The analysis does not cover the most restrictive period since 1986 and therefore the current impact of the agreements on world fiber prices is likely to be at the upper end of this range. While the impact of the MFA was to reduce raw fiber prices by around 5%, the impacts on production and consumption were small. As a result of the agreements, cotton and non-cellulosic fibers production and consumption were changed less than 1% in most years.

These results lead to the conclusion that while the effect of the MFAs have been substantial in terms of welfare losses and economic inefficiency in the T&C manufacturing and trade sectors (Pelzman, Tarr and Monke, Keesing and Wolf), the effects on the raw fiber market have not been large. This reflects the small size of the price transmission elasticity between raw fiber and textile prices and of the elasticities of raw fiber supply and demand with respect to price. However, the results are a useful contribution to the overall debate on the economic impact of the MFA that has been ignored previously by researchers.

8.6. Summary

The simulation results discussed in the section provide many important insights into the how the world fiber market operates and where it is headed in the future. Especially interesting are the forecasts for the period 1990 through 2005, while the simulations

involving policy shocks in individual countries (i.e., the USSR, China and the United States) provide information on how the forecasts must be modified in light of new developments in these markets. The MFA simulation sheds light on an important aspect of the agreement that has not been the subject of earlier research.

9. Sensitivity Analysis

9.1 Introduction

The simulation results are conditional on the model's assumptions and equation specifications. These were described fully in earlier sections. Parameter estimates were also presented and compared with those from other studies, which gave rise to a fairly good set of validation statistics. While the results from previous stages in model building lead to confidence in the model's results, it is important to assess how robust the model forecasts and policy analyses are to different parameter estimates.

A model's robustness can be tested with sensitivity analysis, which is defined by Anderson (1974) as 'testing of the robustness of the model through recognition of its imperfections'. Sensitivity analysis shows how the simulation results change under different settings of the parameter estimates. If the model's output is shown to change little with adjusted parameter estimates, then the results can be considered robust and more confidence can be placed in the forecasts and policy analyses. Conversely, if the simulation results are shown to differ substantially with changes to unsure parameter estimates, then the forecasts and policy impacts should be treated with caution. In this section, the results from a number of sensitivity analyses are reported, based on the discussion and a procedure outlined by Anderson.

9.2 Procedure

Complete testing of the model's sensitivity to changed parameters requires performing an almost infinite number of analyses. The dimensionality of reporting the results can easily get out of hand in terms of, (i) the number of unsure parameters, (ii) the number of performance variables, (iii) the number of accounting intervals, and (iv) the number of measures of sensitivity. Therefore, it is necessary to limit the analysis by selecting a subset of all the possible analyses. The selection for the fiber model relate to each of (i)-(iv) above and are discussed briefly below.

Changes in unsure parameters were confined to equations explaining five key variables in the model--the world cotton price, per capita total fiber use in the United States, cotton production in China, the world polyester price, and world non-cellulosic fibers production. These were considered the most important equations in determining the simulation results. The choice of performance variables was limited to cotton and non-cellulosic fibers prices, world production, and world consumption. These were selected as variables of most interest in the policy analysis and forecasting exercises. Following Anderson, the accounting interval by which parameters were changed is one standard deviation. In each equation, a single parameter--that of an important explanatory variable--was changed by this amount in each direction[1]. Sensitivity to changing parameters on the performance variables is measured by merely reporting the results from the models with changed parameters along side the original model results. This allows the absolute changes and percentage changes in the performance variables to be assessed with ease.

---

[1] Initially, for each equation, all parameters were changed one standard deviation in the direction giving the greatest change in the performance (independent) variable (i.e., to increase the value of a performance variable, parameters with a positive coefficient were raised by one standard deviation, while those with a negative coefficient were lowered by one standard deviation). However, for some equations it was found that the models failed to converge when all parameters were adjusted. For example, the cotton price equation is estimated in terms of logarithms. Adjusting all the coefficients by one standard deviation resulted in huge changes in CTPWOR when the exponential was taken. This suggests that the model is highly sensitive to the parameter estimates of this equation.

9.3 Results

9.3.1 Sensitivity of Results to the Equation Explaining World Cotton Price

The equation explaining the world cotton price (equation 5.7) is,

LN CTPWOR = 7.24 - 0.78 LN CTESWORXCHI + 0.92 LN MUV + 0.31 LN CTCONWORXCHI - 0.86 LN TIME (5.7)
(-6.32) (5.12) (1.75) (-3.33)

R-SQUARED (CORR): 0.94 SEE: 0.03 DW: 2.09 PERIOD OF FIT: 1964-88

Where: CTPWOR = World cotton price (Outlook Index "A"),
CTESWORXCHI = World cotton stocks excluding stock held in China (also see equation 5.8),
MUV = Manufacturing unit value[2],
CTCONWORXCHI = World cotton consumption excluding consumption of China (also see equation 5.9),
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

A base model was simulated with parameters set at these levels. Sensitivity of the model's results to the parameter estimate on the stocks variable (CTESWORXCHI) was tested by increasing and decreasing it by one standard deviation, giving high and low simulated values of CTPWOR. To raise CTPWOR, the cotton price equation was adjusted as shown in equation 9.1., and substituted for equation 5.7. This created a new model (model A) which was then simulated for policy analyses and forecasts.

LN CTPWOR = 7.24 - 0.66 LN CTESWORXCHI + 0.92 LN MUV + 0.31 LN CTCONWORXCHI - 0.86 LN TIME (9.1)

A second model (model B) was created by replacing equation 5.7 with equation 9.2 below. This contains a parameter adjustment on the stocks variable, giving low simulated values of the cotton price.

LN CTPWOR = 7.24 - 0.90 LN CTESWORXCHI + 0.92 LN MUV + 0.31 LN CTCONWORXCHI - 0.86 LN TIME (9.2)

---

[2]Unit value in US dollar terms of manufactures exported from the G-5 countries (France, Germany, Japan, United Kingdom and the United States) weighted proportionally to the countries' exports to the developing countries.

The results from the original and adjusted forecast simulations are reported in Table 9.1a. For 1990, the cotton price forecasted by model A is about 14% higher than by the base model. Similarly, the cotton price is about 14% lower in model B. Between 1995 and 2005, in all three models, the cotton price declines, and by the end of the sixteen -year simulation period, the cotton price forecasts from the adjusted models are about 12%-14% different from the base model forecasts. The narrowing of the gap between base and adjusted models is due to differences in the levels of the stocks variable in each case.

The results for cotton production are consistent with results for the cotton price. A higher forecast of the real cotton price by model A, leads to a higher cotton production forecast for 1990, increasing to 19,369 thousand tons, compared to 18,342 thousand tons forecasted by the base model. This is a difference of about 5.3% and this gap remains fairly stable over the sixteen-year simulation period. For model B, production forecasts are lower, with the difference never exceeding more than 6%.

Cotton consumption forecasts are consistent with the price forecast adjustments reported above. From the base model, for 1990, consumption is forecasted to be 18,043 thousand tons, increasing to 21,634 thousand tons in 2005. Model A gives a forecast of 19,906 thousand tons in 1990, increasing to 20,365 by the end of the sixteen-year forecast period, while using model B, the forecast are 19,179 thousand tons in 1990, and 20,903 thousand tons in 2005. Overall cotton consumption forecasts from the adjusted models are always within 5%-6% different from the base model forecasts.

Table 9.1a. Impact on Forecasts of Parameter Changes in the Equation Explaining the World Cotton Price.

Variable	1990	1995	2000	2005
World Cotton Price[1/]				
Base Model[2/]	133.0	119.1	117.7	116.1
Model A[3/]	151.6	135.8	134.2	132.4
Model B[4/]	114.4	102.4	101.2	99.8
World Cotton Consumption[5/]				
Base Model	18,043	19,151	20,328	21,634
Model A	16,906	17,971	19,127	20,365
Model B	19,179	20,330	21,528	22,903
World Cotton Production[5/]				
Base Model	18,342	19,517	20,626	21,826
Model A	19,369	20,429	21,746	22,999
Model B	17,315	18,429	19,505	20,652
World Polyester Price[1/]				
Base Model	117.6	112.8	127.0	149.9
Model A	122.9	118.5	133.8	158.3
Model B	112.3	107.1	120.7	141.5
World Non-Cellulosic Consumption[5/]				
Base Model	13,770	15,706	17,219	18,615
Model A	13,091	14,819	16,166	17,427
Model B	14,449	16,593	18,272	19,803
World Non-Cellulosic Production[5/]				
Base Model	14,870	16,806	18,319	19,715
Model A	15,003	16,991	18,533	19,961
Model B	14,737	16,621	18,105	19,469

[1/] Deflated by MUV, 1985=100.
[2/] Base Model - Model with parameters of the cotton price equation set at base model level (equation 5.7).
[3/] Model A - Model with parameters of the cotton price equation set according to equation 9.2.
[4/] Model B - Model with parameters of the cotton price equation set according to equation 9.3.
[5/] '000 metric tons.

The adjusted forecasts for the non-cellulosic fibers market are also reported in Table 9.1a. From model A, for 1990, the polyester price is about 4.5% higher than in the base model, while it is about 4.5% lower in model B. A similar trend in the polyester price forecasts was found using the adjusted cotton price equations. That is, the real price of polyester falls in the first part of the simulation period, and then increases after the mid-1990s. As a consequence of dynamic relationships captured in the model, the gap between the base forecasts and the adjusted forecasts narrows, so that by the end of the simulation period, there is about a 4.5% difference between the adjusted models and the base model. The non-cellulosic fibers production and consumption levels differ from the base model in a consistent manner with differences between the base and adjusted forecasts of the polyester price. Over the entire simulation period, the gap between the base and adjusted forecasts of non-cellulosic fibers production and consumption never exceeds 2%.

The results show that the model forecasts are fairly robust to changes in the parameter on the stocks variable in the cotton pricing equation. However, the price forecasts are more sensitive than the quantity forecasts, and the adjusted model cotton price forecast does differ by more than 15% from the base model in some years.

The effects of the parameter change in the cotton price equation on policy analysis are shown in Table 9.1b. In general, the results are fairly similar between the original and adjusted models. However, an interesting observation is that the policy effects are larger with model B than the base model, and smaller with model A. This is because, by adjusting the parameter on the stocks variable, creates a model that is more inelastic with respect to price (model B). Therefore, this model is relatively more sensitive to policy shocks, since price has too move more to equate consumption and production for any given quantity change. This results in larger policy effects. For example, taking the cotton price results for simulation 2, we observe that the impact, average and final percentage changes are 5.07, 9.16 and 12.6, respectively. For the more inelastic model (model B), the equivalent results are 5.89, 11.37, and 15.79, respectively, and for the more elastic model

(model A) the results are 4.45, 7.50, and, 10.06, respectively.

