CHAPTER II
REVIEW OF LITERATURE

Cotton is being produced in approximately 70 countries in the world, but the 10 top producing countries share 85% of world’s production. They are Australia, Brazil, China, Greece, India, Pakistan, Syria, Turkey, the United States, and Uzbekistan (Chaudhry, 2000AD). During 2000, the five largest producing countries, China, India, Pakistan, the United States, and Uzbekistan produced around 70% of the total crop. The largest producing country is usually China, the United States is second, India is third, and Pakistan is fourth.

The world’s four largest cotton consuming countries are China, the United States, India, and Pakistan. Together, these four countries utilize around 60% of the cotton world’s production. The next three largest consumers are Turkey, Brazil, and Mexico. Although they produce cotton, they are also larger importers of the fiber. The United States is the world’s leading cotton exporter, accounting for 25-30% of global raw cotton trade. The U.S. cotton industry generates more than $25 billion in products and services annually, and provides over 400,000 jobs among its various sectors, from the farm to the textile mill. The next three largest exporters are Uzbekistan, Francophone Africa, and Australia. These four world regions altogether account for about 70% of the global cotton exports.

Accounting for about 40% of total fiber production, cotton is the single most important fiber in the world. During 2000, 89% of the world’s cotton
production was expected to be produced in the Northern Hemisphere and only 11% in the Southern Hemisphere (Chaudhry, 2000AD)\(^1\). In 1993, the International Cotton Advisory Committee (ICAC) estimated that the world cotton economy consisted of between 100 and 200 million growers, with a similar number of people employed seasonally in the production and harvest of 87 million 480-pound bales of lint per year.

According to McDonald (2000)\(^2\), in recent years six importers have accounted for 40% of the world trade: the European Union, Indonesia, China, Brazil, South Korea, and Thailand. The United States exports to all of these markets, but only accounts for a small share of imports by the European Union and Brazil. The leading markets for the United States are Mexico, Turkey, Japan, and Korea. In summary, although many countries in the world participate in the production, consumption or trade of raw cotton, a high percentage of these activities is concentrated in a few countries.

Cotton is a major agricultural, industrial and consumer commodity in the U.S. and the rest of the world. The cotton industry has experienced severe economic stress in recent years and many changes have occurred in world cotton markets. World consumption stagnated in the 1990s and only rose in 1999/2000 after five years of price declined. During the 1990s, cotton consumption was affected by the collapse of the Russian’s textile industry, the problems of the Asian-dominated textile industry due to the Asian financial


crisis, the stagnation of consumption in China and Pakistan, and the increase of polyester consumption in the late 1990s.

The average world cotton yield has not increased since 1991/1992, when it reached a record of 533 pounds of lint per acre. On the other hand, the cost of production has increased in many countries. Some countries have gone out of production because of high costs. With increasing inputs costs, the failure of yields to increase implies that the average cotton grower in the world is earning less per acre of production that at the end of the 1980s (Townsend, 2001).\(^3\)

As the rest of the world, the U.S. cotton industry has also faced the problems of flat yields, low prices, and rising in the cost of production. In addition, improper weather during the recent growing seasons and the passage of the 1996 "FAIR" Act reducing government involvement in the sector have negatively affected the U.S. cotton sector. This reduced involvement has been seen as a reduction in cotton price (Townsend, 2001).\(^4\)

As with other major agricultural commodities, the current trend towards globalization has liberalized and increased cotton international trade (Ethridge, 1998; Hudson, 1998). This is critical since trade is particularly important in cotton. Before processing, 30% of the world's consumption of cotton fiber crosses international borders, and through trade in yarn, fabric and clothing, much of the world's cotton again crosses international borders at least once more before reaching the final consumer. Additionally, the


Uruguay Round Agreement on Agriculture and the Agreement on Textiles and Cloth provide for a more transparent and open market on world cotton and textile trade (MacDonald, 2000)\(^5\).

The problematic situation confronted by the cotton sector during recent years and the increasing level of globalization has led to a greater need for understanding production and marketing systems of countries other than the United States. A better understanding of the supply and demand forces underlying cotton markets in other countries can improve policy and industry decisions in the United States. The assessment of the magnitude and direction of the global future cotton supply and demand relations could provide U.S. producers and processors with useful information in appraising the potential and sustainability of cotton production and trade. The study of the cotton supply and demand forces would be useful to U.S. policymakers to design market and trade policies to sustain and develop the cotton industry.

Since the activities of production, consumption and trade of cotton in the world are concentrated in very few countries, the study of the foreign cotton industry needs to focus primarily in those countries that are major participants in the global cotton market. Given the resources constraint (i.e., time, data availability, etc.) only a subset of those countries was selected for this research, and the cotton subsector in which this study focused was the production sector. Three countries were chosen: India, Pakistan, and Australia. Current information about production response\(^5\) for cotton in these

countries is limited. The most recent studies found in the literature for India and Pakistan date back to the 1980s, and in the case of Pakistan the early 1990s. Therefore, there is a need for further research to develop updated production response functions for these major producing countries. These three countries are key players in the world cotton market. India is the largest producing country in the world after China and the United States, and the second consuming country after China. Although during the last decades India has not imported or exported large quantities of raw cotton, it is predicted that this country will become a net importer of cotton in the near future (FAO, 1999AD). Pakistan is the third largest consuming country, and the fourth largest cotton producing country in the world, and it is likely that it will become an importer of cotton as well (FAO, 1999BC). Australia is the seventh largest producing country and the third largest exporter.