Table 9.1b. Impact on Policy Analysis of Parameter Changes in the Equation Explaining the World Cotton Price 1/.

Variable	Simulation 2[2/]			Simulation 3[3/]			Simulation 4[4/]		
	Impact	Average	Final	Impact	Average	Final	Impact	Average	Final
World Cotton Price									
Base Model[5/]	5.07	9.16	12.60	-1.02	-10.10	-22.17	1.30	3.70	5.30
Model A[6/]	4.45	7.50	10.06	-0.89	-7.66	-16.66	1.14	4.23	4.12
Model B[7/]	5.89	11.37	15.79	-1.19	-13.33	-29.47	1.51	4.72	6.86
World Cotton Consumption									
Base Model	-0.19	-0.48	-0.80	0.04	0.42	0.91	-0.58	-0.19	-0.27
Model A	-0.20	-0.56	-0.95	0.04	0.51	1.11	-0.68	-0.14	-0.24
Model B	-0.18	-0.49	-0.84	0.04	0.45	0.98	-0.55	-0.12	-0.21
World Cotton Production									
Base Model	-2.07	-0.94	-0.69	1.82	1.84	1.53	-0.58	-0.31	-0.15
Model A	-1.96	-0.74	-0.46	1.72	1.76	1.41	-0.55	-0.26	-0.08
Model B	-2.19	-0.82	-0.51	1.93	1.95	1.57	-0.61	-0.29	-0.07
World Polyester Price									
Base Model	2.09	3.72	5.39	0.41	3.63	8.25	0.42	1.46	2.12
Model A	2.00	3.50	5.10	0.39	3.39	7.79	0.40	1.31	1.98
Model B	2.19	3.95	5.79	0.43	3.97	8.81	0.44	1.61	2.31
World Non-Cellulosic Consumption									
Base Model	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model A	0.00	0.36	0.47	0.00	0.31	0.59	0.00	0.13	0.16
Model B	0.01	0.34	0.42	0.00	0.27	0.52	0.00	0.14	0.16
World Non-Cellulosic Production									
Base Model	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model A	0.00	0.34	0.42	0.00	0.29	0.48	0.00	0.13	0.15
Model B	0.01	0.34	0.45	0.00	0.29	0.50	0.00	0.13	0.15

1/ Results reported in terms of percentage change between base and shock.
2/ Simulation 2 - 10% decrease in USSR cotton production.
3/ Simulation 3 - 10% increase in Chinese cotton production.
4/ simulation 4 - 10% decrease in U.S. cotton price.
5/ Base Model - Model with parameters of the cotton price equation set at the base model level (equation 5.7).
6/ Model A - Model with parameters of the cotton price equation set according to equation 9.2.
7/ Model B - Model with parameters of the cotton price equation set according to equation 9.3.

It is important to keep in mind that the results are reported in terms of percentage changes between base and shock simulations, and that different bases are used in each of the models. Therefore, the percent changes reflect changes in the levels of model forecast, as well as the change in the responsiveness of the model to different policy shocks. In general, however, the differences are fairly small, and would not lead to different policy conclusions or recommendations.

9.3.2 Sensitivity of Results to the Equation Explaining U.S. Per Capita Total Fiber Use

The equation explaining per capita total fiber use in the United States (equation 3.28) is,

$$PCTFUUSA = -191.0 + \underset{(7.79)}{23.1}\ LN\ PDGDPUSA - \underset{(-1.32)}{0.28}\ UNEMPUSA - \underset{(-1.65)}{1.21}\ DMFAI - \underset{(-3.42)}{2.30}\ DMFAII - \underset{(-3.12)}{2.74}\ DMFAIII \quad (3.28)$$

R-SQUARED (CORR): 0.82 SEE: 0.77 DW: 1.51 PERIOD OF FIT: 1964-1987

Where: PCTFUUSA = Per capita total fiber use, United States,
PDGDPUSA = per capita deflated gross domestic product, United States,
UNEMPUSA = Unemployment rate (%), United States,
DMFAI = Zero-one variable for MFAI period, equal 1 1974 to 1977 else 0,
DMFAII = Zero-one variable for MFAII period, equal 1 1978 to 1981 else 0,
DMFAIII = Zero-one variable for MFAIII period, equal 1 1982 to 1985 else 0,
LN = Indicates variable transformed into logarithms.

In the base model, parameters used in the equation explaining per capita total fiber use in the United States were set at levels reported in equation 3.28 above. In order to test the sensitivity of the model to uncertain parameter estimates, the coefficient on the per capita income variable (LN PDGDPUSA) was changed in both directions by one standard deviation and the adjusted models were simulated. The PCTFUUSA variable was adjusted in model A by replacing equation 3.28 with the US per capita total fiber use equation given by equation 9.3 below. This was equivalent to changing the income elasticity of total fiber use in the United States from 1.04 (see Table 3.3) to 1.1.

PCTFUUSA = - 191.0 + 26.06 LN PDGDPUSA - 0.28 UNEMPUSA - 1.21 DMFAI - 2.30 DMFAII - 2.74 DMFAIII (9.3)

To obtain low simulated values of PCTFUUSA, the US per capita income parameter was adjusted according to equation 9.4 below, giving rise to a new income elasticity for the United States of 0.98. This model (model B) was also simulated over the sixteen-year period.

PCTFUUSA = - 191.0 + 20.13 LN PDGDPUSA - 0.28 UNEMPUSA - 1.21 DMFAI - 2.30 DMFAII - 2.74 DMFAIII (9.4)

The forecasts from the three models are reported in Table 9.2a. The results from model A are for higher levels of per capita total fiber use in the United States. This change is equivalent to a right-ward shift of the cotton and non-cellulosic fibers demand curves of the United States and the world. (The slopes of the demand relationships are unchanged because the U.S. per capita income variable is exogenous in the model.) The forecast of cotton consumption in 1990 is adjusted upwards to 18,674 thousand tons, an increase of about 3.4% from the base level forecast. This is consistent with the fact that the United States consumes about 14% of world cotton and that the change in the coefficient causes the U.S. fiber consumption to increase about 24%.

The higher consumption forecast leads to higher price forecasts. For example, the cotton price forecast from model A in 1990 is 143.3, 7.7% higher than the forecast of 133.0 given by the base model. Throughout the sixteen-year simulation period, the gap between model A and the base model remains fairly constant at this percentage level. Forecasts using model B, give a similar proportional difference between the base model, but with lower consumption forecasts leading to lower price forecasts. As a consequence of higher price forecasts, the production forecasts from model A are higher also. Production is forecasted to be 18,342 thousand tons in the base model for 1990. Model A gives a forecast 3% higher at 18,912 thousand tons. Forecasts for 2005 from the base model and model A are 21,826 thousand tons and 22,466 thousand tons, respectively, an increase of 2.9%. Using model B, cotton production is expected to be lower than in the base model, by 2.5%-3.5% throughout the simulation period. The major conclusion emerging from this sensitivity analysis is that changing the income parameter in the per capita total fiber use equation does not result in large differences in the model cotton forecasts and therefore can be considered quite robust with respect to the income variable in the US per capita total fiber use equation.

The non-cellulosic fibers forecasts are reported in Table 9.2a. It is shown there that, for model A, higher total fiber consumption leads to greater consumption of non-cellulosic fibers, resulting in higher polyester price forecasts, which, on average, are also about 5% higher than in the base model forecasts. Differences in the non-cellulosic fibers production can be explained by differences in the polyester price forecasts. The results for model B are more or less symmetrical to those from model A. That is, higher fiber consumption forecasts, lead to higher price and production forecasts. The most striking feature of the differences between the results for the base and adjusted models is that they are almost identical, showing that the non-cellulosic fibers results are robust with respect to this parameter change.

Table 9.2a. Impact on Forecasts of Parameter Changes in the Equation Explaining U.S. Per Capita Total Fiber Use.

Variable	1990	1995	2000	2005
World Cotton Price[1/]				
Base Model[2/]	133.0	119.1	117.7	116.1
Model A[3/]	143.3	128.3	127.0	125.0
Model B[4/]	122.6	109.9	108.4	107.2
World Cotton Consumption[5/]				
Base Model	18,043	19,151	20,328	21,634
Model A	18,674	19,802	21,004	22,326
Model B	17,411	18,500	19,651	20,941
World Cotton Production[5/]				
Base Model	18,342	19,517	20,626	21,826
Model A	18,912	20,117	21,257	22,466
Model B	17,771	18,916	19,994	21,185
World Polyester Price[1/]				
Base Model	117.6	112.8	127.0	149.9
Model A	118.4	113.7	128.1	151.3
Model B	116.8	111.9	125.9	148.5
World Non-Cellulosic Consumption[5/]				
Base Model	13,770	15,706	17,219	18,615
Model A	13,662	15,562	17,041	18,412
Model B	13,878	15,850	17,397	18,818
World Non-Cellulosic Production[5/]				
Base Model	14,870	16,806	18,319	19,715
Model A	14,891	16,836	18,355	19,757
Model B	14,849	16,776	18,283	19,673

1/ Deflated by MUV, 1985=100.
2/ Base Model - Model with coefficient on the income variable in the equation explaining U.S. per capita total fiber use set at original level (equation 3.28).
3/ Model A - Model with parameters of the U.S. per capita total fiber use equation set according to equation 9.3.
4/ Model B - Model with parameters of the U.S. per capita total fiber use equation set according to equation 9.4.
5/ '000 metric tons.

The impacts on policy analysis of parameter changes in the equation explaining US per capita total fiber use are reported in Table 9.2b.

Table 9.2b. Impact on Policy Analysis of Parameter Changes in the Equation Explaining U.S. Per Capita Total Fiber Use 1/.