Since the main focus of this research is the study of the cotton marketing response, the following literature review summarizes previous studies dealing with this topic. The literature review is subdivided into five categories: supply response models for India, Pakistan, and Australia; basic agricultural supply models; price specifications in supply models; policy variables; and the yield effect.

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Several studies have been conducted to analyze the supply response of cotton in India, all of them are from periods previous to 1984. Coleman and Thigpen (1991) specify and estimate an econometric model for the world fiber market. In the justification of their study, the authors point out the need for a greater analytical insight into various areas of the fiber market, given the substantial changes observed since the early 1960s.

The model is used to forecast prices, production and consumption by the major world fiber market participants, and to estimate the impact of different market and/or policy changes on these variables. Equations for the demand and production of cotton and non-cellulosic fibers are specified for different regions. The countries included in the model are Argentina, Australia, Brazil, Central Africa, China, Egypt, India, Mexico, Pakistan, Turkey, and the United States. In some of the countries, regional disaggregation is used to account for differences in regional prices, alternative crops, and weather conditions.

Cotton production in each region is modelled by two behavioural equations for yields and area planted, as well as an identity making production the product of yields as per area. All equations are estimated using OLS. The explanatory variables used in the yield equation are current cotton price, price of fertilizer, weather (rainfall and temperature), and the area of planted. Dummy variables are included in some cases to explain extremely good or bad weather during a given year.

Cotton acreage is specified as a function of lagged prices of cotton and competing crops. In some of the cases, a lagged dependent variable is added
to capture adaptively formed expectations. A time trend and/or dummy variables for some years are also used in several equations to account for region specific situations such as policy effect, bad weather, etc.

International cotton and competing crop prices are used in most of the country models. However, since the producers in some countries did not face international prices; local prices were used for the United States, India, and China. Overall, the majority of the yield and area equations had a corrected R^2 greater than 80%. Coleman and Thigpen (1991)\textsuperscript{8} is an important reference for understanding the international cotton supply phenomenon, since it is one of the few recent studies including supply functions for the three of the countries to be considered in the proposed research. Some of the limitations for this study are the level of aggregation used in countries like China and the lack of policy and weather variables in some of the country models.

Coleman and Thigpen (1991) determine behavioural equations for yield and area planted for the three cotton production regions in India for the period between 1965 and 1984. Specifically, the yield equations estimated by these authors are:

1. **Northern Region**

   \[
   CY = 0.32 + 0.06 \ln(\text{Time}) - 0.0002 \text{ CA} + 0.0001 \text{ RN} + 0.15 \text{ D1971} + 0.06 \text{ D1973} \quad (2.1)
   \]

2. **Southern Region**

   \[
   CY=0.10+0.05 \ln(\text{Time}) - 0.00001 \text{ CA}+0.00009 \text{ RN} - 0.20 \text{ D1984} \quad (2.2)
   \]

3. Western India

\[ CY = 0.04 \ln(\text{Time}) + 0.00006 \text{RNS} + 0.03 \text{D1976} - 0.02 \text{D1983} \]  
(2.3)

where CY is cotton yields, Ln indicates variable transformed into logarithms, CA is cotton area, RN is annual rainfall (mm), and RNS is summer rainfall (mm). D1971, D1973, D1983, and D1984 are dummy variables (equal to 1 in the corresponding year and 0 otherwise).

All the estimated parameters are statistically significant at the 0.05 significance level and the three equations show R\(^2\)s higher than 0.86. According to the authors, no statistically significant relationships were found between yield and economic variables such as cotton, competing crops and inputs prices. Except for the dummy variable D1983 included in the yield equation for the Western region, no rational explanation is provided for the inclusion of the other dummy variables in the models. It is argued that the abnormally low yields in 1983 were caused by heavy unseasonal rainfall that prevented timely spraying of insecticides.

The acreage equations estimated by Coleman and Thigpen (1991) are:

1. Northern Region

\[ CAt = 0.95 \ CAt-i + 13.86 \ CPt-i + 117.4 \ D1983 - 225 \ D1985 \]  
(2.4)

2. Southern region

\[ CAt = 1504-h \ 44.65 \ CPt-i, - 236.9 \ D1973-f-233.2 \ D1976 \]  
(2.5)

3. Western India

\[ CAt = 6231 + 134.1 \ CPt-i - 510.3 \ln(\text{Time}) - 497.1 \text{D1974} \]  
(2.6)

where CAt is cotton area at time t, CAt-i is cotton area lagged one year, CPt-i is deflated lagged cotton price, and Ln is natural logarithm. D1974, D1976,
and D1985 are dummy variables (equal to 1 in the corresponding year, and 0 otherwise). All the estimated parameters are statistically significant at the 0.05 significance level and the three equations show \( R^2 \)'s higher than 0.87.

The lagged area in the Northern India equations and the logarithm of time in the Western India equation are said to capture a strong trend in the area data. No statistically significant relationships are found between cotton area and prices of competing crops (i.e., corn in the North, sorghum in the South, and millets in the West). The dummy variables included in the models are supposed to capture the effect of prices of competing crops, as well as changes in policy variables.

With the objective of analyzing alternative policies to promote growth and structural transformation of the agricultural sector in India, Narayana, Parikh, and Srinivasan (1991)\(^9\) construct a Policy Model for Agriculture, Growth and Redistribution of Income (AGRI Model). The model has four components: supply, demand, policy, and exchange. The supply component includes the farm supply response models of 25 individual crops for the whole country for the period from 1953 to 1974, including cotton. The equations for crop acreage and yield response are estimated independently of each other.

With regard to crop acreage response, these authors argue that the farmer's desired allocation of land among competing crops depends basically on the expected revenue of the crop relative to that of competing crops,

rainfall, technological features, and past allocation decisions. The acreage response model for each crop is specified as follows:

$$A_t^* = a (E[Z_t])^b (R_t) (IA/GIA)t^c (IAsc/GIA)^d (GIA)^e W_t^f \quad (2.7)$$

$$A_t = (A_t^*)^{(A_t-i)^g} \quad (2.8)$$

where $A_t^*$ is long-term desired acreage, $A_t$ is actual acreage, $E[Z_t]$ is expected revenue of the crop relative to that of its competing crops, $R_t$ is a crop specific rainfall index, $L$ is irrigated area of competitive crops, $GIA$ is total irrigated area, $IAsc$ is irrigated area of sugarcane, $Log(V_t)$ is a normally distributed random error with mean zero and constant variance, and $a, b, c, d, e, f$ are parameters.

The process followed to estimate the acreage response equations is:

1. **Estimation of the crop revenue expectation equation**

   The authors postulate that the farmer's process of formation of revenue expectations is an Auto-Regressive Integrated Moving Average (ARIMA) process. They contend that farmers take into account not only past observed revenues, but also the extent by which their expectations differed from the actual realizations in the past. In addition, gross revenue per hectare (yield $x$ crop wholesale price index) is used as a proxy variable for profit instead of prices to account for the effect in the variations in yields because of technological progress. This equation expressed as an ARIMA process is:

$$nt = E[nt] + W_t \quad (2.9)$$

$$E[nt] = (pnt-i + 9nt-2 + cpnt-3 + \ldots + n + eiWt-i + e2Wt.2 + e3W.3 + \ldots, \quad \text{where } H_t \text{ is actual revenue of the crop, } E[nt] \text{ is expected revenue of the crop, and } W_t \text{ is a random white noise or random disturbance. Different ARIMA}$$
schemes are used to estimate equation and the best schemes are selected by checking stationary restrictions on the estimated parameter values and applying chi-square tests on the residual auto correlations.

The expected revenue of the crop relative to that of competing crops \(E[Z_{it}]\) is calculated using one of the following equations:

\[
E[Z_{it}] = \frac{E[n_{it}]}{(E[n_{e1, it}] \cdots E[n_{c, it}])^{1/n}} \quad (2.11)
\]

\[
E[Z_{it}] = \frac{E[n_{it}]}{(E[n_{ei, it}]+ E[n_{c2, it}] + \cdots E[n_{cnt}])^{i/n}},
\]

where \(E[n_{ci, it}]\) is expected revenue of the ith competitive crop.

**2. Estimation of the acreage response equations**

The reduced form of the acreage model shown in equations 2.7 and 2.8 is as follows:

\[
\ln(A_t) = a + (1 - T) \ln(A_{t-1}) + b \ln(E[Z_{it}]) + c T \ln(R_t) + d \ln(\frac{IA/GIA}{t}) + e T \ln(IASC/GIA) + f T \ln(GIA) + T \ln(V_t).
\]

A first-order auto correlation scheme is assumed and the parameter ‘p’ is calculated using the Hildreth-Lu procedure. In the case of the cotton acreage response equation the authors indicate that they did not obtain acceptable results using \(\ln(A_t)\) as the dependent variable, but that the results became acceptable when they used the area of cotton related to the area of maize as the dependent variable. Jowar, bajra, and maize are considered as the main competing crops. The estimated cotton acreage response equation is:

\[
\ln\left(\frac{A(Cotton)}{A(Maize)}\right) = -0.000051 + 0.0182 \ln(R_t) + 0.0654 \ln(E[Z_{it}]) + \ln\left(\frac{A(Cotton)}{A(Maize)}\right).
\]
The cotton yield response function is postulated to be a function of irrigation intensity, fertilizer use, rainfall, time, and lagged yield. The final estimated equation for cotton yield is:

\[
\text{CY} = 0.37777 + 1.6607 \ PI + 0.0035 \text{Time},
\]

where CY is cotton yields, and PI is the proportion of irrigated area of cotton to the total planted area. In order to analyze the long-run prospects of the cotton sector in India, Hitchings (1984) builds a simultaneous supply/demand model for cotton and textiles. The model includes three equations (supply of lint, mill consumption of lint, and private consumption of cloth) and two identities for raw cotton lint and cloth.