Variable	Simulation 2[2/]			Simulation 3[3/]			Simulation 4[4/]		
	Impact	Average	Final	Impact	Average	Final	Impact	Average	Final
World Cotton Price									
Base Model[5/]	5.07	9.16	12.60	-1.02	-10.10	-22.17	1.30	3.70	5.30
Model A[6/]	4.71	8.50	11.68	-0.95	-9.38	-20.55	1.21	3.43	4.91
Model B[7/]	5.50	9.93	13.68	-1.11	-10.95	-24.02	1.41	4.01	5.75
World Cotton Consumption									
Base Model	-0.19	-0.48	-0.80	0.04	0.42	0.91	-0.58	-0.19	-0.27
Model A	-0.18	-0.46	-0.77	0.04	0.41	0.88	-0.56	-0.18	-0.26
Model B	-0.20	-0.50	-0.83	0.04	0.43	0.94	-0.58	-0.20	-0.28
World Cotton Production									
Base Model	-2.07	-0.94	-0.69	1.82	1.84	1.53	-0.58	-0.31	-0.15
Model A	-2.01	-0.91	-0.67	1.77	1.79	1.49	-0.56	-0.30	-0.15
Model B	-2.14	-0.97	-0.71	1.88	1.90	1.58	-0.60	-0.32	-0.15
World Polyester Price									
Base Model	2.09	3.72	5.39	0.41	3.63	8.25	0.42	1.46	2.12
Model A	2.08	3.69	5.34	0.41	3.66	8.18	0.42	1.45	2.10
Model B	2.10	3.75	5.44	0.41	3.66	8.32	0.42	1.47	2.14
World Non-Cellulosic Consumption									
Base Model	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model A	0.00	0.34	0.42	0.00	0.29	0.55	0.00	0.13	0.16
Model B	0.00	0.36	0.44	0.00	0.31	0.53	0.00	0.13	0.16
World Non-Cellulosic Production									
Base Model	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model A	0.00	0.34	0.48	0.00	0.29	0.49	0.00	0.13	0.15
Model B	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15

1/ Results reported in terms of percentage change between base and shock.
2/ Simulation 2 - 10% decrease in USSR cotton production.
3/ Simulation 3 - 10% increase in Chinese cotton production.
4/ Simulation 4 - 10% decrease in U.S. cotton price.
5/ Base Model - Model with coefficient on the income variable in the equation explaining U.S. per capita total fiber use set at original level (equation 3.28).
6/ Model A - Model with parameters of the U.S. per capita total fiber use equation set according to equation 9.3.
7/ Model B - Model with parameters of the U.S. per capita total fiber use equation set according to equation 9.4.

As mentioned above, in model A, the parameter change causes an upward shift in the demand curves for cotton and non-cellulosic fibers, but involves no change in their slopes. Therefore, the impacts of each of the policies on the model's endogenous variables in

absolute values do not changed. However, the percentage changes are different, because the changes are measured from different base levels. For example, the absolute difference between the shock and base run for the base model is the same as the absolute difference between the shock and base run for model A and for model B. However, since the base run forecasts from the base model differ from the base run forecasts from the models A and B, the percentage changes are different. For example, using the base model, the impact elasticity of a 10% reduction in the USSR cotton production is to raise the world price of cotton 5.07% over the base run cotton price. In model A, the same absolute increase in the cotton price gives only a 4.71% increase in percentage terms, because the price forecasts from this model are higher.

In this respect, the results from this sensitivity analysis are less useful than others presented. However, it can be seen that there do not appear to be large differences between the model results, except with the possible exception of those for the cotton price.

9.3.3 Sensitivity of Results to the Equation Explaining Chinese Cotton Production

Another key variable in the model is cotton production in China. This was demonstrated in section 8.3, where the effects of a 10% increase in China's cotton production on the world fiber market were reported. To test the robustness of these results, forecast and policy simulations were undertaken to assess to what extent the model is sensitive to changes in the supply elasticity of Chinese cotton with respect to the cotton price. Recall that production in each region model is derived from the product of yield per

hectare and the total number of hectares. Therefore, it was necessary to change parameters in equations explaining both these variables. The equations explaining China's cotton production are given by 4.5 and 4.22 below.

CTYDCHI = - 2.58 + 0.003 DFCTPCHI - 0.001 DFFNPCHI + 1.15 LN TIME - 0.16 D88 (4.5)
(1.95) (-3.45) (9.20) (2.67)

R-SQUARED (CORR.): 0.95 SEE: 0.0289 DW: 2.31 PERIOD OF FIT: 1977-1988

Where:
CTYDCHI = Cotton yield, China (m.tons / hectare),
DFCTPCHI = Deflated cotton price, China,
DFFNPCHI = Deflated fertilizer price, China,
TIME = Time variable,
D88 = Zero-one variable, equals 1 in 1988, 0 otherwise,
LN = Indicates variable transformed into logarithms.

CTHACHI = 4705 + 26.21 DFCTPCHI(-1) + 1377 D84 - 1087 D86 (4.22)
(2.63) (3.28) (-2.67)

R-SQUARED (CORR.): 0.82 SEE: 383.0 DW: 2.32 PERIOD OF FIT: 1977-1988

Where:
CTHACHI = Cotton area, China,
DFCTPCHI = Deflated cotton price, China,
D84 = Zero-one variable, equals 1 in 1984, 0 otherwise,
D86 = Zero-one variable, equals 1 in 1986, 0 otherwise.

As in previous sensitivity analyses, a base model containing the equations 4.5 and 4.22 was simulated to provide base model forecasts and policy analysis results. Next, the base model was adjusted by replacing equations 4.5 and 4.22 with equations 9.5 and 9.6. These are shown below.

CTYDCHI = - 2.58 + 0.00453 DFCTPCHI - 0.001 DFFNPCHI + 1.15 LN TIME - 0.16 D88 (9.5)

CTHACHI = 4705 + 36.21 DFCTPCHI(-1) + 1377 D84 - 1087 D86 (9.6)

These differ from 4.5 and 4.22 in that the coefficient on the price variable (DFCTPCHI) in each equation is raised by one standard deviation. Using this model (model A), simulations for forecasts and policy analysis were undertaken and the results reported in Table 9.3.

In addition, a model B was created when equations 4.5 and 4.22 were replaced by 9.7 and 9.8 below. These contain parameters on the price variables lowered by one standard deviation.

$$CTYDCHI = -2.58 + 0.00146\ DFCTPCHI - 0.001\ DFFNPCHI + 1.15\ LN\ TIME - 0.16\ D88 \qquad (9.7)$$

$$CTHACHI = 4705 + 16.21\ DFCTPCHI(-1) + 1377\ D84 - 1087\ D86 \qquad (9.8)$$

The forecast of cotton production in China in 1990 from model A is about 6% higher than the base model forecast. Given that China produces about 22% of world production, total output increases by about 1.4% from 18,342 thousand tons to 18,599 thousand tons. Between 1990 and 2005, model A production forecasts are about 1.2% higher than in the base model. Higher production forecasts lead to lower price forecasts. For example, for 1990, the base model price forecast is 133.0, while the model A forecast is 128.3, a decrease of about 3.5%. The lower price forecast makes the cotton consumption forecast to be 0.5% higher at 18,327 thousand tons. Comparing the base model and model A, over the entire sixteen-year forecast period, the cotton price and world consumption are 2.1% lower and 0.4% higher, respectively. This indicates that the model forecasts are robust to changes in the supply elasticity of Chinese cotton.

Table 9.3a Impact on Model Forecasts of Parameter Changes in the Equation Explaining Chinese Cotton Production.

Variable	1990	1995	2000	2005
World Cotton Price[1/]				
Base Model[2/]	133.0	119.1	117.7	116.1
Model A[3/]	128.3	115.1	113.8	112.2
Model B[4/]	137.7	123.1	121.6	120.0
World Cotton Consumption[5/]				
Base Model	18,043	19,151	20,328	21,634
Model A	18,327	19,437	20,615	21,939
Model B	17,758	18,865	20,041	21,329
World Cotton Production[5/]				
Base Model	18,342	19,517	20,626	21,826
Model A	18,599	19,780	20,894	22,107
Model B	18,085	19,253	20,357	21,544
World Polyester Price[1/]				
Base Model	117.6	112.8	127.0	149.9
Model A	116.7	111.8	125.8	148.3
Model B	118.5	113.8	128.2	151.5
World Non-Cellulosic Consumption[5/]				
Base Model	13,770	15,706	17,219	18,615
Model A	13,649	15,547	17,025	18,394
Model B	13,891	15,865	17,413	18,836
World Non-Cellulosic Production[5/]				
Base Model	14,870	16,806	18,319	19,715
Model A	14,846	16,773	18,280	19,669
Model B	14,894	16,839	18,358	19,761

1/ Deflated by MUV, 1985=100.
2/ Base Model - Model with parameters of China's yield and area equations set at original levels (equations 4.5 and 4.22).
3/ Model A - Model with parameters of China's yield and area equations set according to equations 9.5 and 9.6.
4/ Model B - Model with parameters of China's yield and area equations set according to equations 9.7 and 9.8.
5/ '000 metric tons.

As seen in Table 9.3a, the impacts of this parameter change on the forecasts for the non-cellulosic fibers markets are very small. For model A, a lower cotton price forecast leads to lower consumption of non-cellulosic fibers, decreasing, on average over the 1990-2005 period, less than 1% below the base model forecasts. Less consumption results in a

lower polyester price forecast, also falling less than 1% below the base model forecast throughout the sixteen-year simulation period. Non-cellulosic production forecasts are lower for model A as a consequence of the lower polyester price forecast. These results indicate that the model is robust to changes in the made to the cotton price elasticity of supply in the China production equations.

The impacts of changing the cotton price parameters in the production equation in the China region of the model are shown in Table 9.3b. The effect of changing the price elasticity of supply in China is to change the slope of the supply curve of world cotton. In terms of a Marshallian supply-demand diagram, when the coefficient on the price variables are increased (model A), the supply curve becomes flatter so that the model becomes less responsive to policy shocks. Conversely, in model B, when the parameters are reduces, the world cotton supply curve becomes steeper, and the policy shocks will have larger effects on the model's endogenous variables.

Clearly from Table 9.3b the models' sensitivity to the parameter changes is small. For example, the results for the world cotton price for simulation two give, for the base model, impact, average and final elasticities of 5.07%, 9.16% and 12.60%, respectively. The equivalent results from model A are 5.26%, 9.27% and 12.64%, respectively; while for model B they are 4.90%, 9.06% and 12.56%. The differences are very small. The effects of the policy shocks based on model B are smaller in percentage terms, as a result of using a larger base, however, they show greater variability because of the lower cotton supply elasticity. Similarly, using model A, the percentage changes are larger due to the smaller base price levels, and are less variable, due to the higher cotton supply elasticity.

Table 9.3b Impact on Policy Analysis of Parameter Changes in the Equation Explaining Chinese Cotton Production 1/.