The lint supply equation relates lint production to lagged real lint and food grains price indices, and to the lagged proportion of cotton area under irrigation. The lagged proportion of cotton area under irrigation is used instead of the current irrigated proportion arguing that the farmer’s production decision depends on past crop profitability which is affected by irrigation. This study covers the period from 1955 to 1979. After concluding that all the equations of the simultaneous system are exactly identified, the author estimates the system using indirect least squares, which is equivalent to the OLS estimation of each reduced form equation. Moreover, the supply equation used in the study is as same as in the structural model and the reduced model since lint production is not a function of current endogenous variables. From these equations, three sets of price elasticity are calculated. When using nominal prices, the own and cross price supply elasticity (with respect to food grains)

are almost equal in magnitude and opposite in sign. However, when estimating the elasticity with real prices the value of the elasticity changes depending on the deflator used.

The majority of the studies have been dealt with cotton supply response (acreage) at the level of specific states or regions, and a wide variety of model specifications have been used. Most of the studies include as explanatory variables deflated lagged cotton prices and lagged cotton area. Rainfall and a trend variable are very common variables related to yields. No considerations have been made for the effect of risk or policy variables in the models. From the estimated own price elasticity’s, it appears that the cotton acreage is more responsive to changes in cotton prices in the Northern region than in the Southern and Central regions.

Summarizing this section, although there are several studies dealing with the cotton supply response in India, a very few have been conducted in the last two decades. The majority of these studies have used the Neriovan approach to model the cotton supply response. All these studies are relevant for this research because they provide insights about the variables that should be included in the model. Their results are useful for comparison purposes.

Hudson (1997) estimates a cotton supply model for Pakistan, using 1971 to 1993 data. This model is part of a study to determine the impact of price policy on the raw cotton market, income distribution, and economic growth of the cotton and yarn sectors of the Pakistani economy. Two equations are used to represent the cotton supply: a yield and an area equation. The remainder of the cotton and yarn sector is modelled using a
system of 19 simultaneous equations. The yield and acreage equations are estimated by OLS, while the simultaneous system is estimated by using Three Stage Least Squares (3SLS). Overall, Pakistani price policy was found to increase production and export of cotton yarn, but at a very high social cost. The formulation of the area equation in Hudson (1997)\textsuperscript{11} is similar to Evans and Bell (1978)\textsuperscript{12}. Area is hypothesized to be a function of cotton price and the ratio of cotton to sugarcane revenue lagged one year. To account for the effect of the two-price policy established by the government, the price used in the specification was higher between the benchmark government price and the internal market price. The author justifies the use of the lagged price of cotton as the price expected by producers arguing that the uncertainty inherent in government decisions gives the producers little alternative foundation on which to base their expectations. Yields are specified as a function of cotton price, total cotton production costs and a variable to account for the departure of rainfall from its average during the Pakistani growing season. The sensitivity of crop yields to the amount and timing of rainfall and the fact that varieties and production systems are usually developed for average conditions are the reasons given by the author to include this variable in the model.

The R\textsuperscript{2}s for the yield and area equations are 0.63 and 0.83, respectively. The production cost variable does not appear to significantly affect the yield. The ratio of revenue from cotton to sugarcane variable in the acreage equation is not statistically significant either. The estimated values of


the yield, area, and production elasticity with respect to own prices are 0.66, 0.25, and 0.62, respectively.

Coleman and Thigpen (1991) estimate equations for cotton acreage and yield response in Pakistan's Punjab and Sindh provinces from the period 1965 to 1985. The equations reported in the study only contain the independent variables that are statistically significant. The authors point out that all the prices used in the estimation were average national prices since regional prices were not available. The variables found to best explain the variability of cotton yields in the Punjab region are the time trend variable and two zero-one dummy variables for 1971 and 1983. No significant relationship is found between yield and economic or climatic variables. With regard to the acreage equation, the statistically significant independent variables are the lagged deflated cotton price, the lagged cotton area and dummy variables for the years 1971, 1975, and 1976. The R^2's of the yield and acreage equations are 0.80 and 0.90 respectively.

In the case of the cotton yield equation for Sindh Province, the statistically significant independent variables are the deflated cotton price, the area of cotton planted in the region, a variable for the number of tube wells in the region, and dummy variables for the years 1972, 1978, and 1983. Cotton area in the Sindh province is found to be a function of lagged cotton area and dummy variables for 1976 and 1977. The R of both the yield and acreage equation is 0.91.

Ali (1990) estimates the supply response for five major crops in Pakistan: wheat, cotton, rice, sugarcane, and maize based on the production and expected wholesale-price data for the period 1957-1986. The supply response model used in this study is a system of five equations (one for each crop) expressed in log-linear form. The supply response of each crop is assumed to be a function of expected own output price, expected prices of all other relevant crops, fertilizer price, lagged crop area, and a time trend. All prices are deflated using fertilizer price. Arguing that each crop has contemporaneous relationships with other crops, the Seemingly Unrelated Regression (SUR) model is used to jointly estimate the parameters of the system of equations.