Variable	Simulation 2[2]			Simulation 3[3]			Simulation 4[4]		
	Impact	Average	Final	Impact	Average	Final	Impact	Average	Final
World Cotton Price									
Base Model[5]	5.07	9.16	12.60	-1.02	-10.10	-22.17	1.30	3.70	5.30
Model A[6]	5.26	9.27	12.64	-1.06	-9.98	-21.84	1.35	3.70	5.27
Model B[7]	4.90	9.06	12.56	-0.99	-10.81	-22.48	1.26	3.70	5.32
World Cotton Consumption									
Base Model	-0.19	-0.48	-0.80	0.04	0.42	0.91	-0.58	-0.19	-0.27
Model A	-0.19	-0.49	-0.82	0.04	0.43	0.94	-0.57	-0.17	-0.25
Model B	-0.19	-0.50	-0.84	0.04	0.45	0.97	-0.59	-0.17	-0.26
World Cotton Production									
Base Model	-2.07	-0.94	-0.69	1.82	1.84	1.53	-0.58	-0.31	-0.15
Model A	-2.04	-0.83	-0.57	1.79	1.82	1.50	-0.57	-0.29	-0.13
Model B	-2.10	-0.85	-0.58	1.85	1.89	1.54	-0.59	-0.30	-0.13
World Polyester Price									
Base Model	2.09	3.72	5.39	0.41	3.63	8.25	0.42	1.46	2.12
Model A	2.11	3.75	5.44	0.41	3.66	8.33	0.42	1.47	2.14
Model B	2.07	3.69	5.34	0.41	3.60	8.17	0.42	1.45	2.10
World Non-Cellulosic Consumption									
Base Model	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model A	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model B	0.00	0.35	0.43	0.00	0.30	0.55	0.00	0.13	0.16
World Non-Cellulosic Production									
Base Model	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model A	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model B	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15

1/ Results reported in terms of percentage change between base and shock.
2/ Simulation 2 - 10% decrease in USSR cotton production.
3/ Simulation 3 - 10% increase in Chinese cotton production.
4/ Simulation 4 - 10% decrease in U.S. cotton price.
5/ Base Model - Model with parameters of China's yield and area equations set at original levels (equations 4.5 and 4.22).
6/ Model A - Model with parameters of China's yield and area equations set according to equations 9.5 and 9.6.
7/ Model B - Model with parameters of China's yield and area equations set according to equations 9.7 and 9.8.

9.3.4 Sensitivity of Results to the Equation Explaining the World Polyester Price

The equation explaining the world polyester price (equation 6.16) is,

PSPWOR = 79.6 + 1.74 MUV - 0.05 NCUROW + 1.81 OILPR(-1) (6.16)
(6.83) (-5.66) (6.16)

R-SQUARED (CORR.): 0.96 SEE: 5.56 DW: 2.61 PERIOD OF FIT: 1969-88

Where: PSPWOR = Polyester price, World,
MUV = Manufactures unit value (deflator),
NCUROW = Non-cellulosic fibers use, Rest-of-the-World,
OILPR = Price of oil.

In the base model, parameters used in the polyester price equation were set at the values shown in equation 6.16 above. In order to test the sensitivity of the model to uncertain parameter estimates, the coefficient on the non-cellulosic fibers use in the Rest-of-the-World (NCUROW) was changed in each direction by one standard deviation. The new models created by these adjustments were simulated as before. The NCUROW variable was adjusted in Model A by replacing equation 6.16 by equation 9.9 shown below. This was equivalent changing the elasticity of demand for non-cellulosic fibers with respect to the price of polyester from -1.1 to -1.35.

PSPWOR = 79.6 + 1.74 MUV - 0.04 NCUROW + 1.81 OILPR(-1) (9.9)

To simulate the model for low values of PSPWOR, the non-cellulosic fibers use parameter in the equation was adjusted up according to equation 9.10 below, changing the elasticity of demand to -0.85. This model (model B) was also simulated over the sixteen-year period.

PSPWOR = 79.6 + 1.74 MUV - 0.06 NCUROW + 1.81 OILPR(-1) (9.10)

The results of the forecast simulation are reported in Table 9.4a. For 1990, the polyester price forecasted by model A is about 15% higher than by the base model. Similarly, the polyester price forecast is about 18% lower based on model B. All three models gave the same pattern of price movements. That is, a price decline between 1990 and 1995 ranging between 3.5% and 5% over the three models. Then price is predicted to increase to the year 2005 at similar growth rates. By 2005, the price forecast by model A is 14% above the base model forecast, and from model B the forecast is 16% below.

The results for non-cellulosic fibers production are consistent with price forecasts. The higher forecasted prices by model A lead to higher production forecasts--approximately 3% higher in each year reported in Table 9.4a. A decline of about 3% below the base model forecasts of non-cellulosic fibers production is reported for model B. Non-cellulosic fibers consumption forecasts are consistent with the price forecast adjustments reported above. From the base model, for 1990, consumption is forecasted to be 13,770 thousand tons, increasing to 18,615 thousand tons in 2005. Model A gives a forecast of 11,498 thousand tons, increasing to 15,644 thousand tons by the end of the sixteen-year simulation period, while using model B, the forecasts are 16,042 thousand tons in 1990, and 21,586 thousand tons in 2005. Overall, non-cellulosic fibers consumption forecasts from the adjusted models are consistently less than 20% different from the base model forecasts.

Table 9.4a Impact on Model Forecasts of Parameter Changes in the Equation Explaining the World Polyester Price.

Variable	1990	1995	2000	2005
World Cotton Price[1/]				
Base Model[2/]	133.0	119.1	117.7	116.1
Model A[3/]	195.3	167.1	161.8	156.7
Model B[4/]	70.0	71.1	73.6	75.5
World Cotton Consumption[5/]				
Base Model	18,043	19,151	20,328	21,634
Model A	14,237	15,757	17,111	18,461
Model B	21,849	22,545	23,545	24,807
World Cotton Production[5/]				
Base Model	18,342	19,517	20,626	21,826
Model A	21,781	22,646	23,627	24,759
Model B	14,903	16,388	17,625	18,893
World Polyester Price[1/]				
Base Model	117.6	112.8	127.0	149.9
Model A	135.2	129.1	145.1	170.9
Model B	100.0	96.4	108.9	128.9
World Non-Cellulosic Consumption[5/]				
Base Model	13,770	15,706	17,219	18,615
Model A	11,498	13,155	14,397	15,644
Model B	16,042	18,257	20,040	21,586
World Non-Cellulosic Production[5/]				
Base Model	14,870	16,806	18,319	19,715
Model A	15,361	17,340	18,893	20,330
Model B	14,424	16,272	17,744	19,099

1/ Deflated by MUV, 1985=100.
2/ Base Model - Model with parameters of the polyester price equation set at original level (equation 6.16).
3/ Model A - Model with parameters of the polyester price equation set according to equation 9.9.
4/ Model B - Model with parameters of the polyester price equation set according to equation 9.10.
5/ '000 metric tons.

The adjusted forecasts for the cotton market are also reported in Table 9.4a. From model A, for 1990, the cotton price is about 47% higher than in the base model, while it is about 47% lower in model B. These differences between the base and adjusted models are fairly constant between 1990 and 2005. These differences between base and adjusted model results are the largest reported so far in the sensitivity analysis exercise. The reason

for these large differences is due to the inelastic supply of cotton. The higher polyester price forecasts made with model A lead to lower non-cellulosic fibers consumption forecasts, and to higher cotton consumption forecasts. This can be thought of as a shift to the right of the demand curve for cotton, and given an inelastic supply curve (i.e., one that is steeply sloping), price has to increase substantially for the market clearing identity in the model to hold. The cotton production and consumption forecasts differ from the base model in a consistent manner with the differences between the base and adjusted forecasts of cotton prices. Over the entire simulation period, the gap between the base and adjusted forecasts of cotton production and consumption never exceeds 30%.

The major conclusion to emerge from this analysis is that the non-cellulosic fiber results are fairly robust to the specification of the polyester price equation, with the difference between base and adjusted model forecasts never exceeding 20%. However, different consumption forecasts in the cotton component of the model give rise to substantial differences between the models.

The effects of the parameter changes in the polyester price equation on policy analysis are shown in Table 9.4b. As in section 9.3.1, increasing of the parameter in the non-cellulosic fibers use equation causes the non-cellulosic fibers component of the model to become more elastic, resulting in smaller percentage changes than in the base model for the policy shocks. Conversely, the policy effects are larger because lowering the parameter makes the model more inelastic with respect to price. Also, as pointed out earlier, the percent changes are measured from different base levels, so that the policy impacts appear smaller for variables whose base values have increased, and larger for variables with lower base values.

Table 9.4b Impact on Model Policy Analysis of Parameter Changes in the Equation Explaining the World Polyester Price 1/.

Variable	Simulation 2[2/]			Simulation 3[3/]			Simulation 4[4/]		
	Impact	Average	Final	Impact	Average	Final	Impact	Average	Final
World Cotton Price									
Base Model[5/]	5.07	9.16	12.60	1.02	-10.10	-22.17	1.30	3.70	5.30
Model A[6/]	3.45	6.53	9.17	0.69	-7.20	-16.13	0.29	2.64	3.86
Model B[7/]	9.63	15.34	20.15	1.94	-16.92	-35.45	2.47	6.20	8.48
World Cotton Consumption									
Base Model	-0.19	-0.48	-0.80	0.04	0.42	0.91	-0.58	-0.19	-0.27
Model A	-0.24	-0.58	-0.95	0.05	0.51	1.08	-0.74	-0.23	-0.32
Model B	-0.16	-0.41	-0.69	0.03	0.36	0.79	-0.48	-0.16	-0.23
World Cotton Production									
Base Model	-2.07	-0.94	-0.69	1.82	1.84	1.53	-0.58	-0.31	-0.15
Model A	-1.74	-0.81	-0.60	1.53	1.59	1.34	-0.49	-0.27	-0.13
Model B	-2.55	-1.12	-0.81	2.24	2.19	1.79	-0.71	-0.37	-0.18
World Polyester Price									
Base Model	2.09	3.72	5.39	0.41	3.63	8.25	0.42	1.46	2.12
Model A	1.82	3.39	5.01	0.36	3.45	7.91	0.37	1.37	2.00
Model B	2.46	4.16	5.90	0.48	3.87	8.71	0.49	1.59	2.27
World Non-Cellulosic Consumption									
Base Model	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model A	0.00	0.38	0.46	0.00	0.32	0.58	0.00	0.14	0.17
Model B	0.00	0.27	0.33	0.00	0.23	0.42	0.00	0.10	0.12
World Non-Cellulosic Production									
Base Model	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model A	0.00	0.30	0.35	0.00	0.25	0.43	0.00	0.11	0.13
Model B	0.00	0.32	0.37	0.00	0.27	0.46	0.00	0.12	0.14

1/ Results reported in terms of percentage change between base and shock.
2/ Simulation 2 - 10% decrease in USSR cotton production.
3/ Simulation 3 - 10% increase in Chinese cotton production.
4/ Simulation 4 - 10% decrease in U.S. cotton price.
5/ Base model - Model with parameters of the polyester price equation set at original level (equation 6.16).
6/ Model A - Model with parameters of the polyester price equation set according to equation 9.9.
7/ Model B - Model with parameters of the polyester price equation set according to equation 9.10.