Since each of the supply equations is expressed as a function of expected crop prices, this study uses the Auto Regressive Integrated Moving Average (ARIMA) model to estimate the expected price of a crop. The use of this model is justified contending the flexibility of the model to forecast the value of a variable by identifying separately the stationary and random components of each of its past values. Different Auto Regressive (AR) and Moving Average (MA) schemes are tried. The best scheme is selected based on the statistical properties of the coefficients, a chi-square test, and the forecasting power of the scheme.

As expected, the use of the SUR model improves the efficiency of the parameter estimates compared with the single equation OLS results. All the own price elasticity are significant at the 0.20 significance level or lower. With

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respect to the cross price elasticity, the results show that the relationship between crops may be complementary in some cases and competitive in others. Moreover, some of the estimated cross price elasticity are not significant.

In the case of the cotton supply equation, the short-run own-price elasticity was estimated as 0.72. Only the parameter corresponding to the price of rice was found to be statistically significant (0.20 level of significance) with a negative sign. However, in the other crop supply equations, the parameter corresponding to cotton is statistically significant (0.20 significance level) and negative. In other words, cotton price is found to affect all other crops production, but only price of rice is found to affect cotton. The author attributes this result to the different growing periods and the proportion of the acres of competing crops in a given cropping zone. The long-run own-price elasticity for cotton was estimated in 1.4. Except in the case of maize, all the estimated fertilizer price elasticities are negative and statistically significant (0.20 significance level).

Ahmad (1985)\textsuperscript{15} studies the supply response of cotton in various zones of the Punjab province. The author points out the severe paucity of supply response studies for Pakistan. The study is confined to the Multan and Faisalabad zones, which share 64% and 25% of the total Punjab cotton acreage, respectively. Following a Nerioivan approach, the author includes as independent variables the lagged price of cotton relative to the weighted

average price of competing crops, the lagged yield of cotton to the weighted average yield of competing crops, the total area irrigated during the kharif season, the lagged total rainfall during the cotton sowing and growing period, the lagged area affected with waterlogging and salinity, and a time trend variable. The author justifies the use of relative cotton prices and yields with respect to prices and yields of competing crops to avoid the loss of degrees of freedom and the presence of multi-collinearity that would occur if all the prices and yields of the competing crops were included as independent variables in the model. The cotton relative prices and yields are calculated using sugarcane, rice, maize, and bajra as the competing crops, and the area planted in each crop is utilized as the weight. Assuming a geometric distributed lag model, the lagged acreage is also included in the model as independent variable and the Hildreth-Lu procedure is used to correct for serial correlation. The R^2's are 0.90 and 0.82 for the Faisalabad and Multan zones, respectively. In the acreage response function of Faisalabad all the estimated parameters are statistically significant at the 0.20 or lower significance level. In the Multan equation only the parameter estimate of the variable irrigated area resulted statistically significant at the 0.10 significance level. In the Faisalabad zone the short-run relative price elasticity is estimated to be 0.055, and the relative yield elasticity 0.129.

The majority of studies have used the Neriovian supply model. The elasticity for the Punjab region appears to be very low. As in the case of the studies dealing with the cotton supply response in India, these studies are an important reference for this research.
Compared with the number of studies dealing with the cotton supply response in India and Pakistan, the studies related to the cotton supply response in Australia are scarce. In this literature review, only two studies dealing with this topic were identified.

The first study is part of Coleman and Thigpen's (1991)\(^\text{16}\) econometric model of the world fiber market. The details of this study were already presented in a previous section. Both equations were estimated for the period from 1964 to 1988. The estimated acreage equation includes the lagged deflated price of coarse grains; the cotton area lagged one period and dummy variables for 1983 and 1987. The authors argue that the price of cotton is not included in the final specification since it was incorrectly signed when included in the equation. The R\(^2\) of this equation is 0.98. The estimated yield equation is a function of fame and dummy variables for 1972, 1975, and 1976. Prices of cotton and competing crops are not included in the model because these variables were not statistically significant. The inclusion of the dummy variables is justified because of low rainfall in those years. The R\(^2\) of this regression is 0.68.

The second study identified and related to the cotton supply response in Australia is Mues and Simmons (1988, cited by Coleman and Thigpen, 1991)\(^\text{17}\). The area equation specified by the authors includes the lagged world price of cotton, lagged world price of competing crops, and lagged acreage as explanatory variables.


The Neriovian Model Marc Nerlove (1958) study of dynamic supply response has been used as one of the main references in agricultural supply studies. In his work, Neriove stresses the need for an adequate identification of the price variable to which farmers react, as well as consideration of the supply problem in a dynamic context.

Neriove's supply model can be described using the following equations:

\[ Q_t^* = P_0 + P_t E(P)_t + P_2 Z_t + \epsilon_t \]

\[ E(P)_t = E(P)_{t-1} + a(P_t - E(P)_{t-1}) \]

\[ Q_t - Q_{t-1} = Y_{Ct}^t - Q_{t-1} \]

where \( Q_t \) and \( Q_{t-1} \) are production at time \( t \) and time \( t-1 \), respectively; \( E(P)_t \) and \( E(P)_{t-1} \) are expected price at time \( t \) and time \( t-1 \), respectively; \( Z_t \) represents other important variables that could be affecting production; \( P_{t-1} \) is prices at time \( t-1 \); \( Q_t^* \) is the long-run equilibrium output at time \( t \); and \( \epsilon_t \) is an error term. Equation summarizes Nerlove's hypothesis that producers have a notion of a long-run "normal" price. He argues that producers do not react to changes that they think are only temporary. They react to changes considered permanent, i.e., shifts in the "normal" price. The expected "normal" price is adjusted in an iterative process based on the previous year "normal" expected price plus a proportion of the difference between the actual and expected "normal" during the previous year. The long run "normal" price level determines a long-run equilibrium output level, which is also constantly updated.

The problem of changes in actual output in response to changes in prices is conceptually divided in three parts:
1. The effect of a change in actual price on the expected level of future prices.
2. The effect of a change in the expected level of future prices on the long-run equilibrium level of output.
3. The effect of a change in the level of long run equilibrium output on current output. In each period, output is assumed to be adjusted in proportion to the difference between the long-run equilibrium output and actual output in the previous year.

Neriove (1998) also explains the different statistical methods suitable for the estimation of his model and applies them to analyze the supply response of U.S. cotton, corn and wheat.

The Traditional Model

Even though most of the studies of supply response in agriculture have followed the Neriovian approach, the "traditional model" has also been used in some instances. The supply equation of this model is of the form:

\[ Q_t = P_0 + P_t E(P)_t - F_2 Z_t + e_t, \]

where \( Q_t \) is production at time \( t \), \( E(P)_t \) is expected price at time \( t \), \( Z_t \) represents other factors affecting production, and \( C_t \) is the error term. This model is a straightforward application of the economic theory of supply, which holds that production (or amounts supplied to the market) is directly related to price. Singh, Singh, and Rao (1974), in an empirical study of tobacco acreage response in the State of Andhra Pradesh in India, compare to the

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performance of the Neriovian and traditional models. This study also addresses procedural questions about the most relevant price specifications of the producer’s expectation behaviour and the level of aggregation in supply response analyses. Logarithmic specifications of both models are preferred to linear forms. Tobacco prices and lagged cultivated area are included in the Neriovian model. Rainfall, a time trend variable, a dummy variable for pest problems, and a risk variable are also considered as explanatory variables in both models.

The authors find both models equally efficient for estimating short-run supply elasticity. However, they acknowledge that the Neriovian model is superior in distinguishing the short and long-run elasticity, eliminating or reducing serial correlation and reflecting a more realistic supply situation. Adequate consideration of inter-regional differences is suggested in order to make more reliable future projections for policy analysis. Finally, they recommend that the selection of price specification not to be decided a priori, but through the use of alternative specifications in the statistical analysis.

Recognizing that a few studies have considered risk variables in the analysis of agricultural supply response. Just (1974)\(^\text{19}\) proposes the idea of including in the supply response models the variance and covariance of prices and yields as explanatory variables. In order to include these variables in the model, the author suggests that not only the expected prices and yields are formed using an adaptive expectations geometric lag model, but also the variance and covariance of these variables. The computation of consistent

estimators using maximum likelihood procedures are described in the article, and the model is applied to analyze California field-crop supply response.

The study also includes the estimation of Neriovanian models for comparison purposes. The proposed model has a better performance for crops in which production is large and government support is low. The author also concludes that the estimated parameter of the lag variable in the reduced form of a Neriovanian model in a context where a risk model is more suitable carries some of the effects of the variation in subjective risk.

Chavas and Holt (1990) develop an acreage supply model under expected utility maximization and apply it to empirically analyze U.S. corn and soybeans supply response. The authors point out the gap that exists between the economic theory of risk behavior and aggregate supply analysis. The proposed model assumes perfect knowledge of input prices and per acre costs, whereas yields and output prices are considered as random variables with subjective probability distributions. The authors conclude that under uncertainty, producers' decisions depend on wealth, expected profits per acre, as well as on second and possibly higher moments of the distributions of profits per acre.

This study also addresses some of the theoretical implications that can be tested or imposed in empirical applications. In the application of the model, a Tobit model is utilized to account for the truncation in the price distributions caused by the government support programs in corn and soybeans. The

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models perform well as indicated by high R^2's, the consistency of the signs with theory, and the significance and magnitude of the estimated parameters as compared with previous studies.

The authors also find evidence that both risk and wealth effects are important in corn and soyabeans allocation decisions. Price support programmes are found to have more impact in acreage decisions as the price support gets larger when compared with expected market price.

A discussion of price specification is relevant for the proposed research, since the study includes different geographical regions with particular economic, political, cultural, and environmental conditions that could affect the way in which the farmers behave.

The problem of the price specification is extensively discussed in Askari and Cummings (1976)\(^\text{21}\). In this work, a large number of empirical studies related directly or indirectly to Neriovian supply response models are analyzed and compared. The authors point out that although the majority of these studies are applications of the basic Neriovian response model, most of them depart in one or more respects from the original paradigm.

Neriove's original work does not take into account the difference between market prices and prices received by farmers and/or the difference between nominal and real prices to formulate his adaptive expectation model of prices. Therefore, different authors have used alternative price series such as us (Askari and Cummings, 1976)\(^\text{22}\).