In general, the differences in policy effects between the base and adjusted models is fairly slight. This shows that, overall, the model is robust with respect to changing the demand elasticity of non-cellulosic fibers with respect to the price of polyester.

9.3.5 Sensitivity of Results to the Equation Explaining World Non-Cellulosic Fibers Production

The final sensitivity analysis is for the production of non-cellulosic fibers. To test the robustness of the results, forecasts and policy simulations were undertaken to assess the extent to which the model is sensitive to changes in the supply elasticity of world non-cellulosic fibers with respect to the price of polyester. The equation explaining world non-cellulosic fibers production (equation 6.15) is,

$$NCPROD = -27116 - 4397.\ DFOILPR - 127.6\ RIRUSA + 1077.\ DFPSPWOR(-1) + 12211.\ LN\ TIME \qquad (6.15)$$
$$(-2.77) \qquad (-2.53) \qquad (5.49) \qquad (13.18)$$

R-SQUARED (CORR.): 0.99 SEE: 488.7 DW: 1.65 PERIOD OF FIT: 1964-88

Where: NCPROD = Non-cellulosic fibers production, world,
DFOILPR = Deflated price of oil, (OPEC petroleum average prices),
RIRUSA = Real rate of interest (long term U.S. bond yield),
DFPSPWOR = Deflated polyester price,
TIME = Time variable,
LN = Indicates variable transformed into logarithms.

As in earlier sensitivity analyses, a base model containing equation 6.15 was simulated to provide base model forecast and policy analysis results. Next, the base model was adjusted by replacing equation 6.15 with equation 9.11 below.

$$NCPROD = -27116 - 4397\ DFOILPR - 127.6\ RIRUSA + 1273\ DFPSPWOR(-1) + 12211\ LN\ TIME \qquad (9.11)$$

This differs from equation 6.15 in that the coefficient on the price variable (DFPSPWOR) is raised by one standard deviation. Using this model (model A), simulations for forecasts and policy analysis were undertaken and the results reported in Table 9.5.

In addition, a model B was created when equation 6.15 was replaced by equation 9.12 below. This contains a parameter on the price variable lowered by one standard

deviation.

$$NCPROD = - 27116 - 4397\ DFOILPR - 127.6\ RIRUSA + 881\ DFPSPWOR(-1) + 12211\ LN\ TIME \quad (9.11)$$

The results of the forecast simulation are reported in Table 9.5a. Between 1990 and 2005, forecasts of non-cellulosic fibers production by model A are about 2.5% higher than in the base model. Higher production forecasts lead to lower price forecasts. For example, for 1990, the base model polyester price forecast is 117.6, while the model A forecast is 105.8, a decrease of about 11%. The lower price forecast makes the non-cellulosic fibers consumption forecast to be 0.5% lower at 15,285 thousand tons. Comparing the base model and model A, over the entire sixteen-year forecast period, the polyester price and world non-cellulosic fibers consumption are 9.5% lower and 8% higher, respectively. This indicates that the model forecasts are fairly robust to changes in the production elasticity of non-cellulosic fibers.

As seen in Table 9.5a, the impact of this parameter change on the forecasts for the cotton markets is quite large. The reasons for this were given in section 9.3.4. For model A, a lower polyester prices leads to lower cotton consumption, decreasing, on average over the 1990-2005 period, about 12% below the base model forecasts. Lower cotton consumption results in a lower cotton price, falling as much as 34% below the base model forecast during the sixteen-year simulation period. Cotton production forecasts are lower for model A as a consequence of the lower cotton price forecasts. These results indicate that the model is quite sensitive to the changes made to the price elasticity of supply of non-cellulosic fibers.

Table 9.5a Impact on Forecasts of Parameter Changes in the Equation Explaining the World Non-Cellulosic Fibers Production.

Variable	1990	1995	2000	2005
World Cotton Price[1]				
Base Model[2]	133.0	119.1	117.7	116.1
Model A[3]	86.8	87.7	90.1	91.4
Model B[4]	179.2	250.5	145.3	140.8
World Cotton Consumption[5]				
Base Model	18,043	19,151	20,328	21,634
Model A	20,862	21,375	22,340	19,704
Model B	15,224	16,927	18,316	23,564
World Cotton Production[5]				
Base Model	18,342	19,517	20,626	21,826
Model A	20,890	21,567	22,503	23,610
Model B	15,795	17,467	18,749	20,042
World Polyester Price[1]				
Base Model	117.6	112.8	127.0	149.9
Model A	105.8	103.0	116.6	138.1
Model B	129.4	122.6	137.4	161.7
World Non-Cellulosic Consumption[5]				
Base Model	13,770	15,706	17,219	18,615
Model A	15,285	17,232	18,839	20,280
Model B	12,255	14,180	15,599	16,950
World Non-Cellulosic Production[5]				
Base Model	14,870	16,806	18,319	19,715
Model A	15,242	17,125	18,649	20,060
Model B	14,498	16,487	17,989	19,370

1/ Deflated by MUV, 1985 = 100.
2/ Base model - Model with parameters of non-cellulosic production equation set at original level (equation 6.15).
3/ Model A - Model with parameters of non-cellulosic production equation set according to equation 9.11.
3/ Model B - Model with parameters of non-cellulosic production equation set according to equation 9.12.
4/ '000 metric tons.

The impacts of changing the polyester price parameter in the non-cellulosic fibers production equation model are shown in Table 9.5b. The results are similar to those reported in section 9.3.4 and in Table 9.4. In general, the results show that the non-cellulosic fibers component of the model fairly is robust to these made, while the cotton component shows more variation for the different models.

Table 9.5b Impact on Policy Analysis of Parameter Changes in the Equation Explaining the World Non-Cellulosic Production 1/.

Variable	Simulation 2[2]			Simulation 3[3]			Simulation 4[4]		
	Impact	Average	Final	Impact	Average	Final	Impact	Average	Final
World Cotton Price									
Base Model[5]	5.07	9.16	12.60	1.02	-10.10	-22.17	1.30	3.70	5.30
Model A[6]	7.77	11.61	14.98	-1.56	-10.10	-22.17	1.99	4.54	6.14
Model B[7]	3.76	6.78	9.29	-0.76	-6.91	-15.39	0.96	2.64	3.81
World Cotton Consumption									
Base Model	-0.19	-0.48	-0.80	0.04	0.42	0.91	-0.58	-0.19	-0.27
Model A	-0.16	-0.47	-0.81	0.03	0.43	0.95	-0.50	-0.12	-0.20
Model B	-0.33	-0.59	-0.99	0.05	0.53	1.15	-0.69	-0.15	-0.25
World Cotton Production									
Base Model	-2.07	-0.94	-0.69	1.82	1.84	1.53	-0.58	-0.31	-0.15
Model A	-2.04	-0.86	-0.53	2.11	2.06	1.64	-0.30	-0.30	-0.09
Model B	-1.82	-0.70	-0.44	1.60	1.69	1.36	-0.51	-0.24	-0.08
World Polyester Price									
Base Model	2.09	3.72	5.39	0.41	3.63	8.25	0.42	1.46	2.12
Model A	2.32	4.07	5.57	0.40	7.98	8.99	0.47	1.60	2.31
Model B	1.90	3.47	4.78	0.37	3.34	7.63	0.38	1.34	1.96
World Non-Cellulosic Consumption									
Base Model	0.00	0.35	0.43	0.00	0.30	0.54	0.00	0.13	0.16
Model A	0.00	0.37	0.45	0.00	0.21	0.57	0.00	0.14	0.17
Model B	0.00	0.45	0.55	0.00	0.38	0.69	0.00	0.17	0.20
World Non-Cellulosic Production									
Base Model	0.00	0.34	0.40	0.00	0.29	0.49	0.00	0.13	0.15
Model A	0.00	0.33	0.39	0.00	0.28	0.48	0.00	0.13	0.15
Model B	0.00	0.35	0.41	0.00	0.30	0.50	0.00	0.13	0.15

1/ Results reported in terms of percentage change between base and shock.
2/ Simulation 2 - 10% decrease in USSR cotton production.
3/ Simulation 3 - 10% increase in Chinese cotton production.
4/ Simulation 4 - 10% decrease in U.S. cotton price.
5/ Base Model - Model with parameters of non-cellulosic production equation set at original level (equation 6.15).
6/ Model A - Model with parameters of non-cellulosic production equation set according to equation 9.11.
7/ Model B - Model with parameters of non-cellulosic production equation set according to equation 9.12.

9.4 Conclusions

In this section, the results from a number of sensitivity analysis were reported and discussed. The procedure used was one proposed by Anderson, and the analysis was limited to changing a few important parameters in the model and seeing how they impacted on a small number of key performance variables.

Overall, the conclusion which emerged from these sensitivity tests is that the model is fairly robust to the unsure parameters tested. However, the analysis showed the importance of having accurate parameter estimates for equations estimated in logarithms, since small errors in logarithms become magnified considerably when the exponential is taken. Also, the inelasticity of demand and supply caused price forecasts to be different, by sometimes large amounts, for relatively small changes in quantity forecasts.

10. Summary, Conclusions and Areas of Future Research

10.1 Summary

The main purpose of this study was to specify and estimate an econometric model of the world fiber market, with emphasis on the cotton sector, and then, after testing and validation of the model, to forecast prices, production and consumption for the major world fiber market participants. In addition to forecasting, the model was used to estimate the impact of some important market and policy developments. Model simulations were undertaken to analyze: (i) the impact of the expected expansion of China's cotton production; (ii) the impact of continued stagnation in the USSR cotton sector; (iii) the likely effect of the cotton provisions contained in the 1990 Farm Bill on the world fiber market; and (iv) the impact of the MFA on the raw fiber market. Analysis of these developments provide timely and relevant information for many groups and individuals with interests in the fiber market. In section II, the nature of the fiber market was described along with recent trends and market developments. This description provided the basis for the model specifications presented in later sections (e.g., world price determination, choice of model production and consumption regions, and treatment of textile demand).

In section 3, the cotton demand component of the model was discussed. For each demand region in the model, two equations were estimated. The first was for per capita total fiber use which was specified to be related to per capita income. In the second, the cotton share of total fiber use was estimated as a function of the cotton price

relative to the polyester price. This specification captures the price sensitivity of manufacturers to changes in the relative prices of fibers. The econometric results were satisfactory and provided price elasticity measures ranging from -0.02 for India to -0.33 for the Republic of Korea. These conform closely to price elasticity estimates reported in previous studies. The income elasticity estimates ranged from 0.12 for Turkey to 1.08 for the EEC. These also were similar to income estimates found in other studies.