1. The price received by farmers.

2. A ratio of the price received by farmers to some price index (e.g., consumer, farmers’ inputs, or competitive crops price index).

Analyzing the economic and institutional factors affecting planted acreage in the major cotton producing regions of the U.S. over the period 1959 to 1976, Evans (1977) utilizes a "traditional model" specification and introduces a new regional level variable to account for the effect of competing crops, independent of the variable cotton farm price, constructed as follows:

\[ E(P)P E(Y)P - VC P - H VCAVOC = , E(Y)\wedge \]

where:

AVOC = proxy for average variable and opportunity costs of producing cotton

E(P)P = expected farm price of competing crop

E(Y)P = expected yield of competing crop

VC P = variable costs of competing crop

VC \wedge = variable costs of cotton ginning costs

E(Y)\wedge = expected cotton yield.

According to Evans (1977), the variable AVOC identifies the price farmers must receive for their cotton for returns above variable costs from cotton to equal those from alternative crops. The cotton and competing crop prices are the average farm prices in the first 4 months of the year. The cotton and competing crop yields are the average of the previous three years. All the model coefficients are highly significant and the signs of the estimates are correct. The estimated coefficients for the cotton price and the AVOC variable have opposite signs but are nearly equal in magnitude, as suggested by the
theory. Evans uses the estimated equations to analyze the factors causing the increase in cotton plantings observed in 1977.

Chavas, Pope, and Kao (1983) investigate the role of lagged cash prices, future prices and government programmes on supply response in corn and soyabean in the United States. These authors argue that previous work had not considered the possibility that the farmer's price expectations could be affected by those three sources of information. A Nerioivan specification introducing lagged acreage as an explanatory variable is utilized.

Expected prices are defined as a weighted average of deflated future contract prices (FPt), lagged average cash market prices (Pt.i), and support prices (SPt):

E(P) = ai FPt + a2 Pt-i + a3SPt ,

where the parameters ai, a2 and a3 satisfy the conditions: ai -H a: 4- a3 = 1, and 0<a<i= 1,2,3). The expected price of soyabean is included as an explanatory variable in the corn supply response model and vice versa. The models are estimated using non-linear least squares. Policy variables are found to play an important role in the formation of price expectations. Future prices and lagged cash prices appear to be substitutable, reflecting similar market situations. Therefore, inclusion of both future and lagged cash prices in the model may lead to multi-collinearity. The use of future prices as a proxy for expected prices in supply response models appears to be useful only in the absence of government programmes. The possibility of using alternative

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prices as proxy for the expected prices may be important for the proposed research, given the data availability limitations in some of the countries being considered.

Most of the research in agricultural supply response has been based on the assumption that price effects are constant throughout the period studied. Addressing this issue, Parrot and Macintosh (1996)\textsuperscript{24} study price expectations in cotton production in Georgia during the period from 1950 to 1990. These authors use a Neriovian model including lagged cotton acreage, the effective cotton diversion payment, the season average cotton cash price, the effective support price, and the lagged season average soyabean cash price.

As in Chavas, Pope, and Kao (1983)\textsuperscript{25}, expected prices are considered as a weighted average of market and government prices. A Cooley-Prescot adaptive regression model is used to allow the parameters to change from period to period. The parameter estimates for cotton cash prices are significant for all the observations, while the parameter estimates for cotton support prices are significant only in 4 of the 41 observations. The authors conclude that government programmes variables have more effect in programmes years, whereas market forces seem to be more relevant on non-programmes years.


In summary, even though the price specification literature is quite extensive, there is not consensus regarding the issue. Different specifications have been shown to be useful as proxy variables for the expected price under different circumstances. The possibility of having different alternatives to use as price specifications is expected to be useful given the data availability limitations in some of the countries being considered.

Most of the literature dealing with the effect of agricultural policy on supply response of crops has been done for the United States. Even though the methods utilized in these studies do not have a direct application to the particular cotton production situations in the countries under study, they can give some insights about the different approaches that could be taken to address the problem.

According to Duffy, Richardson, and Wohlgenant (1987)\textsuperscript{26}, there are two general approaches to estimating supply response in the presence of farm programmes: a continuous analysis and a disaggregated approach. In the first approach, the periods in which similar programmes were in effect are analyzed independently. These authors find this approach Problematic since sometimes the policy instruments are used during a short period of time, and therefore the information obtained from the analysis is very limited. The degrees of freedom available for the statistical analysis often are very limiting as well. Hence, the authors recommend the use of the continuous analysis.

Utilizing the continuous approach, the authors develop an econometric model of cotton acreage for four producing regions in the U.S. from 1959 to 1983. Their main objective is to update the cotton supply elasticity estimates. In order to capture part of the effect of government programmes, these authors introduce a "supply inducing price" variable weighting the effective support price and the expected market price. The acreage response equations include as explanatory variables the supply inducing price of cotton, the supply inducing price of competing crops, the effective per acre diversion payment for cotton and a linear time trend. OLS and Generalized Least Squares (GLS) procedures are used to estimate the models. The elasticity values estimated are similar to the previous studies. The acreage supply models show that the price of competing crops has a significant impact on cotton acreage in some of the regions.