The production component of the model was described in section 4. Based on previous econometric studies of annual crop production, cotton production in the model was derived from the production of area planted and average yield. Each of these components was estimated separately. Area planted equations contain as regressors the price of cotton and the price of crops in competition with cotton for farm acreage, as well as lagged area, based on the assumption that producers form price expectation adaptively. In the yield equations, weather variables were used if the data were available and were significant in most cases. The short-run supply elasticity estimates ranged from 0.07 for the north region of India and 0.87 for Argentina.

The model was closed by formulating a cotton pricing equation as an inverted world stocks demand equation. This was discussed in section 5. In an earlier formulation of the model, the world price was solved using a world market clearing identity. This did not perform well in simulation and an alternative approach was adopted involving the use of a price equation. The world price of cotton was specified as a function of world stocks, net of stocks held in China. This was because, historically, a large proportion of stocks in this country were isolated from the world market. In addition to world stocks, world cotton consumption (net of Chinese consumption) was included in the equation to capture the transactions demand and gave an estimated flexibility of cotton price with respect to stock levels of -0.78.

The non-cellulosic fibers component of the model was presented in section 6. Only equations for the non-cellulosic fibers (polyester, rayon and acrylics) were estimated. However this fiber group makes up almost 80% of the non-cellulosic fibers market. Non-cellulosic share of total fiber use equations were estimated for each consumption region of the model, which were then combined with total fiber use to determine non-cellulosic fibers consumption. The supply of non-cellulosic fibers was estimated for the world. The polyester price was determined in an inverted demand equation for non-cellulosic fibers in the rest-of-the-world region and influences the cotton market through the cotton share of total fiber use equations.

A number of validation statistics were presented in section 7 that cover various aspects of the model's ability to reproduce actual data. The validation statistics reported were: (i) the Root Mean Squared Percentage Error (RMSPE), (ii) the Mean Squared Error (MSE), (iii) Theil's U-statistic, and (iv) graphical validation. In general, the model withstood these testing procedures and predicted actual market values accurately enough to be used for policy experiments and forecasting.

The forecast and policy simulation results were reported in section 8. Five sets of simulation results were presented. These were for (i) a forecast of price, production and consumption for the period 1990-2005; (ii) a 10% decrease in cotton production in the USSR; (iii) a 10% increase in cotton production in China, (iv) a 10% decline in domestic cotton price in the United States, (v) an evaluation of the impact of MFA on the cotton and non-cellulosic fibers sectors. Finally, in section 9, sensitivity analysis of the model was presented, indicating the model's robustness to changing parameter estimates.

10.2 Conclusions

In general, the study met the research objectives outlined in section I. A model of the world fiber market was developed and provided a number of important insights into how the world fiber market operates and where it might be headed in the future.

The model forecasts that between 1990 and 2005 the real world price of cotton will fall approximately 25%, while a 10% price increase is forecast for polyester. This suggests that cotton should maintain, or even expand, its share of the total fiber market in the coming decade. The forecast simulation results also show that the individual countries' shares of both production and consumption of cotton and non-cellulosic fibers change very little up to 2005. However, to some extent, this results from the fact that the exogenous variables used for forecasting are based on constant growth rates through to 2005.

Three model simulations involved shocking key variables in major producing regions (i.e., the USSR, China and the United States). In each case, the effect on the world market was significant. For example, given a permanent 10% decrease in production in the USSR, the world price rises by about 9%. This indicates that forecasts of price, both near- and long-term, should include information on USSR cotton policy and producer incentive structures. Over an 11-year simulation of the model, for every 1% increase in China's production the world price of cotton falls, on average, about 1% and the price of polyester falls 0.35%. The impact of a 10% decline in the US cotton price during the early 1990s was to reduce US production, on average, less than 3%, and to increase world prices an average of 3.7%.

The conclusion emerging from the MFA simulation is that, while the effect of the MFAs have been substantial in terms of welfare losses and economic inefficiency in the T&A manufacturing and trade sectors, the effects on the raw fiber market have not been large. World prices of cotton and polyester were reduced by, on average, about 5% between 1979 and 1986 (within a range between 3% and 7%), although the period of analysis does not cover the most restrictive period since 1986. Therefore, the current impact of the agreements on world fiber prices is likely to be at the upper end of this range.

10.3 Areas of Future Research

A number of areas have been identified for improving the model and for further policy simulations using the model. Some of these areas are listed briefly below.

While a large proportion of world production and consumption is covered by the regions already included in the model, more countries will be added in the future. In particular, some of the major African countries will be included, such as the Sudan, Nigeria and other West African countries. This will allow the effects of exogenous world market shocks on the cotton sectors in these countries to be measured.

While cotton and non-cellulosic fibers make up about 90% of the world fiber market, cellulosic fibers and wool are also important, especially for the major producers of these commodities (e.g., Australia and New Zealand in the production of wool). Given the framework on the demand side of the model, the inclusion of these fibers would be relatively simple, requiring the estimation of share equations which could then be combined with the total fiber use equations to derive demand.

Another area of future work will be to obtain and incorporate into the model more country-specific data such as local prices, regional production and weather information. As reported in section 4, the use of local price data (e.g., in China) and the breakdown of country production into specific regions (e.g., India and the United States) improved the estimation results dramatically. Also, the inclusion of more weather variables in the yield equations is likely to improve the quality of these equations, as in the case of the US and India yield equations.

To meet the objectives outlined in section I, trade and stock demand equations were not needed in the model. However, within the framework of the model these could be added easily. In fact, by using country market clearing identities, either a stock or net export equation need be estimated and the remaining variable derived from the identity. In practice, the estimation of these equations may prove troublesome. In an initial specification of the model, country-level stock equations were tried but performed unsatisfactorily with the price insignificant in most equations. Also, trade equations are problematic because it is not possible to determine a priori the sign on the price variable if included in the specification.

In the current version of the model the production of non-cellulosic fibers is estimated at the world level. At a later stage world production will be disaggregated and equations estimated for each of the major producing areas of the world. This is important as many developing countries are increasing their non-cellulosic fiber production capacity (e.g., China, India and Pakistan) and it will be important to assess the impact of this development on the world fiber market in the future.

Given the unpredictability of cotton yields, production often fluctuates widely from year to year. It is possible to include a stochastic element into the yield equations and then to simulate the model. When the simulation is repeated a number of times the variances of the endogenous model variables can be estimated. This provides interesting information such as the likelihood that a certain market outcome (e.g., a given production or price level) will occur.

APPENDICES

APPENDIX A

VARIABLE DEFINITIONS

APPENDIX A

Variable Definitions

Endogenous

CTCONCHI = Cotton Consumption ('000 tons), China.
CTCONWOR = Cotton Consumption ('000 tons), World.
CTCONWORXCHI = World Cotton Consumption less China Consumption ('000 tons).

CTESCHI = Cotton Ending Stocks ('000 tons), China.
CTESWOR = Cotton Ending Stocks ('000 tons), World.
CTCONWORXCHI = World Ending Stocks less China Ending Stocks ('000 tons).

CTHAARG = Cotton area (number of hectares), Argentina.
CTHAAUS = Cotton area (number of hectares), Australia.
CTHABRA = Cotton area (number of hectares), Brazil.
CTHACAF = Cotton area (number of hectares), Central Africa.
CTHACHI = Cotton area (number of hectares), China.
CTHAEGY = Cotton area (number of hectares), Egypt.
CTHAINDN = Cotton area (number of hectares), North India.
CTHAINDS = Cotton area (number of hectares), South India.
CTHAINDW = Cotton area (number of hectares), West India.
CTHAMEX = Cotton area (number of hectares), Mexico.
CTHAPAKP = Cotton area (number of hectares), Punjab Pakistan.
CTHAPAKS = Cotton area (number of hectares), Sind Pakistan.
CTHATUR = Cotton area (number of hectares), Turkey.
CTHAUS1 = Cotton area (number of hectares), Delta Region, United States.
CTHAUS2 = Cotton area (number of hectares), Southeast Region United States.
CTHAUS3 = Cotton area (number of hectares), Southwest Region United States.
CTHAUS4 = Cotton area (number of hectares), West Region United States.

CTNECHI = Cotton Net Export ('000 tons), China.

CTPDWOR = Cotton production ('000 tons), World.
CTPRUS1 = Cotton Price, Delta Region, United States.
CTPRUS2 = Cotton Price, Southeast Region, United States.
CTPRUS3 = Cotton Price, Southwest Region, United States.
CTPRUS4 = Cotton Price, West Region, United States.

CTPRWOR = World Cotton Price, Outlook Index 'A' (c/kg).

CTSHARG = Cotton share of total fiber for home use, Argentina.
CTSHAUS = Cotton share of total fiber for home use, Australia.
CTSHBRA = Cotton share of total fiber for home use, Brazil.
CTSHCAF = Cotton share of total fiber for home use, Central Africa.
CTSHCHI = Cotton share of total fiber for home use, China.
CTSHEEC = Cotton share of total fiber for home use, EEC.
CTSHEGY = Cotton share of total fiber for home use, Egypt.
CTSHIND = Cotton share of total fiber for home use, India.
CTSHJPN = Cotton share of total fiber for home use, Japan.
CTSHKOR = Cotton share of total fiber for home use, Korea.
CTSHMEX = Cotton share of total fiber for home use, Mexico.
CTSHPAK = Cotton share of total fiber for home use, Pakistan.
CTSHTUR = Cotton share of total fiber for home use, Turkey.

CTSHUSA	= Cotton share of total fiber for home use, United States.
CTYDARG	= Cotton yield (tons per hectare), Argentina.
CTYDAUS	= Cotton yield (tons per hectare), Australia.
CTYDBRA	= Cotton yield (tons per hectare), Brazil.
CTYDCAF	= Cotton yield (tons per hectare), Central Africa.
CTYDCHI	= Cotton yield (tons per hectare), China.
CTYDEGY	= Cotton yield (tons per hectare), Egypt.
CTYDINDN	= Cotton yield (tons per hectare), North India.
CTYDINDS	= Cotton yield (tons per hectare), South India.
CTYDINDW	= Cotton yield (tons per hectare), West India.
CTYDMEX	= Cotton yield (tons per hectare), Mexico.
CTYDPAKP	= Cotton yield (tons per hectare), Punjab Pakistan.
CTYDPAKS	= Cotton yield (tons per hectare), Sind Pakistan.
CTYDTUR	= Cotton yield (tons per hectare), Turkey.
CTYDUS1	= Cotton yield (tons per hectare), Delta Region United States.
CTYDUS2	= Cotton yield (tons per hectare), Southeast Region United States.
CTYDUS3	= Cotton yield (tons per hectare), Southwest Region United States.
CTYDUS4	= Cotton yield (tons per hectare), West Region United States.
DFCTPARG	= Deflated cotton price, Argentina.
DFCTPAUS	= Deflated cotton price, Australia.
DFCTPBRA	= Deflated cotton price, Brazil.
DFCTPCAF	= Deflated cotton price, Central Africa.
DFCTPEEC	= Deflated cotton price, EEC.
DFCTPEGY	= Deflated cotton price, Egypt.
DFCTPIND	= Deflated cotton price, India.
DFCTPJPN	= Deflated cotton price, Japan.
DFCTPKOR	= Deflated cotton price, Korea.
DFCTPMEX	= Deflated cotton price, Mexico.
DFCTPPAK	= Deflated cotton price, Pakistan.
DFCTPTUR	= Deflated cotton price, Turkey.
DFCTPUS1	= Deflated cotton price, Memphis, United States
DFCTPUS2	= Deflated cotton price, Montgomery, United States
DFCTPUS3	= Deflated cotton price, Dallas, United States
DFCTPUS4	= Deflated cotton price, Fresno, United States
DFCTPUSA	= Deflated cotton price, United States.
DFPSPARG	= Deflated polyester staple price, Argentina.
DFPSPAUS	= Deflated polyester staple price, Australia.
DFPSPBRA	= Deflated polyester staple price, Brazil.
DFPSPCAF	= Deflated polyester staple price, Central Africa.
DFPSPCHI	= Deflated polyester staple price, China.
DFPSPEEC	= Deflated polyester staple price, EEC.
DFPSPEGY	= Deflated polyester staple price, Egypt.
DFPSPIND	= Deflated polyester staple price, India.
DFPSPJPN	= Deflated polyester staple price, Japan.
DFPSPKOR	= Deflated polyester staple price, Korea.
DFPSPMEX	= Deflated polyester staple price, Mexico.
DFPSPPAK	= Deflated polyester staple price, Pakistan.
DFPSPTUR	= Deflated polyester staple price, Turkey.
DFPSPUSA	= Deflated polyester staple price, United States.
DFPSPWOR	= Deflated polyester staple price, World.
NCPROD	= Non-Cellulosic Production ('000 tons), World.
NCSHARG	= Non-Cellulosic share of total fiber for home use, Argentina.
NCSHAUS	= Non-Cellulosic share of total fiber for home use, Australia.

NCSHBRA = Non-Cellulosic share of total fiber for home use, Brazil.
NCSHCAF = Non-Cellulosic share of total fiber for home use, Central Africa.
NCSHCHI = Non-Cellulosic share of total fiber for home use, China.
NCSHEEC = Non-Cellulosic share of total fiber for home use, EEC.
NCSHEGY = Non-Cellulosic share of total fiber for home use, Egypt.
NCSHIND = Non-Cellulosic share of total fiber for home use, India.
NCSHJPN = Non-Cellulosic share of total fiber for home use, Japan.
NCSHKOR = Non-Cellulosic share of total fiber for home use, Korea.
NCSHMEX = Non-Cellulosic share of total fiber for home use, Mexico.
NCSHPAK = Non-Cellulosic share of total fiber for home use, Pakistan.
NCSHTUR = Non-Cellulosic share of total fiber for home use, Turkey.
NCSHUSA = Non-Cellulosic share of total fiber for home use, United States.

PCTFUARG = Per capita total fiber use (kg), Argentina.
PCTFUAUS = Per capita total fiber use (kg), Australia.
PCTFUBRA = Per capita total fiber use (kg), Brazil.
PCTFUCAF = Per capita total fiber use (kg), Central Africa.
PCTFUCHI = Per capita total fiber use (kg), China.
PCTFUEEC = Per capita total fiber use (kg), EEC.
PCTFUEGY = Per capita total fiber use (kg), Egypt.
PCTFUIND = Per capita total fiber use (kg), India.
PCTFUJPN = Per capita total fiber use (kg), Japan.
PCTFUKOR = Per capita total fiber use (kg), Korea.
PCTFUMEX = Per capita total fiber use (kg), Mexico.
PCTFUPAK = Per capita total fiber use (kg), Pakistan.
PCTFUTUR = Per capita total fiber use (kg), Turkey.
PCTFUUSA = Per capita total fiber use (kg), United States.

PSPWOR = Price of polyester (US$/ton), World.

RCTFNPCAF = Ratio Cotton to Fertilizer Price, Central Africa.

Exogenous Variables

CTCONROW = Cotton Consumption ('000 tons), Rest of the World.
CTPDROW = Cotton Production ('000 tons), Rest of the World.

D66 = Annual dummy variable, equals 1 in 1966, 0 otherwise.
D67 = Annual dummy variable, equals 1 in 1967, 0 otherwise.
D68 = Annual dummy variable, equals 1 in 1968, 0 otherwise.
D69 = Annual dummy variable, equals 1 in 1969, 0 otherwise.
D70 = Annual dummy variable, equals 1 in 1970, 0 otherwise.
D71 = Annual dummy variable, equals 1 in 1971, 0 otherwise.
D72 = Annual dummy variable, equals 1 in 1972, 0 otherwise.
D73 = Annual dummy variable, equals 1 in 1973, 0 otherwise.
D74 = Annual dummy variable, equals 1 in 1974, 0 otherwise.
D75 = Annual dummy variable, equals 1 in 1975, 0 otherwise.
D76 = Annual dummy variable, equals 1 in 1976, 0 otherwise.
D77 = Annual dummy variable, equals 1 in 1977, 0 otherwise.
D78 = Annual dummy variable, equals 1 in 1978, 0 otherwise.
D79 = Annual dummy variable, equals 1 in 1979, 0 otherwise.
D80 = Annual dummy variable, equals 1 in 1980, 0 otherwise.
D81 = Annual dummy variable, equals 1 in 1981, 0 otherwise.
D82 = Annual dummy variable, equals 1 in 1982, 0 otherwise.
D83 = Annual dummy variable, equals 1 in 1983, 0 otherwise.
D84 = Annual dummy variable, equals 1 in 1984, 0 otherwise.
D85 = Annual dummy variable, equals 1 in 1985, 0 otherwise.
D86 = Annual dummy variable, equals 1 in 1986, 0 otherwise.

D87	= Annual dummy variable, equals 1 in 1987, 0 otherwise.
DFCGPARG	= Deflated coarse grain price, Argentina.
DFCGPAUS	= Deflated coarse grain price, Australia.
DFCTPCHI	= Deflated cotton price, China.
DFCTPINDN	= Deflated cotton price, Punjab, India.
DFCTPINDS	= Deflated cotton price, Karnataka, India.
DFCTPINDW	= Deflated cotton price, Maharashtra, India.
DFFNPBRA	= Deflated fertilizer price, Argentina.
DFFNPCHI	= Deflated fertilizer price, China.
DFFNPUSA	= Deflated fertilizer price, United States.
DFOILPR	= Deflated oil price, World
DFSBPUSA	= Deflated soybean price, United States.
DFSGPUSA	= Deflated sorghum price, United States.
DFRIPUSA	= Deflated rice price, United States.
DMFAI	= MFA dummy variable, equals 1 in 1974-77, 0 otherwise.
DMFAII	= MFA dummy variable, equals 1 in 1978-81, 0 otherwise.
DMFAIII	= MFA dummy variable, equals 1 in 1982-1985, 0 otherwise.
IRRPAK	= Irrigated area ('000 hectares), Pakistan.
IRRPAK	= Irrigated area ('000 hectares), Pakistan.
MUV	= Manufacturing Unit Value, World Bank.
OILPR	= Price of oil ($/bb1), OPEC.
PDGDPARG	= Per capita deflated GDP, Argentina.
PDGDPAUS	= Per capita deflated GDP, Australia.
PDGDPBRA	= Per capita deflated GDP, Brazil.
PDGDPCAF	= Per capita deflated GDP, Central Africa.
PDGDPCHI	= Per capita deflated GDP, China.
PDGDPEEC	= Per capita deflated GDP, EEC.
PDGDPEGY	= Per capita deflated GDP, Egypt.
PDGDPIND	= Per capita deflated GDP, India.
PDGDPJPN	= Per capita deflated GDP, Japan.
PDGDPKOR	= Per capita deflated GDP, Korea.
PDGDPMEX	= Per capita deflated GDP, Mexico.
PDGDPTUR	= Per capita deflated GDP, Turkey.
PDGDPUSA	= Per capita deflated GDP, United States.
RINDN	= Annual Rainfall (mm) North India.
RINDS	= Annual Rainfall (mm) South India.
RIRUSA	= Real interest rate (US T.Bill), United States.
RSPUS1	= Spring Rainfall Delta Region United States (inches).
RSUINDW	= Summer Rainfall (mm) West India.
SKRWUS1	= Dummy Variable for Skip Row Policy (equals 1 1966-67, otherwise 0).
SMUS3	= Soil Moisture Level, Southwest Region, United States.
TFLUS1	= Fall Temperature Delta Region United States (Degrees C).
TFLUS2	= Fall Temperature Southeast Region United States (Degrees C).
TFLUS3	= Fall Temperature Southwest Region United States (Degrees C).
TSMUS1	= Summer Temperature Delta Region United States (Degrees C).

TSMUS2	= Summer Temperature Southeast Region United States (Degrees C).
TSMUS3	= Summer Temperature Southwest Region United States (Degrees C).
TSMUS4	= Summer Temperature West Region United States (Degrees C).
TIME	= Time trend.
UNEMPEEC	= Unemployment Rate (%), EEC.
UNEMPUSA	= Unemployment Rate (%), United States.

APPENDIX B

EXOGENOUS VARIABLE ASSUMPTIONS FOR THE FORECAST PERIOD

APPENDIX B

Exogenous Variable Assumptions for the Forecast Period

1. Consumer Price Indexes and Exchange Rates.

For the forecast period, the assumption of purchasing power parity (PPP) was made. PPP argues that exchange rates move according to the differential between inflation rates in countries. For example, say US inflation rate is 10% greater than the Japanese inflation rate. PPP says that, over the long-run, the Japanese Yen will appreciate 10% against the US dollar. Therefore, the purchasing power of the two currencies stays the same. In the model, the consumer price indexes and exchange rates were constant at their 1989 level in the forecast period. This means that the model forecasts are generated in terms of real 1989 dollars.