The parameter of the effective diversion payment is significant and negative in every region. The approach used by Duffy, Richardson, and Wohlgenant (1987) is somewhat similar to that of Parrot and Macintosh (1996) and Chavas, Pope, and Kao (1983) in that part of the policy effect is modelled by combining expected market and government support prices into a single variable.

Isengildina, Cleveland, and Hemdon (1997) present a different approach of combining market and government support prices. In an effort to separate the effect of policy and market forces on supply response, the

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authors use different variables, attempting to independently capture the effect of market prices and government programme payments. The acreage response analysis is carried out for 15 cotton producing states in the U.S. during the period from 1975 to 1994. Their acreage response models include the following independent variables: lagged planted cotton area, two policy variables, and a ratio of net returns per acre of cotton to net returns per acre of competing crops. The two policy variables utilized are: area diverted from cotton production and a ratio of government programme payments for cotton to government payments for competing crops. The model is estimated using OLS and corrected for the first order auto correlation. The lagged area variable and the two policy variables are statistically significant in almost all the states, whereas the net return variable is only significant in a few states. The R values are higher than 0.70 in most cases.

Summarizing this section, under a continuous analysis of the effect of policy on crop supply response, price and policy variables have been separately considered as independent variables or pooled together in an attempt to reflect the expected market price. The production policy variable diversion programme payment has been mostly considered as a separate explanatory variable. Although cotton agricultural policies are likely to be different in the countries being considered, this section provides some methods that could be adapted to include policy variables in the analysis of supply response.

The effect of yield in supply response models has received less attention than other explanatory variables. In some studies of supply
response, the variable yield has also been included as an explanatory variable in the model. For example, Askari and Cummings (1976) argue that in practice farmers can respond to price variation by changing planted area and/or other inputs to improve yield. The following specification of the Neriovian model is presented:

\[ Q_t^A = P_0 + P_i E(P)_t + P_2 Z_t - h P_3 E(Y)_t + e_t \]  
\[ E(P)_t = E(P)_{t-i} + a(P_t-i E(P)_{t-i}) + 5, (E(Y)_t-i - Y_{i}) \]  
\[ Q_t - Q_{t-i} = Y(Q_t'' - Q_{t-i}) + 52(E(Y)_t-i - Y_{t-i}) \]

where \( E(Y) \) is expected yield, expressed as:

\[ E(Y)_t - Y_{t-i} = b(E(Y)_t, -Y_{t-i}). \]

This expected yield term accounts for short-term changes in yield or the effect of prices in yield through to change in the level use of inputs such as fertilizers or pesticides. Additionally, it could also capture long-run shifts in yields for reasons like the use of inferior land or technical change.

Although the use of inputs such as pesticides, fertilizers or irrigation has become increasingly important in the determination of farm profitability, yield has mostly been neglected in supply response analysis. Therefore, the inclusion of this variable could improve the analysis of the supply relations.

Sometimes, the agricultural economics literature does not make a clear difference between supply and acreage response. In reality, acreage response is only one component of the supply. Total output is obtained by multiplying total planted area times yield per unit of area. Evans and Bell

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(1978) are probably among the first in making this distinction. To estimate cotton supply, they suggest a system of two behavioral equations and an identity:

\[ A = f(E(P),ZA) \]  \hspace{1cm} (2.26) \\
\[ Y = g(E(P),A,ZY) \]  \hspace{1cm} (2.27) \\
\[ Q = A \cdot Y = f(P,ZA) \cdot g(P,A,ZY), \]  \hspace{1cm} (2.28) 

where \( Q \) is total production, \( A \) is area planted (acreage), \( Y \) is yield, \( E(P) \) is expected price for cotton, and \( ZY \) and \( ZA \) are all other factors affecting area planted and yields. \( ZY \) included rainfall, temperature, acreage planted in "skip row" patterns, and a time trend to account for technological change. \( ZA \) included average variable and opportunity costs of growing cotton and policy variables. The expected prices are calculated by averaging the farm prices from January to April of the current year. Expected yields utilized to estimate the opportunity costs of growing cotton are calculated by averaging the actual yields during the three previous years. The average variable and opportunity costs are calculated as the variable AVOC in Evans (1977).

The regions considered in Evans and Bell (1978) are the four main cotton producing regions in the U.S., during the period 1956 to 1976. The authors show that cotton production response depends on the relative response of acreage to price and yield to acreage and price. The policy variables included in their model are also found to affect production response. These authors conclude that a 13 percent change in cotton acreage is needed to change production by ten percent. Since the proposed study will analyze supply response by separately considering acreage and yield response, the
two behavioral equations system in Evans and Bell (1978) provides a good example of the elements to be considered for such analysis.

Traditionally, percentage changes in acreage have been equated with percentage changes in production. However, there is an evidence indicating that changes in yield also have significant impact on production. Therefore supply response is probably better modelled by specifying and estimating two separate equations: one for acreage response and another for yield response.

In this chapter an elaborate analysis is made in relation to various studies done in respect of marketing of cotton and other related products.