2. Gross Domestic Product (GDP) and Population.

GDP forecasts were derived from expected growth rates for the 1990-2005 period. These growth rates are reported in . Population was derived in a similar way, using growth rates published by . The growth rates used in the model are shown in Table A.1.

Table A.1. Growth Rates of Gross Domestic Product and Population.

Region	GDP	Population
Argentina	0.8	1.5
Australia	3.5	1.4
Brazil	3.3	2.1
Cent. Africa	4.0	3.0
China	2.0	2.5
EEC-12	2.5	1.0
Egypt	3.1	2.5
India	4.0	2.9
Japan	4.3	0.6
Korea	6.5	1.1
Mexico	1.5	2.1
Pakistan	3.5	3.0
Turkey	5.0	2.1
United States	3.0	0.7

3. Commodity Prices.

Forecasts of commodity prices (e.g., oil, fertilizers, soybeans, rice, and coarse grains prices) were obtained from Price Prospects for Major Primary Commodities, Report No.814/88. International Trade Division, World Bank. This publication contains price forecasts for all the major primary commodities, based on econometric commodity models.

4. Weather Variables.

Weather variables were set at their historical mean levels.

5. Production and Consumption in the Rest-of-the-World region of the model.

Forecasts of production and consumption in the Rest-of-the-World region of the model were obtained by regressing these variables against time. The equations gave growth rates of between 1% and 1.5% per year.

LIST OF REFERENCES

List of References

Adams, F.G. and J.R. Behrman (1976), Econometric Models of World Agricultural Commodity Markets, (Cambridge, Mass.: Ballinger Publishing Co.).

Agbadi, I. (1988), An Econometric Analysis of the U.S. Cotton Man-Made Fibers and Textile Sectors, unpublished Ph.D dissertation, Texas Tech University, May.

Anderson, J. (1974), "Simulation: Methodology and Application in Agricultural Economics," Review of Marketing and Agricultural Economies, March:3-55.

Chow, G. (1960), "Statistical Demand Functions for Automobiles and their Use for Forecasting," in A.C. Heberger (ed.), The Demand for Durable Goods, Chicago, University of Chicago Press.

Cline, W. (1987), The Future of World Trade in Textiles and Apparel, Institute for International Economics, Washington, D.C.

ContiCotton (1990), The Administrations 1990 Farm Bill Proposal, Vol. IV, No. VI.

Crook, F.W. (1987), Agricultural Statistics of the People's Republic of China, 1949-86, Situation and Outlook Series, Various Issues, Economic Research Service.

Deaton, A. and J. Muellbauer (1980), Economics of Consumer Behavior, (New York: Cambridge University Press).

Donald, K.R., F. Lowenstein and M.S. Simon (1963), "The Demand for Textile Fibers in the United States," Economic Research Service, USDA, Technical Bulletin No. 1301.

Dudley, G.E. (1974), "U.S. Textile Fiber Demand: Price Elasticities in Major End-Use Markets," Economic Research Service, USDA, Technical Bulletin No. 1500.

Ecevit, L.U. (1987), "Recent Developments in the World Cotton Market and the Future Outlook," International Monetary Fund Staff Papers,380-405.

Evans, S. (1977) "Competitive Relationships Between Cotton and other Crops, by Region, 1976 and 1977," Economic Research Service, USDA, Cotton and Wool Situation, February.

Fackler, P.L. (1988), "Vector Autoregressive Techniques for Structural Analysis," North Carolina State University Department of Economics and Business, Faculty Working Paper No.113, January.

FAO, World Apparel Fiber Consumption Survey, Various Issues.

Fiber Economics Bureau, Inc., Fiber Organon, Various Issues.

Fiber Economics Bureau, Inc., Textile Organon, Various Issues.

Ghosh, S., C.I. Gilbert and A.J. Hughes Hallett (1987), Stabilizing Speculative Commodity Markets, Clarendon Press, Oxford.

Gilbert, C.L. and T.B. Palaskas (1989), "Modelling Expectations Formation in Primary Commodity Markets," unpublished.

Goto, J. (1988), Effects of the Multifibre Arrangement on Developing Countries. A Survey, World Bank, PPR Working Paper, WPS 102.

Hamid, N., T. Pinckney, S. Gnaegy and A. Valdes (1987), "The Wheat Economy of Pakistan: Setting and Prospects," IFPRI, November.

Houthakker, H.S. and L.D. Taylor (1966), Consumer Demand in the United States, 1929-1970, Analyses and Projections, Cambridge, Mass., Harvard University Press.

Houthakker, H.S. and L.D. Taylor (1970), Consumer Demand in the United States, 1929-1970, Analyses and Projections: Second and Enlarged Edition, Cambridge, Mass., Harvard University Press.

Hufbauer, G., D. Berliner and K. Elliot (1986), Trade Protection in the United States: 31 Case Studies, Institute for International Economics, Washington, D.C.

Hwa, E.C. (1981), "A Simultaneous Equation Model of Price and Quantity Adjustments in World Primary Commodity Markets," World Bank Staff Paper, No.99.

Hwa, E.C. (1985), "A Model of Price and Quantity Adjustments in Primary Commodity Markets," Journal of Policy Modeling, 7:305-38.

ICAC (1988), Cotton: Review of the World Situation, 3:3-9.

Intriligator, D.M. (1978), Econometric Models, Techniques and Applications, New Jersey: McGraw-Hill Inc.

Kirmani, N., et al., (1981), Effects of Increased Market Access of Exports of Developing Countries, IMF Staff Paper, Washington, D.C.

Labys, W.C., (1988), "Recent Developments in Commodity Modeling: A World Bank Focus," World Bank, PPR Working Paper, WPS 119.

Leamer, E.E. (1985), Vector Autoregressions for Casual Inference? In Understanding Monetary Regimes, ed. K Brummer and A. Meltzer. Caregie-Rochester Conference Series on Public Policy, 22:255-304, Amsterdam: North-Holland.

Leuthold, R.M. (1975), "On the Use of Theil's Inequality Coefficients," American Journal of Agricultural Economics, 54:84-91.

Maddala, G.S. (1977), Econometrics, New York: McGraw-Hill Inc.

Magleby, R.S. and E. Missaien (1977), "World Demand Prospects for Cotton in 1980, with Emphasis on Trade by Less Developed Countries," Economic Research Service, USDA, Foreign Agricultural Economic Report No. 1000.

Martin, W. and S. Suphachalasai (1988), "Gainers and Losers from the Multi-Fiber Arrangement," presented at 1988 Australian Economic Congress, Australian National University.

Monke, E.A. (1981), "International Market Demand for Cotton: A Survey of the Literature," Working Paper No. 2, The Interaction of Demand, Supply and Government Policy: A Case Study of Egyptian Cotton.

Monke, E.A. and L.D. Taylor (1983), "A Trade-Constrained Model for Cotton," unpublished.

Mues, C. and P. Simmons (1988), "The Effects of US Farm Policy on Australian Cotton Revenues." presented at 32nd Annual Conference of the Australian Agricultural Economics Society, La Trobe University, Melbourne, 8-12 February.

Mundlak, Y. and D.F. Larson, (1990), On the Relevance of World Agricultural Prices, World Bank, PPR Working Paper, WPS 383.

Myers, R.J., R.R. Piggott and W.G. Tomek (1991), "Estimating Sources of Fluctuations in the Australian Wool Market: An Application of VAR Methods," Forthcoming in Australian Journal of Agricultural Economics.

Orden, D., and P.L Fackler (1989), "Identifying Monetary Impacts on Agricultural Prices in VAR Models," American Journal of Agricultural Economics, 71:495-502.

Palaskas, T. and P. Varangis (1989), Primary Commodity Prices and Macroeconomic Variables, World Bank, PPR Working Paper, WPS 314.

Pindyck, R.S. and D.L Rubinfeld (1981), Econometric Models and Economic Forecasts, 2nd Edition, McGraw-Hill Book Company.

Pelzman, J. (1988), "The Tariff Equivalents of the Existing Quotas under the Multi-Fiber Arrangement," (memo).

Sampson, G. (1986), "Market Disturbances and the Multi-Fiber Arrangement," in Snape, R., ed., Issues in World Trade Policy, Macmillan Press, London.

Sargent, T. (1979), "Estimating Vector Autoregressions Using Methods Not Based on Explicit Economic Theories," Federal Reserve Bank of Minneapolis Quarterly Review, Summer:8-15.

Sargent, T. (1984), "Autoregressions, Expectations, and Advise. American Economic Review, 74:408-415.

Sims, C.A. (1980), "Macroeconomics and Reality," Econometrica, 48:1-48.

Sims, C.A. (1986), "Are Forecasting Models Usable for Policy Analysis?," Federal Reserve Bank of Minneapolis Quarterly Review, Winter:2-16.

Spinanger, D. (1987), "Will the Multi-Fiber Arrangement Keep Bangladesh Humble," The World Economy, March.

Starbird, I., E. Glade, W. McArthur, F. Cooke and T. Townsend (1987), The US Cotton Industry, Economic Research Service, USDA.

Starbird, I. and J. Hazera (1983), "Analysis of Factors Affecting Cotton Yields," Economic Research Service, USDA, Cotton Outlook and Situation.

Tarr, D. and M. Morkre (1984), Aggregate Cost to the United States of Tariffs and Quotas on Imports, Federal Trade Commission, Washington, D.C.

Teigen, L. and F. Singer (1988), Weather in US Agriculture, Economic Research Service, USDA.

Theil, H. (1966), Applied Economic Forecasting, Chicago: Rand-McNally.

Theil, H. (1978), Introduction to Econometrics, Englewood Cliffs, New Jersey: Prentice Hall.

Thigpen, M.E. (1978), "International Cotton Market Prospects," World Bank Staff Commodity Paper No. 2, June.

Thigpen, M.E. and D.O. Mitchell (1988), "Modelling the World Fiber Market," presented at the 25th International Conference on International Commodity Market Modelling, Applied Econometric Association, World Bank, Washington, D.C., October.

UNCTAD (1986), Protectionism and Structural Adjustment, Geneva.

US Department of Agriculture (1987), Major World Crop Areas and Climatic Profiles.

US Department of Agriculture, Cotton Situation and Outlook Series, Economic Research Service, Various Issues.

US Department of Agriculture, China Agriculture and Trade Report Situation and Outlook Series, Economic Research Service, Various Issues.

US Department of Agriculture, USSR Agriculture and Trade Report Situation and Outlook Series, Economic Research Service, Various Issues.

WEFA (1990), World Economic Outlook, Volume 1-4.

Whalley, J., et al. (1988), "Do Developing Countries Lose from the MFA," (memo